Communicating Science: Contexts and Channels

Reader 2

Edited by
Eileen Scanlon, Elizabeth Whitelegg
and Simeon Yates

ROUTLEDGE

The Open University

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Preface

This reader is a collection of articles dealing with the communication between scientists and the public – one of two readers which form the key part of the readings in the course. The other reader deals with communication between scientists and between scientists and other professionals.

These two volumes of readings form a small part of the Master's module on *Communicating Science* which is part of a Master's course in Science being produced by the Science Faculty of the Open University. It is being studied by students aiming for a qualification in the Studies of Science, but it also acts as a subsidiary course for students aiming for a Master's degree in the Frontiers of Medical Science. The course aims to help students to develop skills in communicating scientific ideas to a variety of audiences, to develop skills in the study of communication, and to consider ways in which the contemporary mass media influence the communication of scientific information and understanding. Study materials provided by the University also include a study commentary, set texts and a CD-ROM, with a library of selected papers and video material produced by the BBC. Our students also have access to the Internet and receive tutorials using computer conferencing.

Some of the material in this reader is totally new, commissioned by the editors for use in our course; some has been adapted and edited from previously published papers in journals, conference proceedings or books. As a result, a range of styles have been used by the authors, which were appropriate for their original contexts, and also a range of referencing styles are in use in the volume; students of our course may notice that they do not all conform to our course referencing style.

The first part of this reader includes material on what the public needs to know about science and why. It includes some discussion of case studies of the public use of scientific information. The second part looks at the variety of ways in which scientific ideas are communicated to the public, either in formal education or by informal means. The informal sources of scientific knowledge include popular science books, science fiction, and museums and science centres. Chapters include discussion of the role of museum visits in promoting scientific literacy, analysis of museum special exhibits and visitor behaviour, new trends in communicating science in museums, and a discussion of science on television. Science writing for the public is also discussed.

To communicate science it is necessary to have an idea about what people think science is and how it works, and also how the mass media work, and how they represent science. Therefore the third part of this reader includes material on the relationship between scientists and the media and covers representations of science (as an activity) in the media and representations of scientific issues or controversies in the media. For example, we include an empirical investigation of the coverage of the 'Life on Mars' story that occurred in the summer of 1996, and a discussion of media coverage of food scares.

This is a book that encourages scientists to consider these issues but is also suitable for students in the area of science policy, media and communications courses.

The editors would like to thank the other members of the course team for their help in selecting the articles. Opinions expressed in the articles are not necessarily those of the course team or of the Open University.

The editors also wish to thank the authors who produced newly commissioned material: Ben Gammon, Science Museum, London, UK; Jo Graham, Science Museum, London, UK; Jannette Griffin, University of Technology, Sydney, Australia; Jon Turney, University College London, UK; Russell Stannard, Open University, UK; Robert Lambourne, Open University, UK; David Miller, University of Stirling, UK; Richard Holliman, Open University, UK.

Eileen Scanlon

Part I

What the public needs to know and why

Introduction

Eileen Scanlon

The first part of this reader includes material which investigates what the public needs to know about science and why. The first paper, by Brian Wynne, reviews relationships between members of the public and science, 'that diverse body of institutions, knowledges and disciplinary scientists' in local settings and reviews a number of ongoing research projects. It also argues against a simplistic view of the public understanding of science and moving towards locating issues of the public understanding of science within a specific practical social context. It highlights the importance of moving away from large-scale samples and standardized questions to participant observation and in-depth interviews. The projects covered include hill farmers in Cumbria after the Chernobyl crisis and the public involved in familial hypercholesterolemia.

The second paper, by Alan Irwin, discusses the relationship between science, technical knowledge and the wider population, critiquing the notion that 'the future belongs to science and those who are friends with science' and reviewing past and current pressures on scientists to communicate with the public in terms of a number of case studies.

Chapter 1

Knowledges in context*

B. Wynne

Our projects begin by exploring the relationships between 'citizens' and 'sources' – between members and groups of the public and that diverse body of institutions, knowledges and disciplinary specialists that we term *science*. We ask questions such as: What do people mean by science? Where do they turn for scientific information and advice? What motivates them to do so? How do they relate this information or advice to everyday experience and to other forms of knowledge? We focus on the diverse encounters with science and expertise that typify everyday experience, a central analytical issue being the construction of authority.

Some important prior points must be emphasized:

1 Although our *empirical* focus has usually been *local* settings, the common patterns emerging from our findings – and indeed their consistency with those of the group studying formal communication settings[1] – indicate their more *universal* significance and validity, both conceptually and in terms of practical policy implications. The projects were set up and planned separately from one another, making their convergence over findings all the more striking.

2 The findings distilled here for policy consideration are only part of a further range of conceptual issues investigated in these projects. Some of these investigations have produced surprises and falsified initial hypotheses, which we will follow up in forthcoming publications.

3 Just like other social institutions, policy institutions tend to take themselves for granted and recognize 'relevant' or 'feasible' policy proposals only if they fit within the 'natural' framework of existing institutional structures. Our research indicates that the current institutional structures within which science is organized and projected may be part of the problem in public understanding and uptake of science. We feel it is therefore necessary to develop a wider *conceptual* framework clarifying the integration of what are defined as natural knowledges and natural institutional frameworks. Only

*Previously published in *Science, Technology, & Human Values* (1991) Vol. 16, No. 1, pp. 111–21.

with such a conceptual basis can we understand the full dimensions of public uptake and lack of uptake of science. It is only from such a conceptual basis that constructive development and redesign of institutional structures concerning science and policy can take place in a measured and self-aware way, rather than as *ad hoc* piecemeal and blind reaction to political forces and events. The full conceptual structure of this more complex policy-oriented output cannot be articulated here, though we hope the grounds for it can be recognized in this outline of our research findings.

4 As a corollary to the previous observation, we should note as an object of curiosity the science-centered basis of the whole research program on the public understanding of science. In this, it reflects a wider belief in scientific and policy circles that this is *naturally* how the world is. The assumption appears natural that science is unitary and coherent, and that it should be central to everyday beliefs and practices. This allows us not only to measure how far people fall short of some level of scientific understanding – that is, their 'ignorance' – but also to assume that such ignorance indicates a deficit of democratic capability.

In sharp contrast with this common perspective, our research begins from the now everyday insight in sociology of science that there is no clear consensus even among scientists themselves as to what is 'science' or 'scientific knowledge' in any specific context. This question should not be ignored in our enthusiasm to explore people's attitudes toward or understanding of 'it', as if it is unproblematic. We wish to stress, therefore, that studying the public understanding of science requires us to devote equal attention to the various ways in which scientists themselves understand, interpret and represent 'science'. Otherwise, we tacitly consolidate the false view that all the problems have to do with the public's understandings rather than also with scientists and scientific institutions.

In light of this, it should not be surprising, and the fact should not be obscured, that 'science' means different things to different people in different situations. Science is an icon of modern society, and such a pervasive one that asking questions about it phrased in abstract and general terms is not likely to elicit the same responses as would specific encounters with specific bits of science. Thus we should not be puzzled by the ordinary fact that 'science' (in general) enjoys high public esteem and interest in surveys yet suffers apathy and worse in many *specific* encounters. The problem here is not so much public inconsistency but lack of analytical control of what is meant by 'science' in general, and simplistic over-interpretation of large-scale surveys. We return to this point later, in our discussion of methodology.

While maintaining a critical perspective on the meaning and representation of science as part and parcel of the proper public understanding of science research agenda, it is also worth emphasizing the dangers of over-generalization about 'the public' and its levels of understanding/ignorance. Once we move outside a simple 'cognitive deficit' model of the public understanding of science, we become increasingly aware of the range and variety of possible interactions between people's existing understandings of particular situations and those that emanate from science. In order to pursue this, our research has attempted to locate issues of the public understanding of science within specific practical social contexts. Examples include a study of those who have inherited a gene that raises blood cholesterol levels (familial hypercholesterolemia), an investigation into two communities living close to hazardous industry, and an analysis of the role played by scientists in environmental organizations.

These contextual studies do not merely add color or interesting embellishments to the data derived from national quiz-type surveys, but they represent in themselves a point of entry to the real-world encounters within which scientific knowledge is reconstructed to make it fit real situations in all their rich complexity (or rejected if it cannot). Understanding this general process of contextualization is crucial to understanding the social authority (or lack of authority) of science.

Our research has used small-scale and interpretive approaches rather than large-scale samples and standardized questions. The main methods of obtaining data have been participant observation, longitudinal panel interviews, structured in-depth interviews, and some local use of questionnaires on specific issues. In this way, we have attempted to form a picture of the conflicting accounts and interpretations available to specific publics, and to the individual and collective negotiation of everyday practical meanings.

An example of the difficulty of measuring understanding in a standardized way arose from the Bradford project on familial hypercholesterolemia. The standard question, used in a national public understanding of science survey, asked whether eating a lot of animal fats can *contribute* to heart disease. The public involved with familial hypercholesterolemia operates with a more sophisticated distinction of saturated, mono- and polyunsaturated fats. Thus the binary animal/nonanimal-fat distinction was insufficient for this part of the public. The *qualitative* and *interpretive* approaches thus allow insights that are excluded by standardized questions and analytical methods, especially concerning the complexities of beliefs, understandings and responses.

Findings

One of the projects discussed here (at Bristol Polytechnic) has tackled issues of 'science' and its multiple representations as a central focus of investigation. The findings correspond strongly with those of other projects, in which these issues have been approached less directly. Differing – sometimes contradictory – accounts of science are expressed by the experts themselves. No unified concept of science emerged from a series of interviews with scientists, research managers, research council officials and environmentalists. Instead, a series of 'scientific understandings of science' seem to coexist within groups engaged in scientific research. What is more, these different models of science may be associated with specific social roles and positions in institutional networks. A similar picture of diverse models of science among those who were claiming to communicate science was found in all our projects. Thus, for example, our research on scientists' involvement in legal settings in environmental conflicts demonstrates disagreement not only about 'facts' and interpretations but also about what is 'proper' science. This is consistent with broader sociology of science research.

The research from our group shows that people do not use, assimilate or experience science separate from other elements of knowledge, judgment or advice. Rarely, if at all, does a practical situation not need ***supplementary knowledge*** in order to make scientific understanding valid and useful in that context. This supplementary knowledge may be highly specialist and 'expert', even if it is not recognized widely as such.

Thus a sheep farmer may understand that radio-caesium is flushed from lambs more quickly on improved valley grass than on the high fells. But he may also know what the scientist does not – that valley grass is a precious and fragile resource whose loss by intensive grazing can have damaging consequences for future breeding cycles. The scientific account is valuable, but the situation requires more than scientific understanding. Other kinds of judgment are needed – including an assessment of the uncertainties involved and of the previous accuracy of scientific accounts. In cases such as familial hypercholesterolemia, patients over time acquire knowledge about their condition that may be less generally authoritative but more specifically accurate than that held by their physician. Communities close to hazardous installations will similarly compile information and understanding about pollution within which technical data will play only one small part. In all these cases (and others), the public understanding of science represents an ***interactive*** process between lay people and technical experts rather than a narrowly didactic or one-way transmission of information packages.

The extent to which the public is collectively organized, or individualized (as in many medical situations), is an important social variable, we find. Organization allows more comparison of experiences and expert accounts, more accumulation of alternative perspectives and questions, and more confidence to negotiate with or challenge imposed frameworks.

One obvious practical implication is that scientific and policy institutions that want to integrate science into lay public lives must be organized so as to understand and relate to public agendas and knowledges better, rather than appear to wish to impose a scientific (which often means standardized) framework of understanding as if that on its own were adequate.

It is also important to recognize that people judge whether or not they can use or ***trust*** expert knowledge partly by measuring it against elements of their own already-tested knowledge and direct experience. For example, predictions based on average figures for environmental contamination may not be credible to farmers who know in detail the variability of their own micro-environment;

medical advice based upon standard metabolisms or dietary habits may be treated with very great skepticism by people who are well aware of their own or others' variability. In the Lake District post-Chernobyl crisis, many hill farmers reasoned that at least a large proportion of the contamination must be from Sellafield when they saw from Ministry of Agriculture, Fisheries and Food maps a persistent 'crescent' of high contamination near the Sellafield plant. The scientific statement that Sellafield and Chernobyl contamination could be clearly distinguished by the typical Cs-137/Cs-134 isotope ratio was questioned by referring to the scientists' earlier mistake over Cs mobility in acid mountain soils and to unacknowledged uncertainties that the farmers had seen for themselves lay behind public scientific statements about environmental contamination. So (they reasoned) perhaps similar unrecognized uncertainties pervaded the so-called clear Sellafield–Chernobyl Cs isotope distinction.

The supplementary knowledge needed in order to contextualize science embodies not only extra, perhaps situation-specific, physical knowledge (say about a local environment, a particular occupation or hobby, or a personal illness); it also involves institutional or *social* knowledge or judgment. Thus, for example, people never experience scientific knowledge of genetics relating to familial hypercholesterolemia as pure knowledge. They experience it indirectly, as part of their concrete experience of and position in particular institutional processes. Thus it comes clothed in social and institutional forms and cannot easily be divorced from those associated social prescriptions, interests or orientations. It is normal (and rational) for people to respond not to scientific knowledge *per se* but to the whole complex of knowledge plus its particular social 'body language' – the interests people think lie within it, the social values and relationships it is thought to imply, and so on. These may not be deliberately chosen by scientists but may nevertheless be structured into the knowledge, for example via the questions it emphasizes, the degree of standardization it imposes, or the extent to which uncertainties are withheld (even for the best of reasons).

While – from an outsider's perspective – science and technical information are central to everyday life, the closer one gets to everyday discussion of apparently technical issues such as those examined in these projects, the more science seems to 'disappear'. This is not to deny the importance of science in such contexts but to note the extent (and variety) to which it needs translation, or 'reframing'. However, it is also clear that even in areas where technical assessment might be of value (e.g., in seeking action to reduce the hazards of local industry), there is often a sharp contrast between the high salience of the issues and the small number of information requests actually made. Once again, other considerations are likely to be seen as more significant than science – particularly that of which institutions are both trustworthy and competent. In research on the public understanding of radiation hazards, we were surprised to discover that Sellafield apprentices knew little about basic radioactive processes, such as the different properties of alpha, beta and gamma radiation. More significantly, however, they did not feel the need to know. We eventually realized that this was an entirely functional response, in that all this scientific understanding had already been encapsulated by various scientific experts within the design of the plant and its operating procedures; that is, into ***organizational*** norms and relationships. The workers simply learned the organizational procedures, not the science (which could have made life more difficult for them), and they placed their confidence in the institution. (Scientists themselves also do this to an extent not adequately recognized in the public domain.)

Thus the main insight here is that public uptake (or not) of science is not based upon ***intellectual capability*** as much as social-institutional factors having to do with social access, trust and negotiation as opposed to imposed authority. When these motivational factors are positive, people show a remarkable capability to assimilate and use science or other knowledge derived (***inter alia***) from science.

People may appear to be unresponsive or incapable of digesting scientific knowledge (which experts consider to be important to them) when they are rejecting the scientists' agenda. Our research shows that public nonreceptivity to scientific information is often based on judgment that it is not ***useful*** or does not match public or personal experience. Thus advice and emergency-procedure information to people living around chemical plants may well be ignored in a manner that appears quite irrational. However, when the reasoning behind information is not made plain (often because of concern about 'alarming' the public); when it contradicts local experience (reassurances about safety when incidents have previously occurred); when it is conveyed in unreasonably categorical terms (e.g., concerning the precise course of the envisaged emergency); or when it seems to deny accepted social norms (staying indoors rather than seeking out children who are elsewhere), it may be a fine balance whether to ignore the information or follow its rules slavishly as an imposed, inflexible authority.

As a related example, hill farmers in Cumbria refused offers to undergo whole-body radioactivity scans on the grounds that they could do nothing but worry if they discovered high levels. At the same time, their requests for water analysis were ignored, although the supplies could actually have been changed. Thus, from this group's perspective, useless knowledge was offered, while useful knowledge was denied. In the familial hypercholesterolemia case, we found food labeling often offered unhelpful information, such as 'vegetable fat' with no indication of saturation or cholesterol content. Such experiences have a wider negative effect on the credibility of scientific institutions. They point out the need for sensitivity and the ability to listen when devising and communicating not only scientific information but scientific research agendas. This is a matter of the institutional organization of science, not only of individual scientific attitudes.

A more positive corollary of this argument about 'useful knowledge' and the institutional dimensions of access and motivation (at least for a scientific audience) is that when people do see a personal or practical use for scientific understanding and are sufficiently motivated, they often show a remarkable capability to learn and to find relevant sources of scientific knowledge. This is true of medical self-help organizations (for example, in the area of AIDS/HIV), but also of birdwatchers, amateur astronomers and many other groups.

An important discovery from our research has been the enormous amount of sheer *effort* needed for members of the public to monitor sources of scientific information, judge between them, keep up with shifting scientific understandings, distinguish consensus from isolated scientific opinion, and decide how expert knowledge needs qualifying for use in *their* particular situation. They must also judge what level of knowledge is *good enough* for them. This is not necessarily the same level as scientists have assumed; the threshold may be looser, or tighter.

All this public understanding of science is extremely demanding, and unless the motivation is very high, as it is, for instance, with the example of familial hypercholesterolemia, it may well be reasonable for lay people to decide not to be drawn into this open-ended and socially uncertain activism and to opt instead for 'apathy' or a seemingly uncritical trust in a particular source of advice, even if it is partial in some way. The judgment whether or not to show an interest in science is therefore a social one, tied to judgments of one's own power (or powerlessness) to act in one's social environment.

We have found that those who do have or develop the motivation often show great alacrity in seeking out sources and assimilating science. Situations can then arise where these informal expertises confound formal scientific authorities, and local (possibly idiosyncratic) knowledges come into conflict with the generalized claims of more remote technical specialists. We have found frequent examples of this kind from the environmental and medical fields, for example when scientists performed experiments on grazing sheep on contaminated vegetation at stocking levels that farmers immediately realized (correctly, as the scientists discovered) would 'waste' the sheep. Often, also, amateur ornithologists' knowledge about birds' habits may be critical in challenging more general expertise at public inquiries.

The ease with which people can acquire scientific (and para-scientific) competence if sufficiently motivated has implications for the institutional arrangements that serve at present to either encourage or inhibit the growth of public understanding. Are we doing enough at present to increase 'access' to information sources and the motivation to use them?

All of this indicates that, in general, practical policy should be less concerned with feeding people a controlled, 'single correct' scientific understanding and more concerned with providing flexible social access to diverse sources of scientific information. Scientists or policy makers alone cannot prescribe, for example, the degree of scientific uncertainty that people need or how they fit information with other legitimate perspectives and agendas. To enhance public capacity and uptake of science, diverse and accessible sources need to be developed, ones that emphasize advice, negotiation and support rather than control of people's interpretations.

It must also be recognized as part of science 'disappearing' that individuals exhibit a number of ways of 'bracketing off' science from themselves; these may have positive, negative or neutral evaluative connotations and may depend upon perceived power structures and one's own degree of powerlessness within these. There may be a kind of collaborative division of labor, as with the Sellafield apprentices or the majority of interviewees among those having home radon surveys. (To paraphrase them: 'We are helping the scientists, so we don't need to know about what is going on scientifically'.) Or there may be a more clearly defensive social stance, brought about by people's assessment of the institutional interests behind particular scientific statements or by personal experience. Thus skepticism about a company's pollution record will also be applied to any scientific advice that is offered. ('Well, they would say that, wouldn't they?')

Quite commonly, negative attitudes toward science may have developed at school (often linked to identification as an 'educational failure', after which explicitly scientific questions can be met with a strongly emotional and extremely anxious response). The general point here is that these often unseen structures of bracketing and coping are an integral part of the processes of contextualizing science, and of positioning oneself or one's group socially with respect to its institutions. In many cases, they represent solid structural obstacles to the public dissemination of science. Ignorance about science is far more than just a vacuum. It may, as it were, be actively constructed and maintained. These unseen structures need to be understood in their own terms and responded to at that level if an adequate basis for future policy making is to be established.

General conclusions

We have already emphasized the importance of the point that in everyday life people have to interpret and negotiate scientific knowledge in conjunction with other forms of knowledge. We have also stressed the fact that science is itself far from unproblematic but is instead often partial, temporally contingent, conflicting and uncertain to a degree that public statements rarely acknowledge. In these circumstances, people will quite reasonably survey and evaluate many potential sources of advice and assistance. Thus they may well consult sources that they nevertheless regard with some caution; in the Manchester study around hazardous installations, local industry figured prominently as a source of information – yet it was also considered to be by far the least trustworthy.

Scientific communication is normally ignorant of its own tacit 'body languages' of institutional interests, which nevertheless constitute an essential part of people's interpretations of and response to that knowledge. Of course, this lack of self-awareness of the institutional context itself conveys a tacit message to audiences and may encourage a search for alternative sources of advice.

We have created a distinction in our research between three levels of public understanding of science: its intellectual contents, its research methods, and its organizational forms of ownership and control. All of these are necessary in some degree for a rounded public ability to use and act maturely in relation to science and technology. However, the third level may be as important as the first. Indeed, given that, as we have found, the social basis of trust and credibility is a crucial (yet largely neglected) question affecting public uptake of science, neglect of any public discussion of the third factor undermines attempts to improve the other two. One could say that what is often treated as public *mis*understanding of science (in the first sense) may actually be public understanding of science (in the third sense).

It is also necessary to stress that ordinary social life, which often takes contingency and uncertainty as normal and adaptation to uncontrolled factors as a routine necessity, is in fundamental tension with the basic culture of science, which is premised on assumptions of manipulability and control. It follows that scientific sources of advice may tend generally to compare unfavorably with informal sources in terms of flexibility and responsiveness to people's needs. Thus, while science may be judged highly in terms of competence and general credibility, it can appear somewhat low in terms of immediate relevance, *specific* applicability, accessibility and comprehensibility.

Even in apparently 'science-intensive' domains, lay understanding or misunderstanding of science seen as a cognitive issue is not the central point. The institutional forms in which scientific knowledge is clothed, and the social processes of interpretation and integration into other frameworks of knowledge and commitment, should be brought more into research and policy focus.

A general practical conclusion from this is that to advance public understanding of science we need to encourage more awareness and debate about the institutional forms in which scientific knowledge is both presented and created. Our research shows people to be astute at taking up science as a *means* (when the right social conditions prevail) but wary about its *ends* and *interests*. Thus enhancement of public uptake of science would appear to require the development of multiple institutional forms of science, with correspondingly diverse audiences, patrons, interests and objectives. This would also meet the need for more diverse, independent and context-sensitive sources of scientific information.

However, we need to be aware that the *overall* trend in the structure and control of science is currently running in the opposite direction to the one indicated here. Indeed, it is worth asking whether the current concern about the public understanding of science does not reflect a deeper anxiety about the further intensification of the centralized ownership and control of science as a private resource rather than a public good. While many commentators portray a lack of public understanding of science as an obstacle to democratic vitality, it may be that the reverse is also true: that impoverished democracy and intensifying hegemony around science is a major obstacle to the enhanced public understanding of science.

Note

1 See Silverstone, R. 'Communicating Science to the Public', *Science, Technology, & Human Values*, 16(1), 106–10.

Author's note: This article is condensed from a presentation to the conference 'Policies and Publics for Science and Technology,' London, April 1990. It summarizes early results from five projects, led by Hilary Rose and Helen Lambert (Bradford University); Steve Yearley (Belfast University); Harry Rothman, Peter Glesner, and Cameron Adams (Bristol Polytechnic); and Brian Wynne, Frances Price, John Wakeford, Mike Michael, and Ros McKechnie (Lancaster University). See also Alan Irwin and Brian Wynne (1996) *Misunderstanding Science?* Cambridge, Cambridge University Press.

Chapter 2

Science and citizenship*

A. Irwin

> Now, what I want is, Facts . . . Facts alone are wanted in life. Plant nothing else, and root out everything else. You can only form the minds of reasoning animals upon Facts: nothing else will ever be of any service to them.
>
> (Thomas Gradgrind, Esq.)[1]

> I wish I could collect all the Facts we hear so much about . . . and all the Figures, and all the people who found them out; and I wish I could put a thousand barrels of gunpowder under them, and blow them all up together!
>
> (Thomas Gradgrind, Jun.)[2]

Concern over the relationship between citizens, science and technology seems to be characteristic of contemporary society. Right now, for example, various political and social groups (industry, government, environmentalists, scientific organizations, campaigning bodies) are attempting to educate, propagandize or cajole the general public into accepting their own evaluation of a series of technical – or at least technically related – questions (over the best means of tackling environmental issues, the desirability of new consumer products, the dangers of AIDS, the merits of various energy policies and an endless array of social questions such as genetic screening, transport safety and the implementation of new technology). In that sense, we are all barraged with new 'information' about developments in science and technology that might affect our lives and also, of course, with exhortations about what different social groups would like us to do about those developments.

In such a situation, it is unsurprising that many accounts have been put forward by scientists and others which describe (or, more usually, lament) the linkage between science, technical knowledge and the wider population. At present, the topic of 'public understanding of science' – as defined by, for example, the British Royal Society – has once again focused attention on these issues.

*Chapter 1 in *Citizen Science*, Routledge (1995), pp. 9–36.

As the first section of this chapter will discuss, there have been certain recurrent elements within these more general accounts – a concern at the 'scientific ignorance' of the populace, a consequent desire to create a 'better-informed' citizenry, an enthusiasm for making science 'more accessible' (but with strict limitations on the extent of this accessibility). Notably also, and as we will discuss, these accounts have represented a commitment to 'science as progress' and offer a decidedly 'science-centred' (or 'enlightenment') view of society. Frequently, the accounts offered by scientists and others reveal an anxiety lest public ignorance should get in the way of scientific/technological progress. Thus, one senior British scientist entitles his book on this subject *Is Science Necessary?* but provides the answer – before the text even begins – by citing Nehru's exhortation that the 'future belongs to science and those who make friends with science'.[3]

As this chapter will outline, the notion that the 'future belongs to science' has underpinned most accounts of the relationship between citizens and science. However, there have also been a number of more critical accounts which draw upon the 'tragedy of technology' theme and on a notion of 'science as ideology' in order to ask starker questions about the impact of scientific dissemination on everyday life. It is also possible to portray concerns over the public understanding of science as an indicator of anxiety amongst the scientific community lest it should become marginalized in the post-Enlightenment era. This chapter will begin with a brief historical excursion into these differing accounts of the 'public understanding of science' before presenting three case studies of the contemporary interaction between citizens, science and technology.

Discussion of the role of 'ordinary citizens' in 'technical progress' extends back to the beginnings of the Industrial Revolution. In nineteenth-century Britain, for example, there was a lively debate about the general level of science education – which was seen by many as holding back industrial and technical development.[4] Just as in the late twentieth century, public indifference was viewed as an obstacle to scientific progress. Of special relevance to these themes was the establishment of institutions such as the Mechanics Institutes, which represented one attempt to build a bridge between formalized scientific knowledge and working-class people (although, as we shall see, there are differing interpretations of whether the Mechanics Institutes were an attempt to enlighten – or to indoctrinate – the working classes). The Mechanics Institute movement spread across Britain in the 1820s and 1830s and offered a training in science and technology to the skilled working classes.

In the twentieth century, the need for a greater awareness of science became a major theme of the 'visible college' of scientists and writers who adopted a socialist perspective on scientific progress.[5] As J.B.S. Haldane put it in the preface to his 1939 book, *Science and Everyday Life*:

> I am convinced that it is the duty of those scientists who have a gift for writing to make their subject intelligible to the ordinary man and woman.

> Without a much broader knowledge of science, democracy cannot be effective in an age when science affects all our lives continually.[6]

Writing immediately after the Second World War, the Association of Scientific Workers expressed similar sentiments. In so doing, it outlined the three most regular justifications – both of that time and since – for an enhanced 'public understanding':

- that a technically literate population is essential for future workforce requirements ('the present inadequate standards of the available labour').[7] This argument had also been important within nineteenth-century debates over working-class technical education;
- that science is now an essential part of our cultural understanding ('In this age no man can be considered to be cultured who makes no serious attempt to understand and appreciate the broad principles of science');[8]
- that, as Haldane argued above, greater public understanding of science is essential for democratic reasons.

The Association of Scientific Workers made various recommendations for improving public understanding through further education classes and also such media as exhibitions and museums, film, the press, and the radio. It also stressed the need for working scientists to become more involved in public activities and in the dissemination of science – a challenge to which scientists such as Haldane and Hogben had already responded through popular publications on science and mathematics.[9]

The Association of Scientific Workers thus offered a model of 'progress through science' which resonates strongly with many contemporary statements of the need for both greater public understanding and public acceptance of science: 'Science offers means to use unprecedented powers with which a finer, more beautiful and happier world than ever before can be built. With mankind using a vigorously developing science for social ends, the future can be bright and inspiring'.[10]

However, unusually for a group of scientists, the Association recognized that this new world would require scientists to adopt an explicitly *political* role in society. The Association was highly critical of those who simply stood on the sidelines of social change. Important decisions needed to be made about the social control of science and industry – it was the responsibility of every citizen to get involved. Meanwhile, science itself is 'neither good nor bad; it is organized knowledge and a method, a tool or weapon, which society can use for good or evil. It can confer the highest benefits and it can be used to destroy'.[11] Again, this notion of science as value-free has been a regular feature of scientific statements concerning the relationship between citizens and technical change.

Some forty years later, the prestigious Royal Society was to revive these debates in its 1985 report on the 'public understanding of science' – suggesting the durability of these concerns but also a perceived absence of real progress. The Royal Society took a distinctly less 'political' perspective than the Association of Scientific Workers – its recommendations emanate from a more liberal concern with the well-being of both science and society (and perhaps also from a concern that the value of scientific understanding might be neglected by society – the mid-1980s were a time of great anxiety about the future of public support for science).

Despite this difference in political perspective, the 1985 report of the Royal Society presents an argument which many members of the Association of Scientific Workers would readily have endorsed:

> better public understanding of science can be a major element in promoting national prosperity, in raising the quality of public and private decision making and in enriching the life of the individual. . . . Improving the public understanding of science is an investment in the future, not a luxury to be indulged in if and when resources allow.[12]

The report goes on to cite a number of specific areas where an 'improved understanding' would be of personal and national value:

- in terms of *national prosperity*, a better-informed citizenry could appreciate the opportunities offered by new technologies and could provide a better trained workforce;
- in terms of *economic performance*, wider scientific awareness would reduce 'hostility, or even indifference' to science and technology and so aid in the rapid innovation of such product and process changes. There would also be a 'considerable competitive advantage' if those in 'positions of responsibility' were better-informed;
- in terms of *public policy*, science and technology should be major considerations – for the Royal Society there is a strong case that these decisions would be improved by 'better understanding';
- in terms of *personal decisions*, for example regarding diet, smoking, vaccination safety – 'an uninformed public is very vulnerable to misleading ideas';
- in terms of *everyday life*, a basic scientific literacy is needed just to understand what goes on around us (e.g., how a ball-point pen or a television functions);
- in terms of *risk and uncertainty* (e.g., concerning nuclear power or seat-belt wearing), it is important that the public has a better appreciation of the nature of risks and of how to interpret and balance them: 'Once again it must be argued that better understanding fosters better public and personal decisions'.[13]
- in terms of *contemporary thought and culture*, any citizen without an

understanding of science is cut off from the richness of this important area of human enquiry and discovery.

So far, we have briefly examined two major arguments – from the Association of Scientific Workers and from the Royal Society – for greater efforts to be made by scientists and citizens in the dissemination of technical information and understanding. A typical justification for such efforts has also emerged – generally based on a mixture of economic, political, personal and cultural arguments.

Certain assumptions about the relationship between citizens, science and technology have also started to become clear – assumptions which are implicit in the very concept of the 'public understanding of science'. Such assumptions include:

- the notion of contemporary 'public ignorance' in matters of science and technology;
- the notion that a better understanding of science will lead to better 'public and personal decisions';
- the notion that science is a force for human improvement;
- an explicit or implicit notion that science is itself value-free – although there are moral and political choices to be made about its *direction*;
- the notion that the life of citizens is somehow impoverished by an exclusion from scientific thought;
- the notion that wider exposure to scientific thinking will lead to greater acceptance and support for science and technology.

Of course, there are differences between the accounts offered by these two groups of concerned scientists – with the Association of Scientific Workers offering, for example, a more 'political' programme (linked to the aspirations of the postwar Labour government). However, what the two accounts share is a fundamental belief in the centrality of scientific development to the future of society – and a belief (whether as part of a social democratic or more vaguely liberal ideology) that a better-informed citizenry can play a crucial (but essentially reactive) role in this development. The future should indeed belong to science.

There is no suggestion in the Royal Society report that the organization of science is open to change or that it should incorporate citizen views within research policy. The goal is to make the public better-informed about science but not to encourage a critical evaluation of scientific institutions. For the Royal Society and most of the contemporary apologists of science, *science* itself is not the problem – the problem is gaining public understanding and hence *acceptance* of science.

This world view can be characterized as 'science-centred' or (perhaps more accurately) 'enlightened' in its assumptions about science, technology and the wider public. This is not to suggest that all working scientists hold this world view. However, it does provide a powerful and frequently reiterated case for the centrality of scientific reasoning to social development. Within such a world view, any problematic relationship between science and citizens must be a consequence of either public ignorance or public irritationality.

A critical perspective on these issues is required and there are new developments and ways of thinking which suggest that *change* is indeed occurring. We can begin by contrasting the notions expressed so far of 'science as progress' with one account of a nineteenth-century experiment in the 'public understanding of science' – the Mechanics Institute movement as discussed by Maxine Berg and others.[14] Berg's more critical analysis of this movement sets the debates so far concerning citizens and science into a much-needed social and political context.

As already suggested, the Mechanics Institutes appear to offer an excellent example of a highly localized and responsive 'continuing education' (to use the modern jargon) for one section of the working-class community. Institutes were established across Britain and offered technical training at a time when demand seemed to be high – this demand linked, of course, to the rapid progress of industrialization. Berg's account suggests, however, a less attractive ideological purpose for this movement – essentially the institutes were not philanthropic in orientation but were instead one part of the legitimation of the emerging capitalist order. The underlying philosophy of 'self improvement' was designed to divide working-class communities by creating a 'labour aristocracy'. The basis of the movement was to evangelize the harmony between science and industry. The Institutes were largely dominated by the middle classes, whose main purpose was to create a more ordered society and to prevent social unrest. Science was, therefore, an important legitimation of the social order rather than a force for liberation or active citizenship.

The discussion of Mechanics Institutes is important here not for its specific conclusions but for the wider questions which it raises about the relationship between science and citizens. The 'enlightenment' approach – as exemplified by the Royal Society – would argue that the provision of scientific information to public groups will in itself be beneficial – if only in allowing a better appreciation of the scientific changes which are influencing society and in clarifying citizen choices. The analysis provided by Berg suggests that science can present an ideological face to citizens – so that it can be used to obstruct rather than assist understanding. In particular, the control of Mechanics Institutes by middle-class forces meant that training in science was also a propagandizing of a particular political ideology (in this case that known as 'political economy'). At this point, we could add to our discussion a number of Marxist accounts of science which generalize this point about capitalist ideology and its relationship to contemporary science.[15] Thus, for example, Marcuse has argued that: 'The industrial society which makes technology and science its own is organised for the ever more effective domination of man and nature, for the ever more effective utilization of its resources'.[16]

Marx himself expressed such notions of 'technology as domination' with particular clarity:

> Labour [is] . . . subsumed under the total process of the machinery itself, as itself only a link of the system, whose unity exists not in the living work-force, but rather in the living (active) machinery, which confronts his individual, insignificant doings as a mighty organism.[17]

Hill has developed such themes (particularly with reference to the work of Foucault) in *The Tragedy of Technology*:

> Employees generally see technology . . . as an alienated force that stands somewhere behind their left shoulder, and which, with one new breath of change, may extinguish their means of livelihood. The aesthetic is one of externally imposed order rather than human harmony; the words of knowledge are opaque, controlled by the masters of the technological system and the variety of specialists who inform them. The technological aesthetic is unreadable to the layman, but is embodied in words of knowledge that say 'you shall adjust'.[18]

Of course, the argument here is that this relationship to technology is found also ***outside*** the workplace – so that people's general experience of technology fits this pattern of 'unreadability' and 'adjustment'.

It would appear, therefore, that we have reached the point of incommensurability between those accounts of science which stress its empowering and enabling role and those – drawing broadly on a notion of science as a source of legitimation (Habermas), alienation (Marx) or disenchantment (Weber) – which stress its role as a form of social control and dehumanization. One should nevertheless be wary of splitting debate in a conventionally political fashion (the 'establishment view' versus the 'radical opposition'). Certainly, left-wing and environmental groups have been as eager to adopt a scientific mantle ('if only people knew the facts of ozone depletion, acid deposition or factory farming then they'd support us') as have the political establishment – although such groups have typically had far fewer scientific resources at their disposal. What should also be noted at this stage is that, despite the apparent incommensurability over whether science represents progress or disenchantment, all of these approaches stress the centrality of scientific rationality to the modern world. Whilst [. . .] some would argue that the modern world is being radically transformed into late (or post) modernity, the substantial influence of science over the life of citizens seems undeniable and likely to remain so.

[. . .] Rather than pursuing these themes through a general debate, we should begin to look a little closer at actual examples of the contemporary citizen–science interaction. Is there any evidence that science is being used within society as a legitimatory rather than an empowering device? Can the lack of communication between 'science and its publics' be successfully explained by public ignorance or instead by some deeper-rooted set of causes? In order to tackle this, we need to examine questions of science and technology as they occur within people's lives. As a start to this project, we can consider the lessons from three examples of the relationship between science, technology and everyday life. These examples make no claim to representativeness. They are designed simply to illustrate and explore the issues of contemporary citizen–science relations. [. . .]

Three stories of our time

2,4,5-T and the farmworkers

> We shall continue to examine any soundly based new evidence or information. For the present, this Enquiry has strengthened us in our previous view that 2,4,5-T herbicides can safely be used in the UK in the recommended way and for the recommended purposes.
>
> (Advisory Committee on Pesticides)[19]

> It is the NUAAW's conviction, distilled from the experience of thousands of members working in forests and on farms, that the conditions envisaged by members of the [advisory committee] (presumably used to the controlled conditions of the laboratory) are impossible to reproduce in the field.
>
> This single fact must be sufficient to demolish the supposition that the herbicide is safe to use.[20]

In 1980, the National Union of Agricultural and Allied Workers (NUAAW – from here on 'the farmworkers') was engaged in a highly public dispute with the British regulatory authorities over the herbicide 2,4,5-T. By that date, 2,4,5-T had already been controversial for some time because of its allegedly hazardous [effects] (chloracne, birth defects, spontaneous abortion, cancer) and also for its overall impact on the natural environment. Although the herbicide had been produced since the 1940s, perhaps its best-known application was during the Vietnam War, when it was sprayed by US aircraft as a defoliant (and thus as a means of removing ground cover). However, 2,4,5-T has also been used in a number of agricultural, industrial and domestic situations (e.g., by railway workers to keep lines clear of weeds, by forestry workers to clear undergrowth, or by members of the public keeping their gardens free of brambles and nettles).

Given international attention to the hazards of 2,4,5-T, a number of countries had at that time either banned or severely restricted the use of the herbicide, among them the United States, Canada and the then Soviet Union.

There had also been a number of national and international campaigns against 2,4,5-T – with concern being expressed particularly about the usage of this and the other 'dirty dozen'[21] pesticides in developing countries. In Britain, a number of groups had argued for the banning or strict control of 2,4,5-T.

This campaign had some success; many local authorities had by 1980 agreed to cease spraying, as also had major users such as British Rail, the National Coal Board and the electricity generators. However, the British regulatory authorities had historically been resistant to a ban on 2,4,5-T. In this section, and as an illustration of one interlinkage between citizens, science and technical decision making, we will look briefly at one episode in the history of 2,4,5-T: the confrontation between the farmworkers and the regulatory authorities (or, more precisely, their advisory body – the Advisory Committee on Pesticides (ACP)) in just one year – 1980.

Of course, there are a number of ways in which such a story could be told: as a review of the technical evidence (i.e., the 'facts' of the case), as a clash between 'expertise' and 'trade union pressure', as an example of the 'uncaring' nature of modern agro-business or of the use of science as an ideology to oppose workers' rights. For now, it is enough to look at the *kinds* of argument which the farmworkers and the ACP put forward to support their case and to consider the immediate lessons concerning the uses of 'scientific expertise' in such social and technical decision making. Most specifically, does this case suggest any disparity between 'scientific' (as represented by the advisory committee) and 'citizen' (i.e., in this case farmworker) perspectives?

In 1980, the farmworkers presented the ACP with their latest 'dossier' on the herbicide.[22] By that date, the question of the pesticide's safety had been referred to the ACP no fewer than eight times – with the committee standing firm on its contention that 2,4,5-T 'offers no hazard' to users or the general environment 'provided that the product is used as directed'. In their evidence to the ACP, the farmworkers discuss what they consider to be the 'realities' of pesticide use, they present the alternatives to the pesticide, they criticize previous ACP reports, and they offer a number of cases where health damage is allegedly linked to 2,4,5-T exposure.

These cases – which largely represented the 'new' evidence to the ACP – were drawn from a questionnaire which the NUAAW had circulated to its members through its newspaper, *Landworker*.[23] Questions in the survey covered the usage of 'weedkiller 2,4,5-T' (When did you last use a weedkiller containing 2,4,5-T? Are you ever given instructions on how to use protective gear? Are you given any information about the hazards relating to weedkillers containing 2,4,5-T?) but also sought out medical information (Have you ever had any of the following symptoms after using weedkillers containing 2,4,5-T? Do you suffer from any of the following . . . ? Have you or your partner ever had a spontaneous (unplanned) abortion or a miscarriage?). In all, forty questions were asked on a 'voluntary response' basis.

The questionnaire eventually provided a series of case studies (involving fourteen individuals) for submission to the ACP. To take a typical case, one 'victim' is described as having had 'a miscarriage in 1977 and later the same year gave birth to a daughter . . . who has a cleft palate and a hare lip.Her husband had been using 2,4,5-T when he worked for the Forestry Commission'.

This information was then presented to the ACP. The overall conclusion of the farmworkers' submission was that:

> Considering the additional evidence which has not been evaluated by the ACP, the existence of alternative weed killers and the overall lack of information about the effects on users of 2,4,5-T . . . it becomes absolutely incomprehensible that workers, their families and the general public can remain subject to the risks for one minute longer.[24]

The advisory committee's published response to this evidence appeared later in 1980 as the *Further Review of the Safety for Use in the UK of Herbicide 2,4,5-T*.[25] This review is considerably longer than the farmworker dossier – it presented, for example, a thorough review of major scientific developments since the ACP's previous report. It appraised all the evidence in some detail and included a series of appendices on topics ranging from environmental effects and operator exposure to the consideration of alternative pesticides.

As regards the specific matters raised by the farmworkers, the ACP devoted one section of its report to a consideration of the case studies put forward by the NUAAW. For each case the committee concluded that insufficient evidence existed to correlate the medical condition with 2,4,5-T – or at least that it seemed highly improbable that such a correlation could exist. In the above case of miscarriage/birth deformity, for example, the employment records of the father were first of all checked. Following this, the parents and the family doctor were interviewed in order to establish the level of exposure involved and the scale of alleged effects. The ACP's specific conclusion was:

> The type of deformity occurring in this case is common genetically. Mrs K's only possible contact with 2,4,5-T was through handling her husband's working clothes; and the likelihood of her having absorbed sufficient to have produced any toxic effect is remote in the extreme.[26]

In overall conclusion, the ACP argued forcefully that 'there are no grounds to suggest a causal relationship with the stated effects'. The argument is further elaborated during a discussion of the linkage between 2,4,5-T and miscarriage/birth deformity. The committee suggested that the farmworker cases 'neither implicate nor absolve' the pesticide:

> The reality is that some women who have been in contact with such an agent are likely to miscarry, and that some are likely to bear malformed children; but this in itself does not add up to cause and effect. Indeed,

> statistically it would be remarkable if families in contact with particular products such as 2,4,5-T were spared from these misfortunes.[27]

Not surprisingly perhaps, this scientific rationale did not serve to change the opinion of the farmworkers – and during at least one stormy meeting the two sides struggled to communicate their concerns about the issue. As the leader of the farmworkers stated after the meeting:

> We are alarmed at the approach taken by the Committee. In their eyes scientific evidence proving the hazards of a chemical has to be absolutely watertight. In our view the decision has to be made on the balance of probabilities . . . where lives are at stake a responsible body cannot wait, as was the case with asbestos, until there is a sufficiently impressive death toll.[28]

The farmworkers vowed to fight on – both to get a ban on the chemical and to change the regulatory structure for future decisions.

Mad cows and the consumers

> As the Chief Medical Officer has confirmed, British beef can continue to be eaten safely by everyone, adults and children.
>
> (John Gummer, Minister of Agriculture, Fisheries and Food)[29]

> Eating British beef is completely safe. There is no evidence of any threat to human health caused by this animal health problem [BSE].
>
> This is the view of the independent British and European scientists and not just the meat industry.
>
> This view has been endorsed by the Department of Health.[30]
>
> (Advertisement placed by the Meat and Livestock Commission)

> Scientists do not automatically command public trust.
>
> (House of Commons Agriculture Select Committee)[31]

In 1990, one technical issue held an especially prominent place in the British mass media: do cows make you mad? The Ministry of Agriculture, Fisheries and Food (MAFF) – and especially its minister, John Gummer – was under widespread attack for its handling of the issue. The meat industry was greatly concerned at the impact of the scare on meat sales. Consumer groups such as the Consumers' Association and Parents for Safe Food registered their low confidence in both the meat industry and MAFF. British newspapers featured photographs of Gummer feeding a beefburger to his daughter – apparently in an attempt to reassure the public. Various scientific groups stated their concern over the issue – Professor Richard Lacey was quoted as fearing that 'a whole generation would be lost' if the worst anxieties over BSE (bovine spongiform encephalopathy) came true. Other scientific figures dismissed 'public hysteria' over the issue. Professor Sir Richard Southwood claimed that 'we have more reason to be concerned about being struck by lightning than catching BSE from eating beef and other products from cattle'.[32]

Quite clearly, therefore, the 'mad cow' issue represented a major public controversy. BSE is a fatal disease which causes degeneration of the brain. It develops over several years and infected cattle, mostly dairy cows, show no symptoms until the final weeks, when they become nervous and uncoordinated. The first case of BSE was reported in Britain in 1985 – by April 1990, 290 cases a week were being confirmed. The issue that exercised the public was, of course, whether BSE – or 'mad cow disease' as it became more dramatically known – could be a threat to the human population.

As with 2,4,5-T, there are a number of ways in which this story can be told (and, indeed, already has been told) – as a struggle between scientists armed with 'the facts' and an irrational group of citizens (in this case, not farmworkers but consumers), as an example of industrial corruption of both regulatory authorities and scientists, as a use of scientific authority to legitimize an exploitative and inherently dangerous mode of food production. However, as with the 2,4,5-T story, it is instructive to look at the broad characteristics of the arguments made by both sides.

If we take those consumer and allied groups which were most critical of government action and the activities of the meat industry, then a number of features of their argument can be identified. First of all, critical groups tended to highlight certain meat industry practices – particularly the feeding of offal to animals. Second, critical groups took the line of emphasizing the uncertainties concerning BSE transmission – so that, for example, when a Siamese cat developed BSE in 1990 this was seized upon as yet more evidence that the disease could travel across species boundaries. Third, these groups could take advantage of the divided scientific opinion over the issue; Professor Lacey became a particularly public figure on this basis. Accordingly, oppositional groups could make it clear that there was no scientific consensus. Fourth, consumer groups found it relatively easy to capitalize on the inconsistencies and weaknesses in MAFF's handling of the debate. As one report put it: 'Knowledge of BSE is as full of holes as an infected cow's brain . . . while the science of BSE is arguable, much more is known about the handling of crisis to contain risk, limit damage and maintain public confidence'.[33]

However, this report argued that the government had succeeded in breaking every rule of public relations. Between them, MAFF and its minister had:

- failed to err on the side of caution;
- acted slowly at every stage;
- attempted to score debating points rather than enlisting support (Gummer, for example, was widely quoted as labelling vegetarians 'wholly unnatural');

ROUTLEDGE

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