ENGAGING SCIENCE

Thoughts, deeds, analysis and action

Edited by Jon Turney

wellcome trust

WELLCOME TRUST PUBLIC ENGAGEMENT HIGHLIGHTS

1993 — ***Science for Life*** exhibition launched in the Wellcome Building; later transferred to Manchester Museum

1996 — Launch of the first **Sciart** funding scheme

1998 — Publication of *Public Perspectives on Human Cloning*

Launch of **Medicine in Society**, Wellcome Trust's first public engagement and biomedical ethics funding scheme (£1.25m per year)

2000 — **Wellcome Wing** opens in the Science Museum (£17.75m award)

£17m funding for **science centres** in Birmingham, Dundee, Bristol, Glasgow and Newcastle upon Tyne

Publication of *The Role of Scientists in Public Debate* and *Science and the Public*

2001 — Publication of *Valuable Lessons: Engaging with the social content of science in schools*

'Genomic' portrait of John Sulston by Marc Quinn is unveiled at the National Portrait Gallery

Wellcome Wolfson Building (£2.25m award) to house BA and Dana Centre

2002 — **Science Centrestage** initiative involving 91 secondary schools

Launch of **Engaging Science** (£3m per year) public engagement with science grants programme

Launch of **Rediscover**, £33m joint venture with Millennium Commission and Wolfson Foundation for science centres and museums

Medicine in Context exhibitions launched at Science Museum and ran up to 2005: *Head On; Metamorphing; Treat Yourself; Pain; Future Face*

2003 — Opening of £5.4m ***Living and Dying*** exhibition in the Wellcome Trust Gallery in the British Museum

Opening of ***Medicine Man: The forgotten museum of Henry Wellcome*** exhibition at the British Museum

Publication of *Life Study: Biology A level in the 21st century*

2004 — **Darwin Phase 2** at Natural History Museum (£10m award)

Unveiling of Thomas Heatherwick sculpture **'Bleigiessen'** in Wellcome Trust headquarters, 215 Euston Road

2005 — Opening of £25m **National Science Learning Centre** at York (in £51m partnership with DfES)

Re-opening of **Hunterian Museum** (£1m award)

Publication of *Primary Horizons: Starting out in science*

2006 — Opening of **Roundhouse** (£2.5m award)

Engaging Science conference held in Manchester

Generation Genome, a genomics exhibition to tour UK science centres and museums from 2007 (£1.5m award)

2007 — Opening of **Wellcome Collection** at 183 Euston Road, London

Timeline includes the major highlights. Details of projects funded can be found at www.wellcome.ac.uk/publicengagement.

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Cover:
IMPACT Danscience is an interpretation of the emerging science of epigenetics. The intricate moves of the young dancers draw upon both classical Indian dance and the dynamics of cells, nuclei and chromosomes. It is the result of a series of workshops run by the choreographers Mayuri Boonham and Subathra Subramaniam of ANGIKA Dance Company, and biomedical scientist Dr Sheila Ochugboju. The project was funded by a Wellcome Trust Pulse award. *D Kampfner*

FOREWORD

If the public is to trust, debate and value scientific progress, we need a society engaged with contemporary science. Encouraging people's engagement with science – its potential applications, misapplications and impacts, as well as the nature of science itself – is therefore an important part of the Wellcome Trust's work.

For a decade or more, we have supported public engagement activities, funded through grants, partnerships with other institutions, or our own projects. In all, we have invested some £100 million.

This has been an era of profound scientific progress, and considerable social change. Both factors have inevitably influenced public engagement – thinking and practice. This publication is an attempt to take stock of these changes, to reflect on what we have learned and to consider where we might go in the future.

It combines reflective essays from leading figures in public engagement, from a diverse range of fields, with case studies highlighting some of the most significant projects that we have funded. Our aim is to contribute to current thinking about the nature, purpose and future of public engagement, and to communicate how the Wellcome Trust has contributed to the field over the past decade.

The essays have been expertly edited by Jon Turney, who also contributes some thoughtful concluding remarks. The authors have been given free rein. Their thoughts and opinions do not necessarily correspond with ours, but we are sure they will all contribute to further fruitful discussions about the past achievements and future challenges for public engagement.

Mark Walport
Director, Wellcome Trust

ENGAGING SCIENCE: CREATIVE ENTERPRISE OR CONTROLLED ENDEAVOUR?

By Clare Matterson

A dance inspired by epigenetics, the potential impact of new GCSE science curricula, a re-enactment of an 18th-century arm amputation, new online tools for public involvement in policy making: the range of activities carried out under the umbrella of public engagement can seem bewilderingly large.

All these topics and events – and much more – featured in the Wellcome Trust's Engaging Science conference, held in Manchester in spring 2006, which brought together a stimulating mix of people interested in the interactions between science and the rest of society. A notable aspect of the conference was the way people from a multitude of disciplines had the chance to meet and engage with each other. Science centre executives rubbed shoulders with artists, scientists shared coffee and experiences with educationalists, and theatre directors compared notes with website publishers.

While it was undoubtedly stimulating to see so much interdisciplinary mixing going on, it does raise some potentially troubling questions. Are there any common themes underpinning this diversity of work? Does the diversity reflect a flourishing forest of creative solutions or a mushrooming multitude of isolated efforts? And do we know whether all this endeavour is actually having an impact? With public engagement maturing as a discipline, now is a good time to examine these and other difficult questions.

New beginnings

'Public engagement with science' is not so much a new label as a new concept. We've moved on from 'listen and learn'; understanding is out, engagement is in (Tim Boon, pages 8–13).

But public engagement remains an amorphous entity; it does not have any widely agreed coherence. As a term, it means different things to different people. For some, it refers just to 'dialogue', where there is genuine discussion between scientists and the public; for others, it is about the importance of the public voice being fed into scientific policy making; for others still, it covers the full panoply of activities in which scientifically trained or active individuals interact in some way with people or groups without a scientific background.

Similarly, people do public engagement for different reasons. Scientists may want to share the excitement of their discoveries; educationalists strive to improve the schooling of young people; artists may see science as a rich source of ideas and thinking. We have funded, among numerous other projects, websites providing insight and resources on issues in biomedical ethics, a play and associated discussion tackling the rights and wrongs of using animals in research, continuing development opportunities for teachers, and fabulous mechanical figures illustrating science in action. In short, the past five years can be characterised by a blossoming of ideas and activity in public engagement.

In praise of diversity

Although diverse – and that in itself is part of the fascination of public engagement – it is possible to see how such activities form part of a bigger picture. Any definition of public engagement has to recognise, however, that the immediate objectives of activities vary – different projects are attempting to achieve different things. A consultative public engagement exercise, for example, will have different goals and target a different constituency from, say a science and art exhibition. This, of course, has important implications for evaluation (Ben Gammon and Alex Burch, pages 80–85).

Within this context, it is clear that there is no one simple answer to public engagement, no magic wand that will render all other approaches obsolete. So although the vogue recently has been for public engagement that impacts policy making, there is no reason why this should be the only approach adopted. Indeed, it may be positively harmful if it is. Old-style 'public understanding of science' may have neglected to consider the benefits of listening to people. But in rejecting the 'deficit model' so forcefully, a narrow view of public engagement ignores the clear public appetite for science, the thrill of scientific discovery, as well as the way it can aid people in their lives. Individuals can benefit significantly from an awareness of emerging medical opportunities, of risk and safety, and of the role of the media in reporting medical science.

This does not mean we should be promoting uncritical support – far better that we have a discriminating populace able to exercise their own judgement on topics from stem cells to nuclear energy. Indeed, there is a danger that by using public engagement as a catch-all term, scientists could continue to believe their role is to explain and promote science, rather than embrace the more challenging task of genuine dialogue and debate.

As populations go, then, public engagement might be said to be a high-biodiversity field. Ecologically, that's a good thing. We all know the dangers of monocultures, and maintaining and enhancing the public engagement gene pool will be important as we go forward.

FACE TO FACE

What's in a face? Bringing together history, culture, art and the latest technologies, the *Future Face* exhibition encouraged the public to contemplate the many different aspects of the face – in the past, the present and in possible futures.

Future Face, a Wellcome Trust exhibition at the Science Museum, attracted more than 125 000 visitors between October 2004 and February 2005, and was named one of the *Times Higher Education Supplement's* research projects of the year.

Those who came were reintroduced to the significance of their faces, through an inspired collection of imagery and artefacts encouraging visitors to question precisely what a face is, what it does and what it may become. Curated by Sandra Kemp, Director of Research at the Royal →

FUTURE FACE (WELLCOME TRUST 'MEDICINE IN CONTEXT' GALLERY AT THE SCIENCE MUSUEM)

Support
£200 000 (2004, direct activity)

Curator
Professor Sandra Kemp, Royal College of Art

More details
www.sciencemuseum.org.uk/on-line/futureface/

Left: 'Dana_2.0' by Michael Najjar, from the *Future Face* exhibition.

Learning

Nevertheless, it is still reasonable to ask what we have learned and whether we have had an impact. We now have a reasonably coherent view of public attitudes (Sir Robert Worcester, pages 14–19) and know that, despite what is often assumed, trust in scientists is high and rising. We know that scientists are keen to communicate, but see serious obstacles preventing their participation (Nancy Rothwell, pages 38–43; Worcester).

What of science communicators, the intermediaries between science and the public? They face a tough challenge – trying to please sponsors with one agenda while also appealing to consumers with quite another (Colin Johnson, pages 26–31). How can they demonstrate long-lasting impact, to show sponsors they are effective, without spending a fortune or influencing the findings by measuring the impact (Johnson; Gammon and Burch)? The mass media are among the key information sources for the public about science. Many are quick to blame them for providing overly negative or stereotyped views of science. But such preconceptions do not always stand up to close scrutiny (Jenny Kitzinger, pages 44–49) and we need a more sophisticated understanding of the ways in which a plural society relates to science in the media.

The science communicators of the 1940s saw the public just as passive audiences that needed their 'receivers tuned' (Boon). But the thesis that the more the public know about science, the more they will support it does not hold water. Despite some correlation, we now know this is an oversimplification (Dietram A Scheufele, pages 20–25) and we seem to have only limited understanding of how public thinking about science is influenced. The media are conventionally assumed to play a pivotal role here, but they may often reinforce existing attitudes rather than changing them (Kitzinger). People are complicated and, perhaps, the diversity of public engagement activities reflects this complexity.

'Consultative public engagement' in the UK – public impact on policy and practice – is going through a difficult adolescence (Alan Irwin, pages 50–55). There is a danger of it becoming a glib phrase that ticks the right boxes but leaves no real impact and a host of unanswered questions. Give the public a chance to air their thoughts and everyone goes home happy. But who should be involved? How? At what point? How far should it go? Are sponsors duty-bound to integrate public sentiment? Or will public engagement look like a public relations exercise in another guise? Like most adolescents, the reality can be messy and chaotic. Organisations running consultations may be uncomfortable with this idea. Nevertheless, when they finally develop their adult identities, adolescents usually turn out fine, and in time we will likely see a more grown-up and poised face of consultative public engagement.

→ College of Art, the exhibition took the human face as its starting point. It then probed the cultural and scientific significance of this remarkable piece of biological engineering.

Split into five major sections, *Future Face* explored different aspects of the human face. 'The anatomy of the face' revealed what lies beneath, with art and scientific illustration detailing the underlying architecture that breathes life into a face. This intimate facial anatomy was juxtaposed with 'Concealing faces', which examined the role of masks throughout human culture and history, and their unique power to transform the bearer's identity within the context of rituals and theatrical performances.

'The limits of the face' explored the history of facial modification, from the healing alterations made by pioneering surgeons in World War I to our current preoccupation with beauty and surgical 'improvements'. If the face is the core of our identity, might such approaches start to erode what it means to be human?

Within 'Interpreting and identifying faces', the notions of thoughts, feelings, personality and consciousness were examined. The face is a master of both conscious and unconscious communication, and an indicator of our emotional state. Facial expressions are universal: no matter where we travel, a smile means happiness.

The final section asked the question: 'What is the future face?' As the faces

Technologically, there has been an explosion of opportunity, particularly with the growth of the internet and the increased potential for 'user' involvement and control. The ability to produce materials simply and cheaply means the 'set-up costs' for getting involved in public engagement are much lower than they used to be. Internet-based approaches have been used in consultative public engagement, particularly in North America (Edna Einsiedel, pages 56–61), but have played only a small part in the UK and Europe. This is surely one area likely to expand significantly in the future as the first generations growing up with the web reach adulthood.

Public engagement has brought arts/humanities and scientific disciplines together in new and unique ways. It seems clear that artistic practice – in its many forms – has derived inspiration from scientific activity and endeavour (Stephen Webster, pages 74–79). Where the scientists stand on the value of such interactions varies greatly, and this still seems to be open to debate. Has public engagement enabled the narrowing of the gap or is this simply a flirtation that peters out after the initial thrills of attraction?

What of formal education? Here we are at a crossroads. We seem to have reached a point where ever-improving academic achievement (at least as measured by exam results) is being mirrored by ever-decreasing satisfaction with the teaching of science. Children leave school with a clutch of GCSE passes and an innate aversion to science. As a young man interviewed for the Engaging Science conference memorably put it, "I do like science but it's not very interesting."

The education system inevitably separates scientists from everyone else, as they go on to accumulate the specialist knowledge for research or technically specialist roles. Curriculum reform (Robin Millar, pages 68–73) has recognised that different approaches are needed for training these future scientists and for equipping non-specialists for life in a technologically advanced society. But it is by no means certain that this issue has been cracked. Some will lament falling standards and 'dumbing down'. Perhaps we should see it as 'smartening up', providing a better education tailored to different needs.

Almost everyone who is involved in public engagement shares a view that science is a hugely important human activity, practically and intellectually. And everyone sees benefits of narrowing the gap between scientific activity and the rest of society. The diversity of activities we have seen over the past decade has laid the foundations. Now, we need to continue to experiment, and at the same time embed the 'things that work'. And hardest of all, as we build on its foundations, public engagement needs to be able to continue to prove that it is making a difference.

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we see in magazines or in virtual environments become more removed from reality, how will our expectations and perceptions of identity be altered?

As an attempt to encourage fresh thinking, *Future Face* was a great success, combining factual material with exhibits of cultural, artistic and historical interest. More than half of the visitors questioned felt that they left the exhibition having learned something new, with the vast majority inclined to give further consideration to the issues presented in the course of their visit.

Future Face exemplified the approach pioneered at the Medicine in Context Gallery, in which topics of scientific interest are considered against a broader cultural background. In practical terms, the end result may appeal to those who would not be attracted to a straightforward 'science' exhibition; more conceptually, it is a reminder that science is not an isolated activity but a human cultural endeavour.

This multidisciplinary approach will serve as a model for the larger thematic shows to be run at the Wellcome Trust's new public venue, Wellcome Collection, at 183 Euston Road, London, which is due to open in 2007.

1 A HISTORICAL PERSPECTIVE ON SCIENCE ENGAGEMENT

Public engagement with science may seem like a modern preoccupation, but its roots run deep. Science communication was a feature of Newton's world, and, notes **Tim Boon**, the themes of a 1943 British Association conference seem uncannily familiar. The big difference, though, is in the nature of the relationship between scientists and the lay public. Gone are the days of 'send and receive' – communication now is much more two-way.

Science has always needed a public. From the early days of the Royal Society, when it was considered important that gentlemen should witness the conduct of experiments, up to the present when science dialogue is all the rage, the public have been in science's frame. But science's reference to non-scientific publics has neither been constant, nor taken the same form over the centuries. In particular, issues in science communication seem markedly different in the periods immediately before and after the Cold War.

It is easiest to look at science communication historically through particular media in each period. Books, for example, leave more tangible traces than popular lectures. And popular science writing is no recent publishing phenomenon. The new philosophy of Isaac Newton was popularised not just in books for adults but also in John Newberry's 1761 children's text *The Newtonian System of Philosophy*. In this, a character named Tom Telescope lectures a group of children on subjects from the solar system to the human mind, with interjections from the children. The Rev. Dr Brewer arranged the entire matter of *A Guide to the Scientific Knowledge of Things Familiar*, which ran through more than 30 editions in the mid-19th century, in question and answer format. "Why has a dreamer no power of judgement or reason?" it asks. "Because the parts of the brain that are concerned with the performance of these functions are inactive and at rest," comes the immediate reply.

The evidence of titles and editions is that popular science was a genuinely popular medium from at least this period. Charles R Gibson, for example,

wrote a whole series of 'Romances' and 'Wonder' books in the Edwardian and inter-war years, including volumes on scientific discovery and technological titles including *The Romance of Modern Electricity*. The first newspaper science reporters in Britain emerged around 1930; first J G Crowther for the *Manchester Guardian* then Ritchie Calder for the *Daily Herald* and dozens more in their wake. This new band of professional science writers was paralleled by working scientists including Julian Huxley and J B S Haldane, whose columns for the *Daily Worker* were collected together in one of the early Pelican books, *Science and Everyday Life*. In North America, where science journalism started around the same time, it reached a critical mass much earlier than in Britain; the National Association of Science Writers had 63 members in 1945 and 413 by 1960.

The new philosophy of Isaac Newton was popularised not just in books for adults but also in John Newberry's 1761 children's text *The Newtonian System of Philosophy*.

In other media too, science has long been a fixture. It has featured on radio since its first decade in the 1920s. It took rather longer to become a regular element of television, but in Britain, since the establishment of *The Sky at Night* in 1957 and still more BBC 2's *Horizon* in 1964, it has had a small but prominent part in the schedules. Applied science featured strongly in non-fiction cinema aimed at general audiences in the guise of scientific medicine and public health. One example was the director Paul Rotha's film *World of Plenty* (1943), made with the nutrition scientist John Boyd Orr.

It is one thing to establish that science in the media has been in rude good health for much of the history of science itself, but quite another to discern what relationship its practitioners expected the public to have with science. (Still less has historical scholarship yet produced a synthetic account of how lay people understood science over long periods.) The 'public understanding of science' became a commonplace phrase with the publication of the Royal Society's 1985 Bodmer report, the establishment of COPUS (Committee on the Public Understanding of Science) shortly thereafter and the launch of the journal with that title in 1992. There is, however, an earlier incidence of the phrase; over the weekend of 20–21 March 1943, the British Association held a conference under the title 'Science and the Citizen: the Public Understanding of Science'. By looking at this, we can see how science communication has changed. The conference was a busy affair, with 30 papers over two days. Four sessions discussed 'The Exposition of Science', 'Radio and Cinema', 'Science as Humanity' and 'Science and the Press'. The overall impression is of scientists confident in science's powers and relevance. Ritchie Calder, one of its organisers, was outspoken, placing science communication in the context of good citizenship:

BEATTY'S BATTLE

The award-winning film *Trafalgar Battle Surgeon* was notable for its historical accuracy – the result of an unusual history of medicine public engagement award.

In 2005, Channel 4 aired *Trafalgar Battle Surgeon*, a historical docudrama vividly portraying the part played by Sir William Beatty, ship's surgeon, and his accompanying team in the struggle to keep the fighting men aboard Nelson's *HMS Victory* fit enough to prevail over the French. The broadcast was timed to commemorate the 200th anniversary of Nelson's death.

The anniversary was marked in many ways, but this project aimed to delve deeper than most into circumstances surrounding this momentous event in British history. In advance of filming, →

TRAFALGAR BATTLE SURGEON

Support
£130 000 (2003, history of medicine public engagement award – film itself was financed by Channel 4)

Applicants
Justin Hardy, Hardy & Sons
Professor Laurence Brockliss, University of Oxford

More details
www.jhfilms.com

Left: Even Sir William Beatty's medical prowess could not save Nelson's life. By J Heath.

> ...better government will depend on the individual citizen being properly instructed. He must be made alive to the vast potential of the twentieth century and to the vast complexities which science and technology have introduced into the life of society. The scientist has his contribution to make, not only in the shape of his new discoveries, but in impressing upon the public the implications of these new discoveries.

Or, as Crowther put it: "a hundred years ago, it was desirable that the people should know about science: to-day it is necessary for survival". These are forceful statements of the citizen's obligation to understand science, but do not imply any reciprocal obligation on science to listen to the public. This is borne out in one of the governing metaphors of the conference, used by, among others, the biologist Henry Dale, then President of the Royal Society:

> ...the public understanding of science will need for its achievement the co-operation of the two parties concerned – to speak in the terminology of broadcasting, it will require an efficiency in the transmitter and a tuning of the receivers, which only the proper conditioning can provide in either case.

The transmitters were the scientists and the receivers were the public. But Dale was, in fact, concerned with the 'receiver' only in the sense of how to attune them most effectively to the 'broadcasts' that science makes. But this is not a telephonic metaphor; communication here is all one-way. This is not, however, surprising for the 1940s, when the opinion survey was in its infancy as a social scientific tool; to turn it on science itself would have entailed a degree of reflexivity about science communication that only emerged later in the century.

Over the weekend of 20–21 March 1943, the British Association held a conference under the title 'Science and the Citizen: the Public Understanding of Science'.

Two types of science communication – both represented at the conference – went beyond this model. The Army Bureau of Current Affairs (ABCA) had been running discussion groups among soldiers on scientific topics including public health, nutrition and agriculture, as well as social issues including town planning and 'the colour question'. As W E Williams, the scheme's director, stated, the ABCA experiment "most aptly illustrates the special problem before this meeting, namely, how to instigate and organise the common man's wayward and fitful interest in the world about him". The documentary films of Paul Rotha, which used a 'man in the street' interlocutor to challenge the authoritative factual voice of the film's main commentator, suggested another 'dialogic' model. In both examples, the audience member was offered a more active role than simply

→ Professor Brockliss and his assistant John Cardwell undertook a period of highly detailed research. They had access to letters written by Beatty, the *HMS Victory's* log, the surgeon's log and a wealth of original source materials, many of which were located in the Wellcome Library. By the time Brockliss's research made it to Hardy & Sons, it was clear there was a veritable goldmine of authentic period detail to call upon, greatly aiding the subsequent development phase.

Armed with historical facts, Justin Hardy and his team went about the business of bringing them to life. Scriptwriter, actors, props and locations all in place, the team went on to produce a full-scale, one-hour drama revealing an aspect of the Battle of Trafalgar that had, until then, been quietly disregarded: that the diligence of Beatty and his team of surgeons played a pivotal role in Nelson's victory. By keeping Nelson's men ship-shape and well exercised, the balance of power swung in Nelson's favour.

Shown on Channel 4, the programme was well received. The press loved it, 1.4m viewers tuned in, and a book was written (*Nelson's Surgeon: William Beatty, naval medicine, and the Battle of Trafalgar* – Oxford University Press, 2005). In 2005, the Royal Television Society commended the film with a Programme Award for History: "The jury admired its rich, characterful and unexpected take on well-known events. Crisp, passionate and hugely entertaining, it struck the senses like a well-aimed cannonball." →

Right: Filming ***Trafalgar Battle Surgeon*** **on the real** ***HMS Victory.*** *P Fisk*

reception of scientific 'broadcasts'. But we should note that both these exceptions to the general pattern were typical of the decades after the extension of the franchise, when citizenship was a core term in the political lexicon.

After the War, despite continuing output across all media, newspaper attitudes to science rapidly replaced adulation and expectation with disappointment, hostility or simply ambiguity.

It is worth considering the conference's sense of why the public might have wanted to become 'well-tuned' receivers. In brief, most papers there assumed science to be useful; they promoted an Enlightenment model of a science that can be applied to better human life. Sir Lawrence Bragg, for example, was laudatory: "we are at the beginning of an era in which the material conditions of life are being profoundly modified by the results of scientific investigation". He concluded that "we cannot plan wisely for the future unless there is a widespread general understanding of what science is and what it can do".

After the War, despite continuing output across all media, newspaper attitudes to science rapidly replaced adulation and expectation with disappointment, hostility or simply ambiguity, as Martin Bauer and his co-authors have shown. Steve Miller comments that "alongside these 'mood swings' there was a tendency for scientists to retreat into their shells, frowning on those who ventured onto the public stage...the Bodmer Report reflected a concern amongst the scientific establishment that this retreat had reached proportions where funding for scientific research was politically vulnerable". The subsequent problem, as Miller articulates it, was that surveys seemed to show that, despite the extra energy deployed, lay scientific literacy did not rise over the COPUS years. It has become conventional to see the end of that phase of science communication as being marked by the publication of the Third Report of the House of Lords Select Committee on Science and Technology in 2000.

We may ask, however, whether it was the communication that was wrong or the science. The Lords report was published into a world transformed by the Cold War era, in which science and technology had had a remarkable impact on how life is experienced, for the bad as well as for the good. Martin Rees recently commented that "public opinion surveys reveal a generally positive attitude to science". But he noted that "this is coupled with widespread worry that science may be 'running out of control'". Compared with only one very slight reference in 1943 to the negative impact of science, in 2000 risk and danger are said to dominate the relationship between science and society, as the Lords report states:

> Society's relationship with science is in a critical phase. Science today is exciting, and full of opportunities. Yet public confidence in scientific advice to Government has been rocked by BSE; and many people are uneasy about the rapid advance of areas such as biotechnology and IT – even though for everyday purposes they take science and technology for granted.

The dominant new factors are said to be a lack of public trust in science, especially commercial or government science; and the issue of risk associated with the BSE disaster.

We may suspect that society's present concern with trust in science derives from public distrust of science misapplied.

In the place of the earlier broadcast model of communication, the report argues that "the crisis of trust has produced a new mood for dialogue", overturning the so-called 'deficit' model of science communication – in which the main problem was perceived to be lay scientific ignorance – with one emphasising dialogue between the scientist and the citizen and taking seriously the public's knowledge and beliefs. The report's authors surveyed a whole set of different activities including consultations, polling, focus groups, citizens' juries, consensus conferences and internet dialogues. They concluded that "all these approaches have value. They help the decision-maker to listen to public values and concerns; and they give the public some assurance that their views are taken into account, increasing the chance that decisions will find acceptance." The broadcasting metaphor no longer fits: "in modern democratic conditions, science like any other player in the public arena ignores public attitudes and values at its peril. Our call for increased and integrated dialogue with the public is intended to secure science's 'licence to practise'," the report's authors assert.

How are we to account for this change? It would be difficult to argue, given the appeal of popular science in earlier periods, that lay scientific knowledge is now necessarily at a higher level than in previous eras. Instead, we may suspect that society's present concern with trust in science derives from public distrust of science misapplied, as many see it, in military hardware, in the high-protein animal feeds responsible for BSE and in so-called 'Frankenstein foods', to take but three examples. These are all instances of the power of science, which the public generally supports when it leads to enhanced human welfare via medical advance, for example. However, blaming science for its negative effects is scarcely new; inter-war scientists had to deal with the perception that unemployment was a product of the 'march of the machine' and that warfare had been rendered particularly savage by the development of novel scientific weapons.

→

Clearly, the juxtaposition of history and a format mirroring contemporary medical drama struck a chord with viewers. Most of the rules governing *Trafalgar Battle Surgeon*'s success are the same for any production: a gripping story, great actors, and a powerful script and talented director to bring them both to life. But this programme had something more. The excellent historical research and support provided by Brockliss gave the production a foundation of granite, an authenticity that viewers responded to.

The success of the programme also illustrates the potential power of historical approaches to communicate science and medicine to mass audiences. History has undergone a renaissance over the past decade, with landmark series such as Simon Schama's *A History of Britain*. The subject's popularity, and the essential ingredient of human interest provided by a focus on medicine, suggests that this is an area ripe for exploitation in public engagement.

History of medicine public engagement

History of medicine public engagement awards provide flexible support for exhibitions, television, radio or other formats. The aim is to promote the history of medicine, or historical research that stimulates informed dialogue between researchers, policy makers and the public, thereby raising awareness and understanding of biomedical science.

www.wellcome.ac.uk/hom

Right: Extras: John Cardwell and Tony Woods, Wellcome Trust Head of Medical Humanities.

Another possibility is that the applied sciences of the Wartime and Cold War periods have simply fuelled doubt about whether science is necessarily benign just because it is factually truthful. The generation that protested against the Vietnam War and campaigned against nuclear power may simply have been ending their deference to scientific authority, as the experience of their grandparents in the Great War is said to have ended deference to social authority. Bruce Lewenstein has similarly suggested that the development of environmentalist science journalism in North America after Rachel Carson's *Silent Spring* marked the beginning of the end for public understanding conceived as appreciation of science. Over the same period, the academic disciplines devoted to the study of science – as a system of knowledge, as a part of society and as an element of culture – have shown how it is possible for members of lay society to hold sophisticated knowledge and opinions about science. It is this sense that the lay public may validly have views on science that is novel, and that is encapsulated in the dialogic model of science engagement. And, in a sense, this is the coming of age of the democratic citizenship language used by the organisers of the 1943 conference; not only do citizens have a responsibility to understand science, they also have a right to a say in its future direction.

Tim Boon is Head of Collections at the Science Museum, London.

Further reading

Bauer M et al. Science and Technology in the British Press: 1946–1990. London: The Science Museum; 1995.

Boon T. Science and the citizen: documentary film and science communication in World War Two. Actes De Colloque 'History And The Public Understanding Of Science'; 2004 28–29 May; Maison Française d'Oxford. www.mfo.ac.uk/Publications/Actes2/Boon.htm [accessed 5 June 2006].

House of Lords Science and Technology Committee. Science and Society. Third Report of Session 1999–2000. (HL 38) London: The Stationery Office; 2000. www.publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3801.htm [accessed 5 June 2006].

Gregory J, Miller S. Science in Public: Communication, culture and credibility. Cambridge: Perseus Books; 2000.

Lewenstein BV. The meaning of 'public understanding of science' in the United States after World War II. Public Understanding of Science 1992;1:45–68.

Science and the Citizen: The public understanding of science. Conference papers. Advancement of Science 1943;2:283–339.

Miller S. Public understanding of science at the crossroads. Paper prepared for 'Science Communication, Education and the History of Science' conference; 2000 12–13 July; British Society for the History of Science/Royal Society, London. www.bshs.org.uk/conf/2000sciencecomm/papers/miller.doc [accessed 5 June 2006].

Secord JA. Newton in the nursery: Tom Telescope and the philosophy of tops and balls, 1761–1838. History of Science 1985;23:127–51.

Shapin S. Science and the Public. In RC Olby et al. (eds). Companion to the History of Modern Science. London: Routledge; 1990. pp. 990–1007.

2 PUBLIC ATTITUDES TO SCIENCE: WHAT DO WE KNOW?

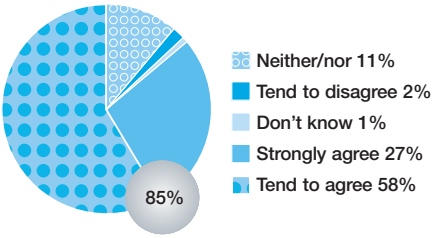
What do the public think about science? Or scientists? Despite much hand-wringing and despair at perceived lack of trust, surveys show that science is valued, scientists on the whole are trusted, and trust is actually rising. Rather than lament a former era of deference for authority, **Sir Robert Worcester** argues that scientists should work to maintain this positive reputation by continuing to build relationships based on mutual respect.

Overwhelmingly, the British public agree that science makes a good contribution to society, and that on the whole, science will make our lives easier. Polls carried out by MORI illustrate the point well.

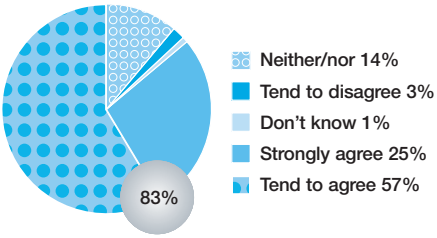
OVERALL ATTITUDES TO SCIENCE

Q. How strongly do you agree or disagree with the following statements...

Science makes a good contribution to society



On the whole, science will make our lives easier



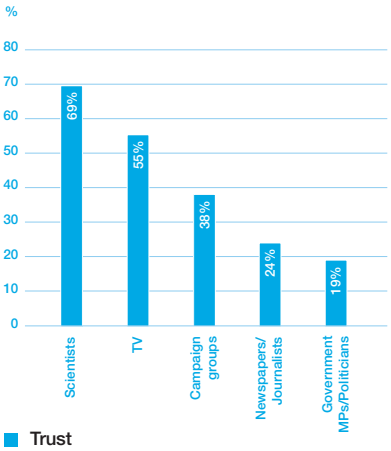
Base: 1831 UK adults aged 16+, September–November 2004; Source MORI/OST

But misconceptions about public attitudes to science abound. Several years ago I was asked to address some 120 scientists from the Department for Environment Food and Rural Affairs. "Hands up, those of you who think that trust in scientists has declined by more than 20 per cent in the last five years." About half raised their hands. "And by between 10 per cent and 20 per cent?" Another quarter. "And by between zero and 10 per cent?" The other quarter raised their hands, all save one chap. "Stayed the same or gone up?" He raised his hand. "He's the only person here who got it right."

They asked me back this year. I played the same trick. I got more or less the same response. Why? Because that's what they glean from the media – never mind solid survey research to the contrary. For over the past decade, there has been a steady increase in the percentage of British people who say they trust scientists to tell the truth, from 63 per cent of the public in 1999 to 70 per cent last year, and a corresponding decline in the percentage of those who believe they don't tell the truth, from 27 per cent in 1999 to 18 per cent in 2005.

TRUST IN SCIENTISTS

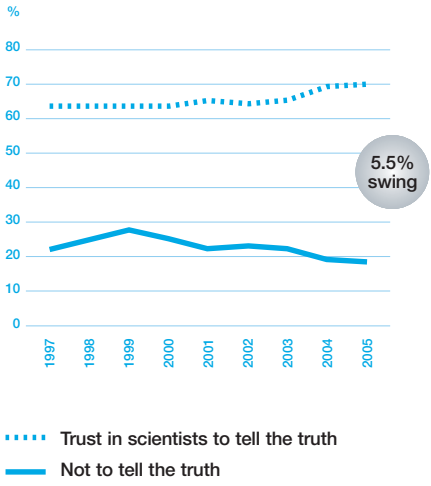
Q. Now I will read you a list of different types of people. For each would you tell me if you generally trust them to tell the truth, or not?



Base: *c.*2000 GB adults aged 15+ per wave, Source MORI/BMA (1997–2005)

TRUST IN INFORMATION ON SCIENCE

Q. Now I will read you a list of different types of people. For each would you tell me if you generally trust them to tell the truth, or not?



Base: 1831 UK adults aged 16+, September–November 2004; Source MORI/OST

LISTENING POSTS

What do the public really think about science? Why is understanding public attitudes important?

The Wellcome Trust supports research that is designed to inform both its own and national policy development and public engagement practice. In 2005 the Trust launched a dedicated Research Awards funding scheme as part of the Engaging Science grants programme. The Trust also commissions attitudinal research and consultative projects.

Most would agree that decision-making in a democratic society should take account of public attitudes. Indeed, over recent years a culture of public dialogue has been established in the UK and has become increasingly important in the formulation of science policy.

Effective engagement with the public on biomedical research issues requires that we have a good understanding of the public's awareness of and attitudes towards biomedical research and the social, ethical and legal issues this research raises.

It is important that the spectrum of views held by the public is understood, and that this underpins the work of the public engagement community. By understanding public interests and →

Left: Public opinion: more positive than is often assumed.

And when we pit scientists against other sources of information about science, scientists win hands down. Seven in ten people, according to the MORI survey for the Office of Science and Technology (OST),[1] say that scientists can be trusted to give accurate information about scientific facts. At the other end of the spectrum, just a quarter of the British public says the same about journalists, and one in five trusts politicians.

Over the past decade, there has been a steady increase in the percentage of British people who say they trust scientists to tell the truth.

So why the hand-wringing, the dismay and the efforts to correct a problem that is overblown? Because of misconceptions among politicians, among journalists and, most of all, among scientists.

What else can we learn about public opinion in this area from survey research, quantitative and qualitative techniques, polls and focus groups, anthropological studies, citizens' juries, deliberative polling and the like?

There are five things we can measure with the tools of our trade:

- **behaviour**, what people do
- **knowledge**, what they know, or think they know
- views, defined at three levels, metaphorically, as:
    - **opinions**, the ripples on the surface of the public's consciousness – shallow, and easily changed
    - **attitudes**, the currents below the surface – deeper and stronger
    - **values**, the deep tides of public mood – slow to change, but powerful.

More elaborately:

Opinions are low-salience, unconcerned reactions to interviewers' questions, easily manipulated by question wording or whatever is the news of the day, unimportant to the respondent.

Attitudes stem from a deeper level of consciousness, are likely to have been thought about and to have been held for some time.

Values are formed early in life and not likely to change; they only harden as we grow older. These include belief in God, abortion, the death penalty, family values and, for many people, their political allegiance; for a quarter of the British public, animal welfare is such a value, which explains much about banning fox-hunting, export of live veal calves and opposition to animal experimentation.

→ concerns, it is possible to develop more responsive public engagement projects, which are tailored to the needs of particular audiences.

One of the Wellcome Trust's landmark studies, *Science and the Public*,[1] arose from a joint project with the Office of Science and Technology examining public attitudes to science, and was published in 2000. Analysis identified six attitudinal groups – 'confident believers', 'technophiles', 'supporters', 'concerned', 'not sure' and 'not for me' – that were found to share common views about science and its impact.

The Trust has also carried out research on particular aspects of biomedical research. For example, in 1998, not long after the birth of Dolly the sheep brought the issue of cloning to public attention, the Trust commissioned a qualitative review of attitudes to cloning.[2] The findings informed the Trust's response to the consultation on 'Cloning Issues in Reproduction, Science and Medicine' issued by the Human Genetics Advisory Commission.

Research sponsored by the Wellcome Trust to explore public attitudes to gene therapy[3] was primarily concerned with building upon existing models of social research to develop more rigorous models of public consultation. The project assessed the impact of innovative stimuli, such as a magazine, a video and group discussions, intended to encourage and support debate about the social and ethical issues raised by the technology. →

Right: Nuclear transfer: reproductive and therapeutic cloning are common survey topics.

This model helps us to define the depths of people's views, and the potential there is for changing them by persuasion, education or example. When considering the questions of science, risk, democratic citizenship and public policy, it is as well to remember that sooner or later, public policy not supported by public opinion will fail. So if a policy is not understood by the public to be in their interests, then the challenge to policy makers is to identify for the public what it is that is in their interests, and either convince them of this, or take the consequences. The House of Lords Science and Technology Select Committee Jenkin Report concluded: "Policy-makers will find it hard to win public support, or even acquiescence, on any issue with a science component unless the public's attitudes and values are recognised, respected and weighed in the balance along with the scientific and other factors."[2]

Research into public attitudes to science

In my testimony to the same Committee, I argued five theses.

1. The British public tend to judge the value of scientific advances by their end purpose.
2. Scientific developments aimed directly at achieving improvements in human healthcare are the most valued by the public.
3. Ignorance about the way in which science is regulated and restricted leads many of the public to assume that the regulation is insufficient, and this in turn makes them more likely to be hostile to science.
4. There is scepticism and mistrust of Government and business alike. While a majority of the public say they trust 'scientists', whenever a scientist's employer or sponsor is mentioned the veracity of the source becomes highly relevant: the scientists trusted by the highest proportion of people are those working for environmental NGOs.
5. Significant numbers of the public are prepared to use their power as consumers to put pressure on those involved when they object to a scientific procedure or principle.

Remember that sooner or later, public policy not supported by public opinion will fail.

I do not have the space here to develop these themes, but would guide the interested readers to both the Committee's Report and a recent book in which they are developed at length.[3]

ATTITUDES UPDATE

More than three-quarters of people in Britain now feel that the public should be consulted on decisions about scientific developments. This does not necessarily mean they want to be asked their personal opinion. More people feel there should be "a fair amount" than "a great deal" of consultation.

The finding comes from the latest national MORI survey for the Office of Science and Technology, published in March 2005 (see note 1, main article). The authors of the survey say this suggests a need to consult the public on key issues, not on everything to do with science.

Other findings tend to confirm those of the earlier surveys. Trust in scientists to tell the truth remains high (69 per cent, up from 65 per cent in 2003), although government scientists and those working for industry are trusted less than those in universities.

Finally, there seems to be a growing appetite for hearing about science. In line with the wish for consultation, a large proportion of those surveyed say they want to hear about new developments in science and technology before they happen, not afterwards. And 49 per cent, more than twice the proportion in 1999/2000, said that they receive too little information about science.

Conclusions

There is a four-stage process of effective communication, starting with awareness, the provision of knowledge, a feeling of openness and the belief that the information is provided without any 'hidden agenda', and from a source of trust. The second stage is involvement, where the individual can see some clear link to themselves and/or their family, and in some way can benefit, be made healthier, richer or better feeling in some way. The third stage is persuasion, in that the individual feels informed and aware, and alert and involved, and is in a receptive mood to listen to the argument. The fourth stage then is action, to do what the giver of the information wishes to be done, whether to quit smoking, or diet, or exercise, or cut energy use, or use the car less.

It is unlikely that the blind faith in the men in white coats will return, so expect that in the future scientists will have to take the time and trouble to explain what it is that they are trying to do, how they are going about it, and who will benefit therefrom.

If that is kept in mind, and scientists accept that people have the right to know for whom they are acting, the right to know what the scientific studies have concluded, and a feeling of being treated as responsible citizens, then bridges can be rebuilt. It is unlikely that the blind faith in the men in white coats will

→ By combining quantitative and qualitative approaches in a panel study, it attempted to offer both breadth and depth of understanding in relation to public attitudes towards gene therapy. So, as well as yielding specific information about attitudes to one particular novel biomedical application, the project offered useful data about methods of deliberation, consultation and public engagement.[4]

A Wellcome Trust-commissioned project currently underway aims to explore awareness, perceptions, expectations and attitudes to the governance of biomedical research.[5] While much previous attitudinal research has found that the public are generally positive about the value and purpose of biomedical research, and its resultant health benefits, there exists much public scepticism about how research is monitored and governed. A large number of the public question the motivations and morality of scientists, lack trust in government regulations, and fear that the pace of scientific advancement is too great for regulation to keep up. Therefore, it is important to understand more fully how, and in what ways, public perceptions about governance issues are developed and established.

These and other studies emphasise the diversity of views held by the public, and the sensitivity to context; neither the public nor public opinion should be treated as homogeneous. They also

return, so expect that in the future scientists will have to take the time and trouble to explain what it is that they are trying to do, how they are going about it, and who will benefit therefrom.

It is clear from a survey that MORI conducted for the Wellcome Trust (interviewing a random sample of 1540 scientists face-to-face at 41 universities in Great Britain, including 112 scientists working for Research Councils, between 13 December 1999 and 24 March 2000)[4] that while many scientists feel that they should take part in the dialogue between science and society, few feel equipped to do so, especially on the moral and ethical issues surrounding their work, and fewer still have had the training to do so. It is good to see that the UK Research Councils are now grasping this nettle, establishing a Science in Society Unit with a strategy of finding out what people think, reaching young people and teachers, encouraging (and training) researchers to engage with the public, and keeping people informed and up to date.[5]

Sir Robert Worcester is the Founder of MORI, Visiting Professor at LSE, Honorary Professor at the Universities of Kent and Warwick, and Chancellor of the University of Kent.

References

1 Science in Society: Findings from Qualitative and Quantitative Research. London: MORI/ Department of Trade and Industry; 2005. www.mori.com/polls/2004/pdf/ost.pdf [accessed 5 June 2006].

2 House of Lords Science and Technology Committee. Science and Society. Third Report of Session 1999–2000. (HL 38) London: The Stationery Office; 2000.

3 Worcester R. Public attitudes to biotechnology in Great Britain. Chapter 4 in JD Miller (ed.). Perceptions of Biotechnology: Public understanding and attitudes. Cresskill, New Jersey: Hampton Press; 2001.

4 The Role of Scientists in Public Debate. London: Wellcome Trust; 2001.

5 Science in Society. Swindon: Research Councils UK; 2006.

Further reading

Dierkes M, von Grote C (eds). Between Understanding and Trust: The public, science, and technology. Amsterdam: Overseas Publishing Association NV (under Harwood Academic Publishers imprint); 2000.

Mackinnon WA. Mackinnon on Public Opinion: On the rise, progress, and present state of public opinion, in Great Britain, and other parts of the world. London: Saunders and Otley; 1828.

Splichal S. Public Opinion: Developments and controversies in the twentieth century. Lanham, Boulder, New York and Oxford: Rowman & Littlefield Publishers; 1999.

Worcester R. Science and Society: What scientists and the public can learn from each other. Discourse at the Royal Institution; 29 September 2000.

demonstrate that 'ordinary' members of the public can readily get to grips with complex biomedical issues and develop reasoned and well-informed opinions.

References

1 Science and the Public: A review of science communication and public attitudes to science in Britain. Wellcome Trust; 2000.

2 Public Perspectives on Human Cloning. Wellcome Trust; 1998.

3 What do People Think about Gene Therapy? Wellcome Trust; 2005.

4 Information and Attitudes: Consulting the public about biomedical science. Wellcome Trust; 2005.

5 Public Attitudes Towards the Governance of Biomedical Science.

3 MESSAGES AND HEURISTICS: HOW AUDIENCES FORM ATTITUDES ABOUT EMERGING TECHNOLOGIES

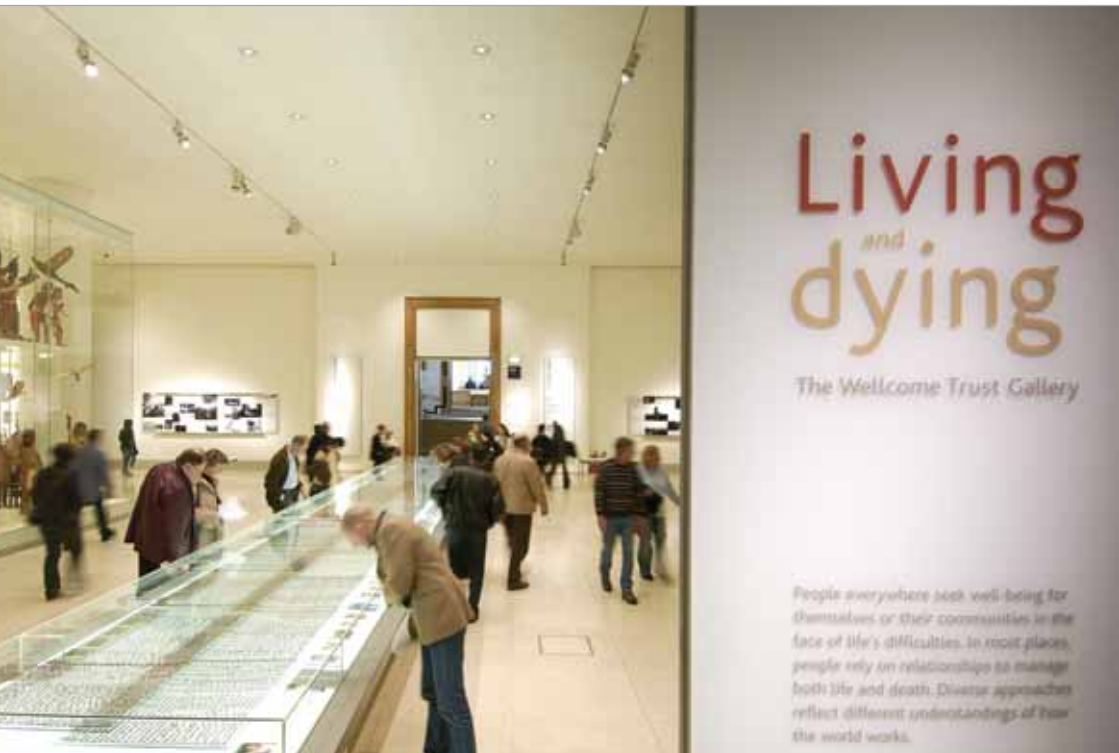
How do people form opinions about scientific issues? It is, suggests **Dietram A Scheufele**, unrealistic to expect people to sift through masses of information to draw up a reasoned conclusion. We are mostly 'cognitive misers', drawing upon a minimum amount of information. What is crucial is how an issue is 'framed' – the context in which it is communicated and how it fits with people's pre-existing thinking. Understanding these aspects is crucial to effective science communication.

Many of the academic debates about how citizens form attitudes about scientific issues come down to a conflict between ideals and realities. On one side, many of the recent public outreach efforts are based on somewhat idealistic views about a 'scientific citizen' who forms attitudes based on an in-depth understanding of scientific controversies, or should do. On the other, we have decades of research in social psychology, political science and risk communication that suggests that knowledge plays a marginal role at best in shaping people's opinions and attitudes about science and technology. In fact, many researchers have suggested that the way media present an issue, and people's value systems and predispositions, play a much greater role in shaping citizens' attitudes toward new technologies.

Scientific literacy versus low-information rationality

The two models that have come to represent this tension between ideals and realities have been labeled *science-literacy* or *knowledge-deficit* models on the one hand, and models based on *low-information rationality* on the other hand.

Knowledge-deficit models assume that audiences can and should acquire as much information as possible about new technologies. Their adherents therefore often attribute the lack of public support for emerging technologies to lack of information among the public. As a result, many researchers and practitioners in this area also argue that a more informed public would be more supportive of scientific enquiry and of emerging technologies, such as nanotechnology or agricultural biotechnology.



Unfortunately, knowledge-deficit models are problematic for a number of reasons. First, empirical support for the relationship between information and attitudes toward scientific issues is mixed at best. Over time, different researchers identified both positive and negative links between levels of knowledge among the public and citizens' attitudes toward science. And the most recent updates on this literature seem to suggest that the relationship disappears after we control for spurious and intervening factors, such as deference toward scientific authority, trust in scientists, and how obtrusive the issue is.[1] Second, and more importantly, research in social psychology, communication and political science has long suggested that citizens rely on influences such as ideological predispositions or cues from mass media when making decisions, and therefore use only as much information as necessary when forming attitudes about scientific issues.[2]

Decades of research suggests that knowledge plays a marginal role at best in shaping people's opinions and attitudes about science and technology.

This idea is often referred to as **low-information rationality**, a term coined by political scientist Sam Popkin.[3] The concept of low-information rationality is based on the assumption that human beings are cognitive misers and minimise the economic costs of making decisions and forming attitudes. Most citizens will therefore not bother to develop an in-depth understanding of scientific issues, which would require significant time and effort. Rather, they collect only as much information as they think is necessary to make any given decision. They rely on *cognitive shortcuts or heuristics* to efficiently sift through large amounts of information and to form attitudes about issues, such as nanotechnology or agricultural biotechnology. And the less expertise citizens have on an issue initially, the more likely they will be to rely on cognitive shortcuts or heuristics. Examples of heuristics include religious or ideological predispositions, cues from mass media about which issues are important or how to interpret them, perceptions of other people's opinions or trust in scientists.[4]

The concept of low-information rationality is based on the assumption that human beings are cognitive misers and minimise the economic costs of making decisions and forming attitudes.

As the label 'low-information rationality' suggests, these patterns of information-processing make perfect sense for citizens who have to deal with thousands of pieces of new information every day, and we all use them. We spend less cognitive effort in buying toothpaste than we do when picking a new car. And that difference in information-seeking is largely a function of the costs

THE DRUGS DO WORK

'Cradle to Grave', a site-specific art installation housed in the British Museum's Wellcome Trust Gallery since 2003, takes visitors on a pharmaceutical journey through the lives of an average UK couple. The result provides striking insight into the impact of medications in modern life.

Produced by the Pharmacopoeia partnership, 'Cradle to Grave' forms the centrepiece of the Wellcome Trust Gallery. Under one of the largest single pieces of glass to occupy a gallery, the monolithic case houses two pieces of fabric, each 13 metres long – one for the man and →

'CRADLE TO GRAVE' AND THE WELLCOME TRUST GALLERY AT THE BRITISH MUSEUM

Funding
£5.4m (2003, Capital Award to the British Museum); with a £40 000 special commission by the British Museum for 'Cradle to Grave'

Project lead
('Cradle to Grave'): Pharmacopoeia, a creative partnership comprising artists Susie Freeman and David Critchley, as well as GP Liz Lee

More details
www.thebritishmuseum.ac.uk/livinganddying/
www.cradletograve.org
www.pharmacopoeia-art.net

Left: The *Living and Dying* exhibition at the British Museum.

and benefits involved, of the anticipated use of each product, and of the relevance of each decision for our daily lives. Most citizens, of course, go through some of the exact same considerations when making decisions about emerging technologies.

The popular notion of 'spin', while used more broadly, often refers to the idea of framing.

The interplay of media frames and audience schemata

So how do attitudes change over time, given what we know about people's patterns of information-processing? The answer, of course, is complicated. But there is one process that is especially relevant to the question of attitude formation about science and technology: the concept of framing.[5,6]

As the term implies, messages are often presented (or framed) in a particular way, and different ways of presenting the same information also influence the way audiences interpret the messages.

A good example is Frank Luntz's work on framing political messages. Luntz is a commercial pollster who has done extensive work for the Republican Party in the USA. Much of his work is summarised in a memo he first circulated in 1997 among Republican members of Congress called 'Language of the 21st Century'. Large parts of Luntz's memo are devoted to how Republican members of Congress should frame messages in order to influence attitudes among voters. When constructing messages about energy policy, for example, Luntz recommends an 'exploring for energy' label instead of 'drilling for oil'. Relabelling or reframing the issue is critical for changing audiences' interpretations, or what Luntz calls the picture that people paint in their minds. The popular notion of 'spin', while used more broadly, often refers to the idea of framing.

People carry interpretive schemata in their heads as an economical way of making sense of things that happen in the world around them.

Research in social psychology and communication science supports Luntz's assumptions. People carry interpretive schemata in their heads as an economical way of making sense of things that happen in the world around them. How a message is framed influences which schemata in people's minds are activated and therefore how they process information. Framing therefore involves two separate concepts: media frames and audience schemata.

Media frames refer to the way journalists, interest groups, policy makers and other players in the policy arena present information. And the reason for the framing is really a secondary concern. For journalists, framing is an important

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→ one for the woman. Knitted into each piece of fabric is the quantity and type of drugs each will consume in the course of an average lifetime. Based on patient prescribing records and figures detailing the commonest ten medical conditions in the UK, the piece is, in effect, a pharmaceutical diary.

Humanising this multicoloured 'trip' through life are various objects and photographs. Like the drugs, the photographs are authentic: handwritten captions adding emotional warmth to these encased strangers.

The Pharmacopoeia partnership owes its existence to Wellcome Trust funding – it was awarded one of the first ever Sciart awards in 1998 and has received other support from the Trust.

The installation, frequently visited by art and medical students, is both a powerful symbol of mortality and a visual insight into the route medicine has taken. The work has also led Pharmacopoeia to find educational outlets, and even a potential collaboration with Pentonville Prison.

The installation is highly popular, frequently stimulating conversations between strangers mesmerised by the sheer volume of pills. It is a graphic representation of the medicalisation of modern life in industrialised countries. As such, it complements well the *Living and Dying* exhibition in which it sits.

Living and Dying, the first exhibition in the Wellcome Trust Gallery, scrutinises the ways in which different cultures approach health and wellbeing. 'Health' →

Right: 'Overnight Bag', decorated with a variety of contraceptives. *Pharmacopoeia*

tool to reduce fairly complicated issues into the format of a news story that audiences will find both interesting and understandable. Special interest groups, on the other hand, use framing as a persuasive tool. For them, framing is an important device for influencing public opinion and shaping public discourse in mass media.

In sum, media frames provide audiences with cognitive shortcuts or heuristics for efficiently processing new information, especially for issues that audience members are not very familiar with. Greenpeace's attempt to reframe the debate about genetically modified organisms around the 'Frankenfood' label, for example, was directly based on this assumption. Even for citizens who knew little about the scientific facts underlying the debate, the 'Frankenfood' label provided a convenient interpretive device (or frame) that allowed them to form opinions.

Frames will only be effective, of course, if they resonate with underlying **audience schemata**. These can be religious beliefs, moral values, trust in scientists (or Greenpeace), prior knowledge or any other interpretive schema that people use to make sense of information. And frames will usually play very explicitly to these underlying schemata. The ongoing debate about abortion rights in the USA and many other countries is a good example. A pro-abortion stance could be framed as 'pro-choice' or 'anti-life'. A pro-choice frame tries to evoke schemata related to constitutionally guaranteed freedoms and a woman's right to choose. A pro-life frame, in contrast, is tailored to fit schemata about unborn life and other religious considerations. A simple terminological difference therefore activates different interpretive schemata and can change the way citizens think about the issue. The way issues and campaigns are framed has been shown have relative broad societal impacts, influencing perceptions of political figures,[7] trust in Government,[8] and perceptions of governmental responsibility for solving social problems.[9]

How it all fits together…or how attitudes are 'framed'

Attitude formation, ultimately, is a competition between frames of public discourse – offered by interest groups, policy makers and mass media – and the value systems and predispositions of citizens. There is a "negotiation of meaning".[10] In other words, media frames or frames promoted by policy groups offer different ways of looking at the same issue. At the same time, audiences bring their own value systems to the table and use them to interpret these different messages.

The fact that people use these pre-existing schemata as interpretive tools also means, however, that the same media frame may be very effective for one social group but largely ineffective for everyone else. And as a result, the same message

about a scientific discovery, for instance, may be interpreted very differently by different cross-sections of the audience, depending on their religious beliefs, prior knowledge and other factors.

The same message about a scientific discovery, for instance, may be interpreted very differently by different cross-sections of the audience.

For example, in a survey of the US public in late 2004, we asked respondents to indicate their general support for nanotechnology.[11] When we correlated their perceptions of potential benefits with their support for nanotech, we found an interesting pattern. For highly religious respondents, benefit perceptions influenced overall support significantly less than for respondents who reported lower levels of religiosity. Religious respondents used their faith to interpret the potential benefits of nanotechnology.

What does this mean for our understanding of how people form attitudes about scientific issues? The fact that we saw weaker effects of benefit perceptions on attitudes toward nanotechnology among highly religious respondents is probably due to what I would label a 'perceptual filter'. In other words, citizens use value systems and predispositions to make sense of what they learn about nanotechnology.

What this means for communication about scientific issues

Information does still matter, in spite of its limited importance for attitude formation. It matters since every scientific issue has its highly informed and highly interested sub-publics. And input from these sub-publics on the ethical, legal and social issues related to technological innovation can be very important for informing policy decisions.

Understanding how citizens form attitudes, and then using that understanding for effective public communication about science and technology, is not an option: it is a necessity.

But we also know from decades of research in political communication that information can be presented and framed in ways that fundamentally change the interpretation among audiences. At this point in the debate about nanotechnology, no frame has really emerged as the predominant one. Some critics of nanotechnology have referred to it as the "asbestos of tomorrow", alluding to the potential unknown and long-term risks connected with nanoparticles. This metaphor is a highly effective way of using asbestos to evoke an existing interpretive schema that many people share. More importantly, the asbestos frame is difficult to counter since it refers to risks that we will not be aware of until decades down the road.

→ is an expression used in the UK to describe how far removed the body is from death. But go elsewhere and the meaning is more equivocal, perhaps incorporating the wellbeing of extended social and family networks. Depending upon the culture, poor health may be perceived as the result of stress, disease or malign spirits. A culture's interpretation of illness reveals a great deal about its heritage. So what does 'Cradle to Grave' tell us about being British?

Sciart collaborations

Collaborations between scientists and artists are supported through Sciart grants, part of the Wellcome Trust's Engaging Science programme. Projects should aim to stimulate fresh thinking and debate in both disciplines. Innovation and experimentation are crucial, but projects should also be accessible to diverse audiences and engage the public in the social, ethical and cultural issues surrounding biomedical science.

www.wellcome.ac.uk/sciart

Right: Visitors follow the length of the installation at the Wellcome Trust Gallery.

But even if information is presented in the most neutral way possible, citizens will still use their own perceptual filters to interpret that information. Understanding how citizens form attitudes, and then using that understanding for effective public communication about science and technology, is therefore not an option: it is a necessity. Interest groups, corporate communicators and other players in the policy arena have long used these strategies for successfully communicating with a miserly public that will often form opinions based on very limited information, whether we like it or not. This essay is not a call to engage in propagandistic attempts to sway opinions one way or another. But if scientists want to have their views heard in public debate, they need to understand and use the tools that are available and appropriate for communicating effectively with different audiences.

Dietram A Scheufele is a Professor at the Department of Life Sciences Communication, and the School of Journalism and Mass Communication, University of Wisconsin, Madison.

The ideas outlined here are based in part on a recent presentation at the annual convention of the American Association for the Advancement of Science in St Louis, Missouri, USA, and an article in Materials Today *magazine.*

References

1 Brossard D et al. Scientific knowledge and attitude change: the impact of a citizen science project. International Journal of Science Education 2005;27(9):1099–121.

2 Scheufele DA, Lewenstein BV. The public and nanotechnology: how citizens make sense of emerging technologies. Journal of Nanoparticle Research 2005;7(6):659–67.

3 Popkin SL. The Reasoning Voter: Communication and persuasion in presidential campaigns. 2nd edn. Chicago, IL: University of Chicago Press; 1994.

4 See note 2 above.

5 Scheufele DA. Framing as a theory of media effects. Journal of Communication 1999;49(1):103–22.

6 Scheufele DA. Agenda-setting, priming, and framing revisited: another look at cognitive effects of political communication. Mass Communication & Society 2000;3(2–3):297–316.

7 Patterson TE. Out of Order. 1st edn. New York: A Knopf; 1993.

8 Cappella JN, Jamieson KH. Spiral of Cynicism: The press and the public good. New York: Oxford University Press; 1997.

9 Iyengar S. Is Anyone Responsible? How television frames political issues. Chicago: University of Chicago Press; 1991.

10 See note 6 above.

11 See note 2 above.

4 RHETORIC AND ROADSHOWS: AN AMBIVALENCE ABOUT AUDIENCES

Science communicators have multiple masters. On the one hand they have to justify their work to their sponsors, whose objectives they are aiming to achieve; on the other hand they have customers, with their own needs and desires – which may not necessarily correspond to those of the sponsors. This tension, suggests **Colin Johnson**, is rarely acknowledged and yet lies at the heart of science communication and public engagement. Can science communication please all its masters, or does it continue to say one thing to one audience and one thing to another?

We science communicators are an ambivalent lot. When we speak to potential funders we have plenty to say about the democratic imperative of a science-literate population, about recruiting and retaining our best young people for science-based careers, and about the significance of building public confidence in scientists (and engineers) and their work. Yet, faced with those audiences – families, young people, the public at large – we are much more oblique: science is fun, we say; you can do it, scientists are real people too. And of course we use the phrases 'science communication' and 'science engagement' interchangeably.

As a community, we have a number of stakeholder groups, all of whom must be courted and satisfied by what I will call 'inbound' messages. Corresponding to each of these is an 'outbound' message that is disseminated to customers, visitors and other participants in science engagement activities (see table, right).

In a similar way, John Holden has argued in a recent Demos report that, for the cultural sector as a whole, "politicians and policymakers appear to care most about instrumental economic and social outcomes, but the public and most professionals have a completely different set of concerns".[1]

STAKEHOLDER	INBOUND MESSAGE TO STAKEHOLDER	OUTBOUND MESSAGE TO CUSTOMER
Politicians	We will help you meet your democratic objectives; associating yourselves with us provides a neutral forum for your policies.	We stand aside from political influences and offer wide-ranging discussion of the interplay between science and society.
Schools	We will support the teaching process and enrich the learning process.	You can relax – we will look after your class, and you may learn some new teaching ideas or techniques for yourself.
Parents	We will give you an educational day out.	Your children will have a safe and enjoyable time, self-paced and in the care of others.
Scientists	We have the audiences, you have the science – work with us. There are no Brownie points in this, but you can present science communication as good institutional PR, which someone else will probably pay for.	You can meet a scientist on equal terms here. See and hear someone who's no different from you underneath, but has a real enthusiasm for science and works on it every day.
Funding partners	Your message can be associated with our delivery method. You will get exposure in an environment that is perceived as impartial.	People as important as X, Y and Z think that our work is significant, and are prepared to support it in cash or in kind. You can benefit from this, and know that the quality of what we do has received external endorsement.
Media	We have lots of human interest stories that will grab your audiences.	The media are interested in us, so you should be interested too. On the other hand, we probably need them more than they need us, and we don't really trust them to get the story right!

SILENT SCIENCE

How do you explain stem cell biology to someone with impaired hearing?

More than 70 000 deaf people in the UK use British Sign Language (BSL), a rich marriage of hand shapes, hand movements and facial expressions, to communicate meaning. However, sign language for scientific words barely exists; what does is cumbersome, slow and limited. It is easy for insiders to forget how exclusive the language of science can be. Important steps are now being taken to generate an entirely new biological sign language, bringing everyone into the discussion. →

SIGN LANGUAGE FOR DEAF PEOPLE

Funding
£12 249 (2003, People Award) – Signing Biotechnology (plus a Royal Society Copus grant)

Project lead
Professor Mary Bownes, University of Edinburgh

More details
www.biology.ed.ac.uk/public/sibe/signingbiotechnology/MMOV/

Left: Sign language for the letter D. Communicating 'DNA' used to mean signing each letter.

Facing reality and declaring our aims

In practice, science communicators are faced with a series of potential conflicts or contradictions. There is:

- an ambivalence between adopting a campaigning approach for science, based upon the expertise of marketing, PR and media activity, or an approach based upon democratic engagement
- a continuing reluctance to accept that the evidence for impact (of a science communication activity) is generally not available at the time, but is normally well separated from it in both time and space
- a growing realisation that those who practise science are frequently not its best advocates, while those with the skills of advocacy (or of drawing others into dialogue) may not have the scientific knowledge and insights to provide rigour in the engagement activity
- an understandable reticence about the real possibility that those who choose to take part in a science engagement activity (e.g. a visit to a science centre) may have had no thought of science in their minds.

So are we engaged in 'education by stealth', in which the fundamental goals are not the same as the objectives that are publicly declared? Do we have our own 'hidden curriculum'?

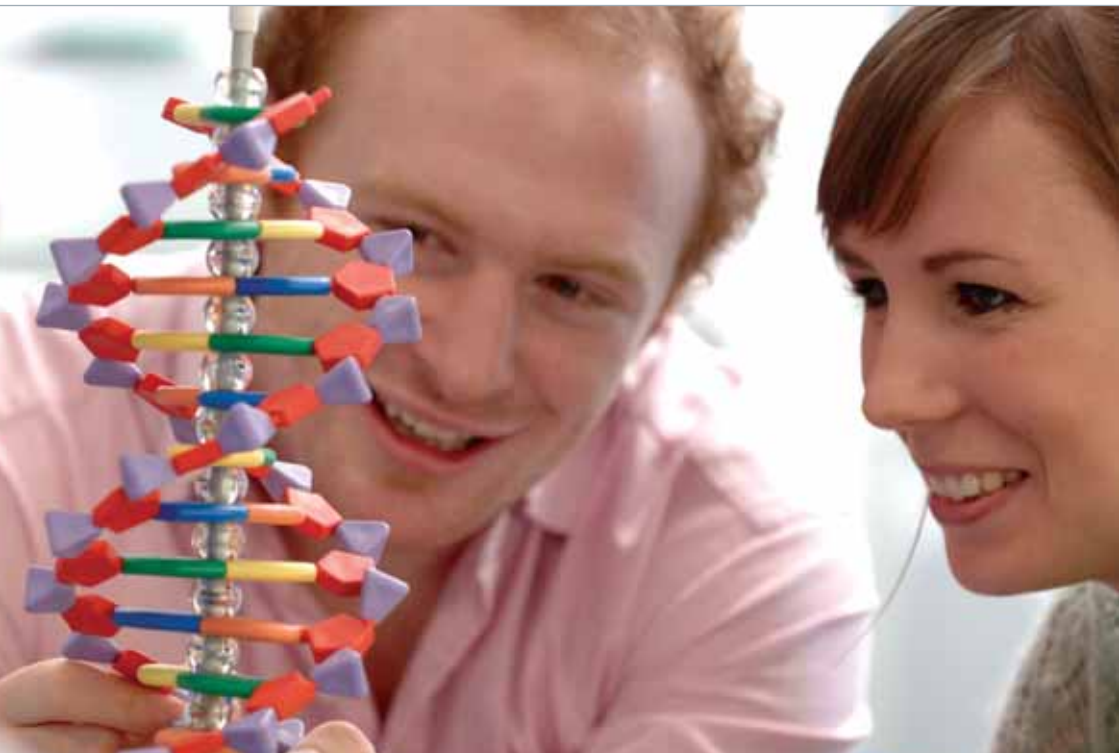
The science centre sector, in which I have worked for some time, shows how difficult it is to chart a course without ambivalence. Consider, for instance, this selection of mission statements from a number of centres, listed here in order of the number of words employed.

Science centre mission statements

> "The Centre is concerned with the resurrection of Scotland's proud spirit of innovation and creativity through the establishment of a scientifically aware and technologically capable society as the foundation for renewed and sustainable social, economic and cultural prosperity."
> (Glasgow Science Centre, Scotland)

> "To promote interest, learning and creativity in science and technology, through imaginative and enjoyable experience and contribute to the nation's development of its human resource."
> (Singapore Science Centre, Singapore)

> "The Centre is committed to helping families and students understand the importance of science and technology in their lives by providing fun-filled learning experiences."
> (Calgary Science Centre, Canada)



> "Bringing science and technology closer to the people."
> (Technopolis, Belgium)

Here we can see that struggle between 'ticking every box' and creating a bland umbrella beneath which all stakeholders can shelter.

The 2006 Research Councils UK publication *Science in Society* sets out its goal: "We aim to foster a climate of trust in which researchers can work and to develop a society equipped to debate scientific issues".[2] Does this not encapsulate the very ambivalence in which the rest of the sector is trapped?

Evaluation: evidence base versus smiley face?

Perhaps a single focus may be found by measuring the outcomes of science engagement activities, though in the words of the Parliamentary Office of Science and Technology, this is "essential, but difficult to do and rarely achieved".[3]

We need two kinds of information: where do our audiences stand when we first meet them? And how have they been influenced by their experience of engaging with science? Audience research based upon microscopic examination of how an individual engages with a particular science experience may be valuable, but the data are rarely capable of generalisation. Time and again we are hampered by the indeterminate interval between the experience and the opportunity to make sense of it through further contextualisation. (See 'A Guide for Successfully Evaluating Science Engagement Events', pages 80–85.)

So are we engaged in 'education by stealth', in which the fundamental goals are not the same as the objectives that are publicly declared?

Consider the following (true) story. A visitor at a science centre is speaking of her granddaughter who is hauling at a rope connected to some sandbags by a series of pulleys:

> I didn't quite realise what she gets out of [visiting the science centre] until the other day, when she was with her father who was moving some heavy boxes in the shed. "What you need, Daddy, she said, is one of those things they have [in the science centre] where you pull down on the rope and the weight goes up easier." She's only six, and of course she doesn't really understand what's happening here – but she has taken away the essential message.

Like that little girl, we all make sense of our experience when a suitable context presents itself. The real challenge for those seeking an evidence base for the impact of science communication is exactly this: we only take ownership and make sense of our 'science engagement' when we get a chance to talk about it or to apply it in a new situation. No amount of microscopic examination of body

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→ The approach taken by Professor Mary Bownes and her associate, Dr Jan Barfoot, Deputy Director of the Scottish Initiative for Biotechnology Education, involved deaf people from the outset as well as interpreters, scientists and teachers, using workshops and an accessible website to maximum effect. They took a hard look at what BSL already existed, plus the new signs naturally creeping into common usage. As with spoken English, non-verbal language evolves, adapting to find new forms of expression – but this takes time and science moves too fast to wait for this drip feed of new terminology.

The next stage was to fill in the blanks, looking at specific topics (genetic modification, for example) and focusing on how to distil the terminology in a way that made sense, in terms of BSL, and was also scientifically relevant. Analogies, for example, are a powerful tool, with DNA being successfully communicated by signing a double helix.

Suddenly, the doors to communication started opening. Teachers gained access to resources transforming the way they could teach modern biological concepts and techniques to their deaf pupils. Deaf people and interpreters became able to access a resource to help them discuss contemporary science – an activity that had, until then, been stilted and difficult.

Even events such as Edinburgh's International Science Festival began to draw larger numbers of deaf people, no longer excluded by the barrier of →

Left: Double helix: the deaf community may wish to join in debates about genetics.

language, conversation with companions, or puzzled frowns and smiley faces will reveal the true effectiveness of an engagement with science or its eventual impact.

How should we conduct our evaluations? If we are ambivalent about our objectives, how can we make a valid evaluation of the extent to which they have been achieved? Do we always have the convenient refuge of allowing ourselves to justify what we have completed in differing ways to different audiences? My report 'Science Centers as Learning Environments', available on the website of the Association of Science-Technology Centers, considers these questions in some detail.[4]

Faced with a government consultation paper on out-of-school education, the National Trust has produced a report based upon a follow-up study after five years of its work with young people.[5] It concludes that school trips can help to improve children's learning through the development of social, practical and cognitive skills, and reported that one in ten students said school trips had been a key factor in their choice of future studies and career.

Ultimately, the key question is: "How will you act differently as a consequence of taking part in a science engagement activity?" And there is an associated question: "How will anyone know?" Rarely is one asked to undertake a public affirmation, such as the BA's recent 'Click for Climate', which attracted 20 000 pledges.

Involving people

Upstream engagement, as exemplified by the Nanotechnology Engagement Group and the Quality Research into Dementia network, attempts to capture public involvement in setting the values and priorities that direct scientific research. It is less readily applicable to blue skies research than to applied science and technology, and we have little experience yet on which to test its value. If it can be validated as a disinterested approach to the setting of public agendas, rather than cynically suspected of being a variant of political spin, then it has important potential. Perhaps the current government Energy Review will prove to be its first real test.[6]

As Jorge Wagensberg points out in his paper for the 4th World Science Centre Congress (Rio de Janeiro, 2005):

> We have a very serious problem, even in the most highly developed societies. All votes have the same value in a democracy; and yet science, which is the form of knowledge that most impinges on our lives and affects the decisions to be made daily on issues that impact our coexistence (energy, hygiene, health, the ethics of science, the environment, technology...)...science is outside the sphere of interest of the great majority of people.

→ language. Now science centres are also accessing these resources, helping them run more inclusive workshops. Perhaps even more significantly, students can now be examined in their first language, signing, rather than their second, written English.

Dr Barfoot feels the success of the project is down to its relatively simple aims plus a strong credibility born of her multidisciplinary project team. Signing Biotechnology is one large step towards a more inclusive society, enhancing BSL with a highly directed approach. This linguistic transformation will help to bring forward a time when everyone can more fully participate in science education and the emerging debates.

People Awards

These flexible awards, of up to £30 000, offer a rapid-response system of funding; they can be applied for any time. They are intended for activities that:

- communicate biomedical science to the public
- stimulate thought and debate about biomedical science
- improve understanding of the powers, and limitations, of science.

www.wellcome.ac.uk/engagingscience

Right: DNA sequence: four letters having an increasing impact on everyone's lives.

This presents our public figures with their greatest challenge in communicating science: should they rely on evidence or emotion? These two contrasting statements exemplify the problem:

> We intend to conduct all our public engagement in accordance with evidence-based best practice.
> (Ian Diamond, Chief Executive of the Economic and Social Research Council, speaking about the emerging Science in Society strategy of Research Councils UK to BA Science Communication Conference, London, May 2005.)

> Your chances of winning the lottery are about 1 in 14 million. Your chances of catching bird flu are more like 1 in 100 million, even if we had H5N1 among the chicken population in Britain.
> (Sir David King, Government Chief Scientist, quoted in *The Times*, April 2006.)

Conclusion

Engaging public audiences with science is not a business proposition. No one has yet suggested that you can make money out of it. So the process of engagement requires an investment of funds – private or public. The motives of the funders are universal – the creation of a public good, relating to nurturing the young, empowering the old or making life easier for the legitimate social, commercial and political aspirations of the sponsor. The motives of the provider of public engagement with science may relate directly to the purposes of the sponsor, but they are more likely to embrace institutional and reputational goals for themselves, and for this reason to be person-directed rather than cause-directed. The funder's goals are not time-limited, but the provider must send the client away smiling, or she/he may not return. This creates an unresolved tension between the funder and the agent, the provider. We are all ambivalent about our audiences – how frequently does the roadshow match the rhetoric?

Colin Johnson is Executive Vice-President, Young People's Programmes for the BA, former director of Techniquest, Cardiff, and founding chair of Ecsite-UK.

References

1 Holden J. Cultural Value and the Crisis of Legitimacy. London: Demos; 2006.

2 Science in Society. Swindon: Research Councils UK; 2006.

3 Debating Science. POSTNote 260. London: Parliamentary Office of Science and Technology; March 2006.

4 www.astc.org/resource/education/johnson_scicenters.htm [accessed 5 June 2006].

5 Peacock A. Changing minds: the lasting impact of school trips. The National Trust; 2006.

6 Our Energy Challenge. London: Department of Trade and Industry; 2006.

5 STRIPPING DOWN SCIENCE TO THE BARE ESSENTIALS: THE BARE–FACED CHEEK OF HOW MEDICINE TURNED INTO MEDIA

New technologies have created new opportunities for public engagement. **Chris Smith**, for example, has used radio and, more recently, podcasting technologies to reach large numbers of people – and not just those who would normally be targeted by science communication activities. His work is good evidence that there is a significant appetite for science – if it is presented in ways that appeal to consumers.

Take an onion, chop it finely, add water, half a pint of washing-up liquid (lemon-scented variety optional) and a handful of salt, and simmer at 60˚C for 10–20 minutes. Pour the attractive-smelling mixture through a coffee filter and collect the juice. Cool, add fresh pineapple juice, and incubate at body temperature for ten minutes. Meanwhile, chill some aftershave in the freezer, and then gently pour twice the volume of ice-cold aftershave over a sample of the onion/pineapple 'jus'. Before your eyes a squidgy substance, not dissimilar in appearance to snot, begins to appear.

This is the recipe for extracting large amounts of DNA from an onion using simple ingredients you can find at home. It's also the recipe that spawned *The Naked Scientists Radio Show*, which has subsequently become one of the world's most downloaded science podcasts.

I've always been very keen on science, and particularly talking to people about it, so back in 1999, when someone emailed me asking if I would be willing to help out at the Cambridge Science Festival by giving a talk or demonstrating something, I jumped at the chance.

I set up the onion-DNA demonstration a bit like a cooking programme and invited members of the audience to 'come on down' and help with the procedure. While volunteers vigorously sliced and diced, blinking red-eyed through the onion vapour, I gave a short talk on the nuts and bolts of life's recipe

book. The result was a spectacular handful of onion DNA, a rapt audience, and a phone call from a local commercial radio station inviting me for an interview.

I took along a colleague to the radio station for moral support. Between us we managed to turn what was supposed to have been a five-minute interview about DNA into two hours of light-hearted scientific banter, punctuated by regular music breaks. The radio station was sufficiently impressed to ask us back a week later, and from there the concept of the Naked Scientists was born.

As luck would have it, at around the same time the Biotechnology and Biological Sciences Research Council (BBSRC) launched a new scheme to promote public understanding of science. I negotiated to buy a year's airtime from the radio station at a (very) reduced rate, and we wrote a grant application to the BBSRC to pay for it. And in January 2000, the BBSRC agreed to fund our project, and the show, which we christened *ScienceWorld*, was on the road.

I'm certain we sounded terrible to begin with. The transition from guest to show host is a difficult one. You suddenly have to worry about playing ads and jingles at the correct times, getting the levels right, answering the phone, and all the time you're trying to talk intelligently about complicated subjects and keep the conversation going.

The website was taking a quarter of a million hits a week, admittedly many of them for the word 'naked'.

Although the learning curve was steep, we improved rapidly and before long it was really starting to hang together. We turned the show into a light-hearted look at what was happening each week in the world of science, technology and medicine, interspersed with popular chart music. We succeeded in dishing out 'Radio 4'-type material to a 'Radio 1'-type audience who would not normally be exposed to educational science radio programming. We also included a few funny stories each week, such as the one about a Reliant Robin seen parked all over York with an industrial-sized sack of potatoes in the passenger seat. It turned out that the driver weighed over 35 stone and, without the counterbalancing effect of the potatoes, the three-wheeled car was prone to rolling over on bends. Naturally we used this story to highlight the importance of eating a balanced diet...

We saw the number of people tuned to the station jumping by 50–100 per cent when we came on air. More and more people were phoning in to enter the competition and to ask us questions. By the end of the series the radio station had been taken over by a new company, but since our ratings spoke for themselves we were offered the chance to make another series. As we all had deadlines looming, including a thesis to complete and clinical finals, we took six months off to get everything finished.

CAFÉ CULTURE

Café Scientifique is not a location, it is an idea, "a place where, for the price of a cup of coffee or a glass of wine, people meet to discuss the latest ideas of science and technology which are changing our lives". This idea, the brainchild of Duncan Dallas (inspired by the French Cafés Philosophiques), is proving an international success.

Like many great ideas, its success owes much to its simplicity. Show up at the organiser's chosen venue – a café, bar or some other welcoming locale – grab a glass of your favourite tipple and take a chair. For around 20 minutes, an expert speaker (scientist or science writer) waxes lyrical about their chosen subject →

CAFÉ SCIENTIFIQUE

Funding
£175 000 (2001, Impact Award) – Café Scientifique Development Project

£9550 (2004, People Award) – Café Scientifique National Conference

£178 150 (2005, Society Award) – Establishing a network of 'Junior Cafés' in UK schools

Project lead
Duncan Dallas

More details
www.cafescientifique.org.uk

Left: Dr Simon Archer talks about body clocks at a Café Scientifique in Manchester. *D Kampfner*

Meanwhile, we got support from the BBSRC for a further series, and to develop a companion website (**www.thenakedscientists.com**). The idea was to maximise the reach and educational potential of the material by archiving it in text and audio formats on the web. The text transcripts would then provide 'search-engine fodder', helping visitors to locate items of interest, while the accompanying downloadable audio meant that they could listen to items being discussed. The renamed *Naked Scientists Radio Show* then hit the airwaves for the first time in the autumn of 2001.

For the new series we focused the show not just on science news stories but on an interview with a guest scientist too. We signed up Richard Dawkins, Sir Alec Jeffreys, Susan Greenfield, Steve Jones and even James Watson. The audience loved it, and so did the competition, as it turned out.

Between us we managed to turn what was supposed to have been a five-minute interview about DNA into two hours of light-hearted scientific banter, punctuated by regular music breaks.

The BBC had been listening to us for a while and in 2002 offered to move the next series of the show to BBC Radio Cambridgeshire. This would see us grow from talking to a few thousand people around the city and outlying villages to talking to an entire county. More importantly, through the use of local radio, we would be able to continue to reach a subset of the population who would not normally be exposed to educational science radio programming.

By this time it was obvious that we were on to something. The website was taking a quarter of a million hits a week, admittedly many of them for the word 'naked', but at least we couldn't be accused of preaching to the converted, and emails were coming in from people all around the world who were enjoying listening to our shows. It was clear that what we were doing had the potential to be much bigger. This was confirmed when a contact with BBC Essex led to an invitation to make some special two-hour bank holiday programmes for them.

Two hours seemed an awfully long time but my initial fears evaporated when those shows were broadcast live at peak time in May and August 2003. They drew an enormous audience response; people of all ages from nine to 90 phoned in with questions like "How many pieces of toast can you make with the energy in a lightning bolt?", "Why does my car do 8 miles to the gallon more with an air-filter full of mothballs?", and "How many organs can I donate and remain alive?". They were certainly one of the most enjoyable experiences I've had with this project mainly because I suddenly realised what it could achieve. Another major benefit of our success on BBC Essex was that the managing editor, a wonderful lady

→ before a break, allowing glasses to be recharged. Then the questions start and the fun begins…

Members of the public have direct access to an expert, on a relaxed verbal battleground in which thoughtful, probing and frequently difficult questions are dealt with in everyday language.

The British Council's adoption of the format helped to spread the cafés globally and, as testimony to their success, they're springing up everywhere. From the first cafés held in Leeds in 1998, there are now well over 150 of them globally, including in Brazil, Japan, Russia, Denmark, Costa Rica and the USA.

Dallas himself has no idea precisely how many there are; but then the viral explosion of cafés fits in perfectly with the 'bottom-up' ethos of the original idea. Anyone can start one – anywhere they want – with zero funding (speaker expenses are provided by a collection from the attendees). All necessary coordination is achieved via a website.

Underpinning the success is the public's genuine curiosity, a real hunger to find out more about the increasing number of scientific issues touching on their health, technology and planet. More than that, the format of the gathering is appealing: when people engage in science, they prefer situations that are relaxed, social, interactive and not intimidating in the way that more formal 'learning environments' can be. →

Right: Duncan Dallas (far right), originator of the Café Scientifique concept. *D Kampfner*

called Margaret Hyde, was sufficiently impressed by what we were doing that she persuaded all of the other BBC radio stations in the region, with a potential audience of 6 million, to take the new series from September 2003.

When this series launched, funded by a COPUS grant from the Royal Society, we switched to a purely talk-based format to increase the time available for content. We opened each week with a digest of topical science news stories, answered general science questions live from listeners and interviewed guest scientists who joined us in the studio to discuss their work. Quickly our brand of 'serious science with a sense of humour' caught on, and we picked up regular listeners all over the world, including people in Australia, Canada, California and even Japan – one young lady in Tokyo phoned in to ask why crying makes your eyes go red. She defiantly told our telephone operator: "You'd better put me on the show because I've stayed up until 4 a.m. to call you!"

In early 2004 we paused for six months while I took up a Winston Churchill Fellowship and joined doyen of radio science journalists Robyn Williams at the ABC in Sydney for six months. While there, in addition to making programmes about landmine-detecting GM cress plants and the origins of HIV, I began contributing live science commentaries to the *Radio National Breakfast Program* each Monday morning, as I have continued to do since I came back to the UK.

A new series of the *Naked Scientists* for the BBC Eastern region followed, which was broadcast between October 2004 and April 2005, along with launch of a series of live weekly science reports, which are currently broadcast nationally each Monday morning, on BBC Radio Five Live.

One young lady in Tokyo defiantly told our telephone operator: "You'd better put me on the show because I've stayed up until 4 a.m. to call you!"

The COPUS grant ended in April 2005. It was clear by this time that there was an unmet need for science radio programming of the type that we were delivering. But to fill that need would require significant effort, so in early 2005 I applied to the Wellcome Trust for funding to support a full-time producer. In June 2005 I was awarded a £200 000 Society Award, and the BBC agreed to return the show to the air from October.

In the interim I began to experiment with turning our back catalogue of archived shows into formal podcasts, with the aim of growing a podcast audience prior to the launch of the new series. For the uninitiated, a podcast is simply a digital audio file that is available on the internet and to which you can 'subscribe'. It's very similar to a magazine subscription in that whenever the podcast producer

publishes a new edition of their programme, a copy is automatically delivered to your computer without you having to go and retrieve it manually. You can then listen at your desk, or transfer the material to a personal player, such as an iPod, for portable consumption.

As soon as the *Naked Scientists Podcast* came online, the shows from our previous series went to the top of the Apple iTunes charts. We became a 'featured podcast' and reached the dizzy heights of the top 30 in most countries.

There has been a downside though, which is that the quarter of a million monthly downloads of our programmes amount to a massive 4 terabytes of data, which is nearly crippling our web server.

Podcasting has been a great leveller. It's brought down the barriers that have constrained traditional broadcasters and empowered listeners.

On the basis of this success, in mid-2005, I approached the journal *Nature* with the idea of producing a free weekly podcast to supplement the contents of the journal. This would comprise interviews with the publishing scientists about their work, together with coverage of the week's most significant science news stories. The *Nature Podcast*, which this became, launched in October 2005 and was the world's first example of an international science journal producing an audio podcast to supplement their published content. It too has since reached the iTunes top 30 and is moving over 40 000 copies of the show per week.

Podcasting has been a great leveller. It's brought down the barriers that have constrained traditional broadcasters and empowered listeners. Now you can hear what you want, when you want, worldwide. It's also revitalised people's awareness of and interest in the power of radio as a broadcast medium, and it's reshaping the media landscape. The download data generated by people subscribing to podcasts are providing some of the first genuinely objective measures of radio listening, and it's also allowing the popularity of certain programmes, which would never normally compete with each other, to be compared. For instance the *Naked Scientists*, which would previously have been confined to regional radio in a small corner of the UK, now stands in the charts alongside national radio giants such as Australia's *The Science Show* and Radio 4's *In Our Time*.

→ Dallas also alludes to another aspect of the cafés' success: that science may have reached a point where it is shifting cultural perceptions of what it means to be human. These are profound issues, provoking many to reflect on life's 'big questions'. The informal forum of a café allows people to talk with experts and, importantly, among themselves, about their concerns and hopes for our future.

The unprecedented growth of Café Scientifique continues apace. It is also flexible, adapting to suit different cultures. Events are being organised for ethnic minorities, groups that tend to have little contact with traditional science communication. The massive scale, reach and impact clearly illustrate that, with the right format, the audience will come running.

Society Awards

Upwards of £50 000, Society Awards come in two forms: activities and research. **Activity awards** support large-scale activities, such as conferences, art projects, workshops or educational resources. The hope is that the activity will make a sizeable, nationwide impact on public engagement with biomedical science.

Research awards are of the same financial scale but are intended to support academic research that advances knowledge of public engagement in the biomedical sciences.

www.wellcome.ac.uk/engagingscience

Right: The audience has full access to speakers at Cafés Scientifiques. *D Kampfner*

Significantly, the *Naked Scientists Podcast* has invigorated the radio show. It provides a valuable source of content because listeners worldwide now submit questions and suggestions for programmes, submit their own short science podcasts for broadcast within our show, and volunteer to appear as interview guests.

The impact of radio and audiovisual programmes is about to explode because now a show will have a lifetime that exceeds the time it is on air.

But is this a flash in the pan? The answer is definitely 'no'. The internet will grow to embrace this technology. Brace yourselves for the arrival of 'enhanced' podcasts – audio shows with images attached, and also video podcasts. What this means for science communication is that that the impact of radio and audiovisual programmes is about to explode because now a show will have a lifetime that exceeds the time it is on air. Through the convenience of on-demand viewing and listening, more people will be able to access more quality science programming than ever. Which means that, while sitting in that traffic jam or on the train, there's now going to be an alternative – day or night, you can switch on the *Naked Scientists* instead...

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6 PUBLIC ENGAGEMENT ON THE USE OF ANIMALS IN BIOMEDICAL RESEARCH

Scientists, on the whole, are keen to engage with the public and can see the value of doing so. They do see a number of obstacles, such as lack of training and the difficulties combining research with serious commitment to public engagement. Here, **Nancy Rothwell** looks at the lessons to be learned from public engagement on animal use in research. Although one of the most highly charged areas of public engagement, open public dialogue has been possible and has influenced public opinion.

Scientists are increasingly aware of calls for public engagement. The Government, research funders and the wider public are all encouraging scientists to explain and discuss their research, to seek views and to consider the sensitivities and concerns of the non-scientific community. A recent MORI survey commissioned by the Wellcome Trust revealed some surprising findings.[1] Over half of the scientists surveyed claimed to have taken part in public engagement and three-quarters felt equipped to communicate their research to non-scientists. These figures are much higher than the experience of those involved directly in public engagement.

Research on experimental animals offers an interesting case study of one of the most difficult areas of public engagement, and allows us to consider which scientists are involved, what problems they face, what might be in it for them, and how they might best go about it.

In this, as in any area, it is first important to ask who is the public and what is engagement? The public of course includes the informed, educated, interested and engaged populations as well as naive, uninterested and poorly educated groups. In sensitive areas, such as animal research, it can also include extreme animal rights groups. The challenge of engagement is influenced particularly by experience and self-interest, by a multitude of conflicting types of information, by a huge media interest, occasionally by violence and fear, and, in the UK at least, by a long history

of public debate. This engagement can mean simply discussing what animal research is or does, or stepping into what some would call 'the firing line' to defend it.

History of the debate

Concerns about the use of animals in research have a long history in the UK, dating back over a century. Indeed, the Research Defence Society (RDS), established to explain and support the use of animals in research, is almost a hundred years old. Then, as now, the argument against animal research has had two distinct strands – first about the morality of using animals in research (if they suffer, or even if they do not), and secondly the value of animals in diagnosing, understanding and developing treatments for medical and veterinary diseases.

There has been much speculation about why the public debate on animal research has been so longstanding, so prominent and at times so polarised in the UK, but much less so in other countries. The answers are usually unconvincing, but are relevant to other ongoing areas of sensitivities. Britain is cited as a nation of animal lovers, which has many pets and makes generous donations to animal welfare and protection charities. But it has also been heavily dependent on farming, with a high proportion of meat eaters. Interestingly, while Britain once seemed to stand alone as a fierce debating ground on animal experimentation, other countries are now facing similar activity. Sweden has seen some violent protests, and animal rights groups are now very active in the USA.

Argument against animal research has had two distinct strands – first about the morality of using animals in research (if they suffer, or even if they do not), and secondly the value of animals in diagnosing, understanding and developing treatments for medical and veterinary diseases.

The longevity and intensity of interest in the animal experimentation debate has led to the establishment and growth of a number of groups to "promote the causes of animal experimentation and experimenters" such as the RDS and the Coalition for Medical Progress (CMP). Other groups that include such aims in their activities include the Association of the British Pharmaceutical Industry, the Royal Society, the Biosciences Federation and many other learned societies.

Specific challenges associated with the debate on animal research

Scientists are often frustrated by the generally poor standards of science education and understanding of even fundamental issues in science by the public, and even by their academic peers. C P Snow lamented the general familiarity with Shakespeare, but widespread failure to grasp even a basic notion of Newton's laws. But in spite of this frustration and broad encouragement, as a result of a series of reports initiated by the Bodmer report in 1985, this is clearly

Y CARE ABOUT ANIMALS?

***Every Breath*, an intriguing 'theatre debate' production from Y Touring, uses drama to draw out audience beliefs and preconceptions about research using animals.**

Every Breath, written by Judith Johnson and aimed at 14-year-olds and above, gently draws viewers into the emotionally turbulent lives of its everyday inhabitants: real lives tinged with pain, fragile people striving to do the right thing. But are those lives more important than those of animals used in research? At what point do you decide to honour the lab rat above your own life? Framing the debate is the well-intentioned, pro-animal rights Sonny, and his volatile sister, Anita – soon to don her new lab coat and start carrying out experiments on animals in pursuit of her PhD… →

EVERY BREATH

Funding
£128 000 (2005, Society Award) plus a further contribution from the Association of Medical Research Charities

Project lead
Nigel Townsend, artistic director, Y Touring Theatre Company

More details
www.ytouring.org.uk

Left: *Every Breath* engages young people with issues without preaching. *D Kampfner*

not a primary area for many or most scientists. There are of course still barriers and disincentives. Scientists admit (see the Wellcome Trust/MORI report) that most have had little or no training, but the real pressure is on their time. Unless and until public engagement is valued alongside research outputs and excellent teaching, it is unlikely to be a major feature in the scientists' diaries. In animal research, the problems are aggravated by sensitivities, and by violence or threats, leading to a culture of fear among those involved in every aspect of the use of animals in research, though the perception of risk by scientists far outweighs the reality.

Numerous groups campaign or protest about the use of animals in research, but their views and actions vary enormously. Animal welfare groups, including many that engage with the scientific community (e.g. the RSPCA and the Universities Federation for Animal Welfare) argue cogently for continued action to limit the suffering of animals used in research, and for intense efforts to reduce or replace animal use by other means. Such groups have played an important role in ensuring high standards of welfare and legislation in the UK and should be supported by the scientific community. More extreme antivivisection groups argue that all experiments on animals are morally unacceptable, and/or that they are misleading in that they have led to no medical or veterinary advances. The first of these arguments is difficult to counter, in the same way that it is difficult for an atheist to challenge religion. It is a matter of belief, or moral conviction. The second, that animal experiments are invalid, challenges a vast scientific and medical literature, and can be readily countered by rational debate. Further, some of the animal rights groups eschew debate in favour of intimidation, harassment and violence.

Unless and until public engagement is valued alongside research outputs and excellent teaching, it is unlikely to be a major feature in the scientists' diaries.

The intensity of feeling on this issue, and the high media profile, has had serious implications for UK science and business. In spite of strong support from Government, and according to most polls from the public, the biotech and pharmaceutical industries, which are the pride of the UK's economy, are inevitably considering the UK as a somewhat hostile environment for their research programmes that use animals. Many animal breeders have now closed, meaning that laboratory animals must be imported, often over long distances, sometimes from countries with a rather less robust record in animal welfare than Britain, and universities are struggling to meet the growing demands for animal facilities – not least the University of Oxford.

→ *Every Breath* doesn't tell the audience what to think; rather, it provokes a wide range of ideas, thoughts and conflicting emotions for the audience to mull over while engaged with a genuinely moving drama. Following the performance, the tables suddenly turn and the performers, still in character, enter into a facilitated debate with members of the audience.

The play is making a big impression wherever it goes. Aiming to reach as many as 15 000 schoolchildren in Britain this year, *Every Breath* has been unanimously well received, both by teachers and students. Invariably, young audiences are sucked into this nebulous world of rights and wrongs, becoming highly vocal participants in an ongoing debate with few clear-cut answers.

Instead, it seems students are frequently left with more questions, turning breaks between lessons into opportunities for further discussion. For those who have left school, Y Touring will be performing *Every Breath* at this year's Edinburgh Festival.

It's no accident that Nigel Townsend's scientific theatre productions are so polished and effective. Well before the writing stage, development was guided by meetings between scientists, animal rights campaigners, playwrights and even a philosopher. From the very outset, the play intended to explore shades of grey, rather than providing a strong moral message. →

Right: Young people performing *Leap of Faith*, another Y Touring project.

The role of the scientist

Professional communicators have an important role in this discussion and may be less fearful of 'personal targeting' by extremist groups. But the scientists who are actually conducting the research, and the clinicians and vets who develop and use medications resulting from research, have the most powerful voices. Recently, patients and their carers have taken on an increasing role in the debate – with significant impact and media interest.

The nature of public engagement varies enormously. Entering a live TV debate or discussion with antivivisectionists or seemingly antagonistic journalists is daunting and requires special skills and training, but reaches a huge audience. The most common grounds for discussions are visits to schools, patient groups and other interested parties (university public presentations, Rotary Clubs, Women's Institutes and other lay organisations). These are almost universally positive experiences. I have never once been challenged about animals in numerous presentations to such fora, and in spite of presenting clearly the use of animals in my research, have never even met a hostile response. The most extreme controversy was from an elderly lady who wanted to state her outrage that "some nutters should try to stop such important research".

Nevertheless, it is valuable to take advice or training in order to feel as prepared as possible. There is much valuable advice on offer, for example from the RDS (media tips, special media training courses, schools training and educational packs such as videos and books), the Science Media Centre, or the CMP. While scientists normally feel quite comfortable discussing and, if necessary, defending their own research, anyone who has talked to schoolchildren will know that questions can be many and varied, from "How many alcopops does it take to kill your brain cells?" to "How many animals do you kill each day?" and "What do you do to cats you catch on the street?" The responses to these and many other questions are straightforward. Just a few facts can instantly dispel myths. In an environment where research suggests that scientists are generally seen as elderly, male and uncaring, it is important that younger scientists enter the debate and clearly state their reservations about using animals. We admit these concerns to each other but seem to feel that public admission is a breach of the 'scientific defence barrier'. But I would argue that any scientist who is not passionate and concerned about animal welfare should never undertake research on animals.

To give a talk about why animals are important in research may prove to be a great challenge to scientists, but presentation of their use in the context of a research programme rarely elicits hostility. Most audiences are fascinated by science, and are highly respectful of scientists. It is important to discuss the array of approaches used (the vast majority of which do not use animals),

when and why they are appropriate, and when and why animals are used. The strict legislation in the UK is such that it is illegal to conduct any experiment on animals if there is a valid non-animal alternative. It is also helpful to put the scale of animal use in context – the numbers used in research in the UK (approximately 3 million per annum) is tiny compared to those used for food (100 times as many) or killed as pests (three times as many rodents).

Scientists need to identify clearly their role in discussions on animal research. Given the intensity of the debate, it is easy to step onto the defensive and assume that the scientific community's job is to persuade 'the public' of the value of using animals. There is a danger of assuming such a role. Science will benefit much more if its protagonists explore the need and value, and confront the concerns and sensitivities about the use of animals. It is particularly important to acknowledge publicly that animals used in research can and do suffer sometimes, and the moral issues that this raises.

RESEARCHERS REMAIN POSITIVE

Scientists in universities are becoming more active in science communication, but without getting trained to do it, according to the latest survey of researchers' attitudes.

The survey, commissioned by the Royal Society, asked scientists in higher education institutions across the UK whether they had been involved in at least one science communication or public engagement activity in the previous year.[1] Seventy-four per cent said they had, a rise of 18 percentage points on the figure recorded by the MORI/Wellcome Trust survey in 2000. However, 73 per cent of those responding also said that they had received no media, communications or public engagement training.

Two-thirds indicated that pressure to spend more time on research was preventing them from doing more public engagement work, and one in five thought that scientists who take their work to the public lose respect in the eyes of their peers. Some of those interviewed in more depth felt that public engagement was seen as 'fluffy'.

The most popular form of engagement remained the public lecture, followed by interacting with policy makers, working with schools, and taking part in public dialogue or debate. However, while they were keen on 'educating' the non-specialist public, most university researchers remained rather more interested in engaging directly with policy makers and industry.

Reference

1 **Factors Affecting Science Communication: A survey of scientists. London: Royal Society; July 2006, in press. See www.royalsoc.ac.uk/page.asp?id=3180 [accessed 5 June 2006].**

→ *Every Breath* is the latest in a long line of science issue-based drama-and-debate productions developed by Y Touring. The company's connection with the Wellcome Trust dates back to 1995, when it produced *The Gift*, a play exploring the issues surrounding embryo selection. Other Trust-funded works include *Cracked*, which tackled mental health issues in young people, and *Learning to Love the Grey*, a study of embryonic stem cell use in medicine.

Society Awards

Upwards of £50 000, Society Awards come in two forms: activities and research. **Activity awards** support large-scale activities, such as conferences, art projects, workshops or educational resources. The intent is that the activity will make a sizeable, nationwide impact on public engagement with biomedical science.

Research awards are of the same financial scale but support academic research that advances knowledge of public engagement in the biomedical sciences.

www.wellcome.ac.uk/engagingscience

Right: A scene from *Cracked*, another Trust-funded Y Touring production.

The other danger is that scientists focus on 'the opponents' and spend more time on criticising the animal extremists or responding to the antivivisection agenda than discussing the real issues and the areas of their expertise.

The changing climate

While animal research has been one of the most sensitive and difficult areas, it is also one of remarkable success. Over the past decade, open discussions on animals and the activity of organisations such as the RDS, the CMP, the Research Councils, charities and the Science Media Centre have intensified enormously. Most leading universities and medical charities now carry statements on their websites about animals and there are many sources of advice available. Concordant with this has been quite a dramatic increase in political and public acceptance. Successive MORI polls reveal positive changes in the perception of the use of animals in research, and analysis of media reports shows a remarkable increase in favourable coverage of animal research. While it is not possible to prove conclusively that these two developments are directly linked, smaller, qualitative case studies show that clear and objective explanations about what animals are used, why and how, seem to result in greater acceptance by lay people. But, at the same time, some of the more extreme actions of animal rights groups, including personal violence, have caused revulsion and may indeed have led to sympathy for the scientific community.

The number of scientists speaking publicly about animal experiments, while still woefully small, is now growing, and the first public demonstration in favour of this research (led by Pro-Test) was seen recently in Oxford, led by students. There is also great support for this area from Government, with clear public statements from the Prime Minister, the Chancellor of the Exchequer, the Minister for Science and several successive Home Office ministers.

Conclusions

Animal research remains one of the most difficult areas of public engagement, and one that many scientists are still reluctant to embrace. However, it also provides a fascinating case study where public opinion has shifted, where any adverse effects on the scientists who speak out are extremely rare, and where openness is gradually increasing. As such, it is an example of the remarkable influence of the benefits of public engagement in one of the most difficult areas of biomedical research.

Nancy Rothwell is Professor at the Faculty of Life Sciences, University of Manchester.

Reference

1 The Role of Scientists in Public Debate. London: Wellcome Trust; 2001.

7 THE ROLE OF MEDIA IN PUBLIC ENGAGEMENT

Most adults are exposed to science predominantly through mass media. The media are therefore often assumed to play a key role in communicating science and shaping public attitudes. However, notes **Jenny Kitzinger**, the relationship between people and the media is more subtle than often assumed. People are not passive consumers of media messages and they bring their own interpretations to what they hear and see. Mass media have many drawbacks as a way of communicating scientific detail yet clearly have the potential to reach large numbers of people. People involved in science communication and public engagement need to think carefully about their objectives before considering how to work with the media.

Talk to any member of the public about science and sooner or later they will describe an image they saw on television, a report in the press, or perhaps mention a science-fiction book or film. Discussions of genetic science, for example, often prompt memories of particularly eye-catching pictures (such as the notorious photograph of a human ear growing on the back of a mouse) or provoke reference to fiction such as *Frankenstein, Brave New World* or *The Boys from Brazil*. Debates about science in the UK are also populated with references to previous high-profile scientific controversy (such as thalidomide, *Salmonella* or 'mad cow disease') and people often comment on the shifting nature of scientific advice about health: "One week the headlines say something is good for you, the next week it's bad for you."

The media are more likely to be used to reinforce, rather than to change, existing attitudes.

Any orchestrated attempt at science communication or 'public engagement' does not, therefore, take place in a vacuum. A museum exhibition, community theatre project or internet engagement activity all happen in a world saturated with news headlines and pervasive cultural images. The mass media are a powerful force

resourcing how people talk about science, scientists and scientific evidence. This can provoke considerable frustration among some scientists or policy makers, and prompt intensive efforts at enrolling the mass media to promote 'more positive' representations. However, quite *how* the media influence public perceptions, and the implications for public engagement, raise complex questions.

How media influence operates

It is a mistake to believe that just because people often reference what they have seen in the media that they must, therefore, have uncritically accepted it. People work with media resources to think, joke, imagine, illustrate their point of view or fuel debate. Sometimes the media *reflect* a cultural anxiety or perspective, as much as they create it. Detailed research into how media influence operates rarely identifies a simple, one-way, causal route. Early notions that the media act as a 'hypodermic' directly injecting ideas into people's minds have now largely been discredited. Research during the 1940s and 1950s, for example, showed how opinion leaders within communities filtered how messages were received by the general population. Other researchers argued that people select from media messages for their own purposes and that the media are therefore more likely to be used to *reinforce*, rather than to change, existing attitudes.

The messages 'decoded' by audiences are not necessarily those intended by the producers.

More recently, audience reception studies have revealed the diverse ways in which people may respond to the same media output. The messages 'decoded' by audiences are not necessarily those intended by the producers. Meaning does not lie in the text (programme or newspaper article) alone; it is created in an encounter between text and audience. How we respond to a particular item may be influenced by class, gender, sexual and ethnic identity, as well as wider cultural context. Programmes that might seem to promote one world view may be used, at least by some viewers, to support another, and representations that seem negative may be used positively. A traditional Western that casts cowboys as heroes and 'red Indians' as savages can still be enjoyed by some Native Americans who identify with the cowboy character and see him as representing a free and autonomous way of life akin to Native American values. An American soap opera, understood by some viewers as a celebration of consumer capitalism, will be seen by others as a critique of mainstream American values. Less work has been done on how people respond to science programmes – but emerging research suggests that similar variation is evident in how, for example, diverse public groups respond to a science documentary or science-fiction film.

MY LIFE, OUR WORLD

Citizen Science is At-Bristol's dynamic answer to getting young people absorbed in emerging biomedical issues.

As befits a science and discovery centre, At-Bristol is at the forefront of experimental informal learning. In its Citizen Science project it has adopted an array of styles and approaches, regularly exploring novel techniques of engaging young people (12–19 years old, a notoriously hard-to-reach demographic) in meaningful discussion about the impact of biomedical science on society.

Working with partner schools, scientists and other external professionals, Citizen Science has combined conventional approaches to engagement, such as →

CITIZEN SCIENCE

Funding
£415 000 (2003, Society Award) – Citizen Science: Engaging young people and teachers in biomedical science issues

Project lead
Catherine Aldridge, At-Bristol

More details
www.at-bristol.org.uk/cz

Left: Young people are increasingly being taught about the ethical context of science.

However, the complexity and diversity of people's responses do not mean that the media have no influence. Experimental work and statistical analysis of trends suggest that the media can set the agenda around what problems are facing society and how we should be setting priorities. Other research suggests that patterns of media coverage (e.g. around crime and violence) may progressively cultivate a particular way of looking at the world.

In-depth focus group studies examining how people relate to specific TV programmes or news reports also demonstrate how media influence might operate. Such research highlights the importance of visuals or narrative structure over the surface logic of any particular media text. For example, John Corner and his colleagues examined four programmes about nuclear power and analysed discussions among groups of viewers.[1] They looked at how people respond to different images (such as steam rising from a pond next to a nuclear power plant), to presentation of facts (such as information about leukaemia pockets) and also to programme structures. One documentary was generally interpreted as suggesting that the Sellafield nuclear power plant was implicated in causing leukaemia. This was in spite of the programme's presentation of many explanations that queried or even rejected this suggestion.

Such research highlights the importance of visuals or narrative structure over the surface logic of any particular media text.

Through close attention to their research participants' conversations, Corner *et al.* suggest why the programme operated in this way. They argue that the documentary's imagery and structure, built around one family's search for answers about their child's leukaemia, was more powerful than the programme's abstract speculation about risk and the evidence. This study also highlighted the power of images, which, they argue, can exert a 'positioning' power upon viewer imagination and understanding of a kind that may prove more resistant to counter-interpretation than the devices of commentary, interview and voice-over.

A large body of work on how people relate to science, health and risk reporting echoes such findings. Media presentations of dramatic stories about women enduring the 'family curse' of 'the breast cancer gene' may have greater impact than reporting about other facts about risk factors for breast cancer.[2] Similarly, dramatic images of people dying of AIDS, which were splashed over the press in the 1980s, undermined the communication of facts about asymptomatic HIV infection. The association that some journalists made between AIDS and morally suspect 'risk groups' also acted as a barrier to understanding that behaviour, rather than identity, was linked to HIV transmission.[3]

The limits and potential of the mass media in public engagement

The mass media do not easily adapt to communicating scientific details – and can often mislead. However, they clearly engage their audience in some ways. Anyone reflecting on potential of the mass media in relation to public engagement needs to consider the different genres in play, the professional practices of those involved, and the industry pressures. Film scriptwriters, for example, are unlikely to make accurate facts the centre of their drama – unless it suits their purpose to grip and entertain an audience at a particular moment. However, for better or for worse, they are likely to provide space for exploring dilemmas or 'what ifs', and raising questions about the potential social consequences of science (however far-fetched those scientific achievements might seem today).

News reporting, for different reasons, is also unlikely to provide the ideal medium for good 'science communication' as traditionally conceived by scientists. Journalists often do not feel they have the space or time to report complex detail. They will also tend to simplify for a general audience, and use familiar and emotive terms in place of scientific ones; they may prefer 'human cloning', for example, to terms such as 'cell nuclear transfer'. In addition, the issues that are newsworthy will not be a simple reflection of the most significant facts as defined by scientists, or scientific risk assessment – front-page coverage of a gene for breast cancer, for example, is more likely than coverage of smoking or health inequalities.

News reporting is also unlikely to provide the ideal medium for good 'science communication' as traditionally conceived by scientists.

It is also not necessarily the science journals that set the agenda for science reporting in the news media. Media interest may be triggered by the release of scientific papers in the major journals – but it will also be triggered by policy decision making, political controversies or civil agitation (e.g. against GM crops). The journalistic definitions of 'balance' can also mean they give equal attention to two sides of a story about risk – regardless of the apparent balance of scientific opinion – a tendency dramatically illustrated in the UK during the MMR vaccine crisis.

All the same it is important not to underestimate either the dedication of some journalists to promote science or the skill of reporters and columnists writing not just on science, but also on politics, environment or women's pages.

Towards a reflective position on the media's role in public engagement

The mass media are sometimes roundly denounced by scientists. However, this is not always justified. The media are often blamed for presenting scientists as evil, power-crazed figures, for example, but for every headline about 'bogus boffins'

→ the use of scenarios and facilitated debates, with more far-reaching methods, such as a TV chat-show format, and projects based on art–science crossovers.

At-Bristol has also forged links with key local groups. It works closely with the University of Bristol's highly rated Graduate School of Education, which takes the lead on evaluation. It has also run projects with the university's 'Children of the 90s' project (ALSPAC, the Avon Longitudinal Study of Parents and Children). And it has worked with others in the Science Learning Centre South West to advance continuing professional development opportunities for the region's teachers.

For students, the main impact of Citizen Science is to instil what At-Bristol refers to as 'active citizenship', a long-term upturn in curiosity about the issues discussed, continuing beyond specific activities and penetrating the students' daily lives. Topics covered have therefore been carefully chosen to appeal to the target age group – including rainforest medicines, the effects of drugs on the brain, and alcohol use and abuse.

Reinforcing this aspect of Citizen Science has been the strong relationship fostered with teachers. The activities benefit from ongoing teacher input, creating projects and online resources that bear direct relevance to the curriculum, allowing teachers to tie lessons into experiences the students are personally familiar →

Left: Understanding how the media report science is important for young people.

or every film portraying the dangers of scientific innovation, others cultivate the view that Western science is a fail-safe and authoritative way of knowing that will provide an answer to all modern ills. It is misleading, therefore, simply to typecast the media as 'anti-science'.

Protesting against media sensationalism, for example, ignores the role of scientists' own hype.

It is also important to take account of how media messages are produced and received, and to consider the risks of simply blaming the media. Protesting against media sensationalism, for example, ignores the role of scientists' own hype. Scientists and funding bodies have increasingly become engaged in PR battles that can involve promoting exaggerated claims for what science can offer in the imminent future. It can be tempting to promise clinical applications from research within 'five to ten years', but such claims are likely to be counterproductive for public trust in the long term. Stem cell research is one example of an area of current research where hope can turn into hype.

The way in which policy makers have used scientific facts has also come into disrepute. The photo-opportunity of the UK Government minister John Selwyn Gummer, feeding a beefburger to his daughter to underline the assertion that scientific advice showed beef was safe, is one image that famously backfired.

Thinking about the role of the mass media in 'public engagement with science' benefits from a reflective stance that includes an acknowledgement of these issues.

Caution should also be used when accusing the media of scaremongering. Using the media as whipping boy to account for perceived public distrust in science may miss the point. The danger is that scientists end up believing that, if only the public understood the science, then they would be 'on-side'. However, as other essays in this collection show, this is not necessarily the case. Whether or not the public understand the science, they often have a strong set of concerns about the political and moral economy of the scientific enterprise.

Thinking about the role of the mass media in 'public engagement with science' benefits from a reflective stance that includes an acknowledgement of these issues. This should include questioning the very definition of public engagement with science. The phrase 'public engagement' can be simply a way of reiterating the straightforward goal of educating lay people about the facts. Sometimes it refers to a wish to inform consumers about the value of peer review, or, conversely, to remind them that scientific findings are always contingent. At other times it is used to describe activities designed to inspire youngsters

→ with. Learning gained from the response to each activity also feeds back into the ongoing development of new projects, generating a tight, iterative relationship between new activities and those that went before.

Citizen Science has developed a wealth of learning material, each project and activity having been rigorously evaluated. It hopes to share this mass of valuable information, disseminating what it has learned as broadly as possible.

Society Awards

Upwards of £50 000, Society Awards come in two forms: activities and research. **Activity awards** support large-scale activities, such as conferences, art projects, workshops or educational resources. The intent is that the activity will make a sizeable, nationwide impact on public engagement with biomedical science.

Research awards are of the same financial scale but support academic research that advances knowledge of public engagement in the biomedical sciences.

www.wellcome.ac.uk/engagingscience

Right: Teachers have a vital role in making science relevant to students' lives.

with the excitement of science (recruiting the scientists of the future). In particular, the phrase is used to imply the wish to consult citizens or even involve them in setting the research and development agenda and reflecting on the social context and consequences of diverse choices.

Quite what one hopes for from the mass media will vary depending on one's goals – which may include any or all of the above. Expecting fiction films to be factual or newspapers to behave like popular science journals, however, is neither realistic nor necessarily desirable. Indeed, the questions some journalists ask about the socio-political context of science, and the visions that science fiction raises about future consequences, might be very good bases for some 'public engagements'. A range of media debates and representations can, in this context, be seen as problematic but also as simultaneously productive – a basis for dialogue and for not only 'public engagement with science' but also for 'science engaging with the public'.

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Acknowledgement

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References

1 Corner J et al. Nuclear Reactions: Format and response in public issue television. London: J Libbey; 1990.

2 Henderson L, Kitzinger J. The human drama of genetics: 'hard' and 'soft' media representations of inherited breast cancer. Sociology of Health and Illness 1999;21(5):560–78.

3 Miller D et al. The Circuit of Mass Communication: Source strategies, representation and audience reception in the AIDS crisis. London: Routledge; 1998.

Further reading

Eldridge J (ed.). Getting the Message. London: Routledge; 1993.

Eldridge J et al. The Mass Media and Power in Modern Britain. Oxford: Oxford University Press; 1997.

Gerbner G. Cultural indicators – the third voice. In G Gerbner et al. (eds). Communications Technology and Social Policy. New York: John Wiley; 1973. pp. 553–75.

Hall S. Encoding/decoding. In S Hall et al. (eds). Culture, Media, Language: Working papers in cultural studies 1972–79. London: Hutchinson; 1980. pp. 128–38.

Liebes T, Katz E. The Export of Meaning. Oxford: Oxford University Press; 1990.

McCombs M, Shaw D. The agenda-setting function of the mass media. Public Opinion Quarterly 1972;36:176–87.

8 BEYOND THE TOOLKIT: BRINGING ENGAGEMENT INTO PRACTICE

The past decade has seen a growing awareness of the value of consultative public engagement in science, to enable a wide range of opinions to feed into policy-making discussions. Can this experience be used to develop an 'off-the-shelf' model for public engagement, which could be slotted into policy-making projects? No, says **Alan Irwin**. The nature of public engagement remains too amorphous and open-ended to slot neatly into rigidly constrained project frameworks. This, he argues, presents particular challenges to institutions attempting to integrate public input into policy making.

Not so long ago, even the woolliest advocacy of dialogue, engagement and more open relations between science and its publics was seen as radical. Now that such talk has become almost mainstream and practical experience mounts up, the really interesting questions start to emerge. How has the widespread support for 'engagement' translated into action? And what exactly is engagement for? How in particular does it relate to policy making and decision taking? Such questions are all the more important when members of the public – and especially groups who claim to speak on their behalf – can be quick to challenge what they perceive to be tokenism, empty rhetoric, 'public relations' or 'just going through the motions'. 'Bringing engagement into practice' sounds very straightforward but actually raises profound questions – about the purpose of engagement, and about the relationship between broader social assessments of socio-technical change and the policy process.[1]

Many involved tend to assume that such questions will be answered through practical implementation and argue that what we really need is some kind of toolkit. In other words, now that several engagement exercises have taken place, what we currently lack is a designated set of engagement instruments, preferably accompanied by clear advice on when and where each works best. For a civil servant or institutional manager running a consultation exercise, such a toolkit has obvious appeal. It seems only sensible that practical lessons should be learned

from previous experience and translated into specific do's and don'ts. I also recall one policy maker's frustrated response to my academic analysis of a previous UK engagement exercise: please could you add a final paragraph telling us exactly what we should do next time?

While there is nothing wrong with drawing practical lessons from experience, there are substantial limitations to the 'toolkit' approach and the restricted engagement framework it implies. Attempts to sanitise, rationalise and streamline public engagement and dialogue risk killing the very spark that gives engagement exercises their excitement and makes them worthwhile. And reasonable attention to the practicalities of organising such initiatives should not get in the way of more expansive consideration of the lessons to be learned.

Thus, one increasingly understood dimension of engagement is that public groups may 'frame' the underlying issues very differently to metropolitan policy makers. (See 'Messages and Heuristics', pages 20–25.) What may appear a narrow technical issue to the latter (are GM crops safe to be grown?) can appear much broader to the former (what are the underlying benefits to consumers? What will be the impact on British agriculture and the British countryside? Isn't this just another example of US companies throwing their weight around?). The danger of the toolkit approach is that it risks dismissing, or simply not recognising, such broader interpretations and competing frameworks. The assumption is that public engagement represents an extension of business as usual rather than a potential challenge to institutional priorities and ways of working.

While there is nothing wrong with drawing practical lessons from experience, there are substantial limitations to the 'toolkit' approach and the restricted engagement framework it implies.

Setting the stage

So what can we learn from experience? The STAGE project (Science, Technology and Governance in Europe) provides some insights. Running between 2001 and 2005, this European Commission-sponsored project developed 26 case studies of policy making and social engagement across eight member states. The focus on western European initiatives is informative since the nations of the EU have become absolutely pivotal to practical initiatives in this area – and especially for what has become known as 'deliberative governance'.

The STAGE case studies focused on three main areas: information and communication technologies, biotechnology, and the environment. Unsurprisingly, given the period under study, issues of biotechnology, stem cell research and GM foods featured prominently (all case studies and papers

PLAYING WITH POLICY

Democs – part game, part policy-making tool – provides an innovative way for people to engage with the complex scientific issues affecting society.

It's a game. Before participants even sit down, they know they'll be playing – engaging in a fun activity. Yes, Democs deals with complex issues such as nanotechnology or human enhancement, and yes, players may become embroiled in a debate about the varied issues such provocative subjects throw up. But more than anything, it is a *game*. And the essence of Democs is about more than simply informing those playing.

The structure of each carefully designed game is such that players spend a considerable time exploring an issue before being given the opportunity to →

DEMOCS

Funding
£194 395 (2003, Society Award) – Establishing Democs (Deliberative Meetings of Citizens): Spreading and embedding them

Applicant
Perry Walker, New Economics Foundation (NEF)

More details
www.neweconomics.org/gen/democs.aspx

Left: Perry Walker facilitating a Democs game.

from STAGE can be found at www.stage-research.net). The cases highlighted initiatives towards more open forms of scientific governance, including the 'GM Nation?' public debate in the UK and the earlier Dutch treatment of GM foods, Swedish debates over nuclear waste management, environmental protection in Portugal, and discussions over biotechnology in Denmark, Norway, Finland and Greece. The project analysed contemporary exercises in deliberative governance but also suggested that more conventional approaches – such as governance by the market, corporate stakeholders and groups of experts – remain dominant.

There is a tendency across Europe to view broad public deliberation as a one-off hurdle to be cleared when governments or scientific institutions choose, often quite late in the decision-making process.

Pulling together such a complex range of experiences and a variety of national contexts is far from straightforward. The STAGE project found significant differences across the eight European countries – and even within a single country it is often impossible to identify a unitary policy style. To take the UK as an obvious example, it is tempting to pick out the relatively few high-profile engagement initiatives, such as 'GM Nation?', and neglect the fact that these are decidedly atypical. However, the STAGE team identified several broad features of the governance of science and technology in Europe.[2,3]

While significant activities are taking place across western Europe, these tend to fit within a restricted policy framework, closer in spirit to the toolkit approach than broader reflection. Rather than summarise all the STAGE conclusions, I will focus here on six findings that appear especially relevant.

Democratic engagement has a tendency to become messy, sprawling and all-encompassing.

First, there is a tendency across Europe to view broad public deliberation as a one-off hurdle to be cleared when governments or scientific institutions choose, often quite late in the decision-making process. This sense that engagement is an activity to be initiated by policy makers at 'the right time' has significant planning benefits. However, it does suggest a limited definition of the purpose of engagement, and presents public dialogue as one discrete phase of decision making rather than an essential constituent of the policy process. Moreover, rhetoric is running well ahead of practice. Broad, nationwide debates are still exceptional. More frequent are questionnaires, focus groups and consensus conferences, usually organised on an ad hoc basis.

→ declare their own stance. This allows for introspection and mulling over amid the card play, rather than the usual quid pro quo of standard conversation.

This structure enables players (usually six) to get to grips with the key information they need to discuss a complex issue. Indeed, owing to the very nature of the subject matter, it's the first time many players will have formulated an opinion about any game's central issue, discovering their own feelings about a particular topic. Again, this is key, with the experts involved in developing game subjects taking care to represent all possible viewpoints to minimise bias. Following each game, results are fed back to NEF, where they are collated into a larger overall picture.

The results of each game, available on the Democs website, can have real impact. The approach has helped policy makers and government to take the temperature of public opinion (whether it's GM foods or ambient noise levels in Greater London), so each game played is capable of influencing public policy and helping to shape real decisions.

Participants gain too. Players leave the game with renewed confidence in their own ability to grapple with difficult subjects and more confidence to challenge the 'expert opinions' of others.

Central to its success, Democs offers safety and fun. The innovative, gently guided, playful environment is

Right: Materials used in the stem cell Democs game.

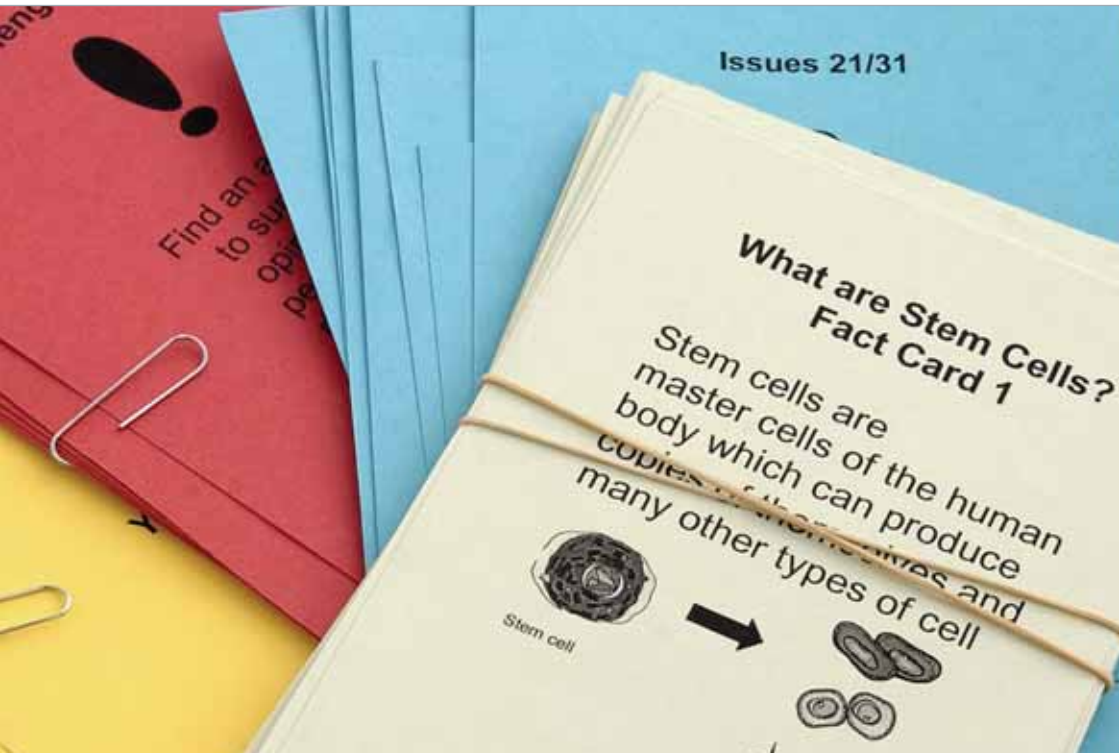
The STAGE studies also suggest that there is still considerable insulation between attempts at engagement and 'mainstream' policy. While there is lots of talk about engagement right now, most policy processes simply continue according to their own dynamic. So, for example, conventional treatments of 'sound science' and, very importantly, science-led economic growth have remained largely unaffected. The importance of global economic competition is often underemphasised within engagement initiatives. High-profile but atypical initiatives are generally marginal in comparison with the infrastructures dedicated to scientific/ technological development.

Deliberative governance is no easy solution to social contention and controversy.

Another general finding is that the framing of debate in Europe is typically decided by a small coterie of officials, organisations and experts of different sorts. Once again we return to the central tension within engagement and consultation exercises. Traditional approaches to public administration put a premium on tight organisational control, clear deadlines and rational planning (often drawing upon the advice of recognised experts and established stakeholders). Democratic engagement has a tendency to become messy, sprawling and all-encompassing as discussion moves away from specific technically defined topics and towards, for example, issues of identity, empowerment and globalisation. If a broader culture of engagement and external scrutiny is to be encouraged then a greater willingness to relinquish central control may be required.

Engagement exercises are also often marked by disputes over timing, organisation and 'bias'. Certainly, deliberative governance is no easy solution to social contention and controversy – despite claims that engagement will lead to 'societal consensus' or else the 'rebuilding of public trust'. While officials tend to see such disputes as a distraction from the 'real' questions as previously defined by debate sponsors, they are a fundamental part of the democratic process. Once again, we can see the challenge posed by a wider engagement culture for institutions less familiar with adversarial, untidy and contentious forms of political expression.

Deliberative governance poses challenges not only for governments, scientific organisations and industry, but also for NGOs, which often claim to speak for the public. Engagement exercises therefore offer at least the potential for that claim to be undermined. Despite frequent accusations that debates have been hijacked by particular groups and interests, public engagement can be risky for all parties.



Indeed, it may be that this 'riskiness' is an important ingredient for a debate's success. (See 'Between People and Power', pages 62–67.)

Finally, an important issue for the relationship between public engagement and public policy is the treatment of scientific evidence. In most countries under study there is a tendency to keep 'science' and 'the public' apart or, more precisely, to limit public engagement to matters of ethics and values. If one of the great merits of engagement is the broad challenge it offers to assumptions and working practices that are taken for granted, this is a very questionable limitation.

Where next?

Where do such findings leave our discussion of 'bringing engagement into practice'? One clear implication is that, while public engagement may have become accepted in certain countries (with the UK one of the most prominent examples), the relationship to scientific governance remains underdeveloped and ill-defined. This is hardly surprising given the relatively limited experience of engagement, consultation and dialogue in a country such as the UK – and also the novelty of deliberative principles within that country's political culture (for example, when compared with Denmark or The Netherlands).

For the first time in the UK, we are in a position to move beyond both broad slogans and specific criticisms towards a greater reflection over just what public engagement is for.

Looking to the future, the point is not to dismiss the undoubted progress that has been made nor to make the administration of such exercises even more demanding. Instead, and for the first time in the UK, we are in a position to move beyond both broad slogans and specific criticisms towards a greater reflection over just what public engagement is for and how this relates to the culture and practice of science and technology governance. Toolkits will be little help. Instead we must address more basic issues of the relationship between social assessments of technical change and the models and projections offered by various groups of experts. And we need to look at the interaction between scientific and other kinds of evidence, and recognise a wider range of expertises than is currently the case.

It is very important that we consider public engagement as above all an opportunity. One of the glaring problems with the old deficit approach was the anxiety, discomfort and defensiveness it revealed about the relationship between technical change and wider social assessments. I suggest instead that we view a robust culture of appraisal, engagement and debate as a major societal asset.

→ unencumbered by the usual 'rules of engagement' that a complex debate would involve. Players feel at ease within the game world and are given the time to explore, discuss and find common ground with other players.

Democs is one of a range of new approaches to public involvement that have been supported by the Wellcome Trust. Another example is the 'deliberative mapping' project developed by Andy Stirling (Science Policy Research Unit, University of Sussex), which aims to bring specialist and lay groups together to discuss policy-related issues. It is no trivial exercise: both groups go through six individual sessions, meeting jointly for a day-long discussion mid-way through. → The advantages are that issues can be gone through in depth and looked at from different angles – a whole range of policy options can be considered. But the time investment means it won't be suitable for every circumstance – evidence that public engagement requires a variety of different approaches.

Helping to attain maximum penetration, a key element of a Society Award, Democs kits are available for both adults and schoolchildren (developed with the help of a government Sciencewise grant). These kits, covering ten important and potentially controversial subjects, are available in printed form, by direct download or on CD-ROM from www.neweconomics.org.

With that in mind, rather than thinking of ways of closing down and limiting engagement, we should maintain a shameless commitment to experimentation. There is no blueprint, no gold standard, no guarantee of success. Instead, and in the best spirit of science, we can explore new approaches, learn from our mistakes and accept that criticism is a necessary part of learning.

One of the greatest challenges of engagement is a challenge of institutional leadership.

As I have already emphasised, it is important that the outcomes of engagement are taken seriously and, equally, are seen to be taken seriously. This does not mean that every exercise should be viewed as a referendum. Instead, an explicit commitment is required to treat public views with respect and as one essential element within the policy process, to reflect upon such views, and to make explicit the institutional response – even if (as is perhaps inevitable) this is to challenge or disagree with certain viewpoints.

Finally, what about the institutions that are largely driving these activities? My sense is that one of the greatest challenges of engagement is a challenge of institutional leadership. How to act in a more complex and, at times, uncertain environment? How to make decisions in the knowledge that social consensus may not be possible? How to broaden the knowledges and expertises that can be drawn upon while recognising the embedded limitations and uncertainties? Engagement as an issue does not stand alone but is one element within a wider pattern of change and opportunity. It follows that engagement cannot be an end in itself but rather one important means of enriching the culture of scientific governance, informing the operation of policy processes and influencing the direction of technical change.

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References

1 See Irwin A. The politics of talk: coming to terms with the 'new' scientific governance. Social Studies of Science 2006;36(2):299–320.

2 Hagendijk RP et al. Report on the STAGE project: Science, Technology and Governance in Europe. 2005. www.stage-research.net/STAGE/content/reports.html.

3 Hagendijk R, Irwin A. Public deliberation and governance: engaging with science and technology in contemporary Europe. Minerva 2006; forthcoming.

It is hoped that Democs will eventually become self-sustaining, as it continues to help stimulate new thinking and understanding of science-based issues in the public domain while decision makers take increasing interest in the results produced.

Society Awards

Upwards of £50 000, Society Awards come in two forms: activities and research. **Activity awards** support large-scale activities, such as conferences, art projects, workshops or educational resources. The intent is that the activity will make a sizeable, nationwide impact on public engagement with biomedical science.

Research awards are of the same financial scale but support academic research that advances knowledge of public engagement in the biomedical sciences.

www.wellcome.ac.uk/engagingscience

9 TRANSATLANTIC PERSPECTIVES ON PUBLIC ENGAGEMENT

Although becoming more common, consultative public engagement is not well embedded in UK policy making procedures. As it becomes better established, there is a tendency to see the UK in the vanguard of a new approach to public engagement. Yet, as **Edna Einsiedel** points out, North America has a number of well-entrenched systems of consultative public engagement, and has learned much about how these systems are best applied.

Organisations and institutions involved with science in many countries share the goal of increasing public engagement and awareness. But the specific ways their efforts play out are affected by different histories and national political cultures. If we recognise that, there is much to be learned from comparing approaches to the issue in different countries.

Public engagement can be analysed in three stages. The first is a recognition of need. This might be expressed in a number of ways, from the development of policy documents to response to outside pressure from different organised interests. In the USA, inclusion of different sectors of society and stakeholders on environmental issues in the 1960s and 1970s exemplified the latter; in the UK, recognition of a democratic deficit was highlighted in various policy papers, as well as by crisis on a number of science and technology issues, initiating greater policy attention to public engagement efforts.

The second stage is experimental, trying out different engagement tools, making information more accessible, and so on. This stage saw the emergence of controversial technologies and issues, from BSE to biotechnology. It has been marked by the emergence of newer forms of engagement, from deliberative models to online approaches, the latter driven by broader interest in e-government and e-democracy.

The third stage is institutionalisation within the policy system. Lessons learned from stage two may be applied to processes or organisational structures. The locus of this policy system is Government, but governance processes – which involve the nature of decisions and decision-making approaches, including who participates and how – are resulting in more dispersed policy making. One response is diffusion of responsibilities, where other networks working together, independently or with Government and/or the private sector, are formed.

Consensus building has not been a tradition in the UK, which remains very much oriented to the use of Expert Advisory Committees.

These stages are not mutually exclusive. Transnational differences, including where a country might be in this sequence, differences in policy responses, and approaches employed, are evident. Political culture, the political-administrative system, stage of democratic development and interest-group activity have all influenced public engagement. France, for example, is steeped in a culture of centralism with heavy reliance on bureaucratic and technical expertise, and experiments with public participation on science and technology issues are uncommon. Denmark, on the other hand, has had a long historical tradition of democratic discussion and consensus seeking. In contrast, consensus building has not been a tradition in the UK, which remains very much oriented to the use of Expert Advisory Committees. Public engagement tends to be expressed through lay representation on these Committees. As is happening in other countries, other fora for and approaches to public engagement are opening up in the UK, the most recent being the diverse set of approaches used in the 'GM Nation?' project.

Space does not permit development of all these comparisons, so for the rest of this essay I focus on some aspects of public engagement in North America, emphasising initiatives that deserve to be more widely known elsewhere.

Public views on science

The US National Science Foundation has included public attitudes and understanding in its annual science indicators for several decades. Despite not being well informed about science and technology topics, Americans have remained optimistic about and express strong support for science and technology. Confidence in the scientific community has remained high. Americans also tend to have more positive attitudes about the benefits of science and technology than people in Canada, Europe or Japan. However, they express reservations and concerns about scientific research not paying sufficient attention to moral values.[1]

Europeans similarly share with Americans this confidence in science. At the same time, they are conscious of the price that comes with rapid scientific progress and believe that technological choices should involve weighing risks and benefits.

STAN'S THE MAN

Adopting a uniquely simple and imaginative approach, Stan's Cafe Theatre Company has mixed up rice, schoolchildren and epidemiology to striking effect.

It sounds like madness. Turn up at a school with a colossal model of the Earth and a tonne of rice – or 989 kilograms to be precise. And precision is exactly what's required, particularly once the students grasp that every grain represents a human life. The Plague Nation project manages to combine statistics and fun, two words rarely found on the same page, as piles of 'people' are weighed, moved and accurately apportioned into their own discrete piles.

One mound shows how many people die of HIV/AIDS each year, another the →

PLAGUE NATION

Funding
£10 000 (2003, Pulse award)

Main applicant
Stan's Cafe

More details
www.stanscafe.co.uk

Left: People by the pound: one grain of rice represents one person.

The consideration of ethical consequences is also an important one for many Europeans. There is considerable diversity, of course, among European countries. For example, views on science and moral values as well as the precautionary principle vary significantly among countries in the region. Those countries that have achieved a high degree of prosperity remain interested in science but also have ambivalent attitudes and often engage in critical discussions. They are more likely to raise questions about environmental impacts, ethics and regulation.[2]

Public engagement

Public engagement and participation in science and technology issues have a long history in North America, underpinned by experiences in environmental regulation stretching back to the late 1960s. These regulations were prompted by public concerns around air pollution and toxic emissions, other environmental impacts of chemical or pesticide use, nuclear power, and food safety. The growth of environmental and consumer movements was fed by the perceived serious 'side-effects' of science and technology, breaking the unquestioned authority of science and unproblematic associations with 'progress' after World War II.

The growth of environmental and consumer movements was fed by the perceived serious 'side-effects' of science and technology.

The underpinnings of policy responses to demands for greater transparency, accountability and participation became codified as 'rights' that are the foundation for approaches to public engagement and participation in the USA, and later in Canada: access to information, public participation in decision making and access to justice. Freedom of information legislation began in the USA in 1966. Legislation also requires agencies to consult. And citizens have a right to challenge decisions in court. In Canada, this includes the right to sue for damage to the environment if the Government fails to enforce the Canadian Environmental Protection Act.

These policies and laws do not, in themselves, make for good public engagement but rather are starting points. Agencies have learned that public engagement and participation do not happen on their own; they need to be made possible through provision of resources and capacity building, and elucidating processes and procedures for potential participants. And sometimes, government agencies have had to be prodded – through court action if necessary – to meet their mandated responsibilities.

The forms of public participation

In the USA, public hearings and negotiated rule making have been common forms of public engagement. Notices of public hearings are published in the *Federal Register* (the *Gazette* in Canada). Transcripts of such hearings are made available on websites and all public comments received are also made publicly available, as is

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→ number of people who might die of malaria – every day – throughout the world. Humour too, finds its way in, in the form of famous 'celebrity grains', unceremoniously bagged, tagged and sold off to charity, for example.

Soon, this 'performance installation' takes on a life of its own. Rather than being guided from one statistic to the next, the students, awakening to the true impact of the reams of numbers before them, want to see for themselves the impact of medical advances, such as polio vaccination. Faced with such a graphic manifestation of human life, they become deeply immersed, treating each grain with reverence, each neat pile with care. The significance of epidemiology, statistics and medicine, and the value of human life, are suddenly summed up in a tiny capsule of carbohydrates.

James Yarker, Stan's Cafe's Artistic Director, is pleased with the impact and ripples caused by Plague Nation, not least because it illustrates so well the power of creative approaches to engaging children (especially years 8 and 9) with scientific issues. The simplicity of the original concept, one grain per human being, lies within the grasp of the youngest of minds. And, once the students' confidence grows, there's no stopping them. Never still, they calculate, weigh and rearrange, exploring the limits of the installation.

Stan's Cafe is now touring internationally with what James Yarker refers to as →

Right: A brush with death: students divide the world's population.

the final report. This form of participation has been criticised as expert-focused and unreliable as a forum for hearing public views, since such hearings tend to draw people who are primarily opposed, as was also said of the 'GM Nation?' exercise in the UK.

Negotiated rule making is invoked when an agency is promulgating a new or revised regulation. A diverse set of stakeholders is convened to negotiate prior to moving the draft rule through the standard administrative process. Negotiated rule-making strategies seek agreement. The agency commits, within its existing rules, regulations and guidelines, to draft new or revised regulations consistent with the recommendations of the negotiating committee. It is a formalised, specific kind of consensus-building approach and has been a successful forum for public engagement.

Ballot initiatives are another form of participation – albeit an uncommon one – in the USA, but are non-existent in Canada. These are generally proposed by members of the public to introduce or amend laws. In California, an initiative to raise US$3 billion in tax-free state bonds to support stem cell research was passed by voters in 2005.

Trends in public engagement

In many countries, there has been growing interest in deliberative forms of public engagement. For example, the deliberative poll was pioneered by American political scientist James Fishkin and combines features of representativeness from public opinion surveys with discussion with experts and deliberation. Citizen juries are frequently held at the local level. In Canada, a national consultation on xenotransplantation was held using a combination of multi-stakeholder meetings, expert advisory committees, public opinion surveys and citizen juries in six regions.

The use of new information and communication technologies to expand or enhance public engagement and participation efforts has also been gaining currency in the last decade. This covers information provision and service delivery (e-government). A more important change is the use of computer networks to allow expanded public involvements in policy deliberations, sometimes referred to as 'e-governance'. In the USA, established processes of public hearings or negotiated rule making are being expanded with electronic deliberations for more significant public involvement. In Canada, at the time of writing, there were close to a dozen online consultations on science and technology issues going on.

Online deliberation and 'groupware' (collaborative software) such as discussion fora, chats, 'webinars', surveys and social networking tools are also being deployed. This model of online public engagement in policy deliberation is one that is more

challenging to generate and sustain. As the information flows move to the highest levels of public involvement, new roles and functions are required on the part of the institutions and processes, tailored more carefully to account for integrating technological innovations with policy objectives.

The increasingly global context of many science and technology issues has encouraged a move to trans-border public engagement.

A growing emphasis on voluntary initiatives to complement or even replace regulation has found public engagement efforts carried out by the private sector, in tandem with civil society organisations. The development of codes of practice to ensure that such voluntary mechanisms can produce desired results has resulted in more partnerships between Government, industry, civil society organisations and citizens. For example, the New Directions Group in Canada is a coalition of major Canadian corporations and environmental NGOs. This group created criteria for the use of voluntary or non-regulatory initiatives to achieve environmental policy objectives. Especially in the USA, such voluntary initiatives have benefits in terms of expanding the range of participants, but have also been criticised as an unwelcome turn toward cost-cutting and more market-based approaches.

The increasingly global context of many science and technology issues, from climate change to infectious diseases and air and water quality, has also encouraged a move towards trans-border public engagement. The recently concluded Great Lakes Water Quality Agreement between Canada and the USA, which focused on restoration and maintenance of the ecosystem, included a public engagement component, with provision of information and consultation of communities, including a web-based process.[3] Another example is an EU public consultation on brain science involving a panel of 126 citizens from nine countries.[4]

Is public engagement sustainable?

Efficacy and sustainability of public participation and engagement require both support for engagement and organisational learning. Support means adequate provision for the process and for participants. In Canada, the Canadian Environmental Assessment Agency administers a Participant Funding Program,[5] which supports individuals and nonprofit organisations interested in participating in environmental assessments. Such support can cover travel, lost wages in some instances for participants or fees for experts.

Support also means recognising that people come to public engagement with different skills and awareness. Agencies have learned that capacity may need to be developed before fuller engagement can take place. Finally, capacity building needs to be recognised as a two-way street. That is, it also needs development among regulatory and policy communities.

→ the ‘professional version’ of Plague Nation, entitled Of All The People In All The World. Over a period of days, rice is used to represent everything from the number of people who have walked on the moon to the number of people killed in the Holocaust.

Anyone keen to try out their approach can read a simple guide in the *Pulse Annual* and DVD, available free from the Wellcome Trust. As well as a feature on Stan’s Cafe, the *Annual* showcases other successful Pulse projects, while the accompanying DVD features performances, interviews and useful resources for anyone interested in creative science education.

Pulse awards

Part of the Engaging Science funding programme, Pulse awards provide funding for projects aimed at those 22 years and younger and encourage the use of any art form (or combination of art forms) to engage young people in the historical, social, ethical, cultural or contemporary issues arising from biomedical science.

www.wellcome.ac.uk/pulse

Right: A Pulse award supported Double Vision’s dance piece on handedness, *Left*.

As consultative public engagement efforts approach maturity, the opportunities for reflection and institutional learning increase. In Canada, an analysis of online consultation efforts has uncovered patterns of roles and responsibilities. Further efforts at institutionalisation are taking place through more systematic provision of information through the new institutional arrangements. Attempts to address earlier difficulties with accessing information include comprehensive listings of consultations. For example, a complete listing of consultations on bioengineered foods is available on the US Food and Drug Administration's website. Agriculture Canada's website has a listing of all its 'Science Consultations' and the Government of Canada has created a single window to all federal consultations.[6] In terms of institutional reform, Health Canada instituted a cross-division Office of Consumer and Public Involvement to systematise approaches and learning within the agency.

Reviews of the wealth of public engagement initiatives in the UK and Europe may give the impression that there has been little comparable activity elsewhere. As this essay shows, the North American scene is also varied and vigorous. Not all of these engagement methods would fit other political cultures. But there is undoubtedly much to learn from the best work on both sides of the Atlantic.

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References

1 Science and Engineering Indicators 2005. Washington, DC: National Science Foundation; 2005.

2 Eurobarometer 2005: Citizens, science and technology. European Commission; 2005.

3 www.ijc.org/rel/agree/quality.html.

4 www.meetingmindseurope.org.

5 www.ceaa-acee.gc.ca/010/0001/0002/index_e.htm.

6 www.consultingcanadians.gc.ca.

Further reading

Abelson J et al. Deliberations about deliberative methods: issues in the design and evaluation of public participation processes. Social Sciences and Medicine 2003;57:239–51.

Allum NC et al. Science knowledge and attitudes across cultures: a meta-analysis. Public understanding of science. In press.

Blumler JG, Coleman S. Realising Democracy Online: A civic commons in cyberspace. IPPR/Citizens Online; 2001.

Einsiedel E, Wambui Kamara M. The coming of age of public participation. In G Gaskell, M Bauer (eds). Genomics and Society: Legal, ethical and social dimensions. London: Earthscan; 2006.

Environment Canada. Our commitment to effective consultations. 1996 May 27. www.ec.gc.ca/consult/policy_e.html [accessed 5 June 2006].

Kass G. Recent developments in Public participation in the United Kingdom. TA-Datenbank-Nachrichten 2000;3(9):20–8.

10 BETWEEN PEOPLE AND POWER: NONGOVERNMENTAL ORGANISATIONS AND PUBLIC ENGAGEMENT

Campaign groups aim to exert influence. Although their objectives and ways of working may vary, commonly they aim to focus the spotlight on their chosen topics. They usually claim to be acting in the public interest, to hold up issues for public scrutiny and to provide a broader input into decision-making processes. But, says **Jack Stilgoe**, growing trends for more consultative public engagement have significant implications for NGOs, which may have this element of their work undermined. It is time, he suggests, that they also reassessed their relationship with the public.

Thirty years ago, a previously obscure American interest group turned its attention towards the UK. The first oil crisis had left Britain's energy industry in turmoil. Among those clamouring for attention and expansion was the nuclear industry. But Friends of the Earth had other ideas. Their campaign began as a small environmental pressure group, but broadened its base by mobilising citizens to take action. Backed up by others in the environmental movement, this interest group opened up the debate about nuclear power by highlighting a new set of economic and environmental costs. In the words of one campaigner at the time, Friends of the Earth "turned nuclear power into a problem".

In a sense, public engagement is what all NGOs, campaign groups, interest groups (call them what you will) do. Their aims and the issues they take up vary widely – so patient groups that work on particular conditions are very different from national environmental organisations, for example. But typically they all look to open things up, put things in context, find quiet voices, amplify them and ensure that decisions are made in the interests of the many rather than the few. They prompt debate and action on issues. They force things into the public sphere. They encourage others to join them and they try to encourage those

in power to look at things differently. In science and technology, such groups have been central in challenging the assumption that there is one correct, scientific way of looking at issues of public concern.

They all look to open things up, put things in context, find quiet voices, amplify them and ensure that decisions are made in the interests of the many rather than the few.

NGOs derive their legitimacy in part from an implicit claim that what they do is in the public *interest*, even if they do not claim to represent public *opinion*, which is a complex and ambivalent thing. NGOs will often, as with Bob Geldof's Live 8 or Oxfam's call for a text-message petition, build up a mass of public support to add weight to their campaigns. However, in another sense, real public engagement gets in the way of what NGOs do. Interest groups are happiest when they are opposing something. But public engagement, if it is to work, asks for a more constructive, shared conversation about the future. This essay looks at the role that campaign groups have played in past attempts to engage members of the public in science, and suggests how, as we move 'upstream', NGOs might rethink their relationships to politics and the public.

Such groups have been central in challenging the assumption that there is one correct, scientific way of looking at issues of public concern.

The argumentative NGO

The pattern of public engagement by NGOs might be understood in two ways. NGOs, as a part of civil society, engage themselves in science and technology issues. Frequently, single-issue groups are formed with the sole purpose of introducing a new message, a new point of view. They become part of the democratic process. Occasionally, as we saw with the development of treatments for HIV/AIDS, such groups become part of the scientific process.[1]

But NGOs also aim to mobilise other members of the public, asking for their support or at least their attention. A recent example is the involvement of Greenpeace and Friends of the Earth in the GM controversy. Around MMR and the risks of mobile phones, we have seen the creation of specific single-interest groups – for example, JABS (Justice, Awareness and Basic Support) and Mast Action UK, respectively. These smaller interest groups, whose presence within their chosen issue belies their scant resources, are very much children of our time. The internet makes it easy to collect and publish information and to bring together interested people.

The involvement of interest groups in these controversies has in some ways opened them up, questioning how they are understood and presented. Whether

LARKS AND OWLS

In 2004, members of the public were given the opportunity to discover how their own genes worked to shape their sleeping habits, gaining an insight into the molecular biology of circadian rhythms and, perhaps, an excuse to get more sleep.

'Lark or Owl?' was held in the 'Who Am I?' Gallery in the Science Museum, London. Participants were invited to fill out a seemingly simple questionnaire – actually a powerful research tool – about their attitudes to different times of the day. This resulted in a numerical score betraying details of their circadian type – whether they were a morning person (a 'lark') or an evening type (an 'owl'). →

LARK OR OWL?

Funding
£31 093 (2004, People Award) – Engagement of the public in the discussion and investigation of the importance of the circadian body clock for diurnal preference and sleep–wake timing in modern society.

Project lead
Dr Simon Archer, School of Biomedical and Molecular Sciences, University of Surrey

More details
www.surrey.ac.uk/SBMS/lark-owl/

Left: Late riser: it could be in the genes.

you see this as a good or a bad thing depends on your opinions of the issues. Most NGO involvement in science has come from the environmental movement. But interest groups from across the political spectrum have injected themselves into controversies around animal testing, abortion and creationism.

Involvement of interest groups in these controversies has opened them up, questioning how they are understood and presented. Whether you see this as good or bad depends on your opinions of the issues.

Groups like Greenpeace and Friends of the Earth are a world away from the single-interest groups that form to oppose particular things, exist on a meagre diet of charity and tabloid stories, and frequently follow the public profile of their particular controversy into collapse. Since the 1970s, when environmental NGOs made their mark on science with campaigns around nuclear power, biodiversity and road-building, Greenpeace have expanded and grown closer both to traditional political processes and to orthodox science. This has led to their involvement in the new wave of public engagement initiatives. But what role do they play?

Building a conversation

The 21st century has seen an explosion in deliberative public engagement processes, all of which aim to generate some sort of dialogue between science (and the institutions that govern science) and members of the public. The motivation for these exercises might be to seek new perspectives with which to make better decisions. Or they might aim to create greater trust between science and the public. In either case, the purpose should be to explore, through conversation, new areas of what Demos calls "the public value of science".[2]

The most striking example of an official deliberative exercise was 'GM Nation?', staged in the summer of 2003. Created as part of a government attempt to understand and rethink its handling of the GM controversy, it consisted of a series of local and regional discussions. After successful campaigns to attract public attention to the GM issue, battle-weary NGOs were keen to be involved in a process that promised the ear of Government.

'GM Nation?' was new and high-profile. When its results were presented to the world, many of the nuances were lost. The public had seemingly come out with a 'not yet, if ever' verdict. This definitive outcome attracted criticism. The NGOs were accused of taking hold of the process, filling town halls and focus groups with Greenpeace and Friends of the Earth supporters.[3] So, according to the critics, 'GM Nation?' did not accurately take the pulse of the nation. Doug Parr, Greenpeace's chief scientist, looks back on 'GM Nation?' as the start of Government's move towards public engagement with science:

→ So far, a standard scientific survey. But Dr Simon Archer was specifically interested in the extremes – the 10 per cent of the population with the most skewed daily rhythms. The people inhabiting these extremes were offered the opportunity to have their own DNA analysed, to engage in a real-time course of research and seek out the specific genetic reasons for their day-worshipping or nocturnal existences.

You don't get much more personal than having your very own DNA analysed – with sampling carried out in the Science Museum itself. Dr Archer and his team subtly demystified the process, revealing why and how it works with a very real, direct approach. There is a genuine possibility those who subjected themselves to analysis will never see their body in the same light again, while also gaining a deeper understanding of what goes on behind closed laboratory doors.

This was possibly the first time in their lives many people had given thought to the underlying biology at the heart of their body clock. By alerting people to their own natural cycles, the scientists set in motion a gentle cultural awakening, asking people to consider how they live their lives – from when they go to bed to what kind of job they're more suited to.

The project received considerable media attention, helping to spread the message still further. By increasing public awareness of circadian biology and exploring how variations in day/night preference and sleep timing can be

Right: Space at the Science Museum for the 'Lark or Owl?' study. *S Archer*

> I think it was a valuable exercise, although it was far too late...our take on it was a pretty cynical one. Government were forced into it...They held the 'GM Nation?' debate because they were losing the argument in a public forum...and it demonstrated that concerns about GM were widespread, well-informed and that they ran quite deep.[4]

Responding to the criticism that NGOs were overrepresented in the process, Parr argues that public engagement is about much more than representing public opinion:

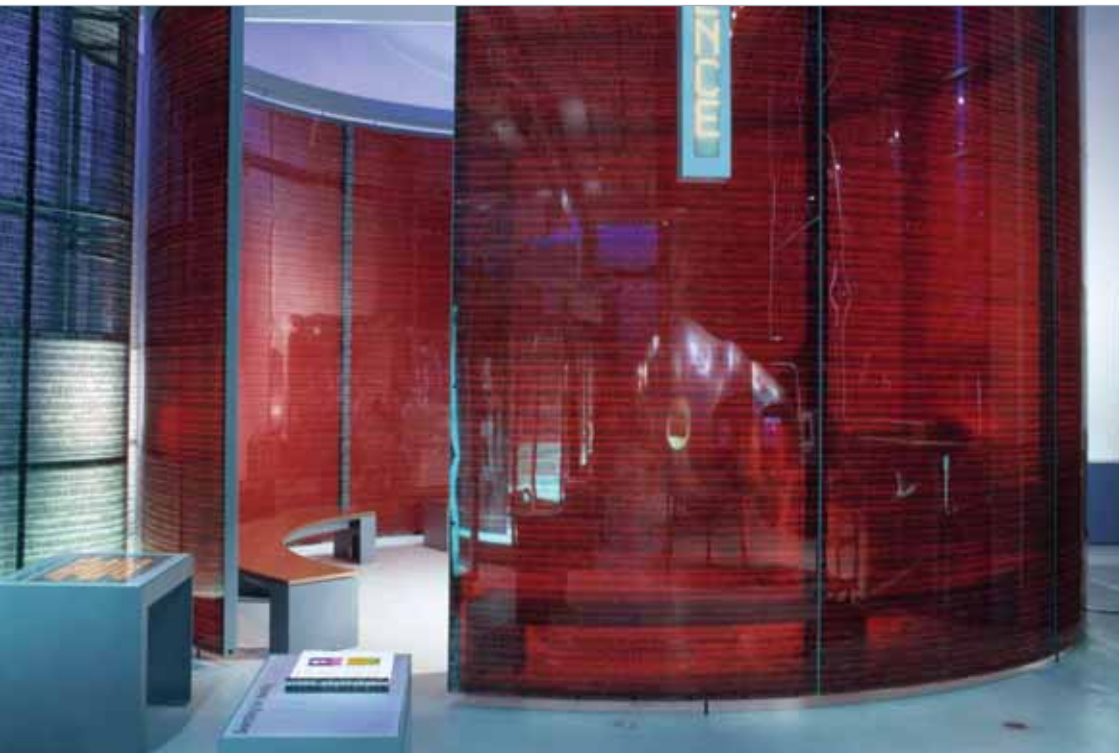
> If you wanted to just find out what 'real' public opinion was, you could do an opinion poll and that would be much cheaper...It was also a political process. Just in the same way as it's a political process when people go out and vote. And when 60 per cent of the public turn out, we don't say, "Let's do some market research to find out what the other 40 per cent think and then decide what the real intentions of the public were"...the fact that people are prepared to spend an evening discussing these things is something of importance and political significance.

Upstream public engagement allows us to go beneath questions of technological benefit versus technological risk to the deeper question of "what kind of world do we want to live in?"

NGOs upstream

'GM Nation?' reminds us of one of the dangers of public engagement. If it is not done early enough, interests will be so well defined and positions so entrenched that any chance of constructive conversation is lost. This realisation is behind more recent moves towards 'upstream' public engagement. Demos, as an NGO of sorts (although not a campaigning one), has played a role in advocating earlier, broader, more productive dialogue about science and innovation. We argue that upstream public engagement allows us to go beneath questions of technological benefit versus technological risk to the deeper question of "what kind of world do we want to live in?"[5] For other NGOs, the move upstream, where science, interests and public opinion are all up for grabs, asks difficult questions of their own role. If we engage early, when the relationship between technology and society is still undefined, and there is a productive conversation to be had, how do NGOs shape their positions and their place in debates? In the last two years, a few have been experimenting with deliberative engagement to answer this question.

Practical Action (formerly the Intermediate Technology Development Group) is an NGO with an interest in technology and developing countries. Drawing on the inspiration of their founder, E F Schumacher, they campaign for the empowerment and involvement of local people in decisions about the



technologies that they use and that impact upon them. Through recent experiments with citizens' juries, they have sought to bring political attention to people and viewpoints that conventional politics would find it easy to ignore. One citizens' jury, in Zimbabwe, allowed a group of farmers to provide recommendations to the Zimbabwean Government that covered a range of current and future concerns, from the provision of water, finance and education, through HIV/AIDS, to GM crops.[6,7]

Greenpeace and other environmental NGOs operate in a political environment that is much clearer to Western audiences. They must fit deliberative public engagement into their everyday activities of arguing, campaigning and mobilising members of the public. In 2005, Greenpeace initiated a deliberative public engagement process on nanotechnology – the science of the very small. The Nanojury, following Greenpeace's earlier GM jury, was made up of ten sessions run over five weeks.[8] It took 20 members of the public and a collection of expert witnesses through a discussion of the opportunities and uncertainties that lay ahead. The process was an experiment in deliberative democracy – giving a small group of people the chance to have their say in debates about new technologies. But Greenpeace also had a more direct motive for starting such a process. Robin Grove-White, a leading social scientist and former chair of Greenpeace's board, admits that, with NGOs, "everything they do is instrumental," directly serving their campaign purposes. For Doug Parr, the purpose of the Nanojury was to:

> ...expose some of the myths behind the rejection of public and NGOs' scepticism about new technology...here are a load of ordinary people off the street, exposed to a balanced set of experts, and come to some conclusion. In no way could they be described as ill-informed or prejudiced. Yet if they're still coming to conclusions that are broadly supportive of our [Greenpeace's] views, then clearly the mythology in Government and scientific institutions about why there's such a worry about new technology can be seen as misplaced...

At the time of the Nanojury, Greenpeace's position on nanotechnology suggested a new approach. Following an attention-grabbing report from a Canadian-based NGO, the ETC group,[9] which called for a moratorium on the commercialisation of new nanotechnologies, Greenpeace took up a sceptical but balanced stance, arguing that while there are important concerns and uncertainties under the nanotechnology umbrella, there are also promises of sustainable technologies that need to be encouraged to materialise.[10] In a world in which early public engagement is officially endorsed, it is interesting to see NGOs taking subtler, more constructive positions on emerging issues.

→ influenced by circadian clock genes, → the project raised interesting questions about society's tendency to cultural homogenisation, such as the ubiquitous '9 to 5'.

'Lark or Owl?' was genuinely novel and innovative. It showed a complete picture: the fusion of interactivity and public participation, demonstrating scientific methodology, with the real-world implications of its findings. With so much science depending on public involvement, projects such as this can give everyone a much clearer picture of what actually happens in biomedical research.

Right: Wake-up call: people may benefit from understanding their personal circadian rhythms.

Also connect

The relationship between NGOs and public engagement is complex. NGOs are a crucial part of civil society. They act to hold governments and others to account, in what they guess is the public interest. But they would rarely claim to represent public opinion. And, as we have seen with recent attempts to engage members of the public in upstream dialogue about technology, it is not at all clear what public opinion is. So public engagement – if it is done properly, with the intention of opening up debates, exploring alternative viewpoints and connecting people to politics – has the potential to be just as disruptive to the work of NGOs as to Government.

With official recognition of arguments about sustainability, large NGOs became insiders, playing governmental politics. NGOs now need to consider therefore whether their own narrow views of scientific and technological issues are engaged with public values. In the next decade, as public engagement becomes the norm across a range of areas, large NGOs might consider how they can use its potential to re-energise their work. This might involve more deliberative experiments like those by Greenpeace, or connecting with smaller, community-based groups who are looking to build public interest from the bottom up.

Dr Jack Stilgoe is a researcher at Demos.

Acknowledgements

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References

1 See Epstein S. Impure Science: AIDS, activism, and the politics of knowledge. Berkeley, California: University of California Press; 1996.

2 Wilsdon J et al. The Public Value of Science. London: Demos; 2005.

3 See, for one example: Campbell C. A genetically modified survey. Spiked 2004 11 August. www.spiked-online.com/Articles/0000000CA661.htm [accessed 5 June 2006].

4 Interview with Doug Parr, 30 March 2006.

5 Wilsdon J, Willis R. See-Through Science. London: Demos; 2004.

6 Coupe S et al. A Farmers' Jury – The future of smallholder agriculture in Zimbabwe. Rugby: ITDG Publishing; 2005.

7 Rusike E. Exploring food and farming futures in Zimbabwe: a citizens' jury and scenario workshop experiment. In M Leach et al. (eds). Science and Citizens. London: Zed Books; 2005. pp. 249–55.

8 See www.nanojury.org and www.gmjury.org.

9 The Big Down – Atomtech: Technologies converging at the nanoscale. ETC Group; 2003. www.etcgroup.org/documents/thebigdown.pdf [accessed 5 June 2006].

10 Arnall AH. Future Technologies, Today's Choices. London: Greenpeace Environmental Trust; 2003. www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/5886.pdf [accessed 5 June 2006].

11 SCIENCE IN EDUCATION: IMPLICATIONS FOR FORMAL EDUCATION?

People's experience of science in schools is crucial in shaping attitudes to the subject. And their recent experience has not been great. School education has the need both to educate the next generation of scientists and to prepare much larger numbers of people for life in a technologically advanced society. These twin aims can come into conflict. Recent GCSE curriculum reform, says **Robin Millar**, has finally grasped the nettle, offering options that are more tailored to these different needs – and are more closely linked to students' everyday lives.

For most people, most of what they know and feel about science comes from their school science education. Science is a mandatory part of the curriculum between the ages of five and 16. Yet discussion of public engagement with science tends to focus on informal science learning – from newspapers, magazines and television, through science centres and Science Week events, to the arts. If we want to have a significant and lasting impact on public views of science, and public engagement with science and scientists, then thinking about – and seeking to influence – young people's experience of science in school is central.

Perceptions of school science

Science, along with literacy and numeracy, is seen by many influential groups as a critical element of the school curriculum. This gives it status, and perhaps resources. But it also leads to anxiety about outcomes, impact and uptake – which is not expressed to the same degree about other school subjects. There are competing social demands on school science, from politicians, from industry and commerce, and from the scientific community, in addition to its intrinsic educational value in extending individuals' knowledge and skills.

In the UK, as in many developed industrial countries, there are currently serious concerns about the numbers of students choosing the sciences, particularly the

physical sciences, beyond the compulsory phase of education. Whether this constitutes a 'crisis' is more open to debate; similar concerns have been voiced almost continuously in the UK for the past 150 years, since before the sciences had become established as secondary school subjects. Nonetheless, there may be reasons to believe that recent changes have exacerbated the problems.

If we want to have a significant and lasting impact on public views of science, young people's experience of science in school is central.

Alongside this, also in many countries, there is consistent evidence of a decline in students' attitudes towards school science during the secondary school years – with more recent evidence in the UK suggesting that this may now be starting earlier, in primary school. The consistency of students' views in many countries is a striking finding of the ROSE (Relevance of Science Education) project.[1] Three studies that looked in more depth at students' views of school science in three different countries (Australia, Sweden, UK) identify three common features:

- dissatisfaction with the experience of science lessons as 'teacher-centred content transmission'
- a perception of curriculum content as unengaging and disconnected from students' lives and concerns
- the view that science is a 'difficult' subject (at which many do not feel 'good enough' to succeed).

As a result, while many acknowledge that science is important, they feel it is 'not for them'.

While this research points to changes that might make school science more attractive to students, some aspects of the problem lie beyond the school and the curriculum, in general perceptions of science as an institution, and as a career, in society at large. These are less easy to change. A further challenge is that different aspects of the problem point to different – perhaps incompatible – responses.

There is consistent evidence of a decline in students' attitudes towards school science during the secondary school years.

A central tension

The central challenge in designing a school science curriculum is in resolving the tension between its two main purposes. One is to help all students attain functional 'scientific literacy'. The other is to provide the first stages of a training in professional science, for some students. For the past half century (if not longer), the 'training in science' emphasis has been ascendant. The primary importance of 'sound foundations' for more advanced study is implicit in the

THOSE WHO CAN, INSPIRE

The UK's new network of Science Learning Centres provides science teachers with unrivalled professional development opportunities.

The national network of Science Learning Centres is an ambitious £51m joint initiative from the Department for Education and Skills (DfES) and the Wellcome Trust. Comprising one York-based National Centre (supported by £25m from the Trust), serving the UK, plus nine regional Centres in England (supported by £26m from the DfES), they offer professional development opportunities for teachers and technicians.

The initiative is the highest-profile example of the Wellcome Trust's extensive →

SCIENCE LEARNING CENTRES

Funding
£51 million joint funding from the Wellcome Trust and the Department for Education and Skills (2003)

More details
www.sciencelearningcentres.org.uk

Left: Hair raising: practical science is highly engaging for school students.

structure, and the choice of content. Yet only a minority of those following a science course at any given level actually choose to go on to the next level. The failure to design courses to meet the needs of the majority of those taking them was highlighted by the Higginson Committee (1988) on the future of A levels, which saw it as: "The most fundamental error in the traditional GCE/A level system".[2]

The key to greater student engagement is making stronger and clearer links between the science that young people hear about outside school and the science they learn in school.

For while these two aims are widely recognised, and reflected in general in curriculum policy documents, the school science curriculum has invariably been designed on the assumption that a single form of science education can achieve both. Courses specifically designed for each purpose would, however, differ significantly in content, in depth of treatment and in emphasis. The characteristic quality of scientific knowledge – despite the fact that science educators often choose to stress that it is provisional – is that some of it, including almost all that is taught at school level, is consensually agreed, and to all practical purposes beyond dispute. So teaching science is constrained. The aim is not simply to help students develop their understanding of the natural world, but to help them towards *one particular understanding* of it. Learning science is an induction into a particular view of the world. As a consequence, as David Layton once put it, "at the school level...the acquisition of scientific knowledge is inescapably tinged with dogmatism".[3]

Thomas Kuhn famously argued that science is taught and learned through 'paradigms': "accepted examples of actual scientific practice – examples which include law, theory, application, and instrumentation together".[4] These shape and define a field of enquiry. Learning science for professional level practice requires extensive practice in using these paradigms, to the point where they become second nature. In Harry Collins's words, "it is romantic nonsense to imagine that potential science specialists can learn all the science they need without a lot of routine learning and practice along with indoctrination into traditional ways of thinking".[5]

These, however, are the very features of science education that many students find off-putting – as the following comments, reported by Osborne and Collins from their study of students' views of the school science curriculum, indicate:

> [In science], there's one answer and you've got to learn it...You just have to accept the facts, don't you?...It's just not as creative as English.

→ portfolio of work in science education. Few would argue that science education is fundamental to the public's relationship with science, and to modern society more generally. It has the challenging 'dual mandate': to begin training the next generation of scientists but also to provide a science education that enables the much larger number of people who will not be scientific specialists to thrive in a technologically advanced society.

Paradoxically, while science burgeons in everyday life, concerns continue to grow that young students within schools are losing interest in the subject – not least because what they learn in lessons often bears no relation to the science they experience all around them.

Moreover, modern science presents some unique challenges. The pace of change has never been faster; yesterday's science may well have been superseded by the time it filters into the classroom. New technologies offer a range of new opportunities to enhance the teaching experience. And traditional science teaching, based predominantly on the transfer of facts, now has to incorporate debate and discussion of scientifically or ethically controversial issues.

The Wellcome Trust has adopted a multifaceted approach to these fundamental issues. One strand of work has focused on curriculum development. The Trust has encouraged the consideration of scientific issues in the citizenship curriculum, and has also financially supported and advised on new curricula – such as the new Twenty First Century Science GCSE, which aims to provide a more relevant general education

> In art and drama you can choose, like whether you're going to do it this way or that way, and how you're going to go about it, whereas in science there's just one way.[6]

To address such views seriously, while still offering something that is recognisably *science* education, is a major challenge. If, in addition, it is not apparent to many students how scientific knowledge is useful to them for any practical purpose they can imagine, we should not be surprised that so many study it rather half-heartedly while it is compulsory, and give it up as soon as it is not.

Where do we go from here?

The educational challenge posed by the nature of science and scientific knowledge cannot be denied – but can perhaps be reduced. Successive revisions of the science national curriculum have tried – by giving greater emphasis to the methods and procedures of scientific enquiry, the nature of scientific knowledge, and the forms of reasoning from evidence that are characteristic of science.

The two distinct purposes of the school science curriculum – scientific literacy for all and the first steps in a training in science for some – have for the first time been more explicitly recognised in the 2006 revision of the Key Stage 4 national curriculum. Rather than a single science programme, designed to take 20 per cent of the students' time (a double GCSE), the curriculum is divided into two equal components: core science and additional science. The core course focuses on scientific literacy – the scientific knowledge and understanding of science itself that we would wish everyone to have; additional science augments this by introducing some of the more abstract concepts that provide a foundation for studying science at AS level and beyond. An alternative additional course (applied science) adds further flexibility.

The model seems to offer a way of enhancing the scientific literacy of all students while also catering for the needs of future specialists.

This model has been piloted since 2003 by the Twenty First Century Science project – and a revised version of the course and teaching materials developed for the pilot are one (of the four) GCSE science specifications from which all maintained schools in England can choose from September 2006. The advantage of the core plus additional model is that allows the two purposes of the science curriculum to be considered separately – and courses to be designed that are 'fit for purpose'.

This pilot runs to July 2006, so any evaluation of its impact is necessarily provisional (three external evaluation studies are in progress and will report in autumn 2006). The responses of pilot schools have been strongly positive,

focusing on the nature of science and its social and personal impact, as well as the core scientific 'basics'. The Trust has also funded the development of an AS level in the History, Philosophy and Ethics of Science.

While curricula are crucial, even more so are the professionals that deliver them. The new Science Learning Centres represent a bold initiative to reinvigorate science teaching from the ground up, creating a new generation of highly trained, motivated and inspirational educators.

The Centres aim to deliver the highest-quality professional training for teachers, technicians and support staff working with children from primary to post-16 levels. Everyone attending a course (lasting from one to several days) at any of the Centres has access to one-on-one mentoring, modern facilities, regularly updated resources and support, bringing together research, industry and educational expertise. This training is further reinforced with continuing support in the form of classroom exercises and online materials. Ultimately, the hope is to reconnect teachers with their subject – something that Wellcome Trust-funded research has shown is highly prized by science teachers.[1]

Other specially commissioned research has focused on key questions in modern science education. The influential *Valuable Lessons* report[2] highlighted the difficulties science teachers encountered trying to teach controversial issues in the classroom and suggested possible ways in which they could be tackled, while *Primary* →

in particular teachers' views on their students' engagement and interest. Teacher feedback suggests that the key to greater student engagement is making stronger and clearer links between the science that young people hear about outside school and the science they learn in school. Students respond to the message that that the science-related issues they hear about outside school are part of the school curriculum, not something that cannot be properly explored and discussed because of the pressure to 'cover the material in the syllabus'. In the hands of teachers who are persuaded of its merits, the model seems to offer a way of enhancing the scientific literacy of all students while also catering for the needs of future specialists.

Post-compulsory schooling

So much for the compulsory phase of science in schools. What about post-16 science education? The striking characteristic of A-level study in England is the freedom of choice of subjects and subject combinations, and the requirement to study a few subjects in some depth. Studies of patterns of A-level uptake over the past decade have shown a steady drop in numbers taking physics and chemistry, as a proportion of the age cohort and (more strongly) as a proportion of all A levels taken. More detailed analyses have also shown that more students take a mixed combination of A levels, rather than a group of 'science' or 'arts' subjects – with consequent effects on their available degree and career choices.

We cannot expect to increase participation in science significantly by changing students' views and opinions; rather we need to change the kinds of course we offer them.

Since the introduction in the late 1990s of AS-level qualifications, two new science specifications have been introduced with the aim of attracting students who might otherwise have stopped the formal study of science at GCSE. AS Science for Public Understanding was first offered in 1998. It is designed to consolidate students' understanding of science from GCSE level, and introduce them to some ideas that are useful in analysing and evaluating scientific information and claims. Numbers taking the course have risen steadily, from around 300 in 1998 to over 2000 in 2006. An external evaluation of the course saw it as "distinctive and different from the standard courses that form the core of mainstream, secondary school science education, both in this country and internationally", and found that "the overwhelming majority of students said that the course is both enjoyable and interesting".[7] They also reported similarly positive teachers' views.

→ *Horizons*[3] took a look at the current state of science teaching in primary schools.

To encourage changes in practice, the Trust has also supported the development of creative approaches to science education, for example through the Creative Science initiative, which supported work on new approaches to science education that could be taken up by Science Learning Centres. Funded projects such as Citizen Science (see pages 45–48) continue this tradition.

Formal education arguably has the greatest long-term impact on individuals' relationships with science. It is therefore one of the most crucial areas on which to focus attention.

References

1 **Believers, Seekers and Sceptics: What teachers think about continuing professional development. Wellcome Trust; 2006.**

2 **Valuable Lessons: Engaging with the social content of science in schools. Wellcome Trust; 2001.**

3 **Primary Horizons: Starting out in science. Wellcome Trust; 2005.**

Right: Science education shapes the way students will approach science throughout adulthood.

The more recently introduced AS Perspectives on Science, a course emphasising the history and philosophy of science, similarly aims to attract students who might otherwise opt out of science beyond GCSE. It is too early to assess its impact. These two AS-level courses, however, reflect a common concern to find ways of making the study of science more attractive to students with a wider range of interests – and to show how science can be used to enhance understandings and skills that are of more general value, not only to those with a specific vocational reason for studying science. Both, in different ways, reflect the view that we cannot expect to increase participation in science significantly by changing students' views and opinions; rather we need to change the kinds of course we offer them. Both also offer opportunities – which are already beginning to be recognised and explored – for closer links and alliances between formal and informal science education, which can enable schools to benefit from the creative energy that is evident in many science engagement efforts, and those involved in informal science to hear more clearly the student voice on science and its impact on their lives.

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References

1 www.ils.uio.no/english/rose/.

2 Higginson Committee. Advancing A Levels. London: HMSO; 1988.

3 Layton D. Science for the People. London: George Allen & Unwin; 1975.

4 Kuhn TS. The Structure of Scientific Revolutions. Chicago: University of Chicago Press; 1962.

5 Collins H. On beyond 2000. Studies in Science Education 2000;35:169–73.

6 Osborne JF, Collins S. Pupils' Views of the School Science Curriculum. London: King's College; 2000.

7 Osborne JF et al. Breaking the Mould: Teaching science for public understanding. London: Nuffield Foundation; 2002.

12 ART, SCIENCE AND THE PUBLIC

Over the past hundred years or so, science has become isolated from the arts – physically, as it has become almost totally confined to the laboratory, and intellectually, with its emphasis on scientific methodology, concepts of validity and the search for single, clear answers. What, then, is to be gained by reintroducing these estranged partners? As **Stephen Webster** argues here, the experience of the last decade suggests that science–art interactions have reached a critical mass. But the chief impact has been on the creation of new art and its ability to stimulate new thinking in audiences, rather than shifting science from its current ways of working.

Artists, working alongside scientists, can provide an extra dimension to the public engagement of science. But why might artists find something of value in science, and why, in turn, are some scientists attracted by the chance of working with an artist? My first answers come from a look at two living artists whose work makes plentiful reference to scientific concepts, Marc Quinn and Marilène Oliver. Then I consider the influence of funding organisations that have encouraged artists and scientists to work together. Finally, I suggest why the differing attitudes of scientists and artists to the concept of audience might partly explain the potency of art–science collaborations in public engagement projects.

Marc Quinn is an artist whose work, literally, incorporates science. In the bust 'Self', Quinn modelled his head from eight pints of his own blood, and kept the sculpture exhibitable by displaying it frozen inside a transparent case. Later, commissioned by the Wellcome Trust, he made a portrait of the genome scientist and Nobel Laureate Sir John Sulston by culturing fragments of the scientist's DNA in bacteria on an agar plate and placing it in the centre of an elegant picture frame. The work was hung, to great fanfare, in the National Portrait Gallery, and described by Quinn as "the most realistic portrait in the building".

Perhaps even more striking were the sculptures Quinn exhibited in London's White Cube gallery in March 2005, in his show *Chemical Life Support*. In a large and plain space, a few naked figures, apparently of marble or alabaster, reclined in classical but relaxed pose directly on a cold-looking floor. The surprise was in finding that the figures were in fact made of wax, impregnated with the very medicines that, in real life, were keeping Quinn's subjects alive. Thus 'Silvia Petretti' is the sculptural form of a woman with HIV/AIDS, moulded from an amalgam of wax and quantities of antiretroviral drugs. Another of the sculptures, 'Innoscience', shows Quinn's son Lucas, lying contentedly on the floor of the gallery, the embodiment of health and happiness and babyhood. Yet for a while, early in the child's life, a milk allergy made Lucas dependent on artificial milk. And so the milky form of Lucas, chubby on the floor of the White Cube, turns out to be literally composed of a long list of amino acids.

Marilène Oliver is another artist who makes direct use of the products of science. Her artworks are also sculptural, and many are constructed from magnetic resonance imaging (MRI) scans. Such medical technology is usually pressed into giving clinical information on a particular organ or part of the body. In Oliver's work, however, a research MRI unit at Nottingham University has let the artist scan the whole bodies of herself and her family. The several dozen sections derived from the body are then individually printed on transparent acrylic plates, stacked in the right order, and spaced to produce the correct height. Very vividly the figure, the original person, so to speak, re-emerges from the medical data. A few dozen monochrome medical images have been put into another context, and become unmistakeably human. The shadows and shapes are no longer evidence or reminder of tumours and other forms of bad news made visible by science, but show instead the sturdiness and vitality – even the spirit – of human lives.

The dislocated and shifting work we sometimes call 'sciart' is much less definite about its situation.

Like all good art, each of these works bears multiple interpretations. In *Chemical Life Support* we are jolted into realising the intimacy of the relationship between pharmacology and our bodies. For some people this is an optimistic vision. For others it is a cause for pessimism. As for Marilène Oliver's sculptures, it is hard not to be moved by these life-like bodies re-emerging from a pile of two-dimensional medical scans. In both these artists, in other words, scientific and moral ideas are brought together and debated. It is relevant too that in both cases the work is usually shown (and sold) as art. Science, and scientists, were involved along the way, but there is no confusion about the finished work. It is art, made by artists, exhibited in galleries and public spaces.

WHEN WORLDS COLLIDE

Science and art have moved beyond mutual misapprehension, finding both common ground and virgin territory to explore.

Unveiled in the National Portrait Gallery in 2001, Marc Quinn's portrait of Sir John Sulston is the remarkable product of a meeting of quite different minds: one of the UK's leading artists and a geneticist Nobel Laureate.

A key player in the Human Genome Project, Sir John provided his own DNA for the piece. Following both genetic and artistic modification, the mirror-framed portrait was complete: a series of translucent dots containing around a million pieces of genetic information, frozen for all time in bacterial colonies. →

'A GENOMIC PORTRAIT: SIR JOHN SULSTON'

Funding
£40 000 (2002, special commission by the Wellcome Trust, in conjunction with the National Portrait Gallery)

Artist
Marc Quinn

More details
www.marcquinn.com
www.npg.org.uk

Left: Marc Quinn, the genomic portrait, Sir John Sulston (L–R).

The dislocated and shifting work we sometimes call 'sciart' is much less definite about its situation. This is indicated by the range of contemporary institutions that have come together, in the last ten years, to fund a proliferation of art–science collaborations. In that instititutional effort the Wellcome Trust deserves special mention. After success in 1996 with a pilot scheme, the Trust in 1999 set up the Sciart Consortium, a partnership that comprised also the Calouste Gulbenkian Foundation, the National Endowment for Science, Technology and the Arts (NESTA), the British Council and the Arts Council of England. What would happen, the Trust had wondered, if a funding stream were established that "encouraged and enabled artists and scientists to work together on projects that grew out of genuinely reciprocal processes of inspiration"?

Although there is a long history of earlier connections between science and art, it does seem safe to suggest that the initiatives of the last decade bear particular scrutiny as an emerging tradition.

Ten years later, this experimental activity has become a regular part of the cultural scene. While the consortium dissolved quite soon after its inception, the partners have each carried on funding art–science collaborations. The Trust itself has awarded scores of grants totalling several million pounds, and embedded the scheme in its huge public engagement programme. Meanwhile NESTA's website shows a continuing profusion of art–science enterprises. The Gulbenkian Foundation has been consistent in funding arts residencies in science institutions (for example at University College London's Institute of Child Health, and at the National Institute for Medical Research). We even have the model of 'scientist-in-residence', as shown by the Institute of Contemporary Arts.

Although there is a long history of earlier connections between science and art, it does seem safe to suggest that the initiatives of the last decade bear particular scrutiny as an emerging tradition. I have mentioned the consistent involvement of a number of charities. Also notable is the way the established research councils have now joined in. The Arts and Humanities Research Council has worked with Arts Council England (ACE) to set up two rounds of 'art–science fellowships': the most recent awards were announced in September 2005. In the sciences the Engineering and Physical Sciences Research Council has a well-funded scheme that sets up 'research networks', each of which comprises groups of artists and scientists prepared to sit down together and develop a research agenda that relies on the most diverse sets of skills and methods of working.

Plainly, these initiatives assume there is something to be gained in encouraging artists and scientists to work together. But where should we look for this value? As I pointed out above, it doesn't seem as though the work of a Marilène Oliver or a Marc Quinn should be described as anything other than art. Their artifacts

are not a hybrid creature of art and science. Yet the institutional flyers and websites that seek to fix up the scientist with the artist sometimes suggest interesting art might not be the only outcome. For example, when ACE announced the new art–science fellowships in 2003, the press release described how they would "contribute to the store of knowledge within science and art and explore how art can contribute to science, and science to art in terms of different ways of working and thinking". Statements like this, referring enticingly to art–science partnerships as promoting novel ways of thinking, working or asking questions, suggest that the primary value of such partnerships lies in a process – the way they work – rather than in an end product. But how does this novel process, this unusual way of working, fashion its impact on science?

For those interested in public engagement with science, questions about the way science works are important. For if science is as rigidly prescribed as is sometimes suggested, following strict methodological rules that, properly adhered to, inevitably bring scientific truth into view, then surely 'dialogue' with non-scientists can only be of limited value. Like a patient but unyielding parent, science might listen to the noisy protests, but carries on regardless.

The scientists involved in such projects invariably express their satisfaction at the manner in which collaboration with an artist has given them an audience that differs vastly from the normal specialist arena of laboratory and scientific conference.

This is where the visions of the art–science collaboration, and the anxieties of the dialogue between science and society, begin to show a relation to each other. A look at the Wellcome Trust's lists of science–art projects shows that in many cases the work involves not simply 'a new way of working' but, at some stage, an explicit involvement with an audience. Films, installations, theatre productions and exhibitions pepper the collaborative work of artists and scientists. This of course is no surprise: each of the Trust's calls for proposals in the area has mentioned the goal of public engagement. Yet there is something deeper going on too. For the scientists involved in such projects invariably express their satisfaction at the manner in which collaboration with an artist has given them an audience that differs vastly from the normal specialist arena of laboratory and scientific conference.

These tentative relations between science and art might bear a number of interpretations. There are artists, alive to the astonishing conceptual implications of modern science, who react to the science through their artistic output. Then there are actual partnerships between artists and scientists where much emphasis is on how the relationship works, what insights and changes occur along the way. It is here that questions might be asked about the ways in which scientific

→ The partnership between Quinn and Sulston is evidence of a new spirit of collaboration between scientists and artists. With the disciplines having come to occupy such distinct niches in life, it was not obvious that encouraging the two to work together would be fruitful or even possible.

One of the earliest examples of this new wave of interdisciplinary exploration – the 'Primitive Streak' collaboration between Helen Storey and her sister Kate, a developmental biologist – showed just how stimulating this mixing could be.

The 27 extraordinary dresses created during their project take the viewer on a startling visual journey through the first 1000 hours of human life, from fertilisation to a recognisably human form.

'PRIMITIVE STREAK'

Funding
£25 000 (1997, Sciart award) – Primitive Streak: A fashion collection chronicling human embryonic development

Project lead
Professor Helen Storey and Dr Kate Storey

The exhibition has toured in seven countries since 1997, seen now by more than 3 million visitors.

Apart from winning several awards, 'Primitive Streak's breathtaking originality has led to it being adopted as a blueprint for Arts Council England's Creative →

Left: Fashion meets embryology: dresses from 'Primitive Streak'.

knowledge – or shall we say 'the scientist's life' – might be influenced by the arts. Finally, and most relevantly for the urgent priorities of public engagement, we see that scientists value the way an art–science collaboration brings into the offing a new and wider audience.

In 1969, the philosopher Thomas Kuhn wrote a brief reflection entitled 'Comment on the Relations of Science and Art'.[1] Here Kuhn declared himself the victim of an irony. His own work on scientific revolutions, essentially an examination of the social conventions of science and their translation into knowledge, found patterns that could be interpreted as similar to those within the arts. Kuhn had seen that art historians speak of competing schools of thought, of incomprehension and hostility between such schools, and sudden shifts of the status quo. Famously, Kuhn brought all this into his analysis of the advancement of science: we remember his paradigms, his gestalt shifts, his talk of 'incommensurability'. Yet he was adamant that, in spite of what he might have implied, science and art were highly distinct enterprises. To a lay observer, the differences between art and science were obvious. A child of six would tell you so. Only the meddling attentions of a philosopher of science could make the boundary seem weak. And so, as though to make amends, Kuhn set out to find the reliable foundation to rebuild the wall and make it strong. And among the tools Kuhn contemplates is the concept of audience.

Kuhn was adamant that, in spite of what he might have implied, science and art were highly distinct enterprises.

Kuhn argues that science has no need of an audience, at least not the kind made up of members of the public. "Scientists who attempt to find a wider audience for professional work are condemned by their peers", writes Kuhn. Perhaps the position has changed since 1969. Or perhaps not. But the overall argument remains interesting: that artists seek an audience, depend on it and, often, learn from it. Science – this is Kuhn's point – is by its very nature uncomprehending of the idea that the views and responses of an audience are of any relevance. It is the argument that science lives by the opinion of close scientific colleagues, not on the approval of outsiders. One suspects that Kuhn might look at today's conferences on public engagement and, while approving of the general sentiment – he was after all a great educationalist – doubt the validity of the concept of 'dialogue'. His point would be not that democracy has no place in science, but simply that, when it comes to decisions and directions in science, the voters must always be scientists.

→ Partnerships Initiative. This supports long-term partnerships between schools and cultural and creative organisations.

The relationship between science and art remains complex and nuanced. What projects such as 'Primitive Streak' illustrate is that constructive dialogue is possible, and that the outputs can both have high intrinsic value and appeal to broader audiences.

For Helen Storey, the project was life-changing. She received further Wellcome Trust Sciart funding for 'Mental', a stunning interactive exploration of how the creative process impacts on the mind (in collaboration with Professor John McLachlan and others), and she has developed a career at the intersection of art, science and new technologies.

Sciart collaborations

Collaborations between scientists and artists are supported through Sciart grants, part of the Wellcome Trust's Engaging Science programme. Projects should aim to stimulate fresh thinking and debate in both disciplines. Innovation and experimentation are crucial, but projects should also be accessible to diverse audiences and engage the public in the social, ethical and cultural issues surrounding biomedical science.

www.wellcome.ac.uk/sciart

Right: One of the dresses from the 'Primitive Streak' project. *Helen Storey Foundation*

Must it be like this? Is science so defended and sure of its goals that no audience, no form of artistic practice, can reach in and pull at the levers? We know the answer here is in part political, a matter of how the concept of public engagement is allowed to map onto debates about democracy and the open society. But while those discussions smoulder on, we can meanwhile see in the Wellcome Trust's science–art initiatives some signs that artistic practice can indeed find expression in scientific work, both technically and conceptually.

Better to think of these projects as prising open science, and, perhaps unexpectedly, finding space to work.

In Project Façade for example, the sculptor and casting expert Paddy Hartley is working with materials scientist Ian Thompson on shaping the bioglass implants used by dentists at Guy's Hospital; these are artistic skills brought to bear on behalf of biomedicine. Another project, Fluent Heart, put together the heart imaging specialist Philip Kilner, the choreographer Wayne McGregor and the composer Sir John Tavener, and had as its main product the dance work *Amu*, premiered at Sadler's Wells Theatre in September 2005. When we look at Kilner's role, something remarkable emerges: he himself had an arts training, at Emerson College in Sussex, in addition to his years at medical school. Now working at the Royal Brompton Hospital in London, Kilner reports that this deep immersion in the arts, especially in sculpture, profoundly shapes the way he comes to understand the heart's swirling vortices and rhythms.

We should not squeeze these intriguing projects into crude formulations that speak of 'art influencing science'. The process is more subtle and more interesting. Better to think of these projects as prising open science, and, perhaps unexpectedly, finding space to work. No doubt the form of that work, and its final impression on the scientists involved, varies greatly. The impact is unpredictable, but real. When we consider as well the way these projects often gain such public interest, we can conclude the place of art in science is now secure.

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Reference

1 Kuhn T. Comment on the relations of science and art. In T Kuhn. The Essential Tension: Selected studies in scientific tradition and change. Chicago: Chicago University Press; 1977.

13 A GUIDE FOR SUCCESSFULLY EVALUATING SCIENCE ENGAGEMENT EVENTS

With science communication and public engagement a burgeoning field, it is important to ask what effect it is having. Evaluation is crucial, agree **Ben Gammon** and **Alex Burch**, but difficult. Most interesting – but hardest to identify – is deep, lasting impact. As well as the methodological challenge, disentangling the impact of other factors would be extremely difficult. Better to focus on clear short-term objectives, and to collect the right data to assess how well these objectives have been met.

Evaluation is usually part of the plan for science engagement, and funders often require it. But it is hard to do well. Getting evaluation right demands as much careful thinking as designing an event or activity in the first place, and the two really go together. There is a secret to successful evaluation: clarity – about project aims, target audience, the aims of the evaluation and how the data will be used. If you can achieve this, you are a long way towards successfully evaluating your science engagement programme.

When to evaluate

Evaluation should be conducted throughout a project: during planning (front-end), development (formative) and on completion (summative). Front-end evaluation aims to identify the needs, wants and prior knowledge of the target audience. What topics will capture the audience's interest? What topics that you must cover will be challenging or initially uninteresting for the audience? What do they already know that you do not need to cover? What format of event works best for this topic and this audience? Ideally you will use focus groups or in-depth interviews, but there is also a lot of valuable information freely available in science communication and science education research, evaluation reports from earlier projects, and market research conducted by companies such as MORI.

Formative evaluation aims to identify faults in the design and delivery of events, for example by running trial events in front of test audiences prior to the launch

of the full-scale project. Formative evaluation should be an iterative process quickly identifying problems, making modifications and retesting the event.

Summative evaluation aims to assess whether the project met its objectives. Ideally the summative evaluation from one project becomes the front-end evaluation for the next. Summative evaluation of science engagement events presents a number of particular challenges, especially whether to assess the immediate or the long-term impact. There is often pressure to evaluate the long-term impact yet there are severe practical problems to overcome. How will you maintain contact with a reliable sample of participants to conduct this research? How will you ensure that you are not altering participants' opinions and behaviour by maintaining this contact? Do you have the resources to conduct long-term studies lasting months or even years? How will you ensure that what you are measuring is truly the impact of your event and not of a multitude of different experiences that a participant may have had in the meantime?

Summative evaluation of science engagement events presents a number of particular challenges, especially whether to assess the immediate or the long-term impact.

More fundamentally, we need to decide how long is 'long-term', and what counts as long-term impact. One approach that has been used is Prochaska's model.[1] This model, originally used in studies of public health education, proposes that different people are at different points of readiness to change their behaviour:

1. **pre-contemplation** – not interested in changing behaviour
2. **contemplation** – thinking about changing behaviour over some time period
3. **preparation** – committed to changing behaviour and making plans to change
4. **action** – has changed behaviour and taken action
5. **maintenance** – evidence of long-term change in behaviour.

So one way to assess the long-term impact of science engagement is to explore whether participants' positions along this continuum have shifted. However, this is far from straightforward. Learning is personal and dependent upon the context in which it happens. The outcomes of any science engagement activity will vary dramatically between individuals. It is therefore likely that an extremely complex pattern of long-term outcomes will be generated by any event. Furthermore, there is evidence that outcomes change over time and therefore different results may be attained depending on when you choose to conduct the follow-up evaluation. Falk *et al*. found that immediately after a visit to a science museum, visitors showed outcomes predominantly centred on increased knowledge and

EDUCATIONAL EDEN

Cornwall's Eden Project combines magnificent countryside, architecture, science and the arts, creating an inspiring environment for informal learning.

Opened in 2000, the Eden Project has rapidly become one of the UK's favourite destinations. Two vast greenhouses, or Biomes, are housed in the large crater on which the site is based. Occupying more than two hectares, these vast honeycomb structures house plants, crops and landscapes from the tropics and warmer temperate regions. Outside, in the Outdoor Biome, are a further 15 hectares of beautiful temperate landscape.

But the Eden Project is about far more than beauty. Behind the exhibitions,

EDEN PROJECT

Funding
£734 000 (2004, Rediscover award; £175 000 from the Wellcome Trust) – The Mechanical Theatre of Issues

£40 000 (2003, Pulse award) – Signs of Life

Project leads
Dr Tony Kendle and Will Jackson (Mechanical Theatre of Issues)

Emma Mansfield (Signs of Life)

More details
www.edenproject.com
www.engineeredarts.co.uk

Left: 'Biomes' at the Eden Project in Cornwall. *SPL*

skills.[2] However, after four to eight months, the researchers found far fewer reports of increased knowledge and skills and instead more outcomes based around the awareness of issues and the social aspects of the visit. Similarly, studies of visitors to 'Conservation Station', in Disney's Animal Kingdom, found that the impact of the experience varied according to visitors' prior knowledge and attitudes.[3] In particular, the impact upon visitors' conservation behaviour varied significantly according to how committed they already were to conservation, and across all categories of visitor, impact faded over just two to three months.

It is likely that an extremely complex pattern of long-term outcomes will be generated by any event.

Summative evaluation of long-term impact is certainly not impossible but it requires considerable resources, planning and time, and the data are difficult to interpret. If time and resources are limited it is advisable to focus instead on reliable data about immediate impact rather than poor-quality and potentially misleading data about long-term impact.

What is science engagement trying to achieve?

Science engagement covers a vast array of different initiatives. So once you have decided when to evaluate, the first step is to clarify what a particular project is trying to achieve. Different activities aim to achieve very different goals, yet these differences are often not acknowledged. This leads to choice of inappropriate indicators of success.

The Science Museum's Dana Centre team developed an evaluation of its innovative programme of science engagement events using a 'wedding cake' structure for categorising events. The base of the cake constitutes the largest proportion of science engagement events. These aim broadly to generate public interest in science. For example, these events may include panel discussions, stand-up comedy, drama, poetry, etc., but all feature largely one-way information flow.

The second layer of the cake represents a smaller proportion of science engagement activities. These are 'dialogue events', which aim to generate open-ended discussion between the general public, scientists, policy makers and campaigners. Such events often have the following objectives: to build trust, understanding and empathy between the public, scientists and policy makers; and to provide an opportunity for thoughtful and informed debate. While such events may be traditional debates, the Dana Centre successfully used a wide range of innovative formats including forum theatre, gameshows and small group discussions.

→ stories, art, events, lectures or → workshops is an important educational message: if we want to keep celebrating nature, we need to understand how to work with it – we are a part of nature. Rather than using apocalyptic scenarios to hammer this message home, however, the Eden Project nurtures its visitors, much like its plants, gently reconnecting people with their planet.

Everything about the Eden Project is welcoming. Every plant has a story to tell, and Eden wants you to hear it. Its playground environment, making terrific use of interactive games, striking automata and sculptures, hooks younger visitors and brings out the child in their accompanying parents. Suddenly their world is truly alive and visitors want to understand how plants grow, where soil comes from or how to adopt a more sustainable approach to life.

Throwing itself wholeheartedly into novel routes to science communication, Eden is constantly exploring new means to engage. It has developed collaborations between scientists, artists, teachers and marketing specialists to great effect.

With Rediscover funding, for example, it has collaborated with Will Jackson and colleagues at Engineered Arts to develop an interactive gallery along the lines of an amusement arcade or fairground. Sophisticated mechanical models will provide an immersive experience, in which visitors will be able to explore deep issues about the nature of science and how it relates to people. →

Right: The Mechanical Theatre of Issues. *Engineered Arts*

The final layer represents the smallest proportion of science engagement activities, where the public are engaged in a sustained dialogue to guide the development of government policy. These events typically involve very small numbers of people over an extended period. A recent example of such a project was Meeting of Minds, which involved panels of 12 citizens from nine EU countries and was conducted over the course of 18 months.[4]

While the events in each layer differ in their aims, they are related in the broad intent to increase public interest and participation in science. The important point for evaluation is to be clear about which layer an event belongs to. There is little point in trying to assess an event's impact upon government policy if this was never the intention.

Defining success, defining failure

The next step is to define indicators of success and, equally importantly, of failure. This second set of indicators is crucial if evaluation is to lead to better practice.

Evaluation results from many different science engagement projects show how the needs and wants of participants can be arranged into a hierarchy. Certain basic needs have to be fulfilled, regardless of the aims, audience or format of the event. For example, participants have to be physically comfortable, able to see and hear the presenters and free from distractions. Only when these have been met do more subtle needs and wants become apparent. For example, participants need to feel some sense of identity with at least a portion of the audience; they need to feel that their opinions will be valued and respected even if not agreed with. Furthermore, we found that even when such physical and social needs are met there are other powerful needs that have to be fulfilled: most notably, participants in science engagement events are 'hungry' for information and for new and challenging ideas. People do not – unsurprisingly – want to be told what they already know. They wish to make the most of coming into contact with scientists and expert science communicators. We found that for genuine discussion to occur in dialogue events the audience must first feel confident about the basic issues and terminology in order to express their opinions. Nobody wants to ask a stupid question in front of experts and an audience.

We interpreted these findings using a modified version of psychologist Abraham Maslow's classic hierarchy of personal needs.[5] Participants have needs at a number of levels:

- **Physical needs** – the physical comfort of the presenters/performers/speakers and audience.

- **Social acceptance** – audience and speakers/performers feel emotionally comfortable.
- **Intellectual** – participants feel that they have learned something, that they understand enough about the topic to contribute to the discussion.
- **Self-actualisation** – event achieves full potential. Participants feel they have taken part in something worthwhile and leave with a sense of accomplishment; the impact of the experience lasts over time.

When planning a science engagement event it is important to define the particular higher-level needs and to devise indicators that these are, or are not, being met. For example, for Dana Centre events, dialogue was defined as "the exchange of ideas, opinions, beliefs, and feelings about the topic of the event between speakers and the audience. It is listening with respect to others and being able to express one's own views with confidence." Based on this definition, indicators of success included:

- questions moving quickly from requests for factual information towards the rhetorical or statements of belief, e.g. "if you really believe x then why do you...?"
- contributors reflecting the language of previous speakers/questioners in what they say, i.e. actively listening and referring to previous points or questions.

How to conduct the evaluation

Only when the aims of the event have been clearly defined should methodology be considered. Aims should define methods, not the other way round. The choice of method should be based upon a clear understanding of the strengths and weaknesses of different techniques and of the practical difficulties of applying them to live events.

For evaluation to be successful, the organisation must want to do it, rather than doing it because they are required to by a sponsor.

Interviews with participants will provide in-depth information about their reactions to the event but it is unlikely you will be able to capture a large enough sample to yield quantitative data. Self-completion questionnaires may provide a much larger sample but these are often highly unrepresentative, missing people who do not or cannot fill in the forms. Furthermore, self-completion questionnaires lack depth of response.

An interesting hybrid approach is an email questionnaire. This provides the opportunity for both in-depth questioning and a more representative sampling of the audience. Email questionnaires yield considerable depth of response,

→

And in its Pulse project, Eden teamed up with students from Truro College and experienced theatre artists and writers to develop a drama work based on genetic engineering of foodstuffs.

Overall, the Eden Project exemplifies a key aspect of informal learning: the experience has to engage with people at an emotional level. With this connection made, visitors are motivated to find out more. By focusing on their needs and desires, the project can then lead them on a journey of exploration and discovery.

Right: Immersive techniques can aid engagement. *Engineered Arts*

Rediscover funding
The Rediscover initiative was a £33 million joint venture between the Millennium Commission, the Wellcome Trust and the Wolfson Foundation. It offered grants to science/discovery centres and museums to renew and redevelop their science and technology exhibitions.

Pulse awards
Part of the Engaging Science funding programme, Pulse awards provide funding for projects aimed at those 22 years and younger and encourage the use of any art form (or combination of art forms) to engage young people in the historical, social, ethical, cultural or contemporary issues arising from biomedical science.

typically achieve response rates of 40–80 per cent, and have the added advantage that follow-up interviews can easily be conducted at a later date.

Focus groups are good for obtaining very detailed responses from participants. A skilful moderator can explore participants' opinions in great depth. However, focus groups are expensive, time-consuming and require considerable training and experience to run effectively.

One of the most powerful yet least used techniques for evaluating live events is observation. Through the careful observation of the audience it is possible to gauge how successfully the event is being run.

No one evaluation technique is likely to deliver all the aims of the research. We recommended a mixture of methods.

Conclusions

The first secret to successfully evaluation is clarity. The second is commitment of the organisation to the importance of evaluation. It is entirely possible to follow good practice in evaluation with clarity of aims, outcomes and methodology but for it to have little or no impact. For evaluation to be successful, the organisation must want to do it, rather than doing it because they are required to by a sponsor. Evaluation should be done primarily to improve practice, not merely to 'prove' success. Evaluation needs to be the responsibility of a senior member of staff who will advocate its importance on all project teams. Ultimately evaluation needs to directly influence planning of future projects and training of staff. If you can achieve that, you will have successful evaluation.

Ben Gammon runs Ben Gammon Consulting. Alex Burch is Head of Visitor Research at the Science Museum, London.

References

1 Prochaska JO et al. The transtheoretical model of change and HIV prevention: a review. Health Education Quarterly 1994;21(4):471–86.

2 Falk JH et al. Interactives and visitor learning. Curator 2004;47(2):171–99.

3 Dierking LD et al. Using a behavior change model to document the impact of visits to Disney's Animal Kingdom: a study investigating intended conservation action. Curator 2004;47(3):322–34.

4 www.meetingmindseurope.org.

5 Maslow AH. Towards a Psychology of Being. Princeton NJ: Van Nostrand; 1962.

Further reading

Anderson D. Visitors' long-term memories of world expositions. Curator 2003;46(4):401–20.

Arnstein SR. A ladder of citizen participation. Journal of the American Institute of Planners 1969;35:215–24.

AN AGENDA FOR THE FUTURE

By Jon Turney

Let's agree that public engagement with science and technology is here to stay. It probably isn't coherent enough to call it a movement, but the whole set of activities that this book documents has built up a real momentum over the last ten years or so.

Public engagement work, under various guises from science communication to education, outreach and consultation (with, as the form now has it, stakeholders), crops up in more and more places. It is embedded in research institutes, Government departments, research councils and funding trusts, learned societies, universities and at least some sectors of industry. It is routinely on the agenda of the high committees of science policy, written into mission statements, corporate plans and white papers, and continues to spawn weighty reports and reviews and, to a lesser extent, research. Add the contributions of the proliferating media, formal education and dedicated institutions such as science centres and museums, and public engagement with science begins to amount to a minor industry.

As these pages also document, not all of this is new, but I think it is a fair claim that its prominence is. And that seems likely to continue, too. On the one hand, Government concern to foster a receptive climate for innovation, as a source of economic strength and social improvement, is continually renewed. On the other, as poll results show, there are raised expectations that 'the public' will have some meaningful role in decisions about new science and technology. Somewhere in between, the sheer pleasure to be had from getting acquainted with the astonishing outpouring of new science is getting across to new audiences, in new ways.

So where is all this likely to take public engagement over the next five to ten years? If you have read this far, we hope you have enough to go on to have your own view. But without trying to summarise all the pieces collected here, it is worth highlighting some things that may shape future efforts at delivering science for all. My own suggestions are based on a reading of these pieces, together with a recent involvement with the Wellcome Trust's Engaging Science conference in Manchester in March 2006.[1]

One is that things have been learned over these last ten years that we can build on. Let's try out some generalisations. First, dialogue is doable, but difficult. But it brings benefits that are worth the struggle to find the right format, enough money and the mix of skills to do it properly. There is virtue in scientists just being seen to be willing to give time to genuine discussion with lay people, and this itself helps build trust in the good intentions of scientists in general. What's more, there are encouraging signs that taking a robust line when a position is worth defending pays dividends in the end. The current state of the always-heated debate over animal experiments is a good case in point. The message here is that if researchers are prepared to have the argument, enough people will recognise when they have a good case. Perhaps this applies in other areas, too.

Moving to where passions run less hot, there is a strong impression that engaging with the public is rewarding for researchers. It is not for everyone, but those who do it enjoy it. A real gain of these last years is surely that putting time into thinking of ways of conveying scientific ideas to new audiences, or discussing science with diverse groups, is no longer seen as a lack of commitment to the serious business of doing research. And the great range of formats in which public engagement can now happen means that anyone can probably find a style that will suit them.

That variety also gives reason to be optimistic about the scope for weaving discussion of science into everyday life. Not to say that people will do it every day. But as public engagement activities large and small – from full-scale science festivals to Cafés Scientifiques – become part of the social fabric, they contribute

to a sense that science and technology are just another part of the culture. OK, they may never be as popular as football, but then (whisper it) plenty of people care nothing for football, either.

Add in other positive developments – such as the imminent national introduction of the Twenty First Century Science GCSE – and the general idea that science is an important, interesting, even intriguing endeavour can only spread more widely. This is not necessarily going to deliver scientific literacy, or make it any easier to handle controversial issues when they arise. But it at least contributes to the feeling that science is something worth conversing about, and that scientists can contribute to the conversation without closing it down.

If those are some things to build on, how best to do it? It would be foolhardy to pretend there's a clear prescription here. The essays commissioned for this book were intended to be evidenced-based, but we still do not know enough about what works for whom, when. There is no algorithm for public engagement, and perhaps there shouldn't be. Alan Irwin's argument here about public consultation may apply more generally: asking for the best recipe for how to do it next time may be missing the point.

So instead of an answer, let me offer another question. Or rather a set of questions – ones that any future efforts in this area ought to consider. They will not be comprehensive, but if they are set out as a series of alternative positions, or polarities, they may begin to map the space in which public engagement has to be located. What follows is a first set of six such pairs – each cast as possible reactions to a suggested statement of fact – with brief versions of the arguments on either side.

1. **There are many different agendas embodied in science engagement work.**
   A) Perhaps it will be best to resist the urge to define the aims of public engagement with science too closely. This will maintain a broad church, and license lots of activities that all contribute to the desirable trends outlined above.

   B) It is time we defined the goals, aims, objectives and strategies of public engagement more precisely and with a rigour that has so far been lacking. Start by agreeing what is actually meant by engagement. This is crucial for evaluating what we do. It will also help make it clear what resources would actually be needed to reach a particular goal, and increase the chance of getting them, especially if they need to come from Government.

2. **There are a vast number of initiatives in science engagement, many of them small-scale and local.**
   A) It is apparent that this leads to duplication, waste and reinventing of wheels. It is time there was, at the least, a central repository of information about public engagement activities past and present, including evaluations, or even a national effort to coordinate the work.

   B) The call for coordination is unrealistic. It might be bureaucratically tidy, but would hamper initiative and stifle the creativity that is such an appealing feature of the scene. Allowing people to learn from their own mistakes (rather than other people's) may appear inefficient, but is the best way to harness their enthusiasm, and leads to unexpected results that are often positive.

3. **Public engagement with science in the sense we are now using the term is in many ways still a relatively new thing.**
   A) We need to keep in mind that we do not have all the answers. The thing is to encourage experimentation and new approaches, and these should get priority funding.

   B) The emphasis on novelty carries the danger that we will fail to exploit the useful things we have learned from many past experiments, or to profit from evaluation. Science organisations find it hard to adapt to funding models that are not research-based. But funders must support projects that build on past successes, offer to enlarge the reach of existing initiatives, or simply continue things that are doing good work but where the original sponsor seeks an exit. Time to consolidate, not innovate.

4. **Experience so far has demonstrated how many ways there can be of engaging people with science and technology. We can build on the creative effort and enthusiasm that have been mobilised, and perhaps develop new ambitions.**

   A) While science communication and public engagement have grown, the suspicion remains that they can still often result in preaching to the converted, or at least to already receptive publics. Now is it time to leave the comfort zone and tackle the hard problems of reaching genuinely new audiences – whether defined by race, age, sex, class, education, locality or other criteria.

   B) Science communication and public engagement have grown, but have not kept pace with demand for information about science and technology, and for more consultation about scientific and technical decisions. It makes sense to focus effort on already interested sectors of society, where it will meet with a ready response and be a more effective use of resources. Other audiences should not be neglected, but can be brought in gradually as this work grows.

5. **Science communication and public engagement is going to demand continuing effort from large numbers of people – both the cadre of well-schooled science communicators who are already heavily involved and a steady supply of new voices.**

   A) Science is demanding, so the number of scientists who can commit to public engagement will always be limited. The priority now is to encourage the professionalisation of public engagement that is already taking place: more courses, more jobs, and career paths with recognised routes to advancement.

   B) There is no substitute for having real scientists involved in public engagement. Professionals are mainly helpful as mediators or facilitators, but they cannot deliver authentic access to real scientific practice, or the latest expert findings. We need to train a lot of scientists to do a little, and devise incentives for researchers to dip in and out of public engagement, as their careers permit.

6. **Science engagement is now an established part of science policy – both in terms of policies for how to promote it, and of recognising the need to respond to the results of engagement.**

   A) This has gone as far as it realistically can, in a representative democracy. The public has a voice, but expert knowledge should also weigh heavily with decision makers. And when it comes to actual research funding decisions, we are definitely talking consultation, not participation. Keep the public on tap, but not on top.

   B) Being realistic is seeing that this is one stage in a process that will go on developing. Committing to public engagement seriously means acknowledging that it will fuel desire for more involvement in decision making, including research funding choices, and preparing to deal with that. Trying to call a halt will be counter-productive, and will not protect scientific authority or autonomy. It will engender the mistrust that it is part of the purpose of public engagement to prevent. The future will be one of continual negotiation about the roles different kinds of knowledge, experience, and value should play in decisions about science, technology and innovation.

These six pairs of opposed positions do not all define the same kind of question, and – fortunately – most of the pairs are not mutually exclusive. So in most cases the way forward is likely to feature some mix of both answers. But I suggest anyone involved in public engagement may find it interesting to think where they stand on each one when they are planning their future work.

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Reference

1 A conference report is available at www.wellcome.ac.uk/node5250.html.

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ENGAGING SCIENCE: Thoughts, deeds, analysis and action

The existence of 'Tom Telescope', a character explaining Newtonian mechanics to the masses in the 18th century, is testimony to the enduring nature of public interest in science. Yet the nature of the discourse between science and the rest of society has changed radically over the past few decades. While *A Brief History of Time* may have emulated Tom Telescope's success, interactions between the public and science have become increasingly complex.

So what is the relationship between science and the diverse range of individuals and groups that constitute the public? What do we know of public attitudes to science, how they are shaped, and how well the public has been served by public engagement over the past decade? Do we know what 'works', and how best to deliver information or to consult?

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