CHAPTER ONE

A Guide to Science Communication

One can hardly believe that modern science is almost included within the present century. All before then, except astronomy, was more or less speculation. Scientists had only been playing, like children, in the vestibule of the great Temple. It may be that we ourselves have not advanced far within the precincts at least, those who study these subjects 100 years hence may think so.

—Dr J.E. Taylor (*The Playtime Naturalist*, 1889)

1.1 Introduction

The issue of science communication has risen globally in its importance in recent years, not least due to a belief that science and technology are the basis of a knowledge economy. Science and technology are an integral part of our culture and heavily influence our everyday lives. The knowledge and applications produced from science are powerful and exciting and it's reasonable to suggest that the public should know about these new advances because of the questions they raise for our society. Public money also pays for a substantial amount of research undertaken in many universities and government institutes, although we must also acknowledge that the ratio of private to public funding for scientific research and development has dramatically increased over the past 50 years (OECD, 2004). However, regardless of how research is funded, its impacts must be communicated to citizens, even if the strategies used and the motivations are different for research and development funded by private as opposed to public money (Bauer, 2010).

Communication by scientists to the public is not a new phenomenon. Even before the term scientist was first used (not coined until 1834; Hannam, 2011), Humphrey Davy and Michael Faraday were engaged in the popularisation of science and Joseph Priestly was even encouraging active science experimentation by the public (Broks, 2006). Twenty-first century examples of talented communicators include among others, the physicist Brian Cox and anatomist Alice Roberts, whose enthusiasm for and knowledge about their own subject and science in general has underpinned their willingness to communicate with the public.

Science Communication: A Practical Guide for Scientists, First Edition. Laura Bowater and Kay Yeoman.

1.2 The influence of science societies, charities and organisations

1.2.1 Science societies

Science communication in the UK has been shaped by historical institutions such as the Royal Society, as they have commissioned influential reports that have described the relationship between science and society. The committees producing these reports have often been chaired by eminent and respected scientists and the reports have affected the way that science has been communicated to the public within the UK and across the world. The Royal Society was one of the first science societies to be established and has been in continuous existence for the longest. It was founded in 1660 by a group of well known individuals that included Robert Boyle, Robert Hooke and Christopher Wren. The Royal Society was granted a royal charter by Charles II in 1662 and the society maintained itself with dues from its members (McClellan and Dorn, 2006). The French established the Academie des Sciences in 1663, but it differed from the Royal Society in one key aspect, it was a government institution, with patronage from Louis XIV (Gribbin, 2002). Other countries also saw the value of a science society and by the end of the eighteenth century there were approximately 200 societies across Europe and North America (Fara, 2009). The Royal Society was not established to facilitate communication to a public audience, but it did begin the concept of the 'scientific paper' with the publication of the *Philosophical Transactions of the Royal Society* from 1666, enabling communication between individuals interested in science. This was published by Henry Oldenburg, first secretary to the Royal Society from his own private funds (Gribbin, 2002). Since then the phenomenon of the scientific paper has grown in importance. It can be equated to the 'unit of productivity' of science (McClellan and Dorn, 2006) and it forms a substantial part of the criteria used to judge scientists in the twenty-first century. This is epitomised by the 'scientific paper' being used as a major criteria within the UK's Research Excellence Framework (previously Research Assessment Exercise); a process used to judge research output from universities in order to determine the level of block governmental research funding (HEFCE, 2011).

Over a hundred years after the establishment of the Royal Society, the Royal Institution (RI) was founded in 1779 as a research laboratory. It also had a role in public education, specifically to educate young workmen (RIGB, 2011). The RI was intended to be different from the Royal Society; the science was meant to be sustainable, although in reality its activities were maintained by annual subscriptions. One of the original goals of the RI was to try to apply the latest scientific techniques to improve agricultural practices and reduce the level of poverty (Berman, 1978). This philanthropic goal was soon superseded by the use of science for entrepreneurial and professional purposes to improve and advance society (Berman, 1978; Broks, 2006). Notable scientific advances by the RI include the discovery of new elements calcium, magnesium, boron and barium by Humphrey Davy, confirmation of the structure of benzene in 1925 by Kathleen Lonsdale and the structure of the enzyme lysozyme in

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1965 by David Phillips. The RI also popularised science and developed the public demonstration lectures first started by Humphrey Davy in 1802. Skilled workers would attend these lectures to gain knowledge they could use to advance their careers. The format of these demonstration lectures still exists today; the RI Christmas Lectures, first started by Michael Faraday in 1825, polled 0.86 million viewers when aired on BBC 4 in 2011 (Barb, 2011). These modern lectures have covered a wide range of scientific disciplines, and have been delivered by experts in their field.

Throughout the eighteenth and nineteenth centuries, subject-specific societies began to emerge in England, notably including:

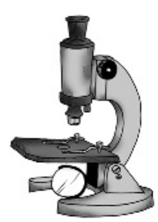
- The Linnaean Society (1788);
- The Geological Society of London (1807);
- The Zoological Society of London (1826);
- The Royal Astronomical Society (1831);
- The Chemical Society of London (1841).

These societies began to publish their own subject-specific journals. The process of peer review materialised as one of the secretaries of the Geological Society, a certain Charles Darwin, developed a system of sending papers out for scrutiny prior to publication. This process is now standard practice among academic journals across all disciplines. Science became a common amateur pursuit in the nineteenth century and in America it became common for even small towns to have a 'science society'. Similarly in the UK, towns and cities were also hubs of amateur scientific activity. Case study 1.1 'The Playtime Naturalist', highlights such a society and pays tribute to its founder Dr John Ellor Taylor.

Case Study 1.1

The Playtime Naturalist

Kay Yeoman



By knowledge, by humour, by rare and excellent gifts of speech, he opened the eyes of many to the order, variety and beauty of nature.

—Memorial to Dr J.E. Taylor

While doing some reading on the history of science, I came across a reference to a British Science Association meeting held in Norwich in 1868. At this time, the president of the British Science Association was Joseph Hooker, the first Darwin supporter to hold this post.

The Darwinians minus Darwin assembled at Norwich for the Association jamboree. From far and wide they came, a rallying call of evolutionary pilgrims of every persuasion.

—Desmond and Moore (1991)

At that meeting, Thomas Huxley, staunch Darwin supporter, gave an address at the Norwich Drill Hall to a group of working men. The lecture was entitled 'On a Piece of Chalk' and described what could be learnt about the geological history of the Earth and the passage of time by examining not only the structure of the chalk, but also the fossil remains of plants and animals that lay within it. The lecture provided a vivid description of animal and plant life at Cromer on the Norfolk coast.

Thus there is a writing upon the wall of cliffs at Cromer, and whoso runs may read it. It tells us, with an authority which cannot be impeached, that the ancient sea bed of the chalk sea was raised up, and remained dry land, until it was covered with forest, stocked with the great game the spoils of which have rejoiced your geologists. How long it remained in that condition cannot be said; but, "the whirligig of time brought its revenges" in those days as in these. That dry land, with the bones and teeth of generations of long-lived elephants, hidden away among the gnarled roots and dry leaves of its ancient trees, sank gradually to the bottom of the icy sea, which covered it with huge masses of drift and boulder clay. Sea-beasts, such as the walrus now restricted to the extreme north, paddled about where birds had twittered among the topmost twigs of the fir-trees. How long this state of things endured we know not, but at length it came to an end. The upheaved glacial mud hardened into the soil of modern Norfolk. Forests grew once more, the wolf and the beaver replaced the reindeer and the elephant; and at length what we call the history of England dawned.

Joseph Hooker the president of the British Science Association had strong links to Norwich; his grandfather was a Norwich merchant and his father, Sir William Jackson Hooker, was born in Norwich in 1785. His father was a keen botanist who began the herbarium which eventually became the herbarium at Kew Gardens. This local link to these eminent past scientists caught my imagination and being interested in people, history and science, I began to delve into the science of Victorian Norwich. I was delighted to find several references to the 'Norwich Science Gossip Club', the records for which still exist today. With a mounting level of excitement (equal to unveiling a perfect Southern blot) I set off for Norfolk County Hall and asked to view the records of the Science Gossip Club. I was astonished to find a beautifully kept set of records detailing the activity of the club that started in 1870 and ended just after the Second World War. While reading and making notes on these records, I found a connection to a man, for whom I developed an enormous admiration, Dr John Ellor Taylor, naturalist, founder of both the Norwich and Ipswich Science Gossip Clubs, editor of the *Science Gossip Magazine*, prolific author, curator of Ipswich Museum and consummate science communicator.

J.E. Taylor was the son of a Lancashire cotton-factory foreman; he had a rudimentary education, but he was motivated and he learnt through private study. He was employed in the railway works at Crewe, but he attended evening classes at the Manchester Mechanics Institute. He became fascinated with geology and published his first work *Geological Essays* in which he described the geology of Manchester. He secured a position as a subeditor at the *Norwich Mercury* in 1863 and he devoted his leisure time to science and in 1864 he co-founded the Norwich Geological Society with John Gunn. I know he attended the 1868 British Science Association meeting in Norwich, as his name appears on a list of contributors (records kept at the Dana Centre in London). As well as being a talented scientist, J.E. Taylor was a natural communicator and gave many popular lectures. He published many books and one of them, *The Playtime Naturalist*, describes a fictional natural history club for boys at Mugby School. It's a beautifully illustrated book, full of hints and tips about collecting and classifying plant and animal species, all intended for a lay audience.

Taylor founded the Norwich Science Gossip Club in 1870 with the following objective:

The object of this society is the promotion among its members of a spirit of enquiry and investigation of scientific and literary knowledge by means of fortnightly papers on such subjects, and occasional excursions for open air study.

In my mind this objective is full of ideas surrounding self-improvement, at which Taylor himself was a master. Many members of the Gossip Club were listed in the records. Using the 1871 census I established that they came from a variety of different professions. The members

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presented papers, discussed new ideas and displayed specimens. Mr Manning P. Squirrell, a corn merchant gave a talk entitled 'Gleanings about Ostriches and Elephants' and Mr Thomas Bayfield, an ironmonger addressed the club on the subject of the *Lamellibranchiates*. In one particular meeting, Mr C.W Ewing displayed the fossilised remains of a tortoise (*Emyslutaria*) he had found at Mundesley, on the Norfolk coast. This specimen was later described by Dr E.T. Newton in the *Geological Magazine* of 1897. You can still see the specimen on display at Cromer Museum.

Taylor became curator of the Ipswich Museum in 1872, only nine years after his arrival in Norfolk, and he also took over the editorship of Hardwicke's *Science Gossip Magazine*. The previous editor and founder had been Mordecai Cubitt Cooke, one of Britain's first mycologists, also from Norfolk. J.E. Taylor was an immensely curious man, but at times this led him into trouble. He contracted smallpox whilst investigating a severe outbreak of the disease in Norwich and he was scarred for life. A contemporary of Charles Darwin, he greatly admired Darwin's work and on the 25th June 1878 wrote a letter to him presenting him with a copy of one of his books, *Flowers, their Origins, Shapes, Perfumes and Colours*.

> *Dear Sir,*
> *I have taken the liberty of forwarding to you for your acceptance a copy of my new book on "Flowers, their Origins, Shapes, Perfumes and Colours" in which I have freely referred to your various invaluable books. Please accept the volume as a sincere and humble tribute of respects from one of your most ardent students I have the honour to be, dear Sir,*
> *Yours sincerely*
> *J.E. Taylor*
>
> —Letter from John Ellor Taylor to Charles Darwin 1878. By permission of the Syndics of Cambridge University Library

Like Darwin, Taylor was a brilliant observer and a meticulous keeper of notes and records, but unlike Darwin, he did not come from a privileged background. Nevertheless, he managed to gain a doctorate and a career in science, which was an incredible achievement considering his lack of formal education.

Ill health forced him to leave Ipswich Museum in 1893 and sadly he died bankrupt in 1895. He was survived by his wife and four daughters.

I think Dr J.E. Taylor would have revelled in today's science and embraced the means for its promotion through the internet. I am convinced that were he alive today he would have been involved in citizen science projects such as iSpot and he would have produced the most amazing blog full of his ideas, observations and tips for the budding amateur naturalist!

It is fair to say that Norwich is not unique in having its own science society and with a little bit of digging there is a good chance that you could unearth similar science clubs and societies in your local area.

In 1830 the Cambridge mathematics professor, Charles Babbage, published his work on *Reflections on the Decline of Science in England and Some of its Causes*. This is still an interesting publication and many of his observations and reflections still apply today. Babbage was concerned that British science was lagging behind the rest of the world because of a lack of public interest. He wanted to see the establishment of a modern profession composed of paid and properly funded researchers. In response to this publication, the British Association for the Advancement of Science (formerly the BAAS, then the BA, now the British Science Association) was founded in 1831. It had a specific remit: to facilitate communication not only to the public but also to government. A similar organisation, the Association of German Researchers had already been in existence for nine years. The first meeting of the British Science

Association was held in York in 1831 and since then it has met annually in different provincial cities, but always avoiding London. Several years later in 1848, the American Association for the Advancement of Science (AAAS) was established with a mission 'To advance science, engineering, and innovation throughout the world for the benefit of all people'. The AAAS still has a strong commitment to public communication (Daley, 2000). It was originally modelled on the British Science Association, but has developed into a well-funded, highly influential society that also publishes the eminent weekly journal *Science*.

More recently, the British Science Association established the British Association of Young Scientists (BAYS), which at its height had 8000 individual members (Briggs, 2003). BAYS days became an established feature of the BA calendar, but it was replaced by the National Science and Engineering Week in 1994 which is still held during March every year. The concept of a science day or week is also seen in other countries, for example Australia, Denmark and Norway have a National Science Week (Riise, 2010), Sweden and Poland run science festivals, and other science communication events occur in Asia and Africa. These events are funded through different organisations and can be on a local, regional or national scale. The US has Public Science Day, founded by the AAAS, which also coordinates Project 2061started in 1985, after the publication of the 'Science for all Americans' report. Project 2061is a long-term, ambitious programme aimed at helping all Americans to become literate in science, mathematics and technology. Initiatives aimed at improving science education have included benchmarking for scientific literacy, which provides specific learning goals used to inform curriculum design in schools (Project 2061, 2011).

1.2.2 Charitable trusts

Charitable trusts and Institutes have also been founded by companies. Henry Wellcome with his partner Silas Burroughs established the pharmaceutical company Burroughs Wellcome and Company in 1880. This company introduced the concept of selling medicine in tablet form in England, and it also established several research laboratories. The Wellcome Trust was set up at the behest of Henry Wellcome in 1936 and it has become the UK's largest charity focused on improving human and animal health. It is also the largest non-profit funder of research in Europe and in 2007–8 gave away £620 million to fund research in and outside the UK (Stephan, 2010). The Wellcome Trust commissions reports and funds a substantial amount of work in the area of public engagement, aimed at raising the awareness of the medical, ethical and social implications of biomedical science. It has several funding streams for engagement between scientists and the public, including Peoples awards, Broadcast awards and larger Science and Society awards.

The Salters' Institute was founded in 1918 by the UK-based Salters' Company, with the initial aim of getting young people back into their chemistry studies after the Second World War. It now has a major role in supporting chemistry education in schools.

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In the US, the Rockefeller Foundation established in 1913 promotes the well-being of humanity around the world (Bauer, 2010). More recently, the Bill and Melinda Gates Foundation, started in 1994, provides funding and resources to support people to lead healthy and productive lives. In the developing world this has focused on issues surrounding health and the foundation has supported work into fighting and preventing diseases such as malaria, HIV/AIDS and tuberculosis (Gates Foundation, 2011).

1.2.3 Organisations

There were also less formal organisations that influenced change in scientific culture. In 1864, eight eminent men from the world of science, including Thomas Huxley, John Tyndall and Joseph Hooker, met for dinner at St George's Hotel in Albemarle Street, in central London. Over dinner they founded the X-Club, a club that despite having no specific aim or rules, managed to have a significant influence over the professionalisation of Victorian science (Barton, 1998). Between them, at some point, members of this club held the presidency of the Royal Society, The Royal Institution and the British Science Association. The X-club seemed to function as a mentoring group for its members. It was relatively short lived and dissolved after their deaths. One of the lasting impacts of the X-Club was the support given to Tyndall and Huxley to establish the journal *Nature*, recognised today as a premier place for scientific publication.

1.3 Modern societies and organisations

Since the turn of the twenty-first century, several organisations and societies have emerged with science communication at their core. The European Science Events Association (EUSCEA) was founded in 2001 as a non-profit scientific society with a membership drawn from across Europe. The aims of EUSCEA are:

- to share good communication practice;
- to provide a forum for marketing communication events;
- to enable people to collaborate;
- to enable participation in EU funded projects.

Another network was established in the US in 2006, the Coalition on the Public Understanding of Science (COPUS). This organisation grew out of a concern about the state of science in the US, and unites universities, science societies, media, science educators, science advocacy groups, business and industry to work towards a better public understanding of science (COPUS, 2011). Throughout the world there are many other science communication societies and some of these are detailed in Table 1.1.

1.4 Science communication as a discipline

As a discipline, science communication faces several challenges and one of the biggest is its multidisciplinary nature; it can encompass communication

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Table 1.1 Science communication societies.

Society	Description	Website
Indian Science Communication Society	Non-governmental organisation committed to bringing science to the public	http://www.iscos.org/
Australian Science Communicators	Supporting making science accessible	http://www.asc.asn.au/
Science Communicators association of New Zealand	Dedicated to improving science communication	http://www.scanz.co.nz/
South African Agency for Science and Technology Advancement	Aims to advance public awareness and appreciation of science	http://www.saasta.ac.za/
Danish Science Communicators	Non-profit organisation devoted to increasing public awareness and understanding of science and technology	http://www.formidling.dk/sw15156.asp
Coalition on the Public Understanding of Science	Network of organisations dedicated to improving public understanding of science	http://www.copusproject.org/

studies, sociology, education, philosophy, history, political science, ethics and, of course, science itself. Science communication is continuing to develop and it is important that scientists appreciate that it is emerging as an academic field of study in its own right with:

- theories and models;
- peer-reviewed journals that publish research and also practical case studies which attempt to bridge the gap between theory and practice (see Table 1.2);
- international conferences, e.g. Public Communication of Science and Technology (PCST) held biannually;
- university courses at both undergraduate and postgraduate levels (Yeoman *et al*., 2011; Mulder, 2008).
- science communication societies, a few of which are detailed in Table 1.1.

The case studies presented in this book cover the practical side of science communication, the majority being designed and delivered by scientists. As Gregory and Miller (1998) point out, practical science communication is often done by scientists, but the reflection on its worth and effectiveness is most often undertaken by social scientists. The result can be a tension and a lack of common language between these two fields. There is an argument that *practical* science communication is separate from research on the *process* of science communication and more would be gained by practitioners learning about good narrative, communication and design (Davis, 2010). As practitioners ourselves, we have some sympathy with this view, but we feel that the evidence-based practice from investigating the process cannot be entirely ignored. As an introduction to this evidence base, in the rest of this chapter

Table 1.2 Science communication journals.

Journal	Access	Website
Public Understanding of Science	Subscription	http://pus.sagepub.com/
Journal of Science Communication	Subscription	http://scx.sagepub.com/
Journal of Science Education, Part B: Communication and Public Engagement (IJSE (B))	Subscription	http://www.tandf.co.uk/journals/RSED
Journal of Science Communication (JCOM)	Open	http://jcom.sissa.it/archive/06/02/
Indian Journal of Science Communication	Open	http://www.iscos.org/ijsc.htm
Journal of Higher Education Outreach and Engagement	Open	http://openjournals.libs.uga.edu/index.php/jheoe/index

we cover the phases of science communication which have been marked by key reports, underpinned by research and have shaped the approach to science communication in the UK and other countries. A first step is to begin to understand the language used by social scientists researching science communication. To help with this, Table 1.3 provides definitions of terms that are often found in the science communication literature.

These definitions are surprisingly hard to pin down, and this Table includes our own more simplified suggestions. You will find that there are alternative, more complex definitions described in the social science literature (Burns *et al*., 2003, NCCPE 2011). Terminology differs within and also between countries for example ‘outreach’ is often used interchangeably with ‘public engagement’ in the UK. Outreach is often a term used in UK universities to describe their engagement with primary and secondary schools. Universities often have outreach offices, which employ people to specifically engage with schools. These offices tend to have a widening participation and a more general university admissions agenda. Many European nations use ‘scientific culture’ to mean Public Understanding of Science (PUS)(Burns *et al*., 2003) but in the US they use scientific literacy to describe this. The US also uses the term the Public Understanding of Science and Technology (PUST) and the Public Appreciation of Science (PAS) (Daley, 2000), but PAS is also used to mean Public Awareness of Science (Stocklmayer, 2002) and can be abbreviated to PAWS. Public Engagement with Science and Technology (PEST) is also used and Holliman and Jensen (2009) also suggest the term SCOPE for Science Outreach and Public Engagement.

1.5 Phases of science communication

Science communication has gone through three phases: scientific literacy, public understanding of science (PUS) and public engagement with science and technology (PEST). There was considerable overlap between these phases and many of the terms are still used interchangeably (Section 1.4). Each

Table 1.3 Definition of terms often used in the science communication literature.

Term	Definition	Reference
Science communication	The popularisation of science	Davis, 2010
Public	Every person in society	Burns *et al*., 2003
Lay public	People, including other scientists who are non-expert in a particular field	Burns *et al*., 2003
Scientific literacy	Knowledge and understanding of science facts and processes	This book
Public engagement	Communication and discussion with a public audience	This book
Outreach	A meaningful and mutually beneficial collaboration with partners in education, business, public and social service	Abridged from Ray 1999
Public understanding of science	A knowledge of science and how it applies to everyday life	This book
Communication	Social interaction through symbols and message systems	Gerbner, 1966
Deficit model	Where the public is seen as lacking knowledge and understanding, which can only be remedied by imparting facts	This book
Dialogue model	Scientists and public in conversation	This book
Upstream engagement	Discussion takes place with the public before any new scientific developments and technology become reality	This book
Citizen science	Lay public participation in research	This book

of these phases had important reports and surveys associated with them, which often spurred a change of strategy for public science communication. Figure 1.1 gives a flow diagram of the models, movements and reports which have influenced science communication phases in the UK.

Science communication has also developed differently in different countries. For example, the US still maintains a strong scientific literacy and educational approach (Gregory and Miller, 1998; Miller, 2011).

1.5.1 Scientific literacy

The first phase of science communication was tied to ideas surrounding scientific literacy. Jon D. Miller (1983) identified the four components of scientific literacy as:

- a knowledge of basic text book facts of science;
- an understanding of scientific methods, e.g. experimental design;
- an appreciation of the positive outcomes of science and technology;
- a rejection of superstitious beliefs (Gregory and Miller, 1998).

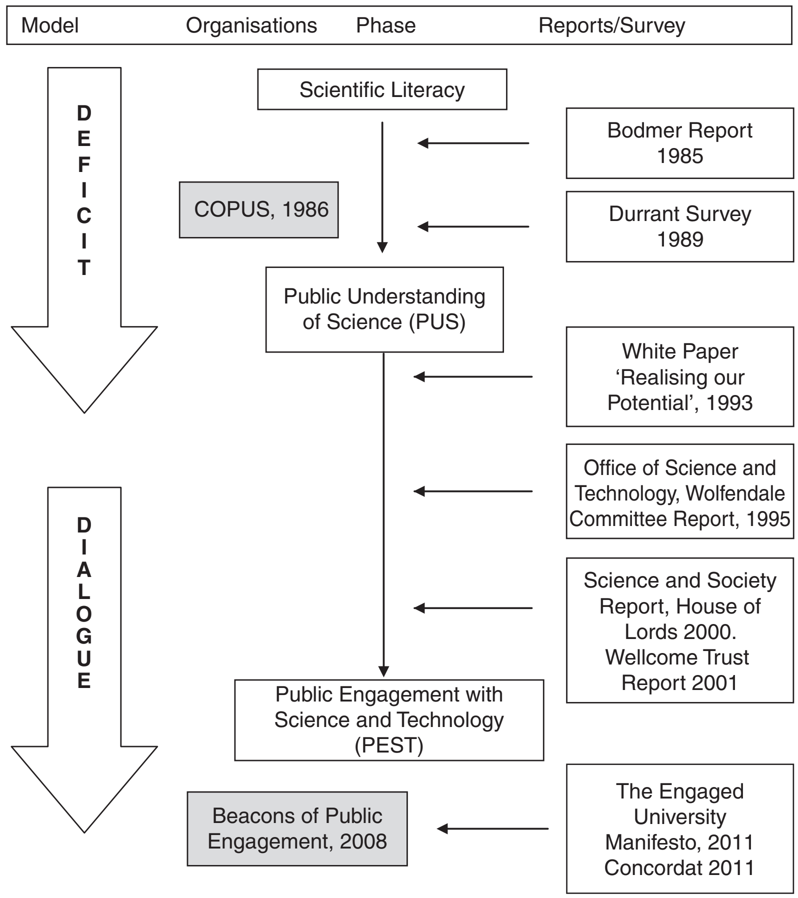

Figure 1.1 Models, organisations, phases and reports associated with the development of science communication in the UK.

Rightly or wrongly, scientific literacy suggests that the public should have a stock of scientific knowledge akin to literacy and numeracy (Bauer *et al*., 2007). The implication is that this stock of knowledge can be tested, in the same way as you test for literacy and numeracy. The testing of public 'science knowledge' has led to many reports of an 'ignorant' public and highlights a knowledge 'deficit' which scientists need to fill with facts. The work commonly cited in this area was undertaken by Durrant *et al*. (1989). Their paper published in *Nature* in 1989 showed that citizens from Britain and the US were lacking knowledge and understanding of science, e.g. only 34% of the British public knew that the Earth went round the Sun once a year and only 17% spontaneously referred to experimentation and/or theory testing when asked what it means to study something scientifically. Similar studies have also been done more recently in the US by the Science Board and in Europe by the special Eurobarometer science and technology survey in 2005. The 13 questions asked in these surveys are given in Box 1.1 and are similar to

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the ones asked by Durrant *et al.* in 1989. In Europe, the level of scientific literacy has increased since 1992 and recent results indicate that Europeans actually have a fairly good, although not outstanding, knowledge of science. The average percentage of correct answers was 66%, although it must be noted that there was some degree of variation. Sweden had the highest rate of correct answers at 79% and Turkey, a non-member EU state, had the lowest at 44%. Despite this more positive data, there are still concerns about the level of scientific literacy, even though Russell (2010) has pointed out that there is a problem in defining how much factual scientific knowledge is needed to be deemed literate. For example, while I have a detailed knowledge of certain aspects of molecular biology, I am sadly lacking knowledge in physics, with a superficial understanding at best. On this theme, the Australian National Centre for Public Awareness of Science ran workshops for scientists on public communication, where the idea of scientific literacy was explored. The scientists were asked to complete a section of the Durrant survey; 193 scientists have taken part and it has highlighted that many scientists were unsure of answers to questions not directly related to their discipline. In addition, there were no questions that all scientists answered correctly and they were critical of the questions (Rennie and Stocklmayer, 2003). Perhaps an important point is not what is known at any one time, because we can't know everything, but instead it is the motivation to look for and the skills required in accessing and analysing information when it's needed.

Box 1.1 Eurobarometer Quiz

Which statements are true and which are false?

- The Sun goes round the Earth
- The centre of the Earth is very hot
- The oxygen we breathe comes from plants
- Radioactive milk can be made safe by boiling it
- Electrons are smaller than atoms
- The continents on which we live have been moving for millions of years and will continue to move in the future
- It is the mother's genes that decide whether the baby is a boy or girl
- The earliest humans lived at the same time as dinosaurs
- Antibiotics kill viruses as well as bacteria
- Lasers work by focussing sound waves
- All radioactivity is man-made
- Human beings, as we know them today, developed from earlier species of animals
- It takes one month for the Earth to go round the Sun

The most important aspect of scientific literacy was the educational agenda and this phase increased the efforts in science education that are still seen today. Presently in the UK, all children up to the age of 16 have compulsory science education. On the negative side, it suggested that an ignorant public is disqualified from participating in science policy decisions. The approach

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of trying to fill the 'knowledge gap' between scientists and the public by imparting factual information has become known as the 'deficit model' of communication. Science and learning in schools is explored in more detail in Chapters 9 and 10.

1.5.2 Public understanding of science

The second phase of science communication was PUS. In the mid 1980s concerns were raised over the public attitudes towards science similar to those raised by Charles Babbage in 1829. These concerns were marked by an influential report by the Royal Society produced by a committee chaired by Sir Walter Bodmer (currently principal at Hertford College Oxford and former director general of the Imperial Cancer research fund), which has become known as the Bodmer Report (Bodmer, 1985). The ramifications of this report in establishing the new paradigm of PUS across the world cannot be underestimated. This report has been highly cited within the science communication literature and is now regarded as a key publication when describing the 'deficit' model of science communication.

The Bodmer report led directly to the foundation of the Committee on the Public Understanding of Science (COPUS – not to be confused with the current COPUS organisation in the US), where the three major UK historic institutions came together, The Royal Society, The Royal Institution and the British Science Association. The UK COPUS aimed to interpret scientific advances and make them more accessible to non-scientists. Several schemes for science promotion were initiated; including a fund for speakers to talk to organisations, e.g. Women's Institute. They also funded an annual book prize. In addition, they had a direct role in bringing about the highly successful National Science and Engineering Week (NSEW), which still operates today (Bodmer, 2010). Indeed many of the case studies in this book came from a desire on the part of scientists to take part in this UK event.

The Bodmer Report has been much criticised in the literature for what it seemed to represent, i.e. a deficit of knowledge and understanding of science within the public. When the original report is examined, one of the main themes is on improved education within the formal school system.

> A proper science education at school must provide the ultimate basis for an adequate understanding of science.
>
> —*Bodmer (1985, p. 6)*

The National Curriculum introduced in 1989 ensured that science was a core subject from the ages of 5 to 16. The Bodmer Report also suggests that *quality* of choice is better when an understanding of the issues is improved.

> Better overall understanding of science would, in our view, significantly improve the quality of public decision making, not because the right decisions would then be made, but because decisions made in the light of an adequate understanding of the issues are likely to be better than decisions made in the absence of such understanding.
>
> —*Bodmer (1985, p. 9)*

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We interpret this as 'it is fine to disagree with the science, but by being better informed, your choice is built on more secure foundations'. We consider the Bodmer Report to have been somewhat misrepresented in the science communication literature. There were many incredibly positive outcomes of the report. It encouraged scientists to get involved with the education process of science at all stages. COPUS enabled scientists to take science communication with the public seriously. It removed the stigma associated with the popularisation of science and it became a more mainstream activity (Bodmer, 2010). This change was partly because COPUS provided a funding stream for engagement projects. In 2002, COPUS disbanded in the UK as more organisations became involved with PUS, but the individual founding organisations have remained committed to providing funds for engagement. For example, The Royal Society funds Partnership grants with schools and scientists and Case study 10.5 by Adam Hart on the Bee Guardian Foundation (BGF), is an example of engagement first established through such a Partnership grant.

The public understanding of science was a key issue in the 1993 science and technology White Paper 'Realising our Potential' which clearly stated the importance of the understanding and application of science to wealth creation and quality of life (British Council, 2001). In 1995, the Wolfendale Committe in the UK (chaired by former Astronomer Royal, Sir Arnold Wolfendale), also concluded that scientists receiving public funding had a duty to engage citizens with their research (Pearson, 2001; Poliakoff and Webb, 2007). The recommendation of this committee was the inclusion of a statement in research grants on how the public should be informed about the findings from the funded scientific research. The restructuring of the research councils, as a result of this White Paper, made it explicit that PUS was part of their responsibility. At the present time, all research councils in the UK require scientists to write impact statements as part of their research proposals. These impact statements are examined in more detail in Chapter 2.

1.5.3 Problems with public understanding of science

The PUS phase was not without its problems. The Economic and Social Research Council (ESRC) established a programme of research to investigate the relationship between science and society (Lock, 2011). As research projects progressed and papers were published it became clear that social scientists were critical of the PUS movement as:

- all the knowledge and expertise lay with the scientists;
- it implied that more knowledge of science on the part of the public would bring about a greater appreciation of science (Gregory and Miller, 1998).

While scientific literacy was seen as a deficit of knowledge, PUS was a deficit of attitude. The crisis surrounding both bovine spongiform encephalopathy (BSE) and genetically modified (GM) food in the UK are often cited in the science communication literature as perfect examples of the failure of the deficit model. The BSE crisis identified a need to try and communicate the ideas of risk and also highlighted the presence of different publics, e.g. consumers, activists, government and farming communities, all of whom had their own knowledge and stance on the issues (Irwin, 2009). There was also a crisis of trust, as the link between BSE and variant Creutzfeldt–Jacob disease (vCJD) became apparent, despite earlier assurances from the government that there was no link. In the case of GM, the campaign to raise awareness and a positive public attitude towards the technology had a negative effect instead, as the public became more sceptical (Irwin, 2006). In the wake of other crises, such as BSE, the public simply did not trust the government to make the right decisions for them and in the UK there is still a moratorium on the commercial growing of GM crops. In a recent meta-analysis, Allum *et al.* (2008) showed that there is only a weak correlation between science knowledge and attitude and sometimes a negative correlation when associated with specific issues, such as GM food. What surprised many supporters of the PUS movement was that their success at increasing the level of scientific literacy ultimately lead to a more sceptical public. Although this was an unexpected outcome, Bauer (2010) suggests that this should not be viewed as a negative result but rather regarded as an asset as it represents a public that is more critically aware of issues.

Nisbet and Scheufele (2009) argue that ignorance of the facts is not the reason why there are conflict issues between science and society. This is an interesting point; citizens are influenced by their own experiences as well as a variety of cultural and religious views (Davies, 2009). This is addressed in the contextual model of science communication, put forward by Falk and Dierking in 2000. This model takes into account the knowledge and experiences that the lay public have built up over time within different contexts. Scientists shouldn't ignore lay knowledge. They should consider that these experiences could be pertinent to science and scientists can learn from them (Irwin, 2009). A classic example from the literature is the work of Brian Wynne (1992), who looked at the knowledge built up by Cumbrian hill-sheep farmers. This group of individuals had considerable experience and knowledge about hill-farming management, sheep behaviour and also fell ecology. Being close to Windscale/Sellafield nuclear power station, they also had experience of grazing sheep on contaminated grassland after the disaster at Windscale in 1957. Thus after the Chernobyl nuclear accident in 1986, and the fallout of radioactive caesium which occurred over Cumbria, these farmers had specialist knowledge which could and should have been immensely useful in determining a response to the crisis. However, scientists chose to ignore the experience of the hill farmers, which left the farmers feeling belittled and threatened.

1.5.4 Public engagement with science and technology

The third and current phase of science communication is PEST, also referred to as Science and Society. The House of Lord's *Science and Society* report which came out of a committee chaired by Lord Jenkins in 2000 stated that the PUS movement was arrogant and outdated and there was only a 'top-down' one-way communication from the science community to the public. PEST has less emphasis on the one-way dissemination of facts, and focuses instead on dialogue, or two-way engagement between the scientists and the public. Simply talking to the public about science is not sufficient. Instead scientists should listen to the public, enter into a conversation with them and record their views. This is essential in terms of public involvement in policy, as it allows democracy and increased trust and confidence in the regulation of science and the decisions that are subsequently taken by the government (Haste *et al*., 2005).

The idea of dialogue isn't new. There are two good examples of dialogue occurring prior to the PEST movement, firstly in the 1970s and then again in the 1990s. The first example is the Genetic Manipulation Advisory Group (GMAG) established in 1976. This was a highly unusual government advisory committee as it included representatives of the 'public interest' (Bauer *et al*., 1998). The second example was in 1994 when the Biotechnology and Biological Sciences Research Council (BBSRC) sponsored a UK National Consensus Conference on Plant Biotechnology (Trench, 2010). This was an example of a citizen jury, where a panel of 16 lay public volunteers set the agenda for the conference, chose the expert witnesses, conducted the questions and then delivered the verdict (NCBE, 2011).

1.5.5 Problems with the dialogue model

Examples of twenty-first century dialogue events include café scientifique, scenario workshops, deliberative opinion polls, citizen juries, people's panels and in the US, consensus conferences (Russell, 2010). On the surface these seem to be good examples of dialogue events, but closer scrutiny has revealed some problems with a dialogue-focused approach. In 2009, Sarah Davies examined informal public dialogue events at the Dana Centre in London (a purpose built centre, part of the Science Museum). These were panel events, where expert panel members spoke and then the public audience were able to comment and ask questions. What she discovered was that this format of comments, questions and responses, was not a simple dialogue event, instead these panel events had elements of both deficit and dialogue. This research indicates that a pure dialogue event is often difficult to achieve. In addition, it isn't clear how these examples of informal dialogue actually feed into government policy.

GM nation was an example of a formal dialogue event with a larger audience and it took place in the UK between 2002 and 2003. This was an ambitious public consultation project costing £1million, where the government promised to take into account both public and expert opinion prior to making any policy decisions about the commercialisation of GM technology. After examining the findings of this event, it became clear that there was a need for upstream engagement, i.e. a discussion that takes place with the public before any new scientific developments and technology become a reality. This enables reflective practice, to discuss ethical issues and risks before the public become polarised in their views (Haste *et al*., 2005). The emerging area of nanotechnology was seen as an excellent opportunity to practice and experiment with upstream engagement. One example was undertaken in the UK by DEMOS (an independent political think-tank) and researchers at Lancaster University in collaboration with the BBSRC and the Engineering and Physical Sciences Research Council (EPSRC). This experiment was a dialogue event, called Nanodialogues, run over three sessions covering public values, concerns, aspirations and also the role of public engagement in influencing scientific research. There were two groups of citizens involved, the first group consisted of full-time mothers and the second, professional men and women. The evaluation, conducted by Chilvers (2006), showed that the events were successful because:

- access to specialists was provided;
- multiway dialogue was observed, with scientists talking to each other as well as to the public.

However, this dialogue process did have a problem – public retention. Only four people attended the last session (out of a total of 14) and all participants claimed that the money offered for taking part was their strongest motivation for attending. It was suggested that while the citizens involved had learnt about nanotechnology and something about the operation of the research councils, the real value in the event was the influence upon the research councils, as the BBSRC/EPSRC learnt and reflected upon the role that citizens could play in shaping the research agenda (Chilvers, 2006).

Another recent example was a synthetic biology dialogue event organised by the BBSRC and EPSRC with support from the Department for Business, Innovation and Skills Sciencewise-ERC programme. The event took place in 2009 with 12 deliberative workshops, 160 members of the public, and it was held three times in four different locations across the UK. The evaluation findings from the event showed that the public were appreciative of the process and felt that their views were valued and listen to. However, they were less clear about how this would feed directly into policy decisions, a point Davies (2009) also mentions in the Dana Centre activities. The participants also indicated that they wanted a continuation of dialogue and the term, 'long stream engagement' was introduced.

The evaluation reports described above highlight that two-way engagement events have their own shortcomings:

- they can only involve a limited number of people;
- participants don't usually have a role in shaping the agenda;
- there is no direct responsibility of the organisers to feed the findings into policy;
- participant expectations need to be managed in terms of continued dialogue;
- the citizens taking part are unrepresentative of the public as a whole – those who take part are likely to be well informed and have strong views on the issues being discussed (Nisbet and Scheufele, 2009);
- there are difficulties in translating a dialogue model into real practical science communication events for large audiences. Most events are likely to be a mixed approach of deficit and dialogue, suggesting that despite the rhetoric of dialogue, a deficit approach is still common.

We agree with the suggestion by Brake and Weitkamp (2010) that it is not necessary for all science communication events to be dialogue oriented, as long as there is the opportunity for citizens to take part in discussion or in policy decisions. Science events which inform and excite the public about science are still very important. The recent Ipsos MORI poll on public attitudes to science for the Department for Business Innovations and Skills (PAS, 2011) suggested that the public were quite cynical about public consultation events, with 50% of respondents agreeing with the statement 'consultation events are just public relations activities and don't make any difference to policy'. People feel that consultation is important, but don't necessarily want to get involved in it themselves. The Danes have recognised the importance of public consultation for many years. In 1995, the Danish Parliament established the Danish Board of Technology (DBT), an independent body committed to the dissemination of knowledge about technology. Its central mission is 'to promote the technology debate and public enlightenment concerning the potential, and consequences of technology'. The DBT advise the Danish Parliament and Government and report to the Parliamentary Committee on Research.

In an article looking at the democratisation of science, Turney (2011) points out that an area missing from public involvement is the setting of the actual research agenda. Whilst there are isolated examples of this happening, it's not universal. One example mentioned in the article is the Medical Research Council (MRC) that had a panel involving the lay public who were specifically involved in assessing grants for the third phase of the Lifelong Health and Wellbeing initiative. Another good example of public involvement in agenda setting is the UK Alzheimer's Society. In 2000, they established a network called Quality Research in Dementia (QRD), patients and carers have involvement in research priorities, they review research proposals and also have a role in assessment and monitoring of research grants (Stilgoe and Wilsdon, 2009). A good example of where consultation events can work to ultimately influence the research agenda is the EPSRC-funded SuScit project which is Citizen Science for Sustainability. This project is coordinated by Brunel University, the Centre for Sustainable Development at the University of Westminster and Capacity Global. The aim of the project was to provide local communities with a voice in environmental and sustainability research. They particularly worked with hard-to-reach groups, including older citizens, people with disabilities and those from ethnic minority backgrounds. SuScit used a mix of panels, focus groups, community videos and deliberative workshops to develop a research agenda and recommendations for the EPSRC. As a result of the project, researchers, practitioners and residents are now working together on local initiatives and future research projects.

1.6 Recent initiatives

In 2008, the Beacons for Public Engagement were established in the UK. This project was the biggest investment of money into public engagement to date and was funded by the Research Councils UK (RCUK), Higher Education Funding Councils and The Wellcome Trust. The investment is to help universities engage better with the public, not just in science, but across all disciplines. Six university partnerships were awarded Beacon status, and they are located in Edinburgh, Cardiff, Newcastle, Manchester, London and Norwich (UEA), with a National Co-ordinating Centre for Public Engagement (NCCPE) at Bristol University.

In the UK there has been a manifesto for public engagement, *The Engaged University*, drawn up by the NCCPE where universities and research institutes have been asked to sign up to 'celebrate and share their public engagement activity, and to express their strategic commitment to engaging with the public'.

The funders of research in the UK have also recently drawn up a set of principles for engaging the public with research: the Concordat. 'The signatories of the Concordat recognise the importance of public engagement to help maximise the social and economic impact of UK research' (Concordat, 2011). More details about these recent initiatives can be found in Chapter 2.

1.7 A way forward

The Ipsos MORI poll on public attitudes to science (PAS, 2011) suggests that the public attitude towards science in the UK is really positive, 86% are 'amazed by the achievements of science' and 82% agree that 'science is such a big part of our lives we should all take an interest'. This is mirrored by other studies in Europe, the US and Australia (Wilkinson, 2010). As scientists wishing to communicate our science to the public, we should be encouraged by these findings. There are many exciting and entertaining ways to communicate science through a variety of different media: face-to-face (e.g. science cafés), exhibitions, popular books, magazines, television programmes, web sites and social media. We also have to acknowledge that we are individuals with our own strengths, experiences and different personalities, and might prefer using some approaches more than others. The case studies contained within this book give marvellous examples of the many different forms of engagement with a variety of audiences. Although we have used this chapter to highlight different models of communication in terms of deficit and dialogue, we mustn't get too hung up on a 'one approach' fits all. We want to use this book and the case studies it contains to demonstrate that it is perfectly acceptable to use different approaches at different times, in different situations and with different audiences. This will lead to a dynamic and vibrant community of scientists communicating effectively with the public.

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