Science Communication

Culture, Identity and Citizenship

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and **Maja Horst**

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It is hard to remember where the idea for this book first came from. We have worked together for some time, and our conversations have often been filled with aspects of science communication that we were excited about, questions that we did not know the answers to, and fascination with the way that the field of science communication is developing. Eventually, those conversations solidified into the idea of writing a book that explored some of the approaches to thinking about science communication we found particularly interesting. Together we worked through different topics, concepts, theoretical lenses, and methodological angles that we thought might open up the study of science communication. The result is what you find in this book.

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Introduction: Science Communication as Culture

Science communication is important in modern knowledge societies. Many societies around the world now expect scientific knowledge and technological development to be at the core of economic growth and welfare, and hope that science will find solutions to challenges such as climate change and scarcity of energy, food, and water. Such expectations imply that science communication is significant in at least three ways.

First of all, science communication is important for the welfare of individuals, organisations and nations. Many countries invest a large part of their GDP in finding solutions to problems in society, and science does indeed often deliver crucial new knowledge and technologies that change our lives for the better. Such knowledge has to be communicated to its potential users in order to take effect. Knowledge about disease prevention, water resources, or energy efficient technologies will only improve the life of citizens if it is communicated to relevant people who can put it to good use, for instance by developing new products. Knowledge about galaxies far away, or the intricacies of metabolic pathways, might not have immediate uses in the same way, but such basic scientific knowledge still needs to be communicated if it is to have effects on the way we as citizens understand our lives and our situation on earth.

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Second, science communication is important for democracy. How can people contribute to decision-making in a knowledge society if they do not have a solid connection with the basis for many decisions—scientific knowledge itself? Such a connection is not just about understanding or the ability to correctly explain scientific facts. Rather it implies that citizens should know about how scientific knowledge is produced as well as about its limitations and consequences.[1] This is not a small demand. If, however, science is one of the most important productive forces in current societies, citizens have to be familiar with the way it works. Science should be debated in democratic institutions by the general public, or we risk creating societies which are more and more polarised between those who understand, use, and make decisions about science and those who do not.

Finally, science communication is important because it relates to culture and identity. Much of everyday life is dependent on technoscience, from the food we eat to our transportation systems, communication technologies, and healthcare. Sometimes the scientific content of these aspects of life is invisible, while at other times its importance is painfully explicit (such as if we need to talk to medical professionals about the best treatment for a particular cancer diagnosis). Most of the time, however, science is somewhere in the background. It shapes thinking about social issues such as climate change, nutrition, or food security, but our experience of it is intermingled with all the other concerns that we, as citizens of knowledge societies, have. It is part of how we understand ourselves, an integral aspect of the cultural fabric in which we exist. For some people it is central—being knowledgeable about science can be a crucial identity marker—whereas for others, it is blended in with other values and ways of knowing. At its core, science communication is an activity that allows us to make sense of science and thereby the societies in which we live.[2]

It is this idea of science as central to the culture of contemporary knowledge societies that is the starting point for this book. Science communication is not simply about making difficult things more simple, and it is something more than the exchange of scientific knowledge from those who know to those who do not. It is an integral part of society which has huge impacts on welfare, democracy and culture. Many writers who have discussed science communication have explored the importance of science communication for the effective translation of scientific knowledge into useful solutions to social problems—the issue of science communication's role in social welfare.[3] This book, therefore, focuses on the latter two issues, democracy and culture. We are interested in the relationship between science communication, culture, identity, and citizenship. Science communication, we will argue, is tied to organisations, identities, spaces, emotions, careers, futures and many other aspects of social life. It is not something that should be imagined and studied as a primarily personal or individual process, but as involving collectives and constituting cultures.

What is science communication?

What are we thinking of when we talk about 'science communication'? An example, the Euroscience Open Forum (ESOF) event held in Copenhagen in June 2014, can help explain how we use this term. ESOF takes place every second year in a major European city. In 2014, it combined a science policy convention with a public festival, called Science in the City, which included different kinds of science communication activities, from a Teddy Bear Hospital run by medical students to an outdoor photo exhibition of underwater life in the Norwegian oceans. Some 40 thousand people visited Science in the City over its six-day course, making the ESOF event as a whole a mix of academics, journalists, families, school groups, policy makers, activists, artists, politicians, and PR teams. Depending on where you were at any particular moment, ESOF could be experienced as a slick think-tank discussion, a traditional public lecture by an eminent scientist, or a lively workshop run by passionate activists in a space decorated with art and hacked technologies. If you wandered into the main ESOF convention hall you would find booths about the Estonian Research Council, the research carried out by the company Johnson and Johnson, or the network for alumni of Marie Curie Research Fellowships. The event as a whole brought together bored teenagers, journalists with deadlines, high-profile policy makers, and enthusiastic university students, taking part in anything from workshops that encouraged you to move your body in order to understand scientific concepts to debates about science's role in society.

ESOF involved many activities that we think of as science communication. This was not just the public-facing events: the workshops for schoolchildren, public lectures, or hands-on demonstrations. We do not want to distinguish between the activities that took place in the convention hall for ESOF delegates and the Science in the City displays and engagement activities. All of the audiences present at ESOF, whether schoolchildren, policy makers, or scientists themselves, were important recipients of the messages about science put forward at the event. The point here is that science communication happens in many different contexts and is designed, consciously and unconsciously, for many different types of audiences. It also communicates diverse things and has many different effects. At a gathering such as ESOF participants do not just learn about specific scientific endeavours and facts, but engage in communication about, for instance, the meaning of the word science, the identities of organisations like the EU or particular universities, or the opportunities and value of a scientific career. Science communication is consumed as part of everyday life, whether that is personal (a day out with your family) or professional (the opportunity to support your employer by communicating your research).

We define science communication as organised actions aiming to communicate scientific knowledge, methodology, processes or practices in settings where non-scientists are a recognised part of the audience.[4] This is a broad definition. It includes mass media presentations of science; information materials aimed at patients or user groups of particular technologies; science in museums; science festivals, events, and workshops; public lectures and debates; and science online and in social media. Science communication therefore takes place anywhere from the stop-smoking leaflets given to you by your doctor to the 'I Fucking Love Science' Facebook page or when governments run consultations on GM crops or nanotechnology in order to gauge public views on new technologies.

We are using the term 'science', but we could just as easily talk about research communication. Science communication is an established term in a way that research communication is not, and we use the phrase for that reason. Research, however, suggests a broader set of practices than science (in that respect it's like the German word 'Wissenschaft', which also includes humanities and social science). Traditionally, there has been rather little attention to the communication of social scientific or humanities research, although this has begun to change.[5] While acknowledging that most practice and study in this area is about natural science and medicine, we do not see our definition as excluding communication of other forms of research-based knowledge. Similarly, we use ‘science’ as a shorthand for ‘technoscience’. Modern science is intricately interwoven with technology, and science communication often relates to aspects of technology and technical development.[6]

What are we *not* using the term ‘science’ communication to refer to? Our definition does not directly include formal science education. This is because this area is a well-defined field in its own right; here, then, it will not be our primary interest. It also does not include science fiction or other uses of science in fictional films, TV or books, or accidental references to science, for instance, in daily life or policy discourses. The reason for this is that we do not want to make the definition so broad that it loses its meaning. If science communication is everything related to science, then it covers so much that it is impossible to talk about it coherently. However, it is obvious that coverage of science in fiction, or its role in popular culture and discourse, is important for how people make sense of science, especially for those who do not have many other connections to science. Depending on the context, then, it may be necessary to recognise that there are other areas of culture and communication which have to be included in discussions of particular examples or aspects of science communication.

Science communication as ecosystem

Science communication is not straightforward. One metaphor to capture its complexity within contemporary knowledge societies is that of an ecosystem. The Science in the City festival was home to research-oriented events, exhibitions, workshops, debates and demonstrations, while at the ESOF policy convention communication took place as university PR officers networked, companies boosted their brands by handing out free pens, or research organisations showed videos about their activities.

Thinking of these diverse activities as part of an ecosystem of science communication is useful for capturing the heterogeneity and multiplicity of this landscape of science communication, more generally as well as at ESOF specifically. We do not use this, we should emphasise, to imagine a stable structure in which everything has a particular place and is connected in very specific ways, but to signify a space teeming with different life forms, all relating to each other in different ways. If science communication is an ecosystem, it has many niches in which different practices of communication sustain themselves and others in a complex web of interdependence and autonomy.

Some of these niches are well established and have been home to science communication for a long time. This is true, for instance, of the media, which has its own tradition of science communication, both with regard to science journalism as a part of general news coverage and in specialist science documentaries and programmes.[7] In recent years, there have been dramatic changes in the media system, driven by digitalisation and the development of social media platforms.[8] These changes have enabled an enormous increase in content produced by many different actors including citizens, activists, organisations, research institutions and other professional producers. We have already mentioned the Facebook page 'I Fucking love Science', but other additions include a growing field of science podcasts, TED talks, and YouTube videos as well as the use of Twitter (e.g., to live tweet science press conferences or events). Universities and research organisations have also expanded their communications departments and the channels of communication they use over the last decades.

Another well-established form of science communication is the public lecture or popular book written by an individual scientist. In many ways, such formats have been the most classical and widespread way to increase public understanding of science over more than a century.[9] This is often seen as the quintessential format of science communication and is one reason why many people think of science communication as something that is primarily done by individual scientists on the basis of their own ambition to inform publics about their field. Scientists are still important for science communication, but new formats have been added to the traditional written or oral presentation. This includes different kinds of performances, such as Science Slams (where competing scientists are given a few minutes to present their science followed by an audience vote), science talks or demos carried out in schools by visiting researchers, or interactions between scientists and artists. We are currently seeing increasing combinations of science communication with art, theatre, comedy or storytelling, suggesting that science communication is becoming more focused on creative and playful aspects than has traditionally been the case.[10]

A third part of the ecosystem is state authorised and promoted information about science. As the welfare state expanded in the twentieth century, it increasingly took upon itself to guide the lives of its subjects with factual information campaigns about how to live a healthy life.[11] Today such information is not restricted to health campaigns but spans many diverse areas of life: sustainability, energy, leisure activities, household waste. Science communication has also become important for other aspects of national governance. As science has risen in political prominence as one of the key drivers of economic growth and prosperity, increasing scepticism towards some scientific fields and emerging technologies has presented itself as a problem for political governance. Since the 1990s, governments and other policy actors in Europe and beyond have found it important to involve publics in the governance of science and science policy.[12] This form of public participation in science policy includes participatory consensus conferences, where a panel of citizens questions a panel of experts about a particular issue and subsequently writes a report about what they believe should be done about it,[13] but there are many similar formats where the ambition is to engage citizens in dialogue and political decision-making about science.

A fourth established niche within the ecosystem of science communication is that of science museums and centres. Most schoolchildren have experienced trips to natural history and science museums, and, outside of formal schooling, museums and similar institutions are perceived as key sites for informal science education. Such institutions have developed from a focus on the collection and display of objects to including interactive elements and using film and audio to advance learning.

The interactive element is even more visible in places like science centres, where hands-on engagement with exhibits is designed to teach visitors about basic principles of natural science.[14] Most recently there have been increasing efforts for museums to involve citizens in science in other ways. While amateur ornithologists and astronomers have been providing useful data for scientists for at least a century, newer forms of 'citizen science', increasingly supported by science museums, involve mass data analysis in astronomy, local environmental monitoring, or beekeeping records.[15] Besides these moves towards increasing interaction and engagement in established institutions and scientific fields, new forms of grassroots engagement have surfaced in the shape of hackerspaces, makerspaces, and DIY biology. Here citizens themselves design spaces for tinkering and learning about science.

All of these examples serve to illustrate that the ecosystem of science is heterogenous and multiple. It is related to health communication, science education, and political participation but also forms a distinct area of interrelated sets of practices and areas for scholarly study. Importantly, this system is dynamic. Some forms of life—TV documentaries, popular science books, public lectures—seem rather stable, while others, such as science slams, citizen science, or public dialogue, are emergent or undergoing change. Both the formats that make up the landscape of science communication and the relations between them are constantly shifting.

Science communication as culture

An event like ESOF draws together many different kinds of knowledge, many different people, and many different formats. None of these forms of science communication can be understood outside of the context of the cultures, organisations, and groups in which they are situated. The key argument of this book is therefore that there is always more to science communication than the transfer of knowledge. Sharing of scientific ideas will, of course, take place in different ways within public communication activities. But there will always be a context of wider meaning-making around science communication practices and formats as they are used to construct particular identities, solidify social relations, shore up organisational cultures, or engage in political debate. Our aim is to contribute to a discussion about these diverse aspects and uses of science communication, and in particular to highlight facets of it that have been under-reported in the research literature so far. What happens, we want to ask, if we move away from thinking about science communication as something that is primarily about the movement of scientific knowledge and imagine it as a space where we can interrogate the meanings that circulate about science, technology, and citizens in contemporary societies?

This book therefore has a number of purposes. At the most basic level, we want to highlight contemporary science communication's relationship with culture, identity and citizenship. Throughout our discussion we will talk about real-world examples and case studies; in particular, we want to point to places—such as the activities of university PR departments, the burgeoning industry in science communication training, or media coverage of high-profile scientists—that we believe warrant further study. We want to open up discussions using real-world practice in order to enrich both scholarly study and the ways in which science communication is imagined and carried out. While we have not written a handbook about how to carry out science communication, we still hope that it might act as inspiration for professional communicators and others who want to communicate research.

We will also suggest that scholarship on science communication could benefit from a fresh perspective on it. Throughout the book we will make suggestions for reimagining the study of science communication, specifically by thinking about it as a cultural phenomenon. Understanding science communication as culture can help us to investigate its organisation, professionalisation, and democratic role, as well as the role it plays in generating resources and creating expectations, emotions, and affects. *Culture* is therefore the key frame we want to apply to the study of science communication; working from this frame, we can start to examine the many different ways it is practised, experienced, and imagined in different sites.

The concept of culture is almost too familiar. It is used widely within the social sciences and humanities, as well as within popular discourse. We draw on one particular take on it which was developed within the

British tradition of cultural studies and specifically in the work of Stuart Hall and colleagues. Culture, Hall explains, is:

> not so much a set of things—novels and paintings or TV programmes and comics—as a process, a set of practices. Primarily, culture is concerned with the production and the exchange of meanings—the 'giving and taking of meaning'—between the members of a society or group. To say that two people belong to the same culture is to say that they interpret the world in roughly the same ways and can express themselves, their thoughts and feelings about the world, in ways which will be understood by each other.[16]

This resonates with the way we understand science communication. It is, centrally, about meaning-making and the way in which science communication is part of the meaning-making of particular societies. When actors in society communicate about science, they narrate stories about the world and about their own as well as other people's places in it. By understanding science communication as a cultural phenomenon, it becomes possible to view it as integrated into the lives of many different people and into the construction of many different kinds of identities, rather than simply seeing it as the transfer of knowledge.

Hall makes it clear that culture is something that is multiple. ESOF, we have said, hosted a wide variety of science communication practices. Overall, however, these practices might be seen as representing a culture that values science as an important part of society. But not all Copenhagen citizens will have found it relevant or meaningful to engage with the activities in Science in the City: their understanding of their culture, in other words, might be different to that assumed by organisers of Science in the City. This is an important point for Hall, who notes that a focus on shared meaning sometimes leads to the misconception that culture is unitary and cognitive. But in any culture, he says, 'there is always a great diversity of meanings about any topic, and more than one way of interpreting or representing it'.[17] Seeing science communication as a cultural practice therefore leads us to expect multiplicity in interpretation, whether that is of the nature of a particular communication event or the role of science in society more generally. This version of cultural theory also helps us to be aware of the contexts of science communication, and the fact that it is always articulated and interpreted at specific moments. Cultures vary, after all. 'To say that two people belong to the same culture', writes Hall, 'is to say that they interpret the world in roughly the same ways'—and that other people, from other cultures and sub-cultures, may do so differently.

Working with a group of colleagues from the UK's Open University, Hall's thinking on culture was summed up in a model called the 'Circuit of Culture'.[18] A circular understanding of the production of culture was first put forward in the 1980s as a means to study the 'regularities of cultural processes'.[19] Building on this, Hall and colleagues used the circuit to broaden the study of cultural artefacts so that production was not seen as the only thing that determined their meaning.[20] The group argues that meanings of cultural products—they focus on the Sony Walkman as an example—are not set in stone by their producers, but are subject to interpretation at multiple moments:

> Meaning is not simply sent from one autonomous sphere—production say—and received in another autonomous sphere—consumption. Meaning-making functions less in terms of a 'transmission' flow model, and more like the model of a dialogue. It is an ongoing process. It rarely ends at a preordained place.[21]

It is through multiple different cultural processes that meanings are attributed (and resisted, changed, and negotiated). The circuit that represents these cultural processes has five moments of 'articulation': production, consumption, regulation, representation and identity. Each of these processes contributes to the creation, translation and exchange of meaning, and, as is visible in the figure, they are linked to each other. For heuristic reasons they are portrayed as distinct, but 'in the real world they continually overlap and intertwine in complex and contingent ways' (see Fig. 1.1).[22]

We think that this circuit is a useful starting point for a renewed understanding of science communication.[23] It's not a model of the communication process or something that can be picked up and applied in any neat or systematic way, but it can provide a framework for analysis that seeks to take into account the richness of any instance of science communication—one that looks at it holistically,

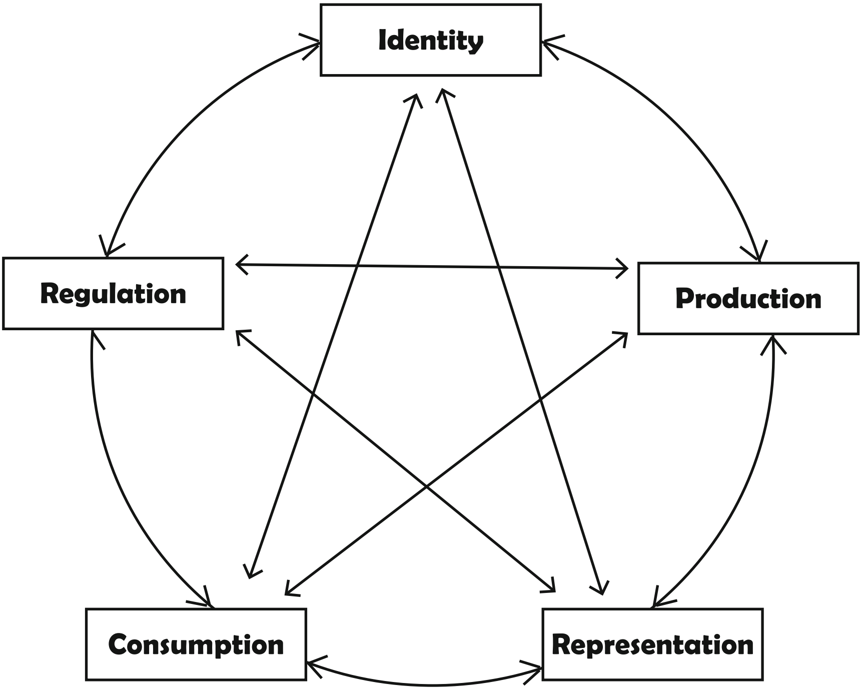

Fig. 1.1 The circuit of culture (Adapted from the work of Stuart Hall et al.)

rather than just in one or two dimensions. In this respect, it can serve as a compass. It sets out some overall navigation points and provides us with directions in a landscape, but it does not tell us what we will find on our way.

In what follows, we use the circuit of culture as a heuristic to discuss how each of the five central processes help us unpack the practice of science communication. For each process (production, consumption, regulation, representation and identity), we reflect on how they relate to the ESOF conference and Science in the City Festival and consider some of the questions they open up for studies of science communication generally. Of course, the segregation of the five processes is artificial; as such, our discussions overflow such that one aspect often blends into another. The important thing is to put the idea of cultural processes to work in the context of science communication. Most of the rest of the book will unpack what this looks like further, and we preview some of the key themes we treat within the paragraphs below. Here the most important question is: what does it look like to think about science communication as a cultural phenomenon?

Identity in science communication

ESOF took place in an area of Copenhagen known as Carlsberg City. This previously housed the Carlsberg brewery and a related industrial complex; in 2014, Carlsberg City was undergoing large-scale redevelopment, with many of the vacant buildings used as makeshift arenas and event spaces. To Danes, Carlsberg has strong connotations of a proud and influential scientific history. The Carlsberg Brewery was founded in 1847 by J.C. Jakobsen, who had visited Pasteur in Paris and was the first to adopt scientific technologies to improve the quality of beer brewing. He is known as an enthusiastic supporter of science: in 1875 he founded the Carlsberg Laboratory, which continues to exist as an exemplary industrial lab which also produces excellent basic science. The Carlsberg Foundation is one of the largest private scientific funders in Denmark, and there are close links between the Carlsberg Foundation and the Danish Royal Academy.

Placing ESOF in this area of the city therefore highlighted important cultural and historical trajectories and values. Carlsberg signifies the importance of science for modern Danish industrialisation, as well as the link between scientific excellence and industrial research. It represents a national identity which has a strong history of productive relations between science and industry—relations which continue to be important in contemporary science policy. A national identity as scientifically world-leading is also boosted by the very fact of ESOF's presence. Its organisation requires significant financial and administrative resources, and the fact that ESOF chose and was successfully run in Denmark is prestigious. The importance of the ESOF conference was signalled by the fact that the opening session featured both the Danish Queen Margrethe II and the chairman of the European Commission, Manuel Baroso. It also included a lot of red carpet, speeches about the importance of science and technology for the development of Europe, and a cocktail reception. Denmark, it was clear, is a key actor in European policy on science and society.

Identity is a key concern of this book. Processes of national identity formation—presenting Denmark as a scientifically advanced, technologically world-leading nation—were particularly apparent at ESOF, but we will also be concerned with other ways that science communication relates to the shaping and management of identities. In Chapter 3, we will argue that scientific identities are intimately linked to science communication activities. When scientists communicate, they are not just presenting facts or information, but making sense of what science is and should be, as well as managing their own professional and personal identities. Throughout the ESOF event it was possible to meet scientists who presented themselves in different ways: some came across as playful and down to earth, while others were more aloof or serious. These performances were not only about who they were but implied different versions of what science is. To some, it is an endeavour full of hard-core facts and certainty, while others introduced ambiguity and uncertainty into their stories about science. Some scientists were clear that they were primarily speaking as individuals, while others saw themselves as representatives of something bigger than themselves—their university or scientific discipline, for instance. Again, we will explore how identity relates to scientific collectives in Chapter 3.

Science communication can also be more or less important for the way in which citizens see themselves and their communities. In Chapter 8, we will introduce the notion of scientific citizenship as one way of thinking about identity construction and the capacity to define this for oneself. Are publics consumers of scientific knowledge, or citizens actively engaged in its management? Certainly a lot of citizens visited the Science in the City festival during ESOF and did so for a number of different reasons: curiosity, pleasure, entertainment, social reasons. We have also met users of science communication who think it is a citizenly duty to ‘keep up’ with science and who talk worriedly about a wider public who do not pay enough attention to it. Going to a science festival can be a status marker or a sign that one is a good citizen. On the other hand, some people may define themselves through being someone who does not understand or care about science.

Science communication therefore relates to identity construction in a number of different ways. Cultural theory tells us that the constitution of identity is not something that happens once and for all, but is an ongoing process; often, 'identity is most clearly defined by difference, that is by what it is not'.[24] Culture is the overall pool of shared meanings which we draw upon when we do this identity work. Woodward writes that 'Identities are produced, consumed and regulated within culture—creating meanings through symbolic systems of representation about the identity positions which we might adopt'.[25] But this continuous identity work also contributes to our shared pool of meanings. Culture and identity are therefore in continual interaction with each other. Science communication may help shape cultural resources for identity formation, but it will also, of necessity, draw upon existing understandings of science, scientists, and public audiences.

Production of science communication

ESOF was a massive undertaking, and many different organisations and individuals were involved in its development. The science communication activities within it were produced by universities, academic departments, research institutes, businesses, NGOs, hackers, artists, and designers. Those products drew on the knowledge and skills of scientists, professional university communicators, freelance science communicators, designers, administrators, students, business people, and construction workers. Beyond the pure logistics of producing science communication—how did all these groups work together or alongside each other?—ESOF also raises questions about the purposes the producers of science communication imbue their products with. Many of the universities and research organisations present at ESOF used it as a site for PR and showcasing positive stories. Science communication was part of a general effort to achieve good branding. In Chapter 5, we reflect further on this aspect of the production of science communication, exploring the ways in which a good brand is a valuable resource for attracting funding and resources for any research organisation. Groundbreaking scientific results are valuable not just in and of themselves, but because they can be used to make salient external communication.

The study of production processes covers all aspects of how meaning is encoded into messages, artefacts and other representations. Production 'entails the logistical constraints surrounding formation of representations as well as how they come to be ideologically informed'.[26] Studies of production therefore involve both analysis of the organisational, logistical and other structures which shape the making of particular representations, as well as the cultures that imbue those representations with particular meanings. What is in focus here are the practices that make up any production of representations, from taken-for-granted assumptions and worldviews to organisational visions and heroic stories and the ordinary habits that result in sense-making.

In the context of science communication, this brings into focus a number of different things: questions of branding, certainly, but also the role of science communication in organisational communication (something we discuss in Chapters 3 and 5) and emerging professional values and practices in the making of science communication products. In Chapter 4 we explore the way in which science communication is increasingly becoming a specialised professional activity, rather than one carried out by volunteer scientists or generalist journalists. Professional values and norms for how to do science communication now play an important role in producing science communication. Science is no longer simply done by individual scientists as an add-on to their normal job. Rather, science communication is rapidly becoming big business, as more and more money becomes available to pay for the dissemination of results from large-scale scientific enterprises. In Chapter 6 we follow this development back to the practice of science and argue that today science communication is no longer simply a way of reporting a scientific result after it is produced. Rather science communication has become part of (and is sometimes a precondition of) producing science. In order to be able to generate necessary resources and legitimacy scientists need to be able to communicate convincingly about their visions and ideas.

Studies of production therefore open many questions about how science communication is organised and carried out, as well as the values attached to it. To take just one example, studying production will raise issues about who controls communication about science. At ESOF, communication of scientific topics was doubtless shaped not just by the scientific content but also by what organisations felt were positive messages, what journalists saw as newsworthy, and the constraints of particular formats. Many different forces helped mould the science communication that was produced.

Representations in science communication

The ESOF conference had a large exhibition area in which universities, funding agencies, businesses, charities and other scientific organisations presented glossy representations of themselves in little booths. Similarly, the festival had a number of tents in which organisations presented their science to festival goers. The differences between these two venues, and the representations displayed within them, were interesting: in Science and the City, although organisational names were displayed, the focus tended to be on representations of the science that those organisations did. At the policy convention, however, branding of particular organisations was key and took priority over representations of the scientific knowledge they were producing. Despite these differences, all of the efforts at the conference and the festival were clearly linked to the deliberate production of certain representations of science—that, for instance, it is important, powerful, useful, and universal. Although representations of science may vary depending on audience, and different aspects of scientific knowledge production are emphasised in different venues (fun was more obvious in Science in the City, economic productivity in the ESOF exhibition), it seems that there are some standard, and powerful, ways of representing science that are not easily deviated from within public spaces.

Representation is about the way in which signs (such as words, images, body language, or symbols) are used to 'stand for' or signify objects, whether physical or mental, in a meaningful way. Such representations are always subject to multiple interpretations. 'It is by our use of things, and what we say, think and feel about them', writes Hall, 'that we *give them a meaning*' (emphasis in original).[27] The process of representation therefore includes all the ways in which we use signs to create and communicate meaning about phenomena. Analysis of representation focuses on the signs, symbols, figures, images, narratives, words and sounds in which symbolic meaning is circulated. Just as 'encoding' covers the processes by which meaning is imbued into cultural artefacts through their production, Hall speaks of 'decoding' as the interpretative process by which people make sense of representations.[28] Representations are always open to multiple forms of decoding, and producers therefore cannot control the process of decoding (even though they might try to make some forms of interpretation more obvious than others).

In the context of science communication, studies of representation are especially concerned with the way in which meaning is ascribed to science, scientists, and scientific knowledge through particular representations. This is one area where there has been a substantial amount of research within science communication, and which crops up repeatedly throughout the rest of this book. There have, for instance, been studies of the use of metaphors, icons or imagery to promote certain imaginations of science (discussed in Chapter 7), or of conflictual interpretations of particular representations. Media frames for science are another key area on which attention has focused (and which we discuss in Chapters 3 and 4). It is important not just to understand these representations in terms of how accurately they represent the scientific knowledge that they are signifying. The representations found in science communication are never just about their scientific content: in addition, they also represent ways of understanding science as a social activity and part of society. One simple issue, for instance, is that of gender. If most representations of scientists are of white men, then what does this mean for how science is decoded by audiences?[29]

Consumption of science communication

Consumption, within cultural theory, is not a passive or meaningless process. While expectations about how audiences consume science communication have tended to focus on education and learning (either in the form of citizens generally improving their 'scientific literacy',[30] or as people in direct need of information, such as patients), in our observations at ESOF it was clear that visitors found multiple meanings and purposes for the Festival and the exhibits within it. It was never a straightforward process of learning about science or meeting scientists, but something that had to dovetail with other parts of visitors' lives. Some people attended because their son was a Ph.D. student at the University of Copenhagen and they wanted to see what he was doing in his festival tent. Others commuted through the area on their way home from work and stopped to see what the fuss was about. Schools used it as a free and entertaining afternoon out for students. Overseas visitors saw it as part of a cultural itinerary in the larger project of visiting Copenhagen. Families and colleagues of scientists involved in communication activities showed their support by touring exhibits made by those they know. All of these aspects of consumption, and more, deserve further study in order to better understand how science communication is connected to different parts of audiences' lives and meaning-making.

Consumption is here used to refer to all the various processes in which representations are decoded and put to use. 'Processes of production', writes du Gay, 'only provide a series of possibilities that have to be realized in and through consumption'.[31] Consumption is therefore about the use of representations and artefacts in everyday life. It is a crucial argument for us that such consumption should be seen as something that is active. Consumers of cultural products are not just passively fulfilling a determining script put forward by producers, but decoding messages according to their values, preferences, and interests. People make sense of science and science communication in ways that suit them, their values and their current circumstances. Sometimes this leads them to consume science communication in a very different way than the producers intended (we will, for instance, discuss 'misbehaviour' in science communication in Chapter 7).

Consumption of science communication can also be linked to the exercise of what we will discuss, in Chapter 8, under the term 'scientific citizenship'. We also explore some of the different ways in which publics consume science communication in Chapter 7, when we think about the role of materiality and emotion within science communication. One example of active, citizenship-oriented engagement at ESOF was found in the exhibits and activities organised by a group of biohackers. The events and workshops they developed were a mix of political discussions about empowerment of citizens and a number of hands-on activities designed to invite visitors to do science on the spot. Such efforts also demonstrate connections with identity formation: the citizen science activists had a different perception of their own agency and engagement than other visitors who might have come to enjoy scientists' talks and displays more passively. Actively consuming science and science communication, and seeking to engage with science policy, is not, of course, necessarily better than simply enjoying listening to a talk. But such choices about how to consume science communication are part of the stories people tell about themselves, the identities they shape, and the place that science has in their civic lives.

Regulation of science communication

We have already noted that there were some differences between the representations of science put forward in the booths in the ESOF exhibit halls and those in the Science in the City Festival. Those in the former were representations of scientific progress, excellence, competition and investment in science and were explicitly related to stories of national prosperity and growth in modern knowledge societies. In the public festival, science was portrayed as playful, spectacular, directly useful to everyday life, entertaining, wonderful and engaging. These two spaces show how science communication is shaped for different instantiations of audience identities and needs. This is not something that solely relates to questions of the representations science communication produces but also to how it is regulated. Some stories about science, it seems, are more suited to some audiences.

Cultural processes of regulation have two aspects. On the one hand, there is explicit and direct regulation of production and consumption: the ways in which we organise, govern, and control the production and use of cultural products. This aspect highlights legislation and other formal means of controlling production. There are also more diffuse means of regulation, in which cultural meanings 'organize and regulate social practices, influence our conduct and consequently have real, practical effects'.[32] Studies of cultural production therefore pay attention to how cultural norms and conventions structure how artefacts are used, circulated, and understood. Regulation may be as concrete as a law or a directive, or as diffuse as the frameworks within which we live and which sanction certain behaviours as meaningful and others as meaningless. In both cases, regulation remains open to negotiation: it cannot 'mechanically reproduce the status quo. It is a dynamic process that is often contested'.[33]

In the context of science communication, regulation therefore concerns both formal legislation and the unstated norms and conventions that govern practice. This might involve not only official rules about obligations to disseminate research (e.g., as a condition of research funding) but also the informal cultures around whether these activities are actually desired, merely accepted, or somehow discouraged. ESOF is a good example of the commitment to science communication which can be found generally in the European Commission, and which is mirrored in the fact that EU research funding programmes often devote a substantial amount of attention and funding to science outreach activities. However, the availability of funds in and of themselves is not enough. There needs to be support from the organisational and disciplinary norms and values which informally govern the behaviour of scientists. This is an issue that we explore further in Chapters 3 and 5, when we consider some of the different cultures that researchers and other communicators operate in, and the kinds of norms that might structure their activities.

In Chapters 2 and 9, we also think about how formal and informal norms about how to do and talk about science communication have changed over the past decades. This relates, for instance, to the ways in which a straightforward focus on education and dissemination of knowledge has been challenged by ideas about making science communication dialogic and participatory. Such competing ideals of science communication were very visible at the ESOF event. On the one hand, the entire endeavour was designed to educate citizens about the importance of science, while on the other hand, it also included lots of dialogic interaction and participatory engagement with audiences of various kinds. As such it can be seen as a space in which different ways of regulating science and society, through the practice of science communication, were being played out.

The circuit of culture as a heuristic

The circuit of culture is not a tool that gives immediate answers. Rather, its value is that it opens up questions, allowing us to notice different aspects of science communication in different kinds of ways. We can thus use it as a framework for navigating science communication, something that we do throughout the rest of this book. It serves as a heuristic that demonstrates the richness of understanding science communication as a cultural phenomenon.

The five moments of articulation that we have described as making up the circuit of culture should not, however, be used rigidly. We have not introduced them in order to devise a structure, but rather so as to use them as a set of lenses that help us bring our discussions of science communication into focus. In the chapters that follow we move through a series of spaces and topics, each of which will involve multiple moments from the circuit.

The next chapter continues to develop the contexts and theories from which we are working. We discuss both our own standpoint—including some of the limitations of our field of vision—and the way in which contemporary science communication has been shaped and imagined. We also further explain the model of communication we are drawing upon as we talk about science communication processes: not only is it *cultural*, but also *material* and *constitutive*. Chapters 3, 4 and 5 then start to unfold the ecosystem of science communication as it is being articulated today. We look at current practice in science communication and explore some of the different cultural spaces and moments in which it is operating. Chapter 3 focuses on identity and on the ways in which scientists engage in public communication. Chapter 4 considers how science communication is developing and changing, focusing on the way in which science communication is becoming a professional domain in its own right—one that interacts not only with the culture of science but also with those of the media, education, and business. Chapter 5 takes as its starting point the changing nature of knowledge production in the contemporary world, exploring how dynamics of globalisation, marketisation and commercialisation in science are shaping, and being shaped by, science communication.

Chapters 6, 7 and 8 then focus on various performativities of science communication. What are different forms of science communication doing in and to the world? Chapter 6 argues that science communication creates futures: public communication of scientific expectations and visions helps to bring particular technologies, and social worlds, into being. Chapter 7 looks at the way in which science communication is entangled with the material and emotional, suggesting that it should be understood and studied as a set of practices that go beyond the discursive. Chapter 8 focuses on scientific citizenship, arguing that science communication needs to be seen as playing a role in this. Science communication is, then, about democracy as much as it is about pleasure, spaces, visions, organisations, identities, professions, stories and cultures. Chapter 9 draws all of this together by returning to some of the recent histories of science communication and in particular to the way in which it has been framed as being either 'deficit' (one-way) or dialogic (multi-way). The book as a whole opens up the complexity of science communication practice and indicates some tools and spaces which deserve further attention in its study. Chapter 9 therefore concludes on this point. Science communication scholarship, we suggest, should make the most of the theoretical, conceptual and methodological resources available to it, as well as of the many and varied empirical spaces in which it takes place.

Notes

1. Much has been written about the notion of 'Public Understanding of Science'. Two key contributions can be found here:

   Durant J (1993) What is scientific literacy. In: Durant J and Gregory J (eds), *Science and Culture in Europe*, London: Science Museum, pp. 129–137.

   Michael M (2002) Comprehension, apprehension, prehension: Heterogeneity and the public understanding of science. *Science, Technology, & Human Values* 27(3): 357–378.
2. We will discuss this idea of sense-making at length in the book, including that it is not just something citizens do. Communication efforts influence everyone involved and certainly also scientists and other people who work within science communication. Sense-making is about our fundamental orientation in the

world. Since science has become such a central activity in modern societies we need to understand this sense-making in very broad terms.

3. Gregory J and Miller S (1998) *Science in Public—Communication, Culture, and Credibility*. Basic Books.

   Shipman WM (2015) *Handbook for Science Public Information Officers*. University of Chicago Press. Available from: http://www.press.uchicago.edu/ucp/books/book/chicago/H/bo18768107.html (accessed 24 October 2015).

   Bennett DJ and Jennings RC (2011) *Successful Science Communication: Telling It Like It Is*. Cambridge University Press.
4. This definition is taken from, and explicated in more detail in, Horst M, Davies SR and Irwin A (2017) Reframing Science Communication. In: Felt U, Fouché R, Miller C and Smith-DoerrL (eds), *Handbook of Science and Technology Studies*, 4th edition. Cambridge, MA: MIT Press.
5. Cassidy A (2014) Communicating the Social Sciences: A Specific Challenge? In: Bucchi M and Trench B (eds), *Handbook of Public Communication of Science and Technology, 2nd edition*. London and New York: Routledge, pp. 186–197.
6. Latour B (1987) *Science in Action*. Massachusetts: Harvard University Press.
7. Hansen A (2009) Science, communication and media. In: Holliman R, Whitelegg E, Scanlon E, et al. (eds), *Investigating Science Communication in the Information Age*, Oxford: Oxford University Press, pp. 105–127.
8. Dunwoody S (2014) Science journalism: Prospects in the digital age. In: Bucchi M and Trench B (eds) *Routledge Handbook of Public Communication of Science and Technology*, 2nd Edition, New York: Routledge, pp. 27–39.
9. Broks P (2006) *Understanding Popular Science*. Berkshire: Open University Press.
10. Kaiser D, Durant J, Levenson T, et al. (2014) Report of Findings: September 2013 Workshop. MIT and Culture Kettle. Available from: www.cultureofscienceengagement.net.

    Riesch H (2015) Why did the proton cross the road? Humour and science communication. *Public Understanding of Science* 24(7): 768–775.
11. Rose N (1999) *Powers of Freedom*. Cambridge: Cambridge University Press.

    Foucault M (2000) Governmentality. In: Faubion JD (ed.), *Michel Foucault: Power*, London: Penguin, pp. 201–222.
12. Irwin A (2006) The politics of talk: Coming to terms with 'new' scientific governance. *Social Studies of Science* 36(2): 299–322.
13. Andersen IE and Jæger B (1999) Danish participatory models. Scenario workshops and consensus conferences: towards more democratic decision-making. *Science and Public Policy* 26(5): 331–340.

Grundahl J (1995) The Danish consensus conference model. In: Joss S and Durant J (eds), *Public participation in science: The role of consensus conferences in Europe*, London: Science Museum, pp. 31–40.

14. McManus PM (1992) Topics in museums and science education. *Studies in Science Education* 20: 157–182.
15. Lewenstein B (2016) Can we understand citizen science? *Journal of Science Communication* 15(1): 1–5.
16. p. 2, Hall S (1997) *Representation—Cultural Representations and Signifying Practices*. London: SAGE Publications.
17. Ibid.
18. Version of this book was published in 1997 along with a whole series of edited collections on the five different elements of the circuit. A second edition which usefully discusses links with other theories, such as actor-network-theory was published in 2013.

    Gay P du, Hall S, Janes L, et al. (1997) *Doing Cultural Studies - The Story of the Sony Walkman*. London: SAGE Publications.

    Gay P du, Hall S, Janes L, et al. (2013) *Doing Cultural Studies - The Story of the Sony Walkman*. London: SAGE Publications.
19. p. 283, Johnson R (1986) The story so far: And further transformations. In: Punter D (ed.), *Introduction to Contemporary Cultural Studies*, Harlow: Longman, pp. 277–313.
20. Thereby broadening a more traditional Marxist view of meaning as something that originates in the forces of capitalist production.
21. p.10, Gay P du (1997) *Production of culture/cultures of production*. SAGE Publications.
22. p. xxx, Gay P du, Hall S, Janes L, et al. (2013) *Doing Cultural Studies - The Story of the Sony Walkman*. London: SAGE Publications.

    Hall gives a nice explanation of these different moments and how meaning is produced and circulated at each of them:

    "Where is meaning produced? Our 'circuit of culture' suggests that, in fact, meanings are produced at several different sites and circulated through several different processes or practices (the cultural circuit). Meaning is what gives us a sense of our own identity, of who we are and with whom we 'belong'—so it is tied up with questions of how culture is used to mark out and maintain identity within and difference between groups (…). Meaning is constantly being produced and exchanged in every personal and socal interaction in which we take part. In a sense, this is the most privileged, though often the most neglected, site of culture and meaning. It is also produced in a variety of different media; especially, these days, in the modern mass media, the means of global communication, by complex technologies, which circulate meanings between different cultures on a scale and with a speed hitherto unknown in history (…). Meaning is also produced whenever we express ourselves in, make use of, consume or appropriate cultural 'things'; that is, when we incorporate them in different ways into the everyday rituals and practices of daily life and in this way give them value or significance. Or when we weave narratives, stories—and fantasies—around them (…). Meanings also regulate and organise our conduct and practices—they help to set the rules, norms, and conventions by which social life is ordered and governed. They are also, therefore, what those who wish to govern and regulate the conduct and ideas of others seek to structure and shape (…). In other words, the question of meaning arises in relation to all the different moments or practices in our 'cultural circuit'—in the construction of identity and the marking of difference, in production and consumption, as well as in the regulation of social conduct". pp. 4–5, Hall S (1997) *Representation-Cultural Representations and Signifying Practices*. London: SAGE Publications.

23. We are not the first to use this model and its associated thinking for analyses of communication around science and technology. See, for instance.

    Allan S (2002) *Media, Risk and Science*. Buckingham: Open University Press.

    Carvalho A and Burgess J (2005) Cultural circuits of climate change in U.K. Broadsheet Newspapers, 1985–2003. *Risk Analysis* 25(6): 1457–1469.

    Burgess J (1990) The production and consumption of environmental meanings in the mass media: A research agenda for the 1990s. *Transactions of the Institute of British Geographers* 15(2): 139–161.

    Wilcox SA (2003) Cultural context and the conventions of science journalism: Drama and contradiction in media coverage of biological ideas about sexuality. *Critical Studies in Media Communication* 20(3): 225–247.
24. pp. 1–2, Woodward K (1997) *Identity and Difference*. SAGE Publications.
25. Ibid.
26. p. 100, Curtin PA and Gaither TK (2005) Privileging identity, difference, and power: The circuit of culture as a basis for public relations theory. *Journal of Public Relations Research* 17(2): 91–115.
27. p. 3, Hall S (1997) *Representation—Cultural Representations and Signifying Practices*. London: SAGE Publications.
28. Hall S (1980) Encoding/decoding. In: Hall S, Hobson D, Lowe A, et al. (eds), *Culture, Media, Language: Working Papers in Cultural Studies 1972–1979*, London: Unwin, pp. 128–138.
29. Chimba M and Kitzinger J (2010) Bimbo or boffin? Women in science: An analysis of media representations and how female scientists negotiate cultural contradictions. *Public Understanding of Science* 19(5): 609–624.

30. A contested concept which we will return to later in the book. For an early discussion, see Durant J (1993) What is scientific literacy. In: Durant J and Gregory J (eds), *Science and Culture in Europe*, London: Science Museum, pp. 129–137.
31. p. 59, Gay P du, Hall S, Janes L, et al. (1997) *Doing Cultural Studies - The Story of the Sony Walkman*. London: SAGE Publications.
32. p. 3, Hall S (1997) *Representation—Cultural Representations and Signifying Practices*. London: SAGE Publications.
33. p. 3, Thompson K (1997) *Media and Cultural Regulation*. SAGE Publications.

2

Histories: Telling the Story of Where Contemporary Science Communication, This Book, and Our Own Work Come From

Cultures are not stable. The way in which science is communicated, and science and society are expected to relate, is not static but continually developing. This book is about giving a snapshot of the richness of contemporary science communication, but, more than that, it is about equipping us, as scholars and students of science communication, to think about how we can study this richness and instability.

Exactly because science communication is rich and complex, this book—any book—can only offer a limited view of it. This view is shaped by our backgrounds and interests, as well as by the particular cultures in which we are immersed. So who are we? Where has this book come from?

One starting point for the development of this text was our own sense, as scholars of science communication with backgrounds in Science and Technology Studies (STS), that the practice of science communication was continually overflowing the analytical frames we placed upon it. Not only was it taking place in a more diverse set of spaces than tended to be discussed in the literature, but it was unfolding in more complicated ways than we might expect. We realised, for example, that although our own universities had extensive communication departments, we did not know enough about science PR as it is carried out by universities, NGOs,

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the public sector, or industry. We were training students from various disciplines and became curious about the ways in which science communication is becoming a professional activity, supported by educational programmes or carried out as a for-profit enterprise. We observed the complexity of our own behaviours when we visited science museums or carried out public communication, and realised that this complexity was not always well captured by studies of visitor or participant motivations in science communication. Science communication research tended to focus on some formats and actors (the media, scientists, and public dialogue) more than others (social media, PR, and lay audiences as active consumers).

This book is an effort to introduce new perspectives and tools into science communication study and analysis. Our ideas have been shaped by our backgrounds in STS, but we are writing this book with a rather light theoretical touch. We will use theory from different fields in a very eclectic way: though we sketch out key aspects of our overall approach in the rest of this chapter, overall we will draw on thinking from different disciplines and traditions, seeking to put these ideas to work in the context of science communication rather than adhering to one particular framework. One of our key ideas has been that science communication could productively draw on a more diverse range of social theory and research fields (such as consumer research, cultural theory, political studies, or organisation and management literature). We are therefore trying to model this in the way we explore different aspects of science communication practice.

If we are eclectic theoretically, we are rather more limited in the cultural contexts and science communication practices we are most familiar with. Our experience has primarily been of working in the national contexts of the USA, the UK and Denmark, and readers will find that many of our examples and case studies are taken from these places. This is not a reflection of where the most interesting research and practice in science communication is going on, but of our own histories and experiences. We look to our colleagues in other countries—and particularly non-Anglophone contexts—to join us in the conversation that this book is designed to stimulate and to remedy the gaps in this account. One wider problem is that much of the research which our linguistic abilities allow us to read continues to focus on Anglophone contexts. We would love, for instance, to be able to read more of the published research on science communication in Asia or Latin America. There are also a number of conterminous fields, including health communication, museum studies, informal science education, and risk communication, on which we have drawn lightly, if at all. Again, this is no reflection on how useful scholarship in these areas is likely to be to science communication. Space constraints—the need to write one book rather than several—has inevitably limited our ability to engage with these fields and contexts, as well as with many emergent practices in science communication. Citizen science, hacking and making, social media, and scientific governance all deserve more space than we have been able to give them.

Who are 'we'? We use the pronoun a lot in the book, and in three ways. 'We' may be us, the authors. *We* argue that science communication is a cultural phenomenon, for instance. 'We' may also extend out to include our readers, and by extension a community of science communication scholars and practitioners of which the two of us are just a part. *We* need to think about how to better capture the richness of science communication, collectively, and to start conversations about this. Finally—and particularly as we move to the closing chapters of the book—'we' may be citizens of democratic societies more generally. *We* have a right, and a responsibility, to interrogate science's role in our societies. This is something we believe as individuals and which (we, the authors, believe that) many societies are committed to.

The rest of this chapter fleshes out the context we have given so far. Science communication is diverse, but there are some key dynamics that have shaped how it is understood in today's knowledge societies. These dynamics—enlightenment thinking, scientific controversy, participation and deliberation—are outlined below. The second half of the chapter provides a map to our understanding of the nature of communication by describing some key theoretical inspirations.

Enlightenment, science, and democracy

Why is science communication important? We are occasionally asked this by journalists, and the question always feels a little redundant because it carries a subtext of agreement that, of course, it is important, and that the journalist also thinks so. (Could one ever get away with saying: well actually, no, it's not?) The importance of science communication is largely taken for granted by the societies we live in, to the extent that it's something that is hard to argue against. This in itself is telling. It reveals the extent to which science, and its publicisation and dissemination, is tied to one of the foundational ideas of European modernity, that of enlightenment.

Enlightenment is about people's willingness to know and their desire to use their faculties of reason to understand the world. It therefore reacts to the idea that *revelation,* usually divine, is the only reliable way to know the world. In 1784 Kant defined enlightenment in these terms:

> Enlightenment is man's emergence from his self-imposed nonage. Nonage is the inability to use one's own understanding without another's guidance. This nonage is self-imposed if its cause lies not in lack of understanding but in indecision and lack of courage to use one's own mind without another's guidance. Dare to know! (*Sapere aude*) 'Have the courage to use your own understanding', is therefore the motto of the enlightenment.[1]

Here the German word *unmündigkeit* has been translated as 'nonage'. Other translations use 'immaturity' or 'tutelage'—so what Kant is saying is that too often humans, as beings with the potential to use our reason to understand the world, are content not to do so. Instead, we should 'dare to know'. What is interesting are that 'have the courage to use your own understanding' would not be out of place as a slogan for contemporary science communication. Just as the idea of enlightenment sought to encourage individuals to use their reason for themselves, science communication can be framed as being about giving lay citizens the tools they need to engage with contemporary technoscientific societies. This is not surprising given the historical development of ideas about enlightenment and democracy and the way in which this history continues to shape the present. Notions of enlightenment were integral to the understandings of democracy that developed in Europe in the seventeenth and eighteenth centuries. The German political philosopher Jürgen Habermas has described how ideas about an emergent public sphere and rational deliberation between citizens were used as the foundation for modern understandings of democratic processes and involvement.[2] In his (idealised) description, free and independent citizens would gather in public and semi-public places to discuss matters of common interest in order to develop informed opinions on public and political issues; such opinions would then shape public policy. These exchanges were based on rational and informed argumentation. As an important provider of knowledge about the world, science was viewed as a natural part of these discussions.[3]

Part of the heritage of the enlightenment age is thus the notion that reasoned engagement between citizens is important for democracy, and that reliable knowledge—as provided by science—is important to such debate. Science communication becomes integral to the functioning of democracies. A 2007 report to the European Commission adds an extra dimension to this. It introduces the notion of 'master narratives'—expressions of "wider imaginations about the world"—which both summarise and reinforce shared understandings about how society functions. One master narrative, the report's authors write, is of technoscientific progress. Within this master narrative, science and technology are an unconditional good. They help us solve problems and form the basis for economic prosperity and cultural enlightenment. They are 'staged unambiguously as the solution to a range of social ills'.[4] Again, this master narrative implies that science communication should be valued as important for the development of prosperous and harmonious societies. Technoscience delivers benefits, such as useful products and economic growth, and citizens should be encouraged to engage with it. Not only is such engagement democratically important—as in Habermas' model of the public sphere—but it supports the economically and culturally valuable activity of science through recruiting people into science and encouraging cultural appreciation of it.

These notions of reason, democracy, and progress—and the role of science in supporting their realisation—are part of a shared cultural heritage in Europe and beyond. They bounce around in our societies and mean that we can take for granted that science, and science communication, are important. These expectations and assumptions are often invisible to us. But they deserve interrogation for exactly that reason. It seems clear, for instance, that the prestige and authority that science has in our contemporary societies, and the expectation that it will unproblematically provide us with good things, has not always been there. The power of science is a historically contingent achievement, and public communication has played an important role in reaching this.[5] Peter Broks describes how nineteenth-century scientists developed a sense of identity as a coherent group: this, he says, was 'a process through which excluding the public became a defining feature of what it meant to be scientific'.[6] Subsequently, the relations between science and society changed radically, so that, as historian Steven Shapin writes, scientists have won 'far greater autonomy in ordering their own affairs'.[7] This has meant that science has gained more power within society. Rather than an embattled group who had to differentiate themselves from the rest of the public in order to carve out a space for themselves as distinctive, our societies now take it for granted that science is unique, and uniquely authoritative. As the master narrative of progress suggests, the idea of technoscientific development as intrinsically positive is widely shared. Elite groups—like politicians and journalists—rarely question this narrative.

Controversy and resistance

Notions of enlightenment, reason, and progress therefore continue to shape how many of us think about science and science communication. Many science communicators, for instance, are passionate about communicating science in order to empower lay citizens. There's a shared sense that knowledge and scientific reasoning are important for engaging in the public sphere. But other narratives are also emerging to shape how we think about the relationship between science and society. The latter half of the twentieth century brought both new scholarly and political interest in the science–society relationship and events which complicated narratives of the power of reason and the inevitability of progress.

The development of the nuclear bomb in the Manhattan project, for example, led to discussions about the 'dual use' of technologies for both good and bad purposes. Unethical and abusive medical research such as that carried out by Nazi doctors or in the Tuskegee project (in which black syphilis patients were left untreated for research purposes) prompted public debates about medical ethics. By the 1970s, it was not just specific areas of research (such as nuclear research or abusive medical studies) that were being challenged, but technoscientific development more generally. Environmental problems had begun to surface, and the wider application of scientific knowledge in new technologies became controversial. The work of the sociologist Dorothy Nelkin has been key to charting these public scientific controversies and investigating how they have reshaped our understanding of the science–society relationship. Nelkin explored many of the conflicts over the understanding, use, and evaluation of new science and technology that emerged over the twentieth century, studying everything from nuclear power to infrastructure development, creationism, and the use of new diagnostic methods in healthcare.[8] Her work demonstrates that public scientific controversies emerge around a number of central issues and recur over many years. The use and regulation of nuclear power, for instance, is a controversy that appears repeatedly over time; most recently, the aftermath of the 2011 catastrophe at Fukushima is a twenty-first-century example of this. Infrastructure, industry and pollution are similarly focal points for public discontent and political conflict. Rachel Carson published *Silent Spring* in 1962, critiquing the catastrophic effects of agricultural pollutants on biodiversity. Since then controversies over environmental damage, risk distribution, and human hazards have continued around the world.

Global controversies over the development and use of biotechnologies[9] are a key iteration of these kinds of concerns. 1975 saw the Asilomar conference on recombinant DNA. This was convened by scientists who were concerned about the safety of new biotechnology techniques and who took the initiative to discuss a possible moratorium on their use until safety measures had been properly installed. At this point, biotechnology was still relatively unknown to wider publics: Asilomar was both initiated by, and primarily involved, scientists (some lawyers, policymakers and medical doctors were also present).[10] The birth of the first test tube baby in 1978 and the 'great embryo debates'[11] that took place in many countries over reproductive technologies increased discussion of biotechnology not only by scientists but also by lay people, policymakers, and representatives of different interest groups. Public debate focused not only on the connection to earlier visions of eugenics (now cast in the form of designer babies) but also on issues around cloning and the use of human embryos as a means rather than an end in themselves. By 1990, and the commencement of the Human Genome Project, more and more voices were explicitly being included in discussions of biotechnological development. The Human Genome Project included a small percentage of funding for research and activities on the Ethical, Legal, and Social Issues (ELSI) of the project. ELSI work aimed to explore concerns relating to the science, for example about the right to privacy and whether insurance companies should be able to access your genomic data. Agricultural developments brought scientific controversy even further into the public domain. The importing of genetically modified soybeans to Europe in 1996 and the birth of the cloned sheep Dolly in 1997 hit front pages and led to public protests all over the world.

The history of biotechnology demonstrates the extent to which debates over the use, evaluation and control of scientific knowledge can now mobilise widespread social protest and activism. In this context, science communication is intrinsically political, rather than the neutral public good it is portrayed as in enlightenment visions of democratic society. Scientists, activists, politicians and scholars now have to take an interest in the way science is communicated and in the effects of this communication. This is particularly the case if they are interested in controversial fields, but it also holds true more generally. '[P]ublic opinion', write Martin Bauer and George Gaskell, 'is not merely a perspective "after the fact"; it is a crucial constraint'.[12] Public communication of and debate about science is thus a battleground between different kinds of stories about science and society, and such debates have the potential to set constraints on what kinds of technoscientific developments are possible.

Even noticing the controversies themselves becomes part of this political discussion. Some see controversies as a signal that public understanding of science needs to be improved. If only people understood the science correctly, this argument goes, they would not be sceptical. Others argue that controversies indicate that science and technology need to be democratised and put under public scrutiny. In this view, the problem is not with lay citizens' understanding of science, but with the way in which science is carried out. These differences of perspective are illustrated by one example of developments in science communication over the past decades, the unfolding of 'Public Understanding of Science' in the UK from the mid-1980s onwards.

Public understanding of science to public engagement with science

In 1985, the Bodmer Report (named after its lead author, Sir Walter Bodmer) on 'Public Understanding of Science' was published by the UK's Royal Society. The report highlighted a lack of public understanding of science; to combat this, it suggested, '[s]cientists must learn to communicate with the public, be willing to do so, and indeed consider it their duty to do so'.[13] Following this publication there was increased interest in, and financial and other support for, science communication throughout the late 1980s and 1990s in Britain. As Sir Walter Bodmer described 25 years later, it effectively mobilised learned societies like the Royal Institution and Royal Society and helped open government coffers, resulting in both openess to communication activities from senior scientists and financial support for such activities.[14] The publication of this report was not a unique phenomenon. Similar debates could be found in many countries around the same time. However, subsequent criticism of this report and its assumptions about science and publics has become a key narrative for understanding the field of science communication.[15]

The report was criticised as building on a 'deficit model' or 'one-way' understanding of communication.[16] The public was seen as a homogenous mass who uniformly required scientific education. Audiences were blank slates upon whom scientific knowledge could be inscribed through accurate media coverage or public lectures by learned professors. As the public became more knowledgeable, the thinking went, they would also become more supportive of science (including of biotechnology).[17] The flaws in this approach were pointed out by a range of actors, but particularly by scholars from Science and Technology Studies (STS) who researched the way in which laypeople engaged with scientific knowledge. Their research highlighted that audiences are, in fact, never 'cognitively deficit' blank slates. A deficit model of publics ignores the knowledge publics have—scientific or otherwise—and the ways in which they will bring these to bear on any instance of communication. In addition, it became clear that (to use a phrase from science communication researcher Jon Turney) to know science is not necessarily to love it. More knowledge about science does not guarantee public trust in or support for scientific developments. This was made particularly clear in the UK throughout the 1990s, when there was a series of public scientific controversies ranging from BSE/vCJD (the development of 'mad cow disease' in British herds) to concerns over the development and use of genetically modified crops.[18]

This series of controversies, and the sense that public trust in science and scientists was slipping, made it clear that there was a need for a somewhat different approach to science communication. Scholars, policymakers, and communicators came to advocate dialogic methods in which lay knowledge was valued and public priorities were seen as relevant to science. This was crystallised in another report, this time from a House of Lords Committee on Science and Society and released in 2000, which talked of a 'crisis in trust' and a 'new mood for dialogue'.[19] In response, the 2000s saw a wave of interest in science dialogue, engagement, and public participation in scientific agenda-setting. There was a government-sponsored national 'GM Nation?' debate on genetic modification of crops,[20] the think tank Demos released an influential report advocating public involvement in emerging technological development through 'upstream engagement',[21] and museums, learned societies, and other science communicators brought in new programmes to engage their audiences in active debate about science.

We have presented this story with a focus on the UK, but many of the terms and concepts that appear in it—'deficit model', PUS, dialogue, upstream engagement—continue to be influential in discussions of science communication throughout Europe and the rest of the world. One US report on informal learning in science, for instance, notes that there are two 'predominant approaches to understanding publics' relationships with science … Public Understanding of Science (PUS) and Public Engagement with Science (PES)', and cites STS literature to support this.[22] European Commission reports, policy and funding structures through the 2000s and 2010s have drawn on the work of STS scholars to promote public participation, engagement and deliberation on science.[23] In many places, 'deficit' and 'dialogue' have become a convenient shorthand for talking about different ways of doing science communication. We will return to a discussion of this narrative and the effects it has in our concluding chapter. The important point here is that this story, of a progression from one-way deficit model science communication to dialogue and engagement, serves an important function as a sense-making narrative for science communication scholars and practitioners today.

Dialogue, deliberation and participation

The development of dialogue on science should not be taken in isolation. Moves towards public consultation and deliberation on science have been influenced by a more general turn to participation and deliberation that has taken place in political theory and practice over the past decades. Theoreticians have argued for 'deliberative democracy', while governments and other political actors have increased their use of consultations and other kinds of engagement with their constituencies. Maeve Cook writes that at its simplest, this 'deliberative turn' involves the promotion of 'a conception of democratic government that secures a central place for reasoned discussion in political life'[24]—a view that brings us back to Habermas, and his vision of the public sphere, which was similarly reliant on reasoned and informed debate. Most thinking goes further, to promote deliberation between diverse partners as something that should take place alongside (or, in some cases, instead of) traditional forms of representative democracy such as voting for political representatives. In deliberative theory, deliberation is a particular kind of talk, one that involves, in the words of Simone Chambers, 'debate and discussion aimed at producing reasonable, well-informed opinions in which participants are willing to revise preferences in light of discussion, new information, and claims made by fellow participants'.[25] Participation is the notion that—in an age in which many citizens feel powerless, and where there is distrust in representative democracy—citizens should have the opportunity to participate more directly in political decision making.[26]

Theorists of deliberative democracy generally trace their thinking back to the work of political philosophers such as Habermas. But there is also a strongly empirical strand of deliberative democracy, one that has attempted to translate at times rather abstract concepts of 'reasoned argument' or 'communicative action' into a set of tools for the practice of deliberation. There have therefore been a range of practical experiments in deliberation, from the large scale and influential (a Citizen's Assembly of 160 representative individuals, set up to redesign the province of British Columbia's electoral system)[27] to the tiny (deliberative processes on small building projects, or those set up by academics as experiments). A number of different formats have been developed: citizen's assemblies, citizen's juries, deliberative workshops, deliberative polling, participatory theatre, consensus conferences. In such formats, efforts are made to remove imbalances of power that might be evident in the outside world and to empower and give voice to those who might normally be silenced. Some action or decision is often at stake; sometimes, deliberators are expected to reach consensus, while at other times they may be asked to write a report, make recommendations or sum up the various positions taken on the issue.

It's important to note that results from these experiments in democracy—both with regard to civic participation generally and the case of science specifically—have been mixed. Deliberation can be hard to put into practice, and commentators have noted that such processes can actually act to disempower some actors and groups. Leaving wider power structures outside the room, and expecting citizens to engage on equal terms, can be difficult. Even the enlightenment-inspired requirement of 'reasoned argument' can privilege some groups over others. 'By valuing rationality, reserve, selflessness and powers of argumentation', write Elam and Bertilsson, 'deliberative democracy is a democratic politics played out on scientists' home turf'.[28]

In both the context of science and the deliberative turn generally, then, an unambiguous understanding of dialogue as a good thing is something we need to question. Louise Philips has described how dialogue has become a buzzword in a number of different social arenas,[29] including public relations and science communication. While she is clear that dialogue can be a positive force in furthering human coexistence across various differences, such as class, gender, nationality, and education, she is concerned with the way it has become a buzzword with a taken-for-granted positive value. 'The ideal of dominance-free communication (…) found in dialogic communication theory', she writes, is:

> not only an impossible ideal but also a dangerous one: by creating an illusion of a dominance-free space, it can work to mask power relations and diverging knowledge interests.[30]

Philips and many others have therefore suggested that deliberation, participation and engagement cannot simply be assumed to act in emancipatory ways. In the context of science, such methods are certainly not a way to 'solve' tensions between science and society, or a prescription for good science communication. Indeed, as Philips argues, they may simply mask relations of dominance and power. It is important to acknowledge that such asymmetries will always be present in science communication generally, as well as in deliberative and dialogic processes specifically.

Modelling science communication

What science communication looks like today, and the way in which societies understand it, is therefore shaped by a number of dynamics. Ideas about enlightenment and progress make it difficult to be 'against' science communication; at the same time, these stories have been complicated by scientific controversy and by recent arguments for public participation in scientific governance. Ideas about 'deficit model' communication, as opposed to 'dialogue', have been particularly influential, and these have gone on to shape more theoretical accounts of the nature of science communication. It is these we want to explore as we move on to discuss the theoretical contexts that our own thinking is located within.

In a 2008 meta-analysis of science communication models, Brian Trench noted that there are some key similarities in the models of science communication that have been developed. Most of them focus on the degree of interactivity within an instance of science communication and either implicitly or explicitly make reference to the distinction between 'deficit' and 'dialogue' approaches. The former is understood as the transfer of scientific knowledge from science to the public, and the latter emphasises an exchange of knowledge and views. The contrast between one-way, PUS-style dissemination and dialogic and interactive forms of communication is therefore central to how science communication has been modelled. Even when models involve three or even four 'types' of communication, this distinction remains central to the typology. Trench identifies three key categories of communication in which knowledge is understood as, respectively, primarily travelling to the public, travelling to science, or being constructed in negotiation between them. These he terms deficit (or dissemination), dialogue, and participation (or conversation)[31]; the latter, he says, is 'multidirectional: communication takes place back and forth between experts and publics and between publics and publics'.[32]

Similarly, Sarah Palmer and Renata Schibeci have developed a four part typology which includes categories of 'deficit', 'consultative', and 'deliberative' communication, but which adds a fourth category, professional science communication, involving intra-scientific communication (such as that which takes place at conferences or in journal articles).[33] Dominique Brossard and Bruce Lewenstein, on the other hand, focus more on the purposes driving different versions of (public) science communication. They also differentiate between communication that focuses on information delivery and that which focuses on engaging the public. Within these larger categories, however, they also include 'deficit' and 'contextual' models, in the case of the former, and 'public engagement' and 'lay expertise', in the case of the latter. These, they argue, can be distinguished by the slightly different versions of politics that they mobilise (a public engagement model of science communication, they write, is related to a 'democratic ideal of wide public participation in policy process').[34]

Most models of science communication have therefore focused on how knowledge travels and is produced. Is it something that already exists within science and moves to the public (a 'deficit' approach)? Is it found within lay public communities and then shared with scientists and policymakers ('consultation')? Or is it produced *within* dialogue and deliberation, as different actors interact, exchange views, and reach new conclusions ('participation' or 'deliberation')?

This understanding of science communication as the movement of knowledge has the advantage of being a relatively intuitive model of what happens within different kinds of communication situations. It is based on our taken-for-granted experiences and understandings of what happens when we communicate. But we think it's useful to complicate this model of communication. It's a rather 'flat' notion: to focus on cognitive processes of production and movement of scientific knowledge in this way means missing some important parts of the functions, experiences and results of science communication. For a start, it misses the smells, emotions, dreams, identities and stories that are also at stake in any instance of science communication. It also tends to focus on individual cognitive processes and overlook the organisational and institutional aspects of communication.

We have already introduced the circuit of culture as one alternative way of modelling science communication. In the remainder of this chapter, we want to add two further aspects to the theoretical base for our argument in this book. Our ambition, however, is not to suggest one single model as being superior to others. Rather we want to point to resources that we find useful and to suggest that the usefulness of any of these models will have to be an empirical question. Even the deficit model, simplistic though it may seem to be, is useful for some contexts, though one should always be aware of its basic assumptions. All models allow us to see some things while others become less visible. The important point is to reflect on the consequences and costs of these (in)visibilities.

Communication as constitutive and material

It is important to distinguish between two different paradigms in communication theory: communication understood as information or message transfer, and communication understood as meaning-making.[35] The models of science communication described above have tended to focus on the former, emphasising how messages are transferred. We think that understanding communication as constitutive—as involving the constant production of meaning, rather than the movement of static messages—is more productive for our present purpose. In the view presented in this book, communication is therefore a basic human activity that is interactive and constructive. When we communicate, we give meaning to things (objects, phenomena, and people) that we find in the world. Communication is the way in which we interpret the world and negotiate these interpretations with each other in a social setting. Such interpretative work is therefore also performative: it creates that which it names. Communication in all its forms does not just represent phenomena, it also constructs them.

The most fundamental implication of this approach is that there is in fact no such thing as one-way communication.[36] Rather, *all* communication is inherently active and interactive, including the apparently passive reception of communication delivered via TV, radio or writing. Even the most apparently uni-directional communication is actively received and interpreted. Audiences always receive information in the context of their prior knowledge, their opinions about the topic, and their degree of interest or distraction. Any kind of communication is thus to some degree interactive, a negotiation between the content of what is being conveyed and what a 'receiver' knows, feels, and desires. Understanding communication in these terms means that the difference between 'deficit' and 'dialogue' approaches becomes much less clear. Meaning is always produced at particular moments through the interaction of communication products and lay and scientific actors. Certainly, science communication includes a lot of situations in which dissemination of messages is important—but a straightforward transfer of meaning can never be taken for granted. 'Receivers' are always active in producing meanings around science communication.

More importantly, such an understanding also places communication at the heart of human activity, since it is through communication that we constantly make sense of the world and our own role in it. This is why our key argument in this book is that science communication is crucial for modern societies and that it is about much more than making difficult things simple so that non-scientists can understand them. Technoscience is part of so much of our daily lives that communication about it is an integrated part of how we understand ourselves as citizens, consumers, and members of organisations and communities. It is for this reason that we suggest that science communication needs to be understood as a cultural phenomenon, something that concerns 'the production and the exchange of meanings' (to use Stuart Hall's language). And this is also why we will cover a variety of different phenomena in the book. In order to understand the cultural importance of science communication, we will need to take an interest in more than the way information or knowledge travels. We will also need to look at phenomena such as organisations, identities, professionalisation, and the changing nature of science (all of which are discussed in Chapters 3, 4 and 5) in order to grasp the broader landscape of science communication.

In addition, we need to address the emphasis on knowledge, information and language that is implicit in much discussion of science communication. Many models of science communication tend to assume that 'science' is encapsulated by parcels of language. Communication occurs, in other words, as information is shared in the form of talk or text. The key issue that is understood as being at stake is how language is used to transmit or construct (either scientific or lay) knowledge. Some research, for instance, theorises public engagement as a process of information transfer, suggesting that it can be analysed according to 'translation quality': the extent to which information from different sources is able to successfully travel (e.g., in the form of public discussion, speeches, transcripts, reports, or media coverage) through the course of a deliberative event.[37] The quality of public engagement thus becomes related to how well information is able to move, intact, between different actors and into a final output (such as a summing up speech or final report). Most analysis of different forms of science communication has similarly focused on (records of) talk or text as its key data source.

STS scholar Mike Michael has highlighted this by suggesting that even science communication research that seems to take radically different approaches to science and society is rather similar in some of its base assumptions.[38] In a 2002 discussion of PUS research Michael distinguishes between 'traditional' PUS, which relies on positivist methods such as surveys or analysis of 'mental models', and critical or 'interpretationist' PUS, which takes a constructivist approach. There are a number of differences between these two schools, Michael suggests—including their methods and conceptual frameworks—but also a surprising number of similarities. It is these that interest him. Both approaches, he writes, involve 'humanism (an emphasis on the pure person), incorporeality (a neglect of embodiment), and discrete sites (science and the public are presupposed as separate entities)'. In other words, they conceive of encounters between science and publics as involving individual human agents—not, for instance, animals or technologies. These human agents are understood as disembodied rather than their knowledge and practices being corporeal and as belonging unequivocally to either 'science' or 'the public'.

It is this notion of corporeality that we want to draw particular attention to. This again suggests that the transfer of information or knowledge[39] is only one way of understanding communication. Corporeality, or embodiment, or materiality, is also important. If communication is performative, involving the active production of meaning, then science communication is about the construction of identities, social relations, and emotional states—and these are mediated not just by words, but by embodied experiences. Meaning is created out of a plethora of inputs and interactions, including sounds, images, bodies, objects, emotions, or places. It is therefore important to view communication as not only mediated by language but also through the material world in all its manifestations. In arguing thus we are also inspired by the constructivist tradition in STS, and in particular by theories that subscribe to a relational ontology, such as Actor Network Theory (ANT).[40] These approaches emphasise that we cannot disregard the material world and that meanings are produced and sustained through networks that incorporate not just language and signs but objects and entities. Networks of meaning become stronger the further they reach and the more entities they include. Within science communication, then, persuasive communication is not only about the immediate context of communication. Although this will impact meaning production—it will make a difference, for instance, if someone's research is described as a 'theory', 'opinion' or 'fact'—broader networks of other actors are also important. It is much easier to argue that climate change is happening if you can point to entities like rising sea levels; similarly, presenting yourself not as a single individual but as a representative of a wider network of scientists, theories and facts will boost your authority.

It is possible to argue that ANT and other theoretical proponents of a turn to 'materiality' did so as a criticism of the cultural theory that we also draw upon (which can include an over-emphasis on discourse and signification).[41] For our purposes, however, there is nothing in the circuit of culture that does not allow us to include materiality, practice, and corporeality, and we will certainly merge these interests in the chapters to come. In particular, we will use Chapters 6, 7 and 8 to investigate the performativity and materiality of science communication.

What does all of this mean for how we think about science communication? We've argued that it's important to understand communication as *constitutive*—involving the active production of meanings—and *material*, mediated not only through language but through networks of actors, objects and entities. Things like 'public engagement', 'climate change', 'branding' or 'science' can be interpreted and given meaning in many different ways. Thinking about this meaning production as constitutive and material can help us notice how meanings depend on networks of other entities, both human and non-human.

Our approach to science communication is thus to pay careful attention to the connections, contexts and meanings at play within any instance of communication. We cannot take for granted phenomena such as 'science', 'the public' or 'communication'; rather, we will be interested in how meanings of these things, and others, are constructed in particular contexts and at particular moments. We might say that this is about emphasising the three dimensionality of science communication. The kinds of events, processes and moments we are interested in, from museum galleries to mass media reporting of science, cannot be understood through a single axis of analysis relating to message production and reception. They are messy—sites at which objects and bodies and stories and identities collide. Because of that, of course, they are interesting. In the chapters that follow, we outline some of the aspects of this three dimensionality of science communication that have particularly interested us. In Chapter 3, we start by looking at the interactions between researchers, identities, and wider social collectives.

Notes

1. This translation is taken from the homepage of Columbia University: http://www.columbia.edu/acis/ets/CCREAD/etscc/kant.html.
2. Habermas J (1962) *The Structural Transformation of the Public Sphere—An Inquiry into a Category of Bourgois Society*. Cambridge: The MIT Press. The book is also claimed as an empirical description of actual transformations of public spheres in Europe, which is not as convincing as his description of the ideal that we use here.
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17. Turney J (1998) *To know science is to love it? Observations from public understanding of science research*. COPUS.
18. For a more developed discussion of this history, see Gregory J and Lock SJ (2008) The evolution of 'public understanding of science': Public engagement as a tool of science policy in the UK. *Sociology Compass* 2(4): 1252–1265.
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35. A standard textbook definition distinguishes between three different paradigms within communication theory: positivist (related to information transfer), interpretative (related to making meaning), and critical (related to critical theory), see Miller K (2005) *Communication Theories—Perspectives, Processes and Contexts*. New York: The McGraw-Hill Companies, inc. Here we are focused on the distinction between the first paradigm and the other two.
36. A seminal study was done by Lazarsfeld and colleagues in 1940s which demonstrated that mass communication does not work as a magic bullet (or a hypodermic needle), able to inject messages into people. See Lazarsfeld P, Berelson B, and Gaudet H (1948) *The People's Choice: How the Voter Makes Up His Mind in a Presidential Campaign*. New York: Columbia University Press. This research has lead to numerous developments within communication theory, but these do not always seem to have had a huge impact on research and practice within research communication.
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    Rowe G and Frewer LJ (2005) A typology of public engagement mechanisms. *Science, Technology & Human Values* 30(2): 251–290.

38. Michael M (2002) Comprehension, apprehension, prehension: Heterogeneity and the public understanding of science. *Science, Technology & Human Values* 27(3): 357–378.
39. Some people distinguish between information and knowledge (see discussion in Horlick-Jones T, Rowe G and Walls J (2007) Citizen engagement processes as information systems: the role of knowledge and the concept of translation quality. *Public Understanding of Science* 16(3): 259–278.), with knowledge being information that has been processed by an individual such that it is useful to them. For the purposes of this discussion we use the terms synonymously.
40. Latour B (1987) *Science in Action*. Massachusetts: Harvard University Press.
    Latour B (1999) *Pandora's Hope*. London: Harvard University Press.
41. p. xviii, Gay P du, Hall S, Janes L, et al. (2013) *Doing Cultural Studies—The Story if the Sony Walkman*. London: SAGE Publications.

3

Identities: How Scientists Represent Collectives, Construct Identities, and Make Sense of Science

Much research on science communication has focused on scientists as the disseminators of scientific knowledge. There is an implicit sense that it is individual scientists who are the important actors in science communication—those who define its practice, and whose experiences and opinions we need to better understand. Just as Rae Goodell's seminal book *The Visible Scientists,*[1] presented a version of science communication defined by the way in which major scientific figures chose to engage with the public, there has been continued interest in why particular scientists get involved in public communication and what their experiences are of it. Research has shown that scientists cite benefits to themselves or to their research (personal enjoyment and gaining insight from interacting with public audiences), to society (informing public debate and empowering laypeople through access to science), or to individuals (educating or enthusing audiences).[2] Often, scientists are motivated by a wish to improve public interest, awareness, understanding, and enthusiasm for science.[3]

This chapter also takes scientists' role in science communication as its starting point. We want, however, to complicate the story a bit. Rather than thinking solely about scientists as individuals with particular personal

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motivations, we will suggest that scientists' involvement in science communication is more complex than this. Scientists can see themselves as representing different things as they take part in science communication and as acting for a range of wider purposes. They are often representing *collectives*, as well as themselves and their work.

To make this clearer—and to acknowledge that this applies to ourselves as much as to any other researcher—we will start with an account of our experience at ESOF, the science policy convention and public festival discussed in Chapter 1. This account is taken from MH's notes on the event and our participation in it, and it starts to show just how embroiled in different personal, professional, and organisational motivations science communication can be.

Communicating Research at Science in the City

I am in the University of Copenhagen tent at the Science in the City festival. One of the exhibits is an interactive installation that I have made with a bunch of colleagues: more than a year ago, when there was a call for funding to do science communication at this festival, I felt obliged to send in an application. I have made this form of interactive installation twice before, and I have won a prestigious prize for this work. So I guess I should do something for this big festival. It is kind of my thing.

And now we are here. Just like the other times, it took far more time and resources than anticipated to create the installation, but I am very pleased with the result. I am proud of it, so I have done my best to make people aware that it is here. I want people to see it. And I want them to engage with it. Mixed with pride is an anxiety that no one will visit and that the installation will stand here in the tent empty, deserted and incomprehensible. I tell everyone else that this uncertainty is part of the experiment—it is an empirical question whether we can communicate in this way—and hence lack of engagement is also a result. As a researcher I will defend this point of view. But as a person, a member of an organisation and a human being—I really, really hope that this scenario will not come true.

Success in this festival is measured in numbers. Almost everyone I meet asks whether we have had many visitors in the installation. I usually answer that it is not really about numbers. It is more important how the visitors we have interact. But of course this is only half the story. I DO want people to come, and, thank God, they do. There are people there almost all the time. Not as many as in the nearby teddy hospital, but certainly enough to call it a success. And many of them spend quite a long time engaging with different activities, so in terms of communicating content, I am also happy.

It was a good decision to place the installation here in the University of Copenhagen (UCPH) tent together with many of the other university events and exhibits. Being together creates a sense of collective spirit, belonging, and togetherness which it is normally impossible to feel across the entire university, and the other exhibits and events are interesting and well done. It makes me feel proud to be part of the UCPH initiative. Although I do sometimes wonder how many of the festival visitors actually work in a university or other research organisations—I meet a lot of people I know, and we all check out each other's tents to see what each of our organisations has done, and how it compares to our own. I think UCPH does well in this comparison.

The designer has made lab-coats with the installation logo and name on them. I wear one most of the time. Partly because I am so proud of the installation, I want to belong to it. Partly because when I walk around it is obvious that I am involved, so it is easier to talk to the visitors. A couple of times I ask some kids in the installation if they want to do the elastic band puzzle with me. It is a game which is supposed to symbolise the science–society relation as collaboration: there are six different large puzzle pieces hanging from elastic bands, but you can only connect them into a picture by asking one or two people standing outside the installation to help you get all the pieces together. Asking kids to help me is fun. I talk with them about the point of it that people need to collaborate. I think about the fact that I could stand there and do that all day. It would be a good way to engage, but I get restless. Is there something else I should be doing?

Then I am told that the Rektor and Pro-Rektor of UCPH[4] will come to the tent and that I should prepare to do a five-minute tour of the installation. By a stroke of luck the student photographer that we have employed to document the festival is in the tent, so I manage to organise that he takes some pictures of Rektor in our installation—one never knows when it is useful to be able to document attention from the higher levels. However, I also genuinely want those two and their entourage to understand the purpose of the installation. I decide that I want to make them engage physically with the installation, not just tell them about it. And the elastic band puzzle is good for that. When the group finally arrive, I can feel that it is hard to keep their attention, and I think they are on their way out even before I have told them what to do. So I skip the main demonstration, and just go rather quickly to the interactive things I want them to try. Before they leave, I get them to do the final vote as well.[5]

Science communication as strategic performance

In putting together the ESOF installation we wanted, of course, to communicate our research so that laypeople could understand it. But MH's account in the previous pages makes it clear that there is more going on than this. The installation was also a performance: to Rektor, to our colleagues, to professional communicators. Scientists and other researchers are not free-floating individuals, and science communication is often part of what you do as an employee of a particular organisation. Depending on the degree to which that organisation values external communication and branding, your contribution is acknowledged as more or less important. In this case, UCPH as a whole had invested in having a presence at the Science in the City festival, and it was important to demonstrate to its leadership that this was a worthwhile investment. The Rektor and Pro-Rektor were themselves communicating interest through their visit, making it clear to whoever was watching that the festival and science communication more broadly is an important part of what this university is and does.

But these dynamics are not just about the university leadership. MH notes a certain satisfaction with the UCPH tent compared to those of the other Danish universities. It is nice to belong to a team that does well, and personal branding is also important. The creation of the installation was experienced as a kind of obligation, a real or imagined expectation to do something for the festival—'it is kind of my thing'—alongside the fact that 'one never knows when it is useful to have some pictures of Rektor in our installation'. It is not mentioned in MH's text, but there was also an obligation, somehow, to Denmark as a whole. The Danish Ministry for Science organised the ESOF conference, and there was a clear expectation that the Danish universities should help contribute to its success. It would have been strange for UCPH not to participate in such a big event in its own city—almost an act of communication by omission. The installation was thus in part communicating the message that we, the authors, are good social scientists, keen to promote our university, city and country on the international stage that ESOF presented.

What all of this makes clear is that there can be a variety of strategic agendas behind any kind of public communication. The production of a piece of science communication can be a mix of academic content, social obligations, and branding opportunities. Importantly, these things are not mutually exclusive. That something is a branding opportunity does not mean that it is not also done for its academic content and a genuine desire to see people engage with scientific knowledge. In fact, we would suggest that science communication almost always involves multiple agendas. As analysts, it does not make sense for us to try and decide whether a given communication effort is an altruistic diffusion of content or an exercise in branding (either of an individual or an organisation). It is often both of these—and probably more besides.

The central point of this chapter is that science communication needs to be understood as located within these multiple contexts. It is not just about scientists and their audiences, but about wider groups and collectives. We therefore want to problematise the taken-for-granted assumption that science communication is 'for' the general public, and that its content is solely 'scientific knowledge'. Rather, public communication is just as often for specialised audiences (such as funders), or involves an organisation performing itself to itself, and thus is not ultimately directed at an external audience at all. This is a process that has been called auto-communication: 'self-referential communication through which the organization recognizes and confirms its own images, values and assumptions'.[6] Public science communication, in other words, may function as a way of signaling what science, or a scientific organisation, is to those working within it. Our argument is that we, as scholars of science communication, need to pay more attention to the way in which science communication constructs identities for science, scientists, and scientific organisations.

Here we are drawing on a distinction between 'institutions' and 'organisations' as forms of scientific collective. In organisational theory, it is common to define organisations as systems for solving tasks which are means-oriented and efficiency-guided, whereas institutions are systems of codified behaviour based on values, rules, norms and routines.[7] In science, an 'organisation' is a collective of people oriented towards solving the task of producing science. Examples of scientific organisations are universities, research institutions, and research groups. In contrast, when we talk about science as an institution, the focus is on science as a normative system of rules for behaviour. The institution of science is thus something that goes beyond particular organisations to encompass all of the actors who promote the norms and values of scientific thought. We will suggest that, compared to most other organisational members, scientists often have a strong identification with the institution of science and a looser identification with the organisation within which they work. This is important for how scientists think about themselves when they represent science in public.

The field of organisational theory from which this distinction comes also provides us with concepts of sense-making, organisational communication, and cultures of communication. All of these help us to connect individuals to wider groups, and understand how identities are shaped by these. In this context culture is usually perceived as an underlying set of values and norms—a taken-for-granted interpretative framework—while identities relate to how we perceive ourselves, and are often expressed more explicitly.[8] Culture and identity are intimately linked, and are studied by exploring the explicit and implicit communication processes that take place within and around organisations.

Institutions and Organisations in Science

The notions of 'institution' and 'organisation' are conceptual lenses that can be used to look at different scientific collectives. But there are no hard and fast rules as to what is or isn't an institution or organisation. Universities, disciplines, research networks and departments might all be viewed as either one or the other by focusing on particular aspects of how they are composed and run.

As an example of this we might look at the UK's Royal Society. The Royal Society is the oldest national academy of science in the world; its mission, its website says, is to 'recognise, promote, and support excellence in science and to encourage the development and use of science for the benefit of humanity'.[9] Its core is a 'Fellowship' of some 1600 distinguished scientists, including about 80 Nobel Laureates. We can readily think of the Royal Society as a scientific organisation: one of its priority areas is to 'support outstanding science',[10] and it certainly acts, as an organisation does, to meet particular goals, including the production of such outstanding science. Bob Ward headed the Society's Press Office until 2006, and has written about its involvement in public climate change debate.[11] In his writing we see clear signs of understanding the Royal Society as an organisation—a collective with a particular, focused goal. It acted, he says, to 'ensure that the views of the scientific community were not misrepresented or ignored' within public debate on climate change. He further explains how the Society acted strategically to meet this goal, assessing the risks its press campaign would face, organising press releases and media launches, and producing targeted reports and statements.[12]

But we can also consider the Royal Society as a kind of institution, or perhaps as a particular instantiation of the institution of science. Institutions are not goal-oriented, but hold together through shared norms, values and behaviours. Such shared norms will certainly be present in the community of the Society's Fellowship and staff, from the trivial (knowing how to address each other, for instance), to the more profound (a shared commitment to furthering scientific knowledge). It is also clear that, in the case of debate on climate change, the Royal Society did not view this campaign as something carried out on behalf of a particular organisation or to further a particular brand. 'The Society', writes Bob Ward, 'does not seek media coverage for its own sake'. Ward describes how the press campaign was carried out on behalf of science more generally: it sought to protect the scientific community at large from misrepresentation, and to show the ways in which climate science was reliable knowledge, produced by robust methods. In these ways, the organisation was thrust into the background. What was important in the Royal Society's presence in these debates was its role as a representative of the institution of science. Despite the sophisticated use of the Society's organisational machinery, the aim was to allow science as a whole, not a particular group or brand, to speak to society.

Making sense of organisations

As we explained in Chapter 2, our understanding of communication is as a form of meaning-making. As such, it is something that allows us to interpret—make sense of—the world around us. This is true generally, but it also applies to how we think about organisations. For organisational theorist Karl Weick, for instance, sense-making through communication is fundamental to how we understand the nature of organisations. Sense-making involves the constant interpretion of the phenomena around us: it is a process in which we tell ourselves stories about the meanings of those phenomena in order to be able to understand the world as something that is coherent. In Weick's understanding, an organisation is the sum of the stories that we tell about it. Just as we can have different images of what a scientist is—we can make sense of scientists in different ways—we also tell very different stories about universities and other research organisations, viewing them, for instance, as a set of buildings and amenities, a platform for taking care of disciplinary traditions, or a means of producing knowledge that is useful to society. Each of these meanings is important for the total understanding of what a university is.

Stories and sense-making are therefore not just a layer that we add to an existing organisation (such as a university); rather, they are the very stuff that organisations are made of. This perspective radically changes the way we understand science communication. Rather than being a peripheral add-on done by dedicated individuals, or the remit of people employed in the university PR office, science communication is part of the total story-telling of what science and scientific research organisations are. It helps to *create* these phenomena and organisations.[13]

Such organisations are not stable or easy to pin down. Cheney and colleagues use the example of a university to explain the elusiveness of any particular organisation:

> [A] university is neither the actual, physical campus where many classes are held nor is it the sum of the people who work in it. Instead, it is a complex system of symbols, messages, efforts, and activities—a network of contributions from its members and from people and groups outside of its boundaries.[14]

In other words, there are many different stories told about organisations, and many different ways of making sense of them. Research organisations such as universities or research institutes are not given or static. What counts as the University of Copenhagen, or the Royal Society, or a particular science museum, changes between contexts. The terms we use to describe organisations can actually be the most stable thing about them: 'the seeming durability of identity' of organisations, Gioia, Schultz and Corley write, is derived from 'the stability of the labels used by organization members to express who or what they believe the organization to be'.[15] While such labels might remain static—the University of Copenhagen, or more accurately *Københavns Universitet*, has had the same name since 1479[16]—the meanings attributed to them might be radically different in different contexts and at different times. What 'the university' is today might be very different depending on whether you ask an undergraduate student, the vice-chancellor, a member of the press office, or a chef working in the canteen.

The presence of diverse stories about any particular research organisation is also tied to organisational culture. Just as organisational identities are not fixed, but fluid and contingent, the culture of an organisation—the stories, values and norms that underpin organisational sensemaking and identity formation—is not stable or singular, but multiple.[17] Organisational cultures are important for shaping organisational communication, including whether and how public science communication is carried out. We know, for instance, that if there is a strong culture of support for science communication, its members are more likely to engage in it.[18] If scientists have participated in communication activities before, think that their colleagues spend time doing such activities, or have positive attitudes towards them, they are more likely to get involved.[19] Organisational cultures also shape what gets communicated: one study of the UK's Royal Society found that the culture around public communication within the organisation resulted in the maintenance of one-way communication practices despite efforts to promote dialogue. The organisation, the authors write, 'had not sufficiently worked through how, or even if, nonspecialist inputs could contribute to its core business of science policy and advice'.[20]

'Strong' cultures[21] may dictate or shape particular recurrent behaviours such as the use of particular communication formats. But organisational culture remains something that is mutable: it may not change overnight, but it is also not a constant. It influences organisational members but is also influenced by what members do and the way they construct their identities over time. Often, organisational members find ways to do different things in different ways than those dictated by a dominant culture. Gareth Morgan argues that in any organisation:

> there may be different and competing value systems that create a mosaic of organizational realities rather than a uniform corporate culture. Besides gender, race, language, and ethnicity, religious, socioeconomic, friendship, and professional groups can have a decisive impact on the cultural mosaic.[22]

For scientists, professional values and norms are part of what we referred to earlier as the institution of science. This institution can be seen as a very strong and partly independent 'value system' which is not necessarily aligned with a research organisation's corporate culture. One instantiation of this value system is the set of the 'CUDOS' norms described by Robert K Merton[23]: Communalism, Universality, Disinterestedness and Organised Scepticism. While these norms should not be understood as an empirical description of actual scientific practice,[24] they do describe a set of values (or an ideology) that scientists use to explain the culture they work in. The point here is that such values are not necessarily aligned with the priorities, strategies, and cultures of a particular research organisation. For instance, the norm of communalism suggests that scientists should share scientific knowledge rather than keeping secrets. A research organisation, however, might not necessarily embrace the lack of any restrictions on information sharing for reasons of intellectual property or patenting (a tension which we will discuss further in Chapter 5).

Furthermore, there are sub-divisions within the normative systems of science, and these can become important means of constructing the 'organizational realities' that Morgan refers to and which can define the experience of participating in an organisation. Scientists may choose to locate themselves within disciplines or sub-disciplines constituted around a particular subject field and the use of certain scientific methods. Belonging to a discipline might be at least as important for identity construction as being employed by a particular research organisation. Universities and other research organisations will therefore always incorporate a range of organisational cultures, and may have difficulties in presenting a single, unified story about the organisation. The challenge for science communication that is sponsored or carried out by research organisations is not only whether the dominant organisational culture encourages or discourages such communication, but how it interacts with the many different and at times competing organisational cultures that will be present and with the ties that scientists have to their disciplinary sub-cultures. What happens when an organisational culture changes, or when the 'story' put out by leadership is dismissed by organisational members, or when competing sub-cultures attempt to communicate their own forms of sense-making about the organisation?

The Professor on the Wall

In 2014, two large posters appeared on the outside of the building which houses the medical faculty of the University of Copenhagen. On one, a 20-metre high picture of Professor Thue Schwartz—one of the faculty's leading researchers—smiled down on the traffic below. Across his chest was a short message (in Danish): 'Obesity and Diabetes: "Research can create new pill"'.

Thue Schwartz is one of those modern scientists who tick all the boxes of excellence, commercialisation and entrepreneurship—he produces lots of papers in high-ranking journals and has had a parallel career in the pharmaceutical industry. It is therefore not strange that the faculty communications office thought that his was a good image to put on the outside of the building. The poster gives a different aura to the austere walls of the building (constructed according to the architectural style of brutalism), and there's something appealing about this very human face of science. Professor Schwartz looks like a rather ordinary person: he's not wearing a lab coat or a business suit, though his title and affiliation are clearly displayed. The wall faces a busy commuter road that goes into Copenhagen from the affluent northern districts of the city, and many people must have passed it every day. It is interesting to wonder what they thought of this benevolent scientist with his message of a simple solution to some complex and widespread problems. Professor Schwartz does do research on the human metabolism, and it is not wrong to say that one of the visions behind his research is to be able to create cures for obesity and diabetes in the form of pills. Such cures are, however, not likely to be realised in the immediate future. Maybe commuters should not understand this promise literally, but more as a general message about what science does?

But commuters were not the only ones who saw this poster. What did the people inside the building think about the poster? Did they think it was a good description of their work to the outside world? It is not clear that everybody in the faculty would subscribe to the promise of research that would produce pills to help cure diseases, particularly not complex lifestyle diseases like obesity and diabetes. Did people inside the building identify with this promise? Or did they engage in entirely different forms of story-telling about why this professor was chosen to be on this wall? The poster is one example of how science communication often has an element of autocommunication, or communication which is picked up by the organisational members themselves. As for any piece of public communication, then, we might ask what the consequences and effects of this piece of science communication will be on organisational identity creation.

Representing science

If scientists are members of multiple and overlapping research organisations, institutions, and cultures, then they might be speaking for any one of these when they participate in public communication. In a previous analysis one of us asked scientists what they were representing (or what they were speaking for) when they talked about science in public.[25] The scientists constructed their role as representatives in three key ways. While some saw themselves as speaking on behalf of a field of knowledge or expertise (the role of Expert), others were representing science as a social institution (the role of Educator). Others again saw themselves as representing a particular research organisation (the Research Manager).

All of the scientists interviewed acknowledged that their organisation (whether a university, research institute or independent lab) had an interest in establishing a favourable public profile. But it was only scientists who primarily subscribed to the last of the three roles—the Research Manager—who described this as an influence on their communication activities. In this mode, science is enacted as a social activity organised through particular research organisations, and it is the task of the Research Manager to establish a positive image of this organisation. In contrast, when scientists represent a field of expertise they act as Experts. Here, science is understood as a collection of expert communities—disciplines—which supply factual knowledge about the world. The university is not seen as having much relevance to what they can say as Experts; instead, the relevant community is comprised of colleagues within the discipline. Finally, when scientists represent science as a social institution ('Science' with a capital S),[26] they take on a role that is best described as Educator of the public. In this mode, science is described as an institution whose function is to find true knowledge about the world and to use this for rational problem-solving. Their role as communicators is to educate society about scientific rationality and to increase enlightenment. As with Experts, the organisation again appears to be invisible or at least insignificant. Rather, it is the scientist, on behalf of their discipline or science as a whole, who represents science.

By showing how scientists enact particular organisations and institutions in their communication, these roles make explicit the fact that scientists do not act, in public communication, as individuals communicating only a set of scientific facts and nothing more. They always represent something larger than themselves: the difference lies in what kind of collective that 'something' is. These three roles are, of course, ideal types which summarise the particular characteristics that make each role distinct. In practice, no scientist takes on these roles systematically and exclusively; in fact, most of them adopt a particular role depending on the immediate context.[27] As ideal types, however, these different roles indicate that the right kind of content for public communication can be understood in different ways, as can the way in which success is evaluated. What is striking is that only the role of the Research Manager is overtly rooted in a particular organisation. Taking on this role can be a result of organisational duties—one becomes a head of department, say, and needs to promote departmental research—but, interestingly, we have spoken to many scientists who occupy managerial positions of leadership who do not seem to take on this role systematically, or even as a first choice in their public communication. This observation again highlights the fact that scientists rarely seem to see themselves first and foremost as organisational members. Their allegiance is primarily to the disciplines or the institution of science, rather than its organisations.

The three scientific roles presented above make it clear that scientists, though they may not associate themselves with particular organisations, do attach themselves to particular imagined collectives when they communicate in public. Their public communication is not just about them and their audiences but about a community that they want to represent or demonstrate (or simply not embarrass themselves in front of). The Expert and the Educator tend to view science as a collegial activity where disciplines or the use of the scientific method are the key devices of community. They may even treat the universities, departments and institutes they are part of as irritations, a collection of performance indicators and management demands which threaten to get in the way of real science (something we will return to in Chapter 5).

This rendering invisible of organisations has important consequences for the construction of science as a social activity in public communication, because it means that other actors or phenomena may be used as focal points or symbols for science. Organisational scholars Guthey, Clark and Jackson[28] have argued that top leaders of large companies often become the central focal point for sense-making about that company. Similarly, Gioia and Thomas investigated top managers of universities and research organisations, suggesting that:

> top management team members' perceptions of identity and image, especially desired future image, are key to the sensemaking process and serve as important links between the organization's internal context and the members' issue interpretation.[29]

High-profile managers and researchers, in other words, act as a kind of resource for wider collectives and organisations. Their perceptions of the organisation's 'identity and image' can be taken up by others in their sense-making about what they are engaged in within that organisation. In the context of science, particularly visible scientists may thus play a role in communicating and disseminating their visions not only of their science but also of the nature of their group, department, discipline or university.

Celebrity scientists

The most visible of these symbolic figures who serve as a focal point for internal and external sense-making about science are celebrity scientists such as Susan Greenfield, Steven Pinker or Oliver Sacks. Such celebrity is not a new phenomenon. In the nineteenth century, Darwin was the high-profile figurehead for evolutionary theory, reviled and celebrated in equal measure. Rae Goodell wrote about a set of twentieth-century 'visible scientists', including Carl Sagan, Margaret Mead and Linus Pauling, whose careers were 'discussed, idolised, cursed, applauded, and ridiculed'.[30] Goodell, writing in the 1970s, suggested that such visible scientists remained unusual even in an age when the mass media was becoming increasingly important. They faced special challenges, including being seen 'almost as a pollution in the scientific community',[31] and posed challenges for public communication of science. Goodell was concerned about the undue degree of influence a charismatic celebrity scientist could have on political and public debate, even in areas outside of their expertise. But they also represented a different way of doing science, one that was conducted in public as much as in the laboratory, and which showed the human and often quirky side of scientific research.

More recently, Declan Fahy has argued that what has been called the 'Sagan Effect'—the career-damaging idea that popular attention is inversely proportional to scientific credibility—no longer holds true. Fahy shows that many celebrity scientists today maintain well-regarded research careers alongside their public communication activities; beyond this, though, popularisers are no longer seen as 'second-class scientists'.[32] Scientists who communicate are valued in a way that was not neccessarily the case when Goodell was writing. Often, they are able to make public communication part of their scientific brand and thereby their living. Fahy writes that celebrity occurs at the intersection of three processes: the merging of an individual's public and private lives; their status as a 'cultural commodity' or brand; and their embodiment, in public consciousness, of certain ideologies or concepts.[33] Celebrity scientists are one part of a wider culture of 'celebrification': as with other celebrities, like sports or film stars, they have power 'because they vividly represent ideas, issues, and ideologies, allowing people to visualize and make sense of abstract concepts … [they] personify and act as figureheads for social movements'.[34] In other words, celebrity scientists are not only charismatic personalities or quirky individualists. They represent wider social and cultural concerns—Fahy notes Richards Dawkins' personification of the relation between atheism and society, for instance, or the USA's vexed relationship with black intellectualism for Neil deGrasse Tyson—and they are relevant, and thereby celebrated, because of these connections. True celebrities, Fahy explains, must 'intersect with history', such that their 'stardom coincides with the Zeitgeist, the spirit of the age'.[35]

In this way, scientific celebrities can cross over between public and scientific domains, becoming a focal point for internal as well as external sense-making about science. The biotechnology entrepreneur Craig Venter, for instance, has become an important symbol of a particular way of doing science, one that is highly entrepreneurial and oriented towards commercial development. In a different corner of the scientific universe, images of Albert Einstein with his wild hair and eccentric style have come to symbolise excellence in science and a focus on basic research. Einstein represents genius and quirky humanity in one package. The form of science he symbolises should—the sense is—be left alone to make tremendous new knowledge without any tawdry consideration of applications or economics, because important applications will nonetheless result. Similarly, Fahy argues that Stephen Hawking symbolises science as a purely cognitive and disembodied effort.[36] Scientific celebrities thus become symbols of science, standing for different imaginations of what science is and should be. The symbolic power of these celebrities implies that they are an important way for media, publics and scientists themselves to make sense of science.

There is, however, still ambivalence around being a visible scientist. The Sagan Effect continues to be referred to within scientific cultures, and scientists may voice concerns about taking on a role as a visible scientist.[37] Simone Rödder suggests that this should be understood as structural ambivalence within the scientific system, deriving from differing expectations connected to the various roles that scientists take on.[38] She argues that we should understand this ambivalence 'in the light of the scientific community's attempt to safeguard the integration of a scientific discipline, i.e., the allocation of rewards according to scientific criteria'.[39] For her, the crucial question to ask is under 'what conditions does a scientist become visible *although* public communication induces ambivalence?'[40] Her conclusion is that while scientists might take on the role of representing science to the outside world, they usually have to do so under three conditions in order not to lose their scientific credibility. They have to appear in public based on a background of sound scientific work; their appearance should be with reference to their institutional or organisational role (speaking on behalf of something other than themselves); and they should not be seen to proactively seek the limelight.

Scientific credibility is therefore crucial for internal sense-making about science. Scientists often have a very strong sense of the auto-communication dimensions of their public visibility as a symbolic figure. Visible scientists run a risk of being seen as less scientifically excellent, and they have to take care to protect themselves from this risk, for instance by meeting the three conditions that Rödder describes. But such auto-communication dimensions of public communication are not just concerned with representations of scientific excellence and ensuring that one's public profile highlights scientific rigour over celebrity. Particular individuals may also come to embody certain visions or ambitions within universities, departments, and research groups. For instance, Caragh Brosnan and Mike Michael studied how a particular interdisciplinary neuroscience research group understood itself.[41] They found that the group leader played a key role in how the group functioned: unlike the rest of the group, his background was interdisciplinary, and he had expertise in both clinical and basic neuroscience. He therefore played an important role in embodying the promise of one day translating basic research into clinically effective interventions, as well as representing in his person the practice of interdisciplinary research. He symbolised, for the rest of the group, the practices they were engaged in, which could sometimes be experienced as incoherent or dispersed.

Similarly, Ulrike Felt and Max Fochler argue that science communication images directed at the wider public are absorbed by researchers and affect their expectations and experiences of doing science. The stories told in science communication, Felt and Fochler write, 'are always successful ones'. The emphasis on inspiring narratives about researchers who are finding satisfaction and excitement in science can mean that 'comparing one's own track record with these accounts becomes a more and more frightening exercise for researchers moving into the post-doc phase'.[42] Here, again, public communication feeds back into the identity work of those within the communicating organisation or institution. The public voices of visible scientists are used both positively and negatively for making sense of science by their students, colleagues, and others.

Representing Science with a Shirt: #ShirtGate and the Rosetta Comet Probe

Scientists who are highly visible in the media represent, or symbolise, a particular version of scientific culture. What happens when these representations are controversial or open to different interpretations?

The Rosetta mission is well documented on the European Space Agency's webpage: launched in 2004, the spacecraft was developed to 'chase, go into orbit around, and land on a comet'.[43] It reached its target comet in August 2014 and spent three months orbiting it before releasing its lander, Philae, on 12 November. Both the orbiting phase and the landing were the first time that such engagement with a comet had been attempted, and the landing was subject to intense excitement in global media. Newspapers live blogged the event, Philae had its own Twitter account, and for a while #cometlanding trended around the world. But at least some of the excitement about the science was deflected shortly after the landing when the project scientist on the mission, Matt Taylor, gave a press briefing wearing a shirt decorated with fantasy-style images of scantily-clad, PVC-corseted women. As Twitter users quickly pointed out, using the hashtags #ShirtStorm and #ShirtGate, the shirt was not the kind of clothing designed to suggest a diverse, women-friendly working environment (an effect heightened by photos of the male-dominated ESA mission room).[44] By the following day, debate had reached such a pitch that Matt Taylor gave an emotional video-streamed apology for making the 'mistake' of wearing the shirt.

There's obviously a lot going on in the story of Rosetta, Philae, and That Shirt. One is the sheer power of social media. As science communication scholar Alice Bell pointed out, Twitter users pointed out something which neither Taylor's colleagues, the ESA press office, or science journalists around the world seemed to notice—that if you are a spokesperson for a scientific project, you are inevitably also a spokesperson for the culture of science, and perhaps you want to think about who you are suggesting does and does not belong in that culture—and made it an international news story.[45] Another is the often invisible way in which the reporting of science and scientists in the media presents a particular version of science. If all we see in news stories about science are mission control rooms full of white men, or if journalists constantly emphasise female scientists' looks while emphasising male scientists' credentials,[46] then this will help shape shared public imaginations of what science is like as a culture and working environment. In this regard, it is nice to draw attention to another space-related news story of 2014: the successful placing of India's Mars Orbiter Spacecraft into orbit. Photos of the Indian Space Research Organisation's mission control room also drew attention—but in this case because of the strong presence of women within it.[47] As *Glamour* magazine commented, 'imagine all the young girls who could see this picture and think, That's what a scientist looks like'.[48]

Dual allegiance and decoupling

Public science communication is important to scientists' identity construction work in a number of ways. It may enable them to present themselves as a representative of a particular collective, identify with or disassociate themselves from research organisations, or provide them with figureheads who can act as symbolic leaders. Such multiplicity, and the ability to simultaneously identify with their organisation and with their discipline or a wider community of science, can be likened to what organisational scholars have called 'dual allegiance'.[49] This is the idea that professionals feel responsible *both* towards their organisation and to their profession: rather than having to choose one or the other, they are committed to both of them. It is not unusual for scientists to think of other members of their disciplines—perhaps even those employed in competing universities—as some of their closest colleagues. This dual allegiance can be a source of frustration for communication professionals within universities, who can find it hard to understand that a particular scientist feels more aligned with disciplinary colleagues in competing universities than with the corporate communication strategy of their own university. A classic example of this is a new result in medical research. While a university might have an interest in reporting 'a break-through done by one of their excellent research groups', the scientist in charge might think more about the uncertainties of the result, and be concerned about the way their colleagues within the discipline will interpret 'the sensationalist news story'.

However, despite their ability to negotiate multiple roles, scientists sometimes experience that their different commitments come into conflict with one another. One response to this is known as 'decoupling'. This term is used in neo-institutional theory to describe a situation in which organisations and their members weaken direct links between the overall (or external) accounts of their nature and purpose and their internal coordination and control.[50] Decoupling takes the form of a separation between the image created in public communications and the experiences and values of those within the organisation. Examples of this can be found in organisations which operate in a political landscape of New Public Management, in which efficiency strategies from private business are applied to the public sector. Such organisations often experience clashes between external demands for accountability—such as the use of key performance indicators—and internal professional values. One way of dealing with these tensions, whether in the public sector generally or in universities specifically, is to loosen the connections between different systems of accountability so that they operate in parallel rather than as one. Decoupling is thus a way of meeting external demands without necessarily changing your own internal work-practices, values and guiding norms. In the context of science, this works by simultaneously paying attention to university performance indicators (graduating students, acquiring funding and working on administrative committees) and to the norms of one's disciplinary community, without ever letting these two systems directly interact with one another.

As an example, a research centre we once visited had a reputation for being entrepreneurial and very good at collaborating with various companies. On a closer look, however, these collaborations were mostly done by BA and MA students as part of their project work, while many of the permanently employed researchers were doing classical academic work oriented towards the publication of basic research. The centre had thus found a way of organising its work that allowed the researchers to talk outwardly about entrepreneurial science, while, internally, they reserved sufficient space for their basic research ambitions. Such decoupling should not be seen as cheating or manipulation. Rather it is a necessary means of survival in a landscape of shifting and conflicting demands and political pressures. These strategies can, however, create other problems for scientists. While being seen to do business-relevant science might be beneficial within a political discourse that values commercialisation, exactly the opposite might be the case in other contexts. If scientists comply with the demand to be entrepreneurial and generate resources, they might be considered less legitimate as spokespeople for a field of knowledge or the entire social institution of science because they could be seen as simply furthering their own interests.

What does this mean for science communication? Decoupling or the management of multiple roles are not things that are internal to universities or to science but are expressed through different public activities. At the same time, universities and research institutes are, in the face of global competition, becoming more corporate and marketised than they have been in the past, and this is shaping emerging relations between science communication on behalf of specific organisations and that carried out (explicitly or implicitly) for science as an institution. Tensions between science communication professionals and scientist-communicators are emerging, for instance, because of the ways that universities are changing (something we will return to in Chapter 5). Science communicators employed by universities may seek to present a unified message, one that 'sells' the strengths of the organisation. The frustrations they feel, and the misalignments that can occur between their vision of public communication and that of university scientists, stem from a sense that lack of organisational identification is a problem for strategic communication goals. However, seen from a researcher's point of view, there might be good reasons to most strongly identify with their discipline or the professional values of science. The strength of the institution of science and scientists' identification with this global set of professional values should not be overlooked by professional science communicators.

We started this chapter with some notes from our own experiences of creating a piece of research communication for the ESOF Science in the City festival. With the installation, we wanted to allow laypeople to understand and discuss our research, certainly, but, as MH's notes make clear, we also had a variety of other concerns. We wanted the university to look good, to enjoy a sense of collaboration with our UCPH colleagues, to let science communicators know about what we thought was an interesting way of doing communication and to raise the profile of STS research (for instance). Getting a photo with the university Rektor was an added bonus. As we carried out the communication, standing beside and talking about the installation, we were at times taking on the role of disinterested communicators of social science knowledge but at other times were doing things like acting as a head of department (for MH), representing a particular, local community (the university) or performing the role of researchers concerned with their personal brand. The installation was entangled with all of these roles. Its meaning is, ultimately, tied to our own sense-making about research, the university, and our discipline.

The main point of this chapter has been to show that, just as with the installation, science communication is rarely simply about a particular individual and their desire to communicate scientific knowledge. This is because scientists are not, in fact, free-floating individuals, but people who are part of a variety of institutions and organisations. The way in which they produce knowledge is tied to collectives like lab groups, departments, universities, disciplines, and research networks—and their science communication will be affected by this. As they communicate, they both construct their own identity as a scientist and present different versions of the nature of science. Science communication is therefore inevitably related to organisational structure, reflecting its changes but also forming part of an organisation's storytelling about itself.

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4

The Changing Nature of Science Communication: Diversification, Education and Professionalisation

The previous chapter focused on scientists as actors in public communication. We argued that we should not view scientists solely as individuals but instead see them as acting as representatives of different collectives. But scientists are not the only actors within contemporary science communication. This is, as we argued in Chapter 1, a highly diverse ecosystem. It is filled not only with a wide range of formats but with different actors with different professional affiliations and interests. For every high-profile celebrity scientist like Dawkins or deGrasse Tyson, there are a myriad post-docs doing outreach activities, press officers publicising their university's science, and museum explainers and communicators writing and speaking and making exhibitions.

A shifting media landscape

Mass media are a key part of this ecosystem. Both legacy (newspapers, public broadcasters, and magazines) and new media are central producers of science communication. As we saw in discussing celebrity scientists, media representations of scientists can have powerful effects in

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symbolising science for both scientific and lay audiences. Because of this prominence of mass media representations of science, there has been longstanding interest in the relationship between science and media, and between scientists and journalists. Scientists have often expressed concerns about this: one researcher, quoted on an NPR blog, talked about the 'tendency for headlines to bypass the subtlety and go for sensation', and that she would prefer to 'simply refuse to return calls from science journalists and stick to taking care of business inside the lab'.[1] Such anxieties are not unusual and have been shared by others outside of science. 'Many commentators and communication researchers', writes Hans Peter Peters:

> diagnosed 'gaps', 'tensions', 'barriers' or miscommunication such as inaccuracies, and lack of motivation and communication skills on the part of scientists […] However, not only the phenomenon of "media stars" among scientists … but also the prevalence of routine interactions of scientific sources and the widespread satisfaction of scientific sources with the media coverage of their own research … suggest the need for a reassessment of the science-media relationship.[2]

Peters argues that the relationship between science and the media is more complex than is suggested by concerns about misunderstandings or differing logics. Most studies indicate, for instance, that there are few factual inaccuracies in science news (one large content analysis of science in the BBC's output found no errors, though some issues around how stories were 'balanced' through the inclusion of diverse voices[3]). A large-scale international survey conducted by Peters and colleagues indicated that contact between scientists and journalists was both rather frequent and less problematic than is often implied.[4] According to the survey, carried out with scientists in France, Germany, Japan, the UK and the USA, '57% of the respondents said they were "mostly pleased" about their latest appearance in the media, and only 6% were "mostly dissatisfied"'. In addition, science has been for many decades, and remains, an important part of mass media coverage.[5] Public interest in it is high, and in at least some contexts, and for some kinds of content, the amount of science in news media is increasing.[6]

Most pertinent to our discussion here are the profound changes that the media landscape as a whole is currently undergoing. Many newspapers, for instance, no longer have dedicated science reporters and are unlikely to have the resources to support in-depth science journalism.[7] These pressures are emerging in part because of the rise of the web, social media, and unpaid citizen journalism. Many people now get their science news from the Internet, either from scientists themselves, writing on blogs or university websites, or through curated platforms such as Science Blogs. In a world in which science-related press conferences are live tweeted and you can follow researchers' status updates on Facebook, the role of the science journalist is moving away from being someone who simply provides information to public audiences about cutting-edge science and technology. Commentators have argued that new roles for science journalists are emerging, such as the curator (helping us deal with the mass of information available) or the public intellectual (taking a distinctive, and sometimes personal, stance on science reporting).[8] The last decades have also seen the emergence of specialised Science Media Centres to try and further smooth the relationship between the scientists and the media. The UK's Science Media Centre (SMC) was founded in 2002[9] and aims to act as an 'independent press office' for science. Its offerings include media training and written guidance for researchers, a database of media-friendly scientific experts for journalists, and sets of written briefings and research summaries giving clear, accurate information on breaking science news. Although SMCs have been criticised as heightening a culture of 'churnalism' (the over-use of pre-packaged materials, like press releases, in news reporting) and the dominance of 'science information as entertainment'[10] over investigative journalism, they are one response to the increasing pressures news rooms are under.

Science in mass media is, then, at a moment of transition. On the one hand, some formats are experiencing a golden age: TV shows hosted by celebrity scientists, such as the British physicist Brian Cox or the US astronomer Neil deGrasse Tyson, continue to be mainstream successes, while online platforms such as TED—which presents 20-minute talks by cutting-edge thinkers—can produce overnight hits (at the time of writing, the most popular TED talk had been viewed 31 million times).[11] On the other hand, there is also a profound fragmentation in the way in which news, and information about science generally, is provided to public audiences. As one media researcher, Dominique Brossard, has written, new media are enabling people to 'access massive amounts of information about virtually anything, from anywhere, and without much cognitive effort'[12]—and it is not clear what the consequences of this will be.

The ecosystem of science communication is diversifying

These changes do not only relate to science communication as carried out by mass media. This chapter, and the one that follows it, make the point that both scientific research generally and science communication specifically are undergoing important shifts in how they are imagined and carried out. This is not to suggest that an earlier age existed when science was stable and science communication was straightforward: neither of these things have ever been the case.[13] But we do want to argue that science communication is within a time of transition. In particular, this chapter explores the idea that the ecosystem of science communication is diversifying and, as part of this, that science communication is becoming professionalised. Science communication is no longer the embattled preserve of a few 'visible scientists'. It is a domain populated by a wide range of full-time communicators (alongside many enthusiastic volunteers), whether those are scientists who have turned to communication full-time, communication professionals from other domains (such as PR), or a growing cadre of individuals specifically trained in science communication.

One example of these changes is the growing emphasis on integrating communication training and practical experience into scientific education.[14] It is now rather standard for junior scientists to receive training in both scientific and public communication, based on the understanding that science students need skills beyond those of the science immediately at hand. Most broadly, they are encouraged to gain 'transferable skills' which will equip them for the world outside of academia;[15] more specifically, junior researchers are given training in topics such as the responsible conduct of research,[16] research ethics,[17] academic writing and speaking and, sometimes, public communication more broadly. Training in science communication largely focuses on supporting styles of communication that involve 'dissemination rather than dialogue'[18] (as one review puts it). Various surveys of such courses, and the science communication scholars who teach them, have indicated that models and theories of science communication are one important element of this kind of education;[19] understanding, and catering to the needs of, the audiences of communication is another.[20] From our own experience such training will introduce science students to different forms of science communication and aim to give some practical guidance in areas such as writing for public audiences, talking to the media, and participating in live events and dialogue.

This form of training does not stop at the student level. As Trench and Miller have shown, there is widespread support for capacity-building in science communication from national governments, research funders, universities, and the European Commission.[21] There are therefore a number of different kinds of opportunities for scientists to become better equipped as public communicators. Take, for instance, the activities of the Science Media Centres mentioned above. The UK SMC runs a half-day course, 'Introduction to the News Media', which is free for working scientists to attend and which aims to 'give a flavour of the news media'.[22] This is not practical training, the SMC emphasises, but an opportunity to understand the logics and practices of science journalism and to build a relationship with the SMC which could lead to further support in talking to the media down the line. Similarly, in Denmark, a range of organisations offer specialised communication training for scientists, including the science news service Videnskab.dk and the newspaper *Information*. Many readers will be able to think of other examples, more local to them.

These efforts are generally positively received and effective in supporting scientists in getting involved in science communication. One study found that formal training and perceived self-efficacy is conducive to scientists' positive interactions with the media,[23] while another surveyed scientists to find that they particularly valued training on creating clear and comprehensible messages (above, say, how to come across as trustworthy, which perhaps smacks of manipulation).[24] The hope, of course, is that better equipped scientists will result in better science communication and from there better relations between science and society. We can add that it is not uncommon to see such hopes associated with a desire to recruit more young people and students into science—an enduring concern that is behind much financial support of public communication. Counter to these positive experiences, however, there is also some evidence that, for junior scientists, demands to train in and carry out public communication can seem an extra burden. In one study, researchers at the post-doc level expressed interest in getting involved in public engagement but felt stymied by the conditions in which they worked.[25] Their jobs were, they said, too insecure, too short-term, and too lacking in autonomy for them to follow their interests and spend time and energy on public communication.

Integration and specialisation in science communication

Training for scientists seeks to give scientists new professional skills, equipping them for a scientific career in which public communication is a standard part of the job. As such it relates to what we might call the *integration model* for public communication in research organisations. If a research organisation understands science communication as an integral part of doing science, it will demand a high level of collaboration between scientists and communication professionals, and it will invest resources, such as training activities, into turning scientists into skilled communicators. Communication is viewed as an essential part of science.

On the other hand, a *specialisation model* of public communication involves the delegation of communication tasks from scientists to others within a research organisation. Here public communication is a specialised task to be dealt with by professionals with relevant training. This model explains the growth in communication professionals within research organisations that has taken place over the past decades.[26] Most had no specialised communications or press teams before the 1990s. The Italian Institute for the Physics of Matter, for instance, was one of the first Italian public organisations to have a dedicated media relations officer, and this role was put into place in 1996.[27] Today many institutions will have not just press and media officers, but other specialised roles and units dedicated to activities such as science outreach, public engagement, events programmes, and alumni relations. Jane Gregory and Martin Bauer describe these changes as a shift from what they call the 'old regime' of science journalism (which focused on scientists as communicators and public education as the key outcome) to a new regime of 'PUS, Inc.', which focuses on the promotion of science, PR for increasingly corporatised science, and mass media events. PUS Inc. is a specialised, professional activity, they write, and

> …for the time being the PR skills required … mean that science communication is the province of the few, rather than of the many. Furthermore, the logic of PR requires a centralized communication function, which will render increasingly obsolete the 1990s attempt of making every scientist a popularizer of his or her own work.[28]

By pointing out that individual scientists are not the powerful actors they once were (or have been framed as), Gregory and Bauer point to the profound changes that have taken place within the landscape of science communication. These developments are also demonstrated in a study by scholars Casini and Neresini. They looked at 40 European research organisations,[29] interviewing both scientists and communication professionals within them to find that few of these actors considered outreach and public engagement activities to be an integral part of the role of scientists.[30] Interaction with the public was a task that was either delegated to others—such as in-house communication specialists or the media—or was seen as a peripheral activity carried out according to scientists' individual priorities or goodwill. Casini and Neresini's interpretation was that because public communication was not considered an essential part of scientists' tasks, it was not part of the 'core business' of a research organisation. But this kind of delegation also relates to the fact that science communication can be organised in different ways within a collective, through both integration and specialisation models. Both are valid options, and in either case, science communication is something that requires specific professional skills. The difference lies in whether those skills are in supporting and training scientists or in carrying out communication on your own terms.

We will return to the kinds of tasks and professionals who now populate universities that operate according to a specialisation model in Chapter 5. The wider point here is that science communication is becoming professionalised: in universities and other research organisations it is either something that requires scientists to be supported and trained in specific ways or an activity that requires skilled professionals in its own right. Professionalisation of science communication is also occurring outside of the context of universities. Other kinds of organisations, such as NGOs, charities, social movement groups and government agencies similarly have specialised roles for individuals who will interact with, and communicate about, scientific knowledge. These roles may be informal or voluntary. But the general theme is that science communication is not something that should be left to scientists—whether they work for Greenpeace, Unilever, a university or a government lab—but that it requires skills in its own right. Public communication of science is an enterprise that has, over the past decades, turned into an industry, complete with specialised educations and training programs. Making science public is a vocation in itself, not necessarily something that is tagged on to a scientific education.

Activists as Science Communicators

When we think about science communicators we might think of famous scientists on TV, science festivals such as ESOF, or university students going into schools. We might even think of science PR officers, medical writers for pharmaceutical companies, or museum curators. But science and science communication are also carried out by social movement and activist groups. The environmental charity Greenpeace has its own science unit, for instance, and uses its findings in its campaigns.[31] Campaigning groups such as those concerned with vaccination, environmental pollution, nuclear power, or particular medical conditions similarly use scientific knowledge in their public communication.

One example of science communication by activists comes from the 1980s and the interventions that AIDS activist groups made into treatment research. Steven Epstein describes how social movements arose around AIDS treatments and the research that was ongoing into them; activists, he argues, were able to insert themselves into scientific knowledge production to an unusual extent.[32] Rather than simply accepting what scientists and doctors told them, they became able to participate in decisions about how clinical trials should be run and, eventually, were accepted as essential partners in the process of research. The activists used a number of strategies to achieve this, many of which involved public science communication. One key method, for instance, was the use of street theatre and protest to draw attention to what were seen as '"paternalistic" policies of drug regulation'.[33] Large demonstrations at FDA and NIH headquarters made the point to both public audiences and those working in science policy that there were alternative ways of carrying out drug trials, and of working with patients, than were currently being used. But activists also used science to gain credibility and to access scientific discussions in this way. Epstein writes that once they 'acquired a certain basic familiarity with the *language* of biomedicine, activists found they could also get in the doors of the *institutions* of biomedicine' (emphasis in original). Treatment activists therefore became adept at using the language and concepts of scientific research to a number of different audiences. By depicting themselves as credible, knowledgeable actors as part of their public campaigning, they were able to draw attention to their cause and, ultimately, to 'challenge the hierarchical relations between experts and laypeople' that biomedical research often involves.[34]

The professionalisation of science communication

While the rise of specialised university communicators is an important aspect of the changes science communication is undergoing, so is the proliferation of professional communicators beyond the university. We see this in a number of different spaces. Increased interest in participation, dialogue, and engagement has meant an increase in consultancies and non-profits specialising in managing science–public interactions (examples include Involve, a UK think tank and charity which supports public participation in science;[35] ThinkLab, which specialises in science PR;[36] and Australian-based Econnect Communication, which 'communicates creatively' about science, technology and the environment[37]). Learned societies (such as the UK's Royal Society or the US National Academies of Science) have teams to manage different aspects of public communication, from dialogue and participation to digital and social media content. Science festivals, science shows (of the type that visit schools and aim to enthuse school children about science) and science-oriented events are run by anything from large organisations to individual freelancers, small businesses or volunteers.[38] Science museums and centres have, of course, always had staff devoted to science communication through exhibition development or 'explainer' roles, but they increasingly also run event programmes, schools outreach teams, and travelling shows and exhibitions, and have specialised units devoted to the development and delivery of these. Science journalism is becoming populated by blogger-entrepreneurs, interested amateurs, and non-profit organisations.[39] Patient organisations and charities may develop public participation activities, employ policy officers to lobby governments about issues important to their remit, and use medical and science writers to clearly convey the science behind their concerns.

One key aspect of this professionalisation is the development of a sense of community and of being part of a collective. There are now a number of more or less formalised communities which identify themselves as science communication practitioners. One example is the PCSI-COM mailing list,[40] which is UK-based but has subscribers from all over the world. Another is the Public Communication of Science and Technology (PCST) Network,[41] which holds biannual conferences and draws a mix of science communication scholars and practitioners. SciDev.Net is a website and resource bank with a focus on science communication in the global south.[42] These communities are often self-consciously reflective about their status and the nature of the activities their members engage in. In 2010, for instance, there was an extended discussion on the PSCI-COM list about the need (or not) for continuing professional development (CPD) courses and accreditation in science communication. The starting point for the discussion was that 'science communicators constituted a distinctive cadre of people',[43] though this cadre was understood as highly diverse and united solely by an interest in public engagement with science or science communication. The resulting discussion made it clear that those on the list included everyone from people with decades of experience as communicators to early career scientists looking to make the switch to working in science communication—a community of interest, in other words, as much as of practice.

What emerges as one looks at groups such as the PSCI-COM list or the PCST network is a strong sense of a field in the midst of change, one of which is a move towards professionalisation. According to theories in the sociology of professions, at least two aspects are important in this:[44] the profession needs to be based on a set of technical and transferrable skills derived from a body of theory taught in designated educational programs; and it should adhere to a set of professional norms (such as a code of ethics) which is enforced by the professional community. The two may evolve into a situation where professional careers are regulated and supported by the profession (for instance as when doctors and lawyers need to earn special licences to be able to practise), though this is, of course, not yet the case for science communication. In thinking about the professionalisation of science communication, we look at each of these issues in turn. What are budding science communication professionals taught? And what are the norms of this field of practice?

Training science communicators

Many people want to work in science communication. A regular topic on email discussion lists, training courses and other science communication resources is, quite simply: how do I get a job (ideally one that pays the bills) doing this? Most answers come down to two suggestions.[45] The first is to get as much experience as possible. As science communicator and scholar Alice Bell says, 'You want to write? Get a blog. You want to run events? Set one up then'.[46] The second is to follow a course or educational program in science communication. To quote Bell again, a good qualification 'will provide a network of contacts in the field, some chance to reflect on what science communication is and means to society, and where in this world you feel most at home'.[47] In favour of arguments for professionalisation, there is evidence that more and more communicators are choosing, or needing, to take the latter option alongside gaining informal experience in the sector. A survey among attendees at the British Science Communication Conference in 2007 demonstrated that some 25% of respondents had had postgraduate training in science communication.[48] For science journalism specifically, there is evidence that the backgrounds of this community now tend to include higher degrees in science and/or specialised training in science journalism.[49]

There has been rapid growth in specialised postgraduate offerings over recent years. These operate at a number of different levels, from part-time courses of a few weeks right through to MA and Ph.D. programmes. Most include some teaching about science as a social process (drawing on disciplines such as STS, history of science, and philosophy), theories of science education, and communication theory more generally; many will also incorporate practical training in, for instance, science writing, media production, or exhibition development.[50] The vast majority are interdisciplinary in nature, drawing on different domains of knowledge wherever they are pertinent to science communication. The assumption is generally that students are or should be coming from a science background and have a base of knowledge about science (some courses will only accept students with an undergraduate degree in natural science). There has also been a rise in postgraduate courses in science journalism specifically (as well as science communication more generally) and in science-specific modules within journalism programmes.[51]

One example of postgraduate training is Imperial College London's 'flagship' MSc Science Communication programme,[52] which, when it first ran in 1991, was the first such course in the UK and one of only a handful globally.[53] The course, writes Felicity Mellor (who has worked on its development and delivery since 2001), was set up by John Durant and first funded in the wake of interest in public understanding of science (it thus forms a small part of the UK history described in Chapter 1). It later led to a more specialised MSc programme in Science Media Production. Both courses—generally completed as one-year, full-time programmes of study—are what Jon Turney has referred to as 'big picture' educations,[54] emphasising not just practical skills but the ability to think critically about the nature of science and the media. 'We stress', writes Mellor,

> that although science communication is, of course, concerned with science, to study the subject and to become a professional science communicator is to cease to be a scientist. Our students are *humanities* students, their scientific qualifications notwithstanding.[55]

This 'change of identity'—the wrenching away of (some of) the assumptions of natural science, and the identity that goes along with these—can be traumatic. But Mellor says that they have found that, quite rapidly, students construct new identities as science communicators, taking pride in their intellectual distance from science and their ability to critically reflect on it and thereby to communicate effectively. This 'intellectual re-orientation' is often what graduates remember, and what they end up using in their careers. Approximately 80% of graduates from the course gain jobs in science communication-related fields.

Taking the Imperial MSc is a serious undertaking: it is a one-year, full-time course based in central London with tuition fees that (at the time of writing) start at around £9000. Although there are scholarships and other financial support available to some students, educational programmes such as these are simply out of reach for many aspiring communicators. Alongside the growth of such programmes, then, there are also a range of part-time, online and shorter-term courses which cater for, for instance, science communicators in existing jobs, or those who need to be based in a particular location. One example is the online course provided by Stellenbosch University, in South Africa.[56] This runs over 10 weeks and involves six taught sessions plus a practical assignment. Run by experienced South African communicator Marina Joubert, the course—titled 'Science Communication: An Introduction to Theory, Best Practice and Practical Skills'—is aimed at people already working at the interface between science and society and particularly those in developing world contexts. It costs (again, at the time of writing) just $500 and has attracted dozens of participants from across Africa in its first iterations.[57]

Well-established postgraduate courses in science communication—such as the Imperial MSc or similar programmes at Dublin City University in Ireland, Australia National University, or Pompeu Fabra University in Spain—have now graduated hundreds of students. Many of these individuals are working as science communication professionals in different areas: as journalists, in broadcast media, as PR officers, in museums, in marketing, or in science policy. We know something about the way in which this group have been trained; now we turn to the question of professional norms and values. What do we know about norms and codes of conduct in relation to science communication?

Norms and values in science communication

We think it is fair to say that there is currently no standard description of norms and values for science communication—or, at least, that there are many competing accounts of these. One aspect of this diversity is that professional practice is not always well connected to academic theory and analysis. The veteran science communication writer Steve Miller, for instance, has argued that there is an uncomfortable gap between those who carry out science communication and those who analyse it. This, he says, is tied in part to the degree in which the profession is made up of individuals with very different backgrounds and career paths:

> People tend to drift into careers that are more or less associated with PCST [public communication of science and technology]. At the 'top' of the academic tree there are even professors of 'public understanding of science' or something similar who have carried out no research in the area; nor have they given a single lecture on the subject. Instead, they may have written some popular science books (or several versions of the same book) or run a science festival. […] on the one hand are the practitioners, often with a background in the natural sciences, medicine or engineering, who organise and take part in public engagement with science activities of one sort or another; on the other hand are the researchers, usually with a background in the social sciences or humanities, writing articles for the journals, aloof from the blood and sawdust of the science communication arena. And the two just do not talk to one another.[58]

Miller is, of course, taking the opportunity to take a side-swipe at celebrity scientists like Dawkins who are made 'professors of "public understanding of science" or something similar' despite having no knowledge of theory or analysis in the field. But he also notes that researchers in the field all too often hold themselves 'aloof from the blood and sawdust' of real-world practice. His effort to examine the relationship between the two took the form of a questionnaire distributed at the 2007 iteration of the UK's annual Science Communication Conference (run by the British Science Association, the equivalent of the US AAAS). As he notes, delegates to this conference are self-selected members of a science communication community, and his survey gives us a hint of their experiences and priorities. Some 50% of respondents said that they worked professionally in science communication, and most had natural science (rather than communication disciplines) backgrounds; only a third had received training in science communication at a university. More than 50% never read peer-reviewed literature on science communication (Miller asked about two of the key journals in the field, *Public Understanding of Science* and *Science Communication*). Taking into account the demographic information he collected, the average science communicator is, he says, 'a (relatively) young and middle-ranking woman, well trained in science but less so in communication, who does not pay a great deal of attention to the relevant research literature'.[59]

It is unclear to what extent Miller's assessment of the UK science communication community holds true for other contexts. Our experience has been that the PCST Network is one of relatively few spaces in which science communication practitioners and researchers rub shoulders with each other, and there have certainly been enduring concerns about the relationship between theory and practice.[60] The extent to which this is a problem for practitioners, who may feel fully capable of doing science communication without the help of more abstract theories, is debatable. There is a high degree of self-reflection within the practitioner community, just not one that draws on the resources of academic scholarship. Similarly, it is not clear that a better relationship between scholarship and practice is strictly necessary for developing a shared sense of professional norms and values. One example of emergent norms, for instance, comes from communicator Matt Shipman's 2015 reflections on responses to a book he had written for Science Public Information Officers[61] (PIO). He had, he said, 'ruffled some feathers' with his claim that the job of science PIOs is to make his or her employer look good. But, he explained:

> I suspect the primary concern of folks who don't like the way I characterized the role of a PIO is that they conflate 'making one's employer look good' with 'fudging the facts and only presenting sunshine and ponies'. That couldn't be further from the truth. The fact of the matter is that 'making one's employer look good' can only be done by communicating clearly, honestly and effectively about the work the institution is doing. Honesty and transparency are essential. Doing otherwise is not helpful to the institution.[62]

'[C]ommunicating clearly, honestly and effectively … Honesty and transparency are essential'. This could serve as one succinct example of what science communication's professional norms could entail. Others have emphasised the need to avoid manipulation or forcing one's own conclusions onto audiences,[63] or that there are particular challenges to communicating uncertain science in a responsible manner.[64] Ideas about 'deficit' and 'dialogue' styles of communication are likewise an important part of the story that science communication tells about itself (for instance in educating communicators).[65] While there is currently no standard set of norms and practices that science communicators have agreed upon (something that is, according to sociology of professions theory, a crucial part of the formation of a profession), there is therefore evidence that shared norms, values and commitments are emerging.

Researching professionalised science communication

Will these norms and values become codified? This remains unclear. The diversity within the field makes it hard to see a common ground for a single set of professional evaluation criteria. It is not obvious that a designer working to build science interactives, a press officer working for a medical research charity, and a freelance science writer will have much in common, or that they will be able to agree upon what constitutes 'good' science communication. At the same time, it does seem likely that there will be more movement towards basing practice and education on theory, as one key way that a profession distinguishes itself. Of course, we also hope that science communication scholarship will actually be a useful resource for practice—not least because the split poses a significant challenge to researchers, who will find it hard to produce robust scholarship if it is not connected to the realities of science communication 'on the ground'. More importantly, we think these dynamics of professionalisation and diversification should be an important part of future scholarship on science communication.

It's important, then, for research to take a step back and think more about the phenomenon of professionalisation and specialisation itself.

We have seen (in Chapter 3) that scientists' public communication is related to processes of identity construction and to the representation of different kinds of collectives. Similar processes of sense-making will be taking place as professional communicators are educated, find work in the field, and become part of a community focused on science communication. We will return, in the last chapter of the book, to a discussion of some of the shared norms in science communication scholarship, and particularly to the use of the deficit to dialogue narrative. Here we want to suggest some areas that we think future practice and scholarship should deal with. For instance, how are norms for 'good practice' in science communication developed and who gets to decide? What trends and developments—economic, political, and social—have enabled the rise of focused educations in science communication and of a stratum of professions which manage the interface between science and the public? In what ways are communities of science communication professionals nationally or locally specific, and how do they interact with other people who communicate science?

The rise of science communication as a vocation is a fascinating development, and one that deserves further study. The point of such study would not necessarily or only be to criticise this emerging professional community, improve educations in it, or even typologise it. It would also be to view it as a sociological phenomenon that will tell us something about the nature of both science and society in contemporary societies. In other words, it would interrogate what it means that science communication is increasingly seen as a specialised, professional activity, and that communities are developing around it.

In closing this chapter, we want to point to one particularly notable job advert for a science communication practitioner. In May 2015, as we were writing this book, the research organisation CERN posted an ad: they were looking for a new Head of Communications, Education and Outreach.[66] CERN is famous for its science communication. Media coverage of its Large Hadron Collider experiments has been intense, and the organisation has a public profile that is the envy of many universities, research organisations, and experimental infrastructures. For many science communicators, this would have been their dream job. So what were CERN looking for?

The successful candidate would 'advise and assist' the Directorate (the central leadership), set 'strategic objectives', and foster collaborations with related organisations. They needed to have competencies in strategic communication, internal corporate communication, and people management (they would be leading a team of 'expert science communicators'). A master's degree in communication or a related discipline, such as science journalism, was necessary; the advert also stated that an additional qualification in science would be an asset (but not essential). What is striking is that the skills and experience that one would need in order to apply are not very different from a Head of Communications job in any other large organisation (whether public or private). Only the last of a long list of technical competences required gave any evidence to the kind of institution the candidate would be working in: science writing, science popularisation, and emerging technology monitoring.

Science communication is becoming a profession in its own right. But it is also being colonised by other professions: individuals with skills in PR, HR, corporate communications, or technology transfer are also increasingly involved in public science communication. The CERN job advert demonstrates this: communication by scientific organisations is, clearly, closely related to the kinds of communication that goes on in most other kinds of large organisations, and requires a similar skillset. Some of these changes result from the increased importance placed on science communication by governments, research funders, and universities themselves. Others, however, relate to the way in which both research organisations and knowledge production more generally have changed over the last decades. It is this topic that we turn to in the next chapter.

Notes

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15. See, for instance, the 'Researcher Development Framework' developed by the UK researcher organisation Vitae: https://www.vitae.ac.uk/vitae-publications/rdf-related/introducing-the-vitae-researcher-development-framework-rdf-to-employers-2011.pdf.
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40. See https://www.jiscmail.ac.uk/cgi-bin/webadmin?A0=psci-com.
41. http://www.pcst.co.
42. http://www.scidev.net/global/. SciDev.Net has a number of regional desks focusing on science communication in particular areas – see, for instance, this report on Latin America and the Caribbean: http://c96268.r68.cf3.rackcdn.com/Building_Science_Communication_Networks_2013.pdf.
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5

The Changing Nature of Science: Academic Capitalism, Entrepreneurial Universities and PR

In 2015, former biochemist Richard Grant wrote a blog post in the *Guardian's* online science section. Titled 'Scientists or beancounters: who decides what's best for UK science?'[1] it discussed changes underway in UK higher education funding. The UK government, Grant wrote, had called in management consultants McKinsey to advise on how best to cut the science budget, there was a discussion of restructuring the research councils (the government bodies that give out research funds), and a drive to 'centralise procurement'. It is the latter that Grant is most exercised about. Any scientist, he says, 'who has been subjected to the sheer horror of centralised procurement will tell you it doesn't work'. He continues with a story from his own experience:

> There was a time when I worked in a government lab. [Under a regime of centralised procurement,] we were told to buy pipette tips from a certain supplier. Yes, they were cheaper than everyone else—and there was a reason for that. Pipette tips are pretty much indispensable to a molecular biologist. […] it's important that these tips (a) deliver the precise microscopic amount you want, and (b) don't fall off the pipette. You're way ahead of me on this one, aren't you? It took a screaming match between my boss and Accounts,

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> and a live demonstration of a dripping tip (just before it fell off), before our lab—yes, just our lab, never mind the rest of the department—was allowed to go to a supplier who could actually make the bloody things properly.

Grant has had too much experience, he says, with the ways of meddling bureaucrats not to be anxious about their continued encroachment into science. 'Beancounters' are interfering with scientific work: their penny pinching is a massive annoyance and is ultimately counter-productive given that what might seem to be cheapest and most efficient is not necessarily best. This kind of centralisation is a recipe for trouble. Scientists should be left alone.

There, in a nutshell, you have one story about the changes universities and research organisations are currently undergoing. Other stories, ones that were more positive, might also be told—from the perspective of the 'beancounters', for instance. Centralised procurement is just one aspect of these changes. Fundamentally, there has been a shift over the last decades towards increased *marketisation* in universities and other public organisations.[2] The sector has grown substantially, it has internationalised, and it has become highly competitive. Universities and research organisations need to generate income for their activities in fierce competition with each other, with regard to both research and higher education. Researchers fight for funding; universities compete for students (customers). Centralised management and effective budgeting—of which centralised procurement is just one example—have become important in a way that was not the case previously.

This chapter focuses on these changes and the implications they are having for the practice of science communication. While we do not agree with the diagnosis presented by Grant above, we do think that current science communication both reflects and feeds into trends of marketisation and commercialisation within science. As we have argued, it is important for scholars and practitioners of public communication to think about communication in its wider social, economic, and political contexts, rather than as an isolated and altruistic exchange of scientific knowledge. How then is the institution of science changing under pressures of globalisation, marketisation, and privatisation? And what does this mean for science communication?

Entrepreneurial science and academic capitalism

It is widely agreed that the nature of knowledge production in contemporary societies is changing. We see this, for instance, in the way in which science and technology are funded and discussed by politicians. More and more, the political focus in research policy is on the relevance and commercialisation of universities specifically and academic research generally. For many politicians, a well-functioning science and innovation system is seen as a prerequisite for national growth. We live, we are told, in 'knowledge societies', and research organisations are understood as crucial contributors to this.[3] In this view, science is not and should not be an activity that is run according to its own internal rules, norms and values alone, but one that is part of a larger system which seeks to generate national economic prosperity.[4]

The commercialisation of science has been emerging over a period of many years. As early as 1983, Henry Etzkowitz wrote about 'entrepreneurial science' in the United States. Such science, he argued, involved the identification, creation, and commercialisation of intellectual property and was becoming an important part of universities' 'third mission' (their activities beyond teaching and basic research).[5] Together with Loet Leydesdorff, he later formulated the hypothesis of the 'triple helix' in which a well-functioning innovation system is based on collaboration between the research system, industry, and the state.[6] In a 'knowledge-based economy', Etkowitz wrote with a group of collaborators in 2000, 'the university becomes a key element of the innovation system both as human capital provider and seedbed of new firms'.[7] Universities are thus not (only) about generating new knowledge, or developing individuals' potential, or even creating social benefits, but are seen as producers of 'human capital' and economically valuable innovation. In these accounts, the commercialisation and marketisation of universities and publically funded research are seen as healthy and as an important means of boosting national economic prosperity. But Etzkowitz and his colleagues are also clear that these changes may not progress smoothly. Controversies will arise, they say, and there will be discussion and debate about whether academic activities should be extended and altered in this way. Ultimately, the development of entrepreneurial science is a process in which a phase of controversy might be followed by a phase in which 'new rules and roles are defined and legitimated'.[8]

Not everyone is as sanguine as Etzkowitz and Leydesdorf. Over the last decades, as these developments have picked up speed, many studies have explored moves towards commercialisation and entrepreneurship in universities and found evidence that they result in stresses, tension or outright rejection.[9] Philpott et al., for instance, point to increasing divides and widespread disharmony between disciplines within the university. Humanities scholars, in particular, find the top-down push for more entrepreneurialism a fundamental 'threat to the purpose of a university'.[10] From a somewhat different theoretical perspective, Sheila Slaughter and Larry Leslie have introduced the notion of 'academic capitalism'. Drawing on criticism of New Public Management and neoliberal policy analysis they argue that the market has become the overriding principle behind higher education policy (for instance, in driving institutional and faculty competition for money), thereby making this policy domain a subset of economic policy.[11] Revenue-generating activity takes centre stage in all aspects of university business, whether undergraduate and graduate education, academic research, or federal research policies. Slaughter and Leslie argue that academics are becoming increasingly autonomous of the public sector, despite notionally being employed by it. They act as capitalists: activities that do not retain economic profit will not be sustained. Substantial organisational restructuring is the result, as new organisational units are established and internal resource allocations are changed in order to maximise the profit within the system.

Whether one views them in positive or negative terms, these changes are affecting the organisational cultures of universities and research institutions. In Chapter 3, we saw that research organisations incorporate various, at times conflicting, 'organisational realities', to use Gareth Morgan's term. New policy demands for entrepreneurial science are certainly forming one such reality, even if immediate efforts to implement them into organisational structures and processes may fail.[12] They form, along with disciplinary and other organisational sub-cultures, one means through which members of a scientific organisation can weave their own pattern of sense-making around identity and purpose. The final result—for instance, in the public messaging that an organisation is able to achieve—is contingent on many different factors. If scientists perceive commercial achievements to be crucial for a good organisational reputation, for instance, they are more likely to engage in such activity.[13] On the other hand, an organisational culture built strongly around support of commercialisation might also produce counter-narratives and decoupling, such that (groups of) scientists experience strong detachment between organisational and individual goals.[14]

In the field of innovation studies, these changes have sparked a large amount of research. Much of this has argued that there is a tension between the entrepreneurial academic role and the classical demands of the academy, and has investigated how research organisations and individual scientists make sense of these potential clashes. This comes down to the ability to form and manage identities that are different in different contexts. Jain and colleagues argue that scientists 'typically adopt a *hybrid role identity* that comprises a focal academic self and a secondary commercial persona' (emphasis ours).[15] This hybrid identity means that scientists are able to invoke rationales for commercialisation that are congruent with, or at least not in direct opposition to, their primary academic role identity. In a similar study, Lam found that 'scientists are active agents seeking to shape the boundary between science and business', and 'have developed different modes of engagement with the emergent knowledge regimes'.[16] Scientists are therefore not helpless in the face of what seem to be competing roles that they are forced—or wish—to take on. Instead, they have a variety of strategies for managing these conflicts and living within roles that may initially seem to involve starkly different assumptions.

Science communication and the marketisation of science

Debates about the marketisation of universities and of science are ongoing. But what is clear is that this changing landscape of knowledge production is important for understanding contemporary science communication and its relation to the organisational cultures of universities. As the research organisation, rather than the researcher, becomes increasingly visible as the site for doing science, it also gains importance for science communication.[17] A group of German researchers, for instance, have shown that organisational culture strongly influences scientists' willingness to 'go public'. Amidst a move from visible scientists to visible universities, they say, the 'preeminance of … disciplinary identification is being challenged', as the organisation becomes more important as the collective through which researchers compete with their peers.[18] This is a direct result of the marketisation pressures acting on universities and science more generally. Shifts in scientific funding have meant that media visibility is increasingly no longer about representing one's discipline or educating the public, but also about legitimising one's organisation:

> Our findings further support the notion that regularly visible scientists fulfill expectations of them as organizational members. […] in the face of growing challenges to universities, science communication is not being left to a small group of particularly active researchers but is also being shaped by a broad base of academics reacting to the needs and expectations of their university.[19]

Such changes will also affect the content of science communication. Richard Grant's blog post warning against the irritations of centralised procurement appeared in the science section of an online newspaper. Campaign groups such as Science is Vital[20] (set up to protest potential government cuts to the UK science budget) or the international movement around 'slow science'[21] have emerged directly in response to the perils and pressures of entrepreneurial science and aim to raise public awareness of them. And public communication around big science—like CERN or the European Spallation Source, a neutron accelerator in the Øresund region—often includes content not just about the project's ability to reveal new insights into the nature of the universe, but to result in knowledge that may, eventually, bring about new products or innovations. In all of these ways, science communication is being shaped by changes in academic cultures.

Interdisciplinary and intersectoral collaboration

Scientists are not only being asked to be entrepreneurial contributors to national innovation and growth and to communicate accordingly. In addition, and intertwined with the idea of the entrepreneurial university, comes the sense that the scientific production of knowledge needs to move beyond traditional disciplinary structures. Helga Nowotny, Peter Scott and Michael Gibbons, for instance, have argued that the traditional paradigm of scientific discovery, which they call 'Mode 1', is being substituted or superseded by a new paradigm of knowledge production, known as 'Mode 2'. Mode 1 is characterised by a taxonomy of discrete disciplines, a linear innovation model, and the autonomy of scientists and academic institutions. It is, in short, a model of science that understands it as separate from society. Mode 2, in contrast, is oriented towards commercial application and societal impact and includes many more actors and organisations than Mode 1. It is also characterised by interdisciplinary problem-solving and is subject to multiple accountabilities and social responsibilities; in Mode 2, scientists no longer self-govern but are accountable to society. In Mode 2, the idea of a linear development from basic science to applied science and finally to commercially useful innovation disappears. Instead, the idea is that heterogenous groups of actors, including university researchers, industry and laypeople, may work together on research that is neither clearly 'basic' nor 'applied'.[22]

Interdisciplinary collaboration is therefore an important trend in much academic research. This in itself requires a lot of communication.[23] Disciplinary specialisation and sub-specialisation can make it hard for researchers to utilise and understand knowledge created in other scientific disciplines; often, scientists do not understand each other or the foundations, evaluations and interpretations of each other's research. It is not uncommon for studies of interdisciplinarity to conclude that communication skills are a key prerequisite for successful collaboration.[24] But this new way of doing research also has implications for communication outside the university and other researchers. One issue is of how science communication across organisational, sectoral and disciplinary boundaries facilitates and shapes understandings and images of science.

In Chapter 3, we discussed the University of Copenhagen's use of Professor Thue Schwartz as the 'face' of one faculty's research: Schwartz, we said, is a good example of a type of new boundary-spanning entrepreneurial scientists, who do excellent research but also collaborate with industry. As described in the previous sections, there are rather a lot of studies of how scientists like him understand their own role and engagement in entrepreneurial activities and how this relates to their academic science.[25] But the use of this kind of entrepreneurial scientist to promote science also affects science communication, and, potentially, public perceptions of science. University scientists are widely seen as disinterested, trustworthy, objective sources of knowledge, who are trusted far more than, say, industry scientists or special interest groups.[26] What difference might it make when knowledge is presented as being produced by collaborations between different disciplines in unusual ways, or by interactions between university and industry scientists?

This concern is particularly visible in medical science, which provides many examples of interdisciplinary research generally and collaboration with industry specifically. For instance, the pharmaceutical industry sponsors a large amount of research in public universities, and many academic institutions are shareholders in health start-ups led by their employees.[27] These kinds of collaborations, however, provide ample grounds for challenges, as illustrated by the *Washington Post* feature article on industry-funded medical research discussed in the grey box below. The article highlights that there are very real concerns with how research funded by pharmaceutical companies favours particular outcomes.[28] But we have also spoken to many medical researchers in universities who feel that they are being caught in a catch-22 situation when they read stories like that. They feel compelled to collaborate with industry by current policy discourse but then run the risk of being criticised as industry lackeys. This also applies to how they publish. Co-authorship between academics and company scientists is sometimes counted as a positive indicator of universities' relevance and their contribution to innovation—but it can also be problematised by external observers as a sign of industry bias.

Such conundrums will not disappear in a future where it seems likely that science will be encouraged to collaborate with industry more and more. Our sense is that the challenge this poses to science communication will become more important, and possibly also more difficult to deal with. Navigating the waters of being relevant and collaborating with industry and other partners without being accused of simply being in the outsiders' pockets will be a crucial future question for communication practitioners in research organisations. It is, however, also a key issue for future research. We are, for instance, curious about whether there are internal conflicts in academic organisations around these kinds of funding collaborations. What if, for instance, one part of the university—public health officers or sociologists or even STS scholars—starts to criticise actions in other parts of the university (such as biochemists who share equity with the university in start-up companies). How, if at all, will these kinds of conflicts fit into corporate communication in service of the university brand? And what goes on, in practice, in public communication of findings from industrial collaborations? Is this a matter for the industry communications team, or do scientists also communicate through their universities or on their own?

Communicating Big Pharma

A 2012 feature article in the *Washington Post* discusses a drug that was kept on the market despite the fact that it was associated with an increased risk of heart attacks.[29] The author, Peter Whoriskey, discusses the various communicative actions the company involved mobilised in order to do this, but also uses the story to talk more generally about the funding of clinical trials and the influence of drug companies. Whoriskey is concerned about this:

> The billions that the drug companies invest in such experiments help fund the world's quest for cures. But their aim is not just public health. That money is also part of a high-risk quest for profits, and over the past decade corporate interference has repeatedly muddled the nation's drug science, sometimes with potentially lethal consequences. (…) When the company is footing the bill, the opportunities for bias are manifold

According to Whoriskey this has led to a crisis in medicine:

> Doctors have grown deeply sceptical of research funded by drug companies—which, as it happens, is most of the research regarding new drugs being published in NEJM.[30] According to a survey published this fall in NEJM, doctors are about half as willing to prescribe a drug described in an industry-funded trial.

The journalist ends by pointing to a possible solution:

> One of the leading proposals would be to compel drug companies to release all of the data from trials of drugs that are on the market. (…) Such transparency about industry-sponsored trials would not eliminate the ability of companies to avoid unflattering studies, or to hire like-minded researchers, or to design research that gives only positive views of their products. But if such measures are carried out across the industry—and there is no sign at this point that they will be—independent researchers could analyse the data from trials and come to their own conclusions. Many believe drug companies should feel obliged to share such information.

This article is not only one example of science communication that delves into the process of how science is carried out, but an illustration of a broader problem. How should scientists and research organisations communicate publically about their collaborations with industry and the commercialisation of their activities?

Corporate communication in science

As we have already suggested, the changing nature of knowledge production has profound implications for how science communication is practised, organised, and studied. Research organisations have become players in a competitive market; in such a climate, organisations need to care about their reputation and brand. In the words of Hans Peter Peters:

> In order to secure the economic resources and political support necessary for their existence, research organizations have to demonstrate their usefulness, excellence, and public support to their (public) funders. The general legitimacy problem for science … is thus transformed into a legitimacy challenge for research organizations that—in a media society—also has to be addressed by public communication.[31]

According to the body of literature known as neo-institutional theory, this need to sustain legitimacy is a general requirement for organisations being able to pursue their mission and goals.[32] Besides public funding, a good brand also supports the generation of other resources necessary for the research organisation, including relevant partners for collaboration, excellent staff, and talented students. In a competitive market, it is the foundation of any organisation's legitimacy and 'license to operate'. And while traditional forms of science communication can obviously be used for such efforts of branding, they are generally no longer seen as sufficient. Research organisations have therefore imported a number of practices from corporate communication in order to support the need for strategic communication and to maintain a good image.

Although such communication strategies will focus on different stakeholders—alumni, potential students, and the general public—the mass media, who are seen as important 'third-party validators'[33], are a central focus for branding and communication activities. Media organisations are key curators of public discussion of science and are thus viewed as potentially providing positive coverage that increases credibility and legitimacy. This has supported a number of studies of the relationship between scientists, scientific organisations, and the mass media under the heading of medialisation.[34] This concept covers the idea that mass media and science are being increasingly more interwoven. One of the key issues for this research has been to investigate what types of effects this has on science and the scientific production of knowledge: does an increased focus on mass mediation of research influence internal norms, values and practices in science? In Chapter 3, we discussed some of the results of this research by pointing to the ambivalence of researchers in taking on a role as a visible scientist. So far, however, it seems that 'science's media resistance is rather high'[35]: structural changes in the practice of science do not seem to take place in response to the attention and priorities of the mass media. Nevertheless, medialisation and the wider development of strategic organisational communication influence the way we should practise and think about science communication in research organisations.

In the following sections, we want to highlight a few areas that we believe are particularly interesting and need further consideration. We will first consider the way in which strategic communication is not just focused on the results of science, but increasingly also on some aspects of the scientific process, such as the generation of grant income. We will subsequently enquire more into what we might term science PR, asking what it means to incorporate PR processes into scientific organisations. Third, we will look at the consequences for the control of communication flows with a particular focus on media policies in research organisations. And finally, we will look at a particular form of corporate communication, that which takes place in situations of crisis. In doing this, we will occasionally make reference to the distinction between specialisation and integration models we introduced in Chapter 4. In the context of the present chapter, these two concepts signify two different organisational communication strategies, or ways of organising communication practices. Do organisations have a specialised communication unit, which takes over and controls communication efforts, or do communication professionals work alongside scientists and other organisational members under the general leadership of the organisation?

Scientific excellence as brand

Building a reliable brand can be done in a number of ways. Some forms of branding used by research organisations are adopted directly from generic corporate communication: this can be seen, for instance, in the glossy words describing the excellence of a particular research organisation in communication outlets like home pages, brochures, merchandise, wall banners, job adverts, Twitter streams, and Facebook pages. Other forms might be more specific to research, as when media coverage of new research results is seen as part of achieving a good brand. At the same time, actions which would previously have been understood solely as part of the internal research process now take on communication and branding value. One example of this is the way in which the acquisition of research funding can be used as a branding tool.

Take, for instance, the very competitive European Research Council (ERC) grant scheme. Not only do many universities offer their employees advice and support in applying for these, but the number of ERC grants given to employees is itself something that universities often choose to boast about. The homepage of the German Universität Würtzburg, for instance, makes it clear that it is a site of scientific excellence. Navigating through their 'About the university' pages one finds a list of 14 ERC grant holders, next to the list of Nobel Laureates (of whom there are 9) and Leibnitz Laureates (of whom there are 10).[36] The homepage of the University of Warsaw also makes it clear that they are proud of their ERC grants. After explaining that these are particularly prestigious awards they write that 'In 2007–2013 European Research Council awarded grants to 14 Polish scientists, 7 of them are employees of the University of

Warsaw'.[37] Seven grants are not as many as the 14 awarded to Würtzburg; but, as the University explains, it is 50% of the total grants awarded to Polish scientists. Everything is a matter of perspective.

How does this affect science communication? One thing that has become increasingly visible is the way in which research organisations, rather than individual scientists, are in competition with each other. Universities are measured and evaluated both formally and informally on the amount of external grant income they can raise, and will thus invest considerable organisational energy into helping their researchers attract funding. Prestigious grants subsequently become a communication tool in their own right. They are used as a shorthand for research quality to other universities and political stakeholders but also in public communication. The interesting thing about such branding efforts is that they move the content of the communication away from scientific results towards symbolic shorthands, such as a grant. Similarly, the sale of an expensive patent or an agreement of collaboration with prestigious international research or industry partners can also be used in this way. All of these stories represent something which has more of a promissory nature than a tangible research result. They serve as shorthands for excellence and relevance, and are used as such in corporate communication to establish a strong brand.

An even more important effect of the use of grants as communication tools is that it makes it clear that science communication has become part of the core business of doing science. In order to exemplify this, we want to go back in time to sociologist Robert K Merton and his 1968 description of the Matthew effect: the accumulation of advantage and disadvantage in science.[38] In Merton's view, well-established scientists tended to get more credit and citations for projects with lesser known scientists, even though those projects had been collaborative. The laboratory ethnographers Bruno Latour and Steven Woolgar identified something similar, which they called the credibility cycle, where grants allow researchers to do research that leads to publications.[39] A large number of publications increases the chance of success (the researcher's 'credibility') when applying for new grants. In both cases, there is a positive reinforcement of credit and credibility. Those who have, are given more; those already lacking become more so. This effect continues in more recent years. In a study of the life sciences from 1998, Powell and Owen-Smith found that universities' efforts to enhance the commercial value of research caused a growing winner-takes-all contest between universities who have and universities who do not have large amounts of external funding.[40]

The point of this story is that an organisational brand, for example of an excellent university with many research grants, itself becomes an advantage for the scientists employed in that university. In this way science communication should no longer be seen as something which in time and place comes after the science itself. Rather it is an integrated part of the doing of science. We will return to this in Chapter 6; here we want to add that we think this interconnection between reputation, brands, and perceptions of excellence and relevance should be considered further in future research. How do public brands interact with concrete markers of success, such as funding, student numbers or collaborations? What are some of the ways in which research brands are being built, eroded and changed within contemporary science communication practice? It is also important to explore how these questions of branding and corporate communicate overflow the context of the university or research organisation to affect science communication carried out by other actors. This might mean, for instance, looking at how science-related charities or museums, or science communication businesses, develop and manage their brands, and the way in which these relate to ideas about 'excellent science'. It will also involve continuing to follow the collaborations universities and research develop with industry and exploring branding in the context of scientific business.

Science PR

Looking more generally at the production of messages in modern universities, 'science PR' has been used as a way of conceptualising the increasing use of strategies and tactics from corporate communication for reputation and product management. In Chapter 4, we mentioned one critical appraisal of these tendencies, succinctly summarised under the heading of 'PUS Inc', by Martin Bauer and Jane Gregory. The notion of PR, however, is not necessarily used as a criticism. Rick Borchelt has introduced the notion of a 'trust portfolio' as one means of understanding PR. This approach, he writes with a colleague in 2015, is to:

> view PR in a scientific organization as managing the trust portfolio—both for the organization and for the scientific enterprise more generally, and as a unifying concept for future scholarship. The trust portfolio has several components: accountability, competence, credibility, dependability, integrity, legitimacy and productivity. Managing the trust portfolio means planning and managing a side variety of strategic communication programs building diverse relationships between science and different publics.[41]

This is an understanding of science PR which is very broad. It is not quite what we think of as traditional science communication (which is rarely framed as 'managing the trust portfolio'), but it also goes beyond the boundaries of a single organisation by incorporating concern for the 'scientific enterprise more generally'. In one way, this can be seen as a straightforward mobilisation of a specialisation model of public commununication: science PR is viewed as a crucial part of a professional science organisation, demanding well trained professionals. It is something that is separate from mundane scientific practice. But Borchelt and Nielsen also warn against the dangers of specialisation, suggesting that 'too many scientific organizations see only the tactical value of PR'[42]. In their eyes, science PR has to be seen as a strategic function, and PR managers must be qualified to speak about science. Their job is not to tactically place stories in the news but rather to speak to scientists and managers about the core business of science and how it is presented externally in order to demonstrate trustworthiness through 'accountability, competence, credibility, dependability, integrity, legitimacy, and productivity'. (A set of values which again hint, as discussed in the previous chapter, that there is some cohesion around emerging norms within science communication practice.) These are attributes that can only be communicated by integrating competences of the PR office and other communication professionals with those of the scientists themselves.

Borchelt and Nielsen are clear that science PR should not be understood as the simplistic process of 'selling science' that it has sometimes been framed as.[43] They use a classification of PR models developed by Grunig and Hunt, which moves from misleading 'press agentry' through 'public information', 'two-way asymmetric' and finally 'two-way symmetric'. The model presents an evolutionary development from manipulative and misleading publicity-seeking to a socially responsible and mutually beneficial dialogue between providers and receivers of information. Borchelt and Nielsen emphasise the fourth model in their discussion, describing science public relations as, ideally, a two-way, symmetrical practice focused on dialogue, participation and engagement.

A dialogic model of science PR is also espoused by others as the benchmark for best practice in science PR. A 2014 report commissioned by the UK Chartered Institute of Public Relations (CIPR) on Science PR and Communications, for instance, suggested that practitioners were not yet living up to the ideal of two-way symmetrical PR. Organisations, it noted, 'could do more to gather, listen to, and understand priority publics'.[44] Although practice may remain varied, then, science PR is imagined as much more than one-directional corporate branding. Just as discussions of science communication have tended to promote genuine and responsive dialogue as integral to public trust in science, thinking in public relations theory suggests that attempts to manipulate publics by 'selling' science, or even to provide the facts with little consideration for the knowledge and views of audiences, is ultimately counter-productive. The idea of science PR as the management of a trust portfolio implies a wide set of activities best carried out through collaborations between scientists, communication professionals, and different audiences. In practice, this suggests more of an integration model of science communication. Responsibility for public communication is not entirely delegated to PR professionals or units, but shared with scientists, with whom PR officers need to engage in order to honestly communicate an organisation's research.

Media policies and offices

The incorporation of corporate communication practices into scientific organisations also influences the way in which science communication is organised and managed in a particular organisation (and, as such, the extent to which a model of integration or specialisation is drawn upon). One key question revolves around who gets to control the communication flow. Who decides about who speaks to whom, where, and when? Corporate communication practices often suggest a heightened streamlining of the communication flow than has been traditional in academic organisations, though the strict enforcement of media or communication policies is not unknown in the world of research organisations. This is shown, for instance, by the story of New Zealand scientist Jim Salinger, who got sacked for talking to the media without prior approval (the full story is described in the grey box that follows).

David Rowe and Kylie Brass have studied contemporary Australian universities' internal media policies. They argue that universities are becoming increasingly self-conscious about the governance of their media relations, and have started to enforce prescriptive guidelines regulating public commentary by academics.[45] Behind these changes is the sense that public attention not only poses risks to organisational reputation and image but also to the legitimacy of knowledge and expertise in general. The organisations of science, then, are increasingly taking on responsibility for the legitimation of the institution of science. Brass and Rowe do, however, find diversity in how universities regulate public commentary by academics: newer universities, they argue, have stricter policies than more traditional ones. We would speculate that one reason for this might be that traditional universities have more existing credibility as scholarly organisations, and therefore do not see the need for—or alternatively do not think they will get away with—controlling their researchers. Brass and Rowe also note that such strict regulation might be difficult to uphold in a communication landscape in which scientists increasingly use social media and forms of dialogical communication; in the long run, they suggest, a light-touch communication management style might be the only viable option.[46]

We would tend to agree with this assessment. It is increasingly hard to control public communication flows in an era of speedy social media, and strict rules about control of communication risks making communication outdated and inauthentic. However, we would also expect that there are important differences between different organisational cultures when it comes to how rigidly media policies are be made and enforced, and suggest that this is something that warrants further study. In a survey of scientists in five nations, Peters and colleagues find that 35% of respondents would have to seek approval from someone in their organisation before talking to a journalist, and that this was true even for senior managers. Approximately half had to ask their PR department, while the other half had to ask their superiors. Interestingly, PR departments in the USA and the UK tended 'to have a more influential position than in Germany, France, and Japan'.[47] This makes us wonder whether there might be different national cultures at play with regard to how much freedom scientists should have in controlling their own communication. Perhaps the acceptance of corporate communication practices in research organisations, and the choices made between an integration or specialisation model, are different between various national and organisational cultures.

Unauthorised Public Communication

In 2009 New Zealand climate scientist Jim Salinger was sacked from his job at NIWA (the National Institute of Water and Atmospheric Research) because he did not comply with the institution's new media policy.

According to NZTV news program One News, Salinger was sacked for something that had in the past brought him high praise: talking to the media. NIWA's policy stated that scientists needed to acquire prior approval before talking to the media, and Salinger had repeatedly defied this.[48] In one case, Salinger had spoken to weather presenter Jim Hickey about heavy rain in an area and been quoted as 'Dr Salinger of NIWA'. Salinger, however, claimed that he had spoken to Hickey as a friend, and that it was Hickey, rather than himself, who had made the link to NIWA. According to press coverage, Dr Salinger also claimed that he had not seen the media policy prior to his dismissal, saying that 'he had been making comments to media for 20 years and was unhappy at being "reined in"'.[49]

Salinger is a high-profile climate scientist, having been involved in the IPCC when it was awarded the Nobel Peace Prize in 2007. There was substantial public criticism of the dismissal: for some, in fact, it was an 'extreme embarrassment for New Zealand'.[50] To observers, it seemed strange that such an established scientist should be rebuked for something that many researchers were being encouraged to do. In such ways the story could be re-cast as a conflict between a scientist speaking as an expert and an organisation demanding the compliance of its members. The management of

NIWA was criticised as being bureaucratic, petty, and not understanding the way that scientists behave. While the critics did not necessarily refute the formal right of NIWA to institute a media policy, they certainly argued against its legitimacy. Salinger himself said to NZTV, 'As scientists we're all a bit eccentric and we all might slightly break protocol, but it's not going to destroy NIWA'.[51]

Crisis communication in science

The use of corporate communication strategies also include methods for how to deal with negative coverage. Organisations, including universities, have to care about what is said about them in public. If their clinical trials go wrong, their researchers are accused of fraud, or their leadership is seen as sexist,[52] the organisation has to react and do what it can to restore its reputation and image.

This kind of restoration work can be complicated. It is normally said that it takes a long time to build up a good brand for an organisation, but it can be seriously damaged in very few days. Whether this is true for scientific organisations is so far an open question. On the one hand, the entire foundation for science as an institution is trust and credibility. On the other, we do not know much about how a crisis in a specific scientific organisation spills over to general perceptions of science and scientists. We can, however, assume from studies of crisis communication in other organisations that the existence of a communication crisis threatens the legitimacy of scientific organisations. One key response to such crises is to create distance between the fraudulent scientist or organisation and the rest of science. This was the case, for example, when South Korean scientist Hwang Woo-Suk was found to have falsified research on human stem cell cloning in 2006.[53] From being portayed as 'industrious and credible', one analysis of the case reads, 'he is now depicted as a rogue scientist and false hero'.[54] The threat to science was therefore isolated: the blame put squarely on a single 'bad apple'.

But this kind of isolation process can be difficult. In the 2006 'elephant man trial'[55], six young men became seriously ill in a phase 1 clinical trial of the drug TGN1412 at the Northwick Park Hospital in London. In an analysis of the media coverage of this crisis, Lynne Stobbart and colleagues concluded that such events pose a problem for the entire medical research system:

> Many of the newspaper reports that we examined constructed a reality in which science and scientists were out of control, the quest for scientific knowledge and progress may overshadow public safety, and our capacity for innovation increasingly outstrips the 'know-how of the relevant experts' in dealing with associated risks.[56]

In other words, this case was not framed as a case of a single problematic scientist, company, or research group, but as a problem with science itself. As Adam Hedgecoe shows in an analysis of the trial, this reputational damage was not easy to repair: government reports on the case refused to assign individual or specific blame for the mistakes made in the trial, and there was therefore little closure on the crisis.[57]

The article by Stobbart et al. on the media coverage of the TGN1412 trial appeared in the British Medical Journal. This is also significant: crises in science, whether connected to a particular organisation or interpreted as being about science more generally, are of interest to scientists. Although scientists construct their organisational membership in varying ways (as we saw in Chapter 3), they still take an interest in what is being said about their organisation.[58] The University of Copenhagen experienced a high-profile scientific crisis of its own when star brain researcher Milena Penkowa stepped down from her position as professor in 2010 after it emerged that she had falsified much of her research data. In addition, she was guilty of financial mismanagement and of lying about her research.[59] While the story of her fraud was in the news most employees of the University of Copenhagen paid close attention to what was being said. Rumours, interpretation, gossip, and other ways of making sense of the story were shared over coffee and lunch; years later, the case still serves as a kind of organisational legend used to explain anything from bureaucratic rules about research ethics to the university leadership's priorities.[60] Importantly, the story is no longer only about a particular employee and how she did her job (if it ever was). Rather it serves as a reference point for wider sense-making about the nature of the university, what science is, and how these two things intersect.

The rise of interface specialists

We want to end this chapter by pointing to the addition of one more layer of complexity for science communicators in research organisations, which is that there is increasing internal competition to be the ones who mediate between scientists and the outside world. We see this, for instance, around efforts to generate research funding. Not only are communication professionals involved in publicising and celebrating research successes, but the high value placed on these resources means many universities and other research organisations now employ people to help their staff write research proposals. To some extent, a scientist writing a grant proposal will be writing to a lay, or at least non-specialist, audience: the panel that assesses them may well be multi-disciplinary in nature.[61] Those working in research support offices will be skilled at simplifying and streamlining the dense text of academics and at pulling out the key concepts that are likely to resonate with assessors.

Research organisations now employ a whole range of professionals whose job is to mediate between research and its various audiences in different ways. Scholars have named this new professional class 'interface specialists[62]'. Etzkowitz and colleagues write that the changes towards increasing commercialisation of intellectual property rights in universities 'requires an enhanced capability for intelligence, monitoring, and negotiation with other institutional spheres, especially industry and government'—a capability that must be met by specialised professionals. As such, the boundary between universities and other areas of society becomes more densely populated. Interface specialists will, Etkowitz et al. write, 'make introductions, organize discussions, negotiate contracts, and otherwise act in an intermediary role to facilitate interaction with their counterparts and other potential partners in government and industry'. Most pertinently to science communication, they will assist in communicating university research in public contexts.

These specialists work in settings that combine communication, public affairs, commercial law, technology transfer, and business development. The rise of these mediation professionals or knowledge brokers[63] poses a number of practical challenges for the way in which science communication has traditionally been organised in universities. On the one hand, it emphasises the importance of the translation and mediation of science, and thus has contributed to the growth of science communication as an emergent professional domain. On the other, it also proposes that mediation and translation should be done through other modes of operation, for instance patent writing, entrepreneurship, or branding activities. There may therefore be internal competition within an organisation concerning who is allowed to speak about science to whom, when and where.

We can exemplify these tensions with the example of patents. A patent is the exclusive right to an invention given by the state to an inventor—it is a form of intellectual property right (IPR) given on the basis of an invention (not a scientific discovery), which can only be granted if the invention has not already been published. In many countries, scientists now have an obligation to consider the commercial value of their knowledge creation before they publish their results, and to involve universities in decision-making about a possible patent application. Since such an application has to demonstrate usefulness, novelty, and non-obviousness these are complicated texts. They are very technical, but they also need to have rhetorical power in order to convince patent agencies that they should indeed grant the patent.[64] Writing patent applications is therefore a skill that one needs to train for. Technology transfer offices will generally have patent law specialists who help scientists write these applications.

Due to the rules about novelty (there should be no prior public knowledge of it), the patent process has implications for the normal scientific communication process, both in terms of academic journal publications and other forms of dissemination. If the invention is part of a groundbreaking scientific finding, it can give rise to complicated negotiations within a university. Everyone will want to achieve as much reputational value out of the discovery as possible, but will try to do this in different ways. The researchers involved may want to publish or talk about their findings at scientific conferences. The PR and media relations team might want to make sure that the research receives international media attention. The patenting officer wants to avoid early public disclosure, since publicly available knowledge cannot be patented. Other parts of the technology transfer office might be interested in sharing parts of the information with relevant key businesses, in order to try and sell them the IPR.

Understanding how different kinds of interface specialists negotiate with each other in the context of public communication is therefore a complicated business. It is not obvious that they will agree on what types of non-university audience are most important, how they should be contacted, and when. It is likely that there will be numerous negotiations and behind-the-scenes interactions in order to present a certain image or story about new scientific research. In modern entrepreneurial science, there are more than just PR and science communication offices involved, but so far we know very little about how these processes are practiced, organised and managed.

Science is changing

We have covered a lot of ground in this chapter, from scientists' frustrations with the 'beancounters' who force them to make cuts on their lab budgets to interface specialists negotiating how to sell science to particular audiences and the crises that scientific fraud can create. The theme that has run throughout is that science is changing. Contemporary knowledge production is not now, if it ever has been, carried out in ivory towers secluded from business, commercial pressures or wider society. It is interdisciplinary and multi-sectoral, enmeshed in the pressures of capitalism and competition for resources. These pressures are reflected in the content and practice of public science communication. In many ways, competition between individual scientists, universities, and research organisations is part of the rise of science communication as a profession. 'Academic capitalism' has led to a need for new cadres of professionals, interface specialists who can effectively manage science PR, brand research organisations, write successful grant applications, and work with specialised audiences such as policymakers. It has also led to changes in the kinds of stories that are told about science. Universities boast about their success in gaining research funding and present academic research as a vital part of national and regional growth and prosperity. Campaigning groups argue that traditional, blue-skies research is under threat.

Science communication is, as we have suggested throughout the chapter, intimately entangled in all this. It is both constitutive of these developments—for instance by telling public stories about the hunt for research funding and the elusive prize of academic and commercial success—and shaped by them. In particular, new opportunities are opening up for specialised practitioners of public communication, professionals to whom scientists can delegate some of the responsibility of making their work public. More needs to be understood about this form of professionalisation. Research organisations are complex entities, and we know little about how multiple communication functions operate within them. If the pressures of contemporary market-driven ideologies are re-shaping science, they are also reshaping science communication.

Notes

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6

Futures: Innovation Communication as Performative, Normative, and Interest-Driven

In July 2013, the UK government released a press release about its earmarking of an extra £60 million for research in synthetic biology. This, the release said, would help ensure that the UK ‘remains at the forefront of synthetic biology’, and quoted a speech by the Minister for Universities and Science. Synthetic biology was an important technology, not just for the UK but for the world. ‘Indeed’, the Minister said, ‘it has been said that it will heal us, feed us and fuel us’.[1]

Some two years later, the press officers of the European Spallation Source (ESS), a neutron accelerator then under construction in Lund, Sweden, coordinated an announcement about the new legal status of the organisation: the European Commission had approved it as a ‘European Research Infrastructure Consortium’, or ERIC. Alongside details of the legal and organisational handover, the release also made it clear why these developments were important. The ESS is ‘the world’s next-generation neutron source’, using ‘a high-power linear proton accelerator to create neutron beams to probe the structures and dynamics of materials’. This technology would be applied to everything from medical research to superconductors; ultimately, the release noted, the ESS facility ‘will be a major driver for innovation in science and industry in Europe’.[2]

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These press releases are not unusual: we could have picked any number of similar announcements about scientific funding or results, using very similar language. Synthetic biology will heal us, feed us, and fuel us. The ESS will drive innovation in Europe. Biotechnology will create new forms of economic growth. Nanotechnology will result in a cure for cancer in 15 years. Stem cell research could lead to treatments for everything from Parkinsons to blindness. Statements like these form part of the backdrop of contemporary knowledge societies. They are one aspect of a collective way of speaking about the future of science and technology. At the same time, many scientists are very much aware that research is a rather uncertain activity, and that we can never be certain of outcomes. Given that science is now often funded and carried out under conditions of high competition and financial pressure, any single line of research cannot be taken for granted.

The point here is not just to say that scientists and policy makers make some big promises when they are talking about the future impacts and relevance of research. Branding activities are now an essential part of securing support for science and are taken for granted by scientists, communicators, and their audiences.[3] What we want to focus on in this chapter is how and why such visions and promises become part of public discourse on science. What effects do they have in science and elsewhere? And what role is science communication playing when it relays scientific promises to different lay audiences, whether that is through press releases, media reports, or live science events or festivals?

This chapter reflects on these questions.[4] It considers the ways in which science communication creates the future—the way that public communication is intimately connected to imaginations of the kinds of future societies we want to live in and to science and technology's own funding and development. In thinking about these dynamics of promising, funding, and public communication, we will argue that science communication should not be seen as something separate to scientific funding and innovation. Instead, the creation of expectations and visions, and the sharing of these in public, is part of doing science. Such expectations are not just statements about the future but also enable—perform—certain things in the present. In the sections that follow, we will look at how promises and visions do strategic work (such as securing funding or highlighting national excellence) by performing particular kinds of futures.

Science communication creates futures

It can be easy to dismiss big promises of revolutionary science as 'just' PR. But, as we have argued in previous chapters, there is not really any such thing as 'mere' PR. Scientific publicity boosting in contemporary research organisations is a rather complicated phenomenon. Of course, at some level, statements like those released by the UK government about synthetic biology or the ESS about its new status are connected to securing or celebrating resources. Every time we hear politicians, policy-makers, scientists, or research managers talk about giving money to science, promises about future impact are found in abundance. As we have seen, researchers are increasingly under pressure to secure scarce funding resources. In an era of academic capitalism it can be easy to believe that the bigger your promises, the more likely you are to gain public, financial and political support. That's one dynamic that shapes the way in which researchers talk about their work. At the same time, we want to emphasise that the creation of expectations and visions is not a separate task from the everyday practice of science, and that these promises do not only work to capture funding, but have other effects. Communication about technological innovation is not distinct from the innovation process itself. It helps constitute both the science and the wider world around it.

Here is one example of this effect. In 1993, Michael Mulkay analysed the 'Great Embryo Debate': discussions throughout the 1980s in the UK concerning how human embryos should be used in scientific research (triggered by the advent of IVF, and leading up to the passage of the Human Embryology and Fertilisation Bill in 1990).[5] Despite the diversity and complexity of the public discussion, Mulkay argued that two key rhetorics circulated within it. Both concerned, broadly, the relation between science and society: the first, the rhetoric of hope, depicts the future benefits of scientific research on embryos. Such research is understood 'as being worthy of support because it has already begun to pay off in practical ways and because it will, if allowed, continue to produce various highly valued outcomes'.[6] In contrast, the rhetoric of fear is pessimistic about the outcomes of research. It tells of 'moral decline and of socially disruptive changes brought about by a scientific community increasingly out of control'.[7]

The two rhetorics Mulkay describes continue to be found in public discussion today: similar kinds of optimism and pessimism about scientific futures are expressed around various controversial topics, such as synthetic biology, geoengineering, or fracking. What is significant, however, is that the two rhetorics have key similarities in that both describe a technology's revolutionary potential and the fundamental ways that a new technoscientific area might change our lives. Proponents and opponents of a technology might disagree about whether those outcomes are for better or worse; both, however, are mobilising particular ideas about what we expect and want of the future. By celebrating or vilifying an area of research, they draw attention to it, make claims about its impacts, and try and use its future potential to make changes in the present. Both rhetorics in some way are therefore *creating* that area of research as a real, important thing with transformative implications in the here and now. In these ways, talking about the future of a technology in public can bring it into being in the present.

The extracts relating to future implications of synthetic biology in the grey box that follows are an illustration of this. For the UK government, synthetic biology is 'one of the most promising areas of modern science', which will have impacts on all kinds of industries and therefore on economic growth. For Friends of the Earth, it could also have significant effects, but these may well be negative—damaging human and environmental health and boosting big business at the expense of local communities. In the extract from the Royal Academy of Engineering report, it is a technological area that may provoke public anxiety and which requires researchers to engage with concerns about social and ethical implications.

Synthetic biology is thus being portrayed in very different ways. At the same time, all of these accounts agree that it is something important with the potential for revolutionary changes to our lives, and a real area of scientific research which requires careful consideration. However, the reality of synthetic biology as a coherent research field is not actually as obvious as this makes it sound. Scientists working in the field come from disciplines including biology, biochemistry, engineering, and computing, and it cannot be taken for granted that they will take up identities as 'synthetic biologists' (although large pots of money for the area probably pushes towards this). The texts here may not agree on what effects

Framing Synthetic Biology

Synthetic biology can be defined as 'the design and construction of new biological parts, devices, and systems, and the re-design of existing, natural biological systems for useful purposes' (according to the syntheticbiology.org website, which was started by key scientists in the field).[8] Here are some of the ways that it is being talked about in public in the mid-2010s:

Over £60 million for synthetic biology

> Synthetic biology, one of the most promising areas of modern science, is to receive boost of over £60 million […] It has potential benefits for a wide range of industrial sectors including chemicals, materials, biosensors, biofuels and healthcare.
>
> (From a 2013 UK government press release)[9]

Synthetic biology

> Synthetic biology is an extreme form of genetic engineering, an emerging technology that is developing rapidly and entering the marketplace. Like traditional GMOs, the products of synthetic biology are virtually unregulated, have not been assessed adequately for impacts on our health or environment and are not required to be labeled. […] Synthetic biology could have serious impacts on the health of people and ecosystems, on our planet's biodiversity and for communities on the front lines of corporations' plans to deploy new technologies and novel organisms for profit.
>
> (From the Friends of the Earth webpage on synthetic biology)[10]

Sensitivity of the public debate and social issues

> Although synthetic biology can be separated from genetic engineering by its sophistication and its genuine grounding in engineering principles, the fact that it involves the creation and manipulation of living organisms is likely to give rise to many of the same fears that were encountered with genetic engineering. […] The synthetic biology community is aware that their research has the potential to be highly contentious.
>
> (From a Royal Academy of Engineering Report, *Synthetic Biology: scope, applications and implications*)[11]

synthetic biology will have, and whether they will be good or bad—but synthetic biology would not exist in the same way if these accounts were not out there in public, telling people about it.

Innovation communication

In a 1962 book, Everett M Rogers argued that the diffusion of technologies is more complex than we might at first assume. Technologies are not necessarily widely taken up because of their technical merits—the fact that they are 'better' than what has gone before. Instead, Rogers suggested that the widespread diffusion and success of a technology, however innovative, is actually rather hard to achieve. In practice, an innovation (whether a technology, an idea, or a new area of scientific research) spreads more easily if it has clear advantages over existing technologies; if it is compatible with existing values, experiences and needs; if it is simple rather than complex; and if it is easy to test and to come to the notice of prospective adopters.[12] Importantly, many of these things are mediated by communication. Successful innovations have proponents who make potential users aware of the technology and help them to understand it.

Rogers' work has since been criticised. STS scholars working in the tradition of actor network theory (ANT) have argued that a technology or innovation cannot be understood independently of the communication around it. Bruno Latour, for instance, argues that a technology is not a stable object with a set of unchangeable characteristics; rather, what it is and what it is used for depends on the context in which it is placed.[13] For instance, early adapters might buy a new technology like an electric car for all kinds of reasons, and ascribe all kinds of meanings to it: a tool for saving the planet; a cheap way to get around; a signifier of a particular kind of identity. The advantages of a technology are therefore not necessarily what its initial developers may have imagined. More than this, though, the meaning of that technology is even then not stable, but depends on the context—and such contexts are inevitably changing. It is through communication that a technology is ascribed meaning as an object in different situations. Communication, including different kinds of science communication, is therefore not an extra layer of a technology, something that is applied to it after it has been developed and its meaning and purpose have been fixed. Instead, it is an integral part of the way in which a technology is developed, appropriated, and used.

Communication therefore needs to be seen as something that is an integral part of the innovation process.[14] Such communication is not just about end users. Any research and development process consists of negotiations between different actors and involves efforts to make as many of those actors as possible interested in the nascent technology and its future possibilities. The idea of *innovation communication* is thus to acknowledge that communicative the concept of processes happen all the way through innovation, from the earliest selling of a new idea to a lab head, funder, or one's disciplinary colleagues right through to the ways in which technologies are appropriated and re-imagined by their users. We can see this particularly clearly in the case of something like synthetic biology, which is currently at an early stage of development and is therefore largely financed in exchange for promises of its expected benefits and impacts. If it is to grow as a research field and later deliver specific technologies, then researchers, politicians, citizens, companies, and users have to see it as a benefit. They have to become interested in it such that they have positive expectations about its future and choose to support it.

Even physical research infrastructures can be seen as something which gradually become alive and 'real' through processes of negotiation and communication as well as their physical development.[15] The European Spallation Source (ESS) mentioned at the beginning of the chapter is one example of this. At the time of writing, it exists as a very large building site in a green field site outside Lund, Sweden and a loosely organised collection of scientific and technical committees—and, perhaps most importantly, as the promise of a significant new research infrastructure that will help deliver groundbreaking science as well as bringing jobs and growth to the Øresund region (which spans southern Sweden and part of Denmark). The plan is for its neutron source—which will shoot fast-moving neutrons at a range of different scientific instruments and which is framed as 'the world's largest microscope'[16]—to go live in 2019.

Although most people have not yet heard of the ESS, it is already the culmination of years of communication and negotiation. Europe's need for a new neutron source has been under discussion for more than 20 years. The ESS website explains that it took many years to deal with the ‘challenge of organizing Europe’s diverse collection of national governments’.[17] Once a technical design and budget had been confirmed, a site had to be agreed. The stakes were high: the ESS will be a research organisation on the scale of CERN or the European Southern Observatory (two other large, multinational research infrastructures). Such organisations are highly prestigious and can transform a geographical region. In Øresund—an area which includes Sweden’s economically sluggish Skåne region—the hope is that the development will bring jobs and growth, as well as having the potential to trigger new kinds of technological industry. After a long period in which communication with local and international policymakers and EU bureaucrats was vital, the emphasis has now shifted to raising financial support and engaging the accelerator’s target scientific and industrial communities. In 2014 and 2015, ESS officers travelled to scientific conferences and organised a series of partner and industry day workshops, seeking to encourage industry to get involved and scientists to get excited about the possibilities the ESS would offer. Ceremonies such as a ground-breaking for the building work and the laying of a foundation stone offered a symbolic moment that signalled the project’s reality. In such ways are ideas communicated, actors entangled in emerging scientific projects, and innovations turned into global realities.

The rest of this chapter builds on the notion of innovation communication as a way of thinking about science communication. We consider some of the ways that public communication of science becomes entangled with scientific visions of the future, and thus how it is involved in the innovation process. We look at three areas in particular: how communication performs particular futures; how it encodes particular normative positions about the future and how it should be; and how we can identify certain intentions within future visions.

The performativity of expectations

We start with the performativity of expectations—a notion that draws not just on the idea of innovation communication but also on a body of literature which is usually referred to as the sociology of expectations.[18]

Such scholarship has explored the work that expectations, visions, and promises about the future can do in the present. One of its central tenets is that we should not simply understand visions and promises as factual descriptions, which will turn out to be true or not, but as a means of mobilising attention and directing choices in various directions. In the context of innovation, expectations have a performative role: they can serve as reasons for particular actions in the present, and therefore are able to actively perform, or bring about, certain futures.

Harro van Lente has explored this dynamic in detail.[19] He argues that expectations function as a resource because they legitimise and justify certain actions and arguments; this is especially useful in science and technology, he suggests, because promises and expectations can be used to decrease the uncertainty that is inherent to much technological development. We can see this in practice when we look at the UK government press release quoted at the start of this chapter and in the grey box. Synthetic biology is a new field. There is a lot of excitement about it, but there are currently very few concrete products or innovations that have emerged from it, and it is rather uncertain what it will lead to. But a press release promising an extra £60 million of funding for it, and explaining that this is happening because it is 'one of the most promising areas of modern science', does a lot to confirm synthetic biology as a real, important field of research, which the government, at least, believes could 'heal us, feed us and fuel us'.[20] This small text—circulated to different public and scientific audiences through the Minister for Universities and Science's speech, its existence as a permanently archived webpage, and through media reporting and blogs—therefore does a lot of work in creating concrete expectations about synthetic biology. We cannot know for sure, but we can speculate that this announcement may have raised the profile of synthetic biology and encouraged researchers, students, and businesses to view this area of research as important and as worth getting involved in—not least because there is clearly funding available for it.

Some researchers make a distinction between expectations, as general promises about or imaginations of the future, and visions, which carry with them a strategic framework for realising expectations.[21] Visions are therefore more practical. As well as making claims about the future—such as that synthetic biology will heal us, feed us and fuel us—they also need to involve some substantiation of those claims (such as that £60 million is being devoted to this quest, that early results are promising, and that young researchers are being trained in the interdisciplinary skills that synthetic biology requires). Again, these visions are performative. The more convincing they are, the more they are likely to enrol a wide range of actors into them and the more resources they will attract towards their realisation. This is similar to the Matthew effect, which we met in Chapter 5: those who have will be given more. The more resources are allocated, the more likely it is that development will proceed along the lines outlined in the vision. But the opposite is also the case. Research fields that attract very few resources can become increasingly marginalised, and are unlikely (all else being equal) to deliver on the promises that they make. There is a certain art to constructing visions. On the one hand, they have to be concrete and convincing enough that they can be used as a reason for making particular actions and decisions in the present (such as allocating special funding). On the other hand, they have to be somewhat vague or fragile so that we understand that these technological opportunities will not arrive without investment or dedicated resources.[22]

How does science communication fit into this? While many expectations and visions may be produced within intrascientific communication, in policy documents, or political statements, it is also clear that scientists and science communicators talk about their hopes for the future of their research in public communication. Indeed, we would argue that science communication is essential to mustering up enough support to make new scientific fields and emerging innovations real. Governments, after all, are sensitive to public opinion. Public expectations about the outcomes of an emerging technological field can therefore feed into policy decisions. The story behind Danish legalisation of embryonic stem cell research in the grey box below is one illustration of this.

Synthetic biology is another good example. As we write in the mid 2010s, this is still a new field, but it is one that has a carefully curated public presence. There are popular books on the topic, art projects inspired by it, and a number of charismatic, high-profile researchers who speak about it, with the US scientists Drew Endy, Craig Venter

Expectations and Stem Cells

The performativity of expectations is not just about ensuring funding: other kinds of resources are also essential if technoscientific development is to take place. For instance, emerging scientific fields need legitimacy, human capital (students and researchers who are prepared to dedicate themselves to that area), and political support. Scientific promises and public expectations can help generate these kinds of resources, as the story of the legalisation of embryonic stem cell research in Denmark in the early 2000s exemplifies.[25]

Up until 2003, Danish law prohibited research on human embryos other than to improve IVF techniques. But around the turn of the century, there was a great deal of excitement about the scientific and medical potential of embryonic stem cell research. The 1998 article that first derived the new stem cell lines noted that they 'should be useful in human developmental biology, drug discovery, and transplantation medicine'[26] (and has since been cited some 12,000 times); in the UK, the research was reported by the BBC as 'a major breakthrough that could lead to a limitless supply of human tissue for transplantation'.[27] There was therefore a moment when such stem cell research was surrounded by high expectations of breakthroughs and medical innovation—including in Denmark. Still, it remained publicly controversial to use human embryos for research purposes. In 2002, a Danish expert committee (known as the Gene Technology Committee) identified stem cell research as a highly promising scientific field and suggested that the ban on research on human embryos should be lifted. Until then, the Danish government had been reluctant to ease the limitations, but the report was discussed in parliament and there were calls for a public debate. Ultimately, a formal hearing was conducted involving many different stakeholders. Importantly, this was not an internal policy process. There was widespread public interest and a network of public support materialised, including from patient groups who were able to frame the research area as providing 'hope for cures'. Finally, the legislation was changed in 2003 to permit research on 'spare' embryos.

This story is a good example of how central public communication can be to enabling the existence of particular areas of scientific research and innovation. In this case, the mobilisation of public support was essential to Danish law being changed and the research becoming possible within Denmark. Danish researchers had to 'sell' the idea of stem cell research and its potential for innovative therapies to the public, and hence to the politicians and, in this case, they succeeded. Notably, of course, public funding of such embryonic stem cell research was banned under the Bush administration in the USA. Scientific promising, and efforts to gather resources to develop new scientific and technological fields, is therefore not guaranteed to win the day.

and George Church as key examples. Importantly, significant energy has been devoted to framing it not just as a technology which promises immense public benefits, but one which is integrated with social and ethical reflection on its implications. It is therefore framed as a science which has learned the lessons of public discontent with genetic modification and which is devoted to solving societal needs.[23] There are also dedicated funding programmes for it and emerging departments and centres of it. What we know rather little about, at the moment, is how these things relate to each other—how, in other words, the visions and expectations that are circulated in public communication can reinforce or modulate those that are produced by scientists or policymakers in more 'back stage' locations.[24] What future visions does science communication tend to portray, and how might these relate to the performance of particular futures?

The normativity of expectations

Science communication can perform particular scientific and technological futures, promising that science will deliver anything from economic growth to medical therapies or knowledge that changes our understanding of the universe.[28] The point we want to make in this section is that these expectations are not innocent—meaning, they are not neutral with regard to the futures they are pointing to. Visions and expectations incorporate assumptions, often unseen and unacknowledged, about what constitutes societal problems and how these should be solved.

Madeleine Akrich has argued that new technologies are always developed with what she calls a 'script', or a set of implicit guidelines as to how they are expected to be used. Their users are understood in particular ways and given implicit instructions as to how to behave; they are imagined, Akrich writes, as having particular 'tastes, competences, motives, aspirations, political prejudices, and the rest'.[29] More generally, we can say that expectations and visions—imaginations of future technologies and the societies their users live in—also imply a script. They suggest a particular interpretation of the future, with technologies and users organised in particular ways within those futures.[30]

We can return to synthetic biology for a concrete example of this. One group of Danish scientists working in this area has publicised the idea of 'green production halls' as the final outcome of their work.[31] Such halls would consist of facilities filled with large vats of plant cells engineered such that they produce valuable compounds in large quantities; working at an industrial scale, the halls could overcome the scarcity of particular medicinal compounds, including treatments for malaria. One thing we might notice about this vision is that it presupposes a society with some division of labour (some people farm the green production halls, others will use what is produced by them) and that it assumes a well-functioning system for the exchange of goods, such as a market (the products become available to a society as a whole, not just the producers of the compounds). In other words, the vision is built on a notion of a society with a high degree of collective organisation. It is about groups, not individuals.

In contrast, a very different vision is found in a Danish government report about synthetic biology. The report talks about the potential to develop 'personal fabricators', which could:

> fabricate most imaginable objects we humans need. One can imagine such a 'personal fabricator' as an extension of our personal computers with a very advanced bio-3D-printer, which also is capable of controlling biofabrication (think of a very advanced bread-baking machine). This opens for all humans being able to design and produce complex objects in a simple and sustainable way.[32]

Although a personal fabricator probably also needs a society to function—for instance, it might require an electricity grid to get power from—it is still a vision that is primarily directed towards individual use. It is a personal tool, an 'extension of our personal computers' and one which could make us self-sufficient in terms of designing and producing 'complex objects'. Compared with the vision of green production halls, then, this is a technology that is aimed at a society with individualised actors, one in which the role of technology is to make them independent of each other. These two visions are not directly in opposition to each other, but they do imply two different imaginations of the role of the individual and the organisation of society. The two visions suggest, in other words, different scripts. They imply different versions of society and of the people in them.

Such scripts are not deterministic. There is always scope for those who consume visions or who are the eventual users of the technologies to reject or alter what they imply. Much as with a script for a play, they are more of a plan for action, and are open to interpretation. The point is that in the development of a new field such as synthetic biology, researchers and technologists make a lot of choices about how and by whom future innovations should be used. These choices are, often, unconscious: it is not necessarily the case that those behind the idea of the personal fabricator are signed up to a future of individualism and that those promoting the idea of the green production halls are imagining a collectivised future. But expectations and visions are powerful. Once they start circulating, people become interested in them, and they can collect supporters and resources and start to shape scientific and political priorities. They can also influence who is seen as relevant to the development process. Are the stakeholders of synthetic biology the pharmaceutical companies who might want to develop new markets for the medicinal products of the green production halls, or the laypeople who might want to use personal fabricators? Or both?

Again, many of these visions will be communicated through public writing, speaking, or other forms of science communication. The green production halls, for instance, featured in a newspaper article, and form an important part of some Danish synthetic biologists' public presentations of their work and its future outputs. The challenge for science communication scholarship is thus to notice not just the visions and expectations—what is being promised?—but the normativities implied by them. What societies are being imagined? Who is present within them, and who is excluded? In the short-term, these dynamics might also relate to how research should be prioritised. How are different research fields being portrayed as more or less exciting, or productive, or promising—and who does this benefit?

What Synthetic Biology Promises

Craig Venter, says the website of the J Craig Venter Institute, is 'regarded as one of the leading scientists of the 21st century for his numerous invaluable contributions to genomic research'.[33] Wikipedia describes Venter as 'an American biochemist, geneticist, and entrepreneur'.[34] One thing is certain: Venter is one of the most famous, and controversial, scientists in the world.

Venter first made headlines as part of the global effort to map the human genome. Having originally worked in the publicly funded part of the project, he moved to the commercial company Celera (of which he was a cofounder) in 1998. His other projects include the Global Ocean Sampling Expedition, an effort to understand the genetic diversity of ocean life, and synthetic biology research at the J Craig Venter Institute.[35] Venter and his organisation have clear expectations of what synthetic biology can and should offer the world. Take the work it is doing under the theme of 'Synthetic biology and bioenergy':

> At the JCVI, we believe we all share a responsibility to find new energy sources and to uncover ways to mitigate our negative impact on the planet. We are using our pioneering genomic science to explore new biologically driven sources of energy. [...] Our scientists (with funding from the company, Synthetic Genomics Inc. and the US Department of Energy) are focused on developing synthetic organisms able to produce various kinds of biological products and renewable fuels. Over the last years, the team has been making steady progress toward their goal of a synthetic organism.[36]

The work of the JCVI is framed as an important response to our dependence of fossil fuel and its attendant 'negative impact on the planet'. The solution, according to Venter, is to engineer new synthetic organisms which can act as new, biologically driven energy sources. Elsewhere, he has talked about designing bacteria to produce 'better and healthier proteins than we get from nature',[37] which will thereby bring about new food sources. His work in synthetic biology thus focuses on the construction of a minimal genome to which different bits and pieces can be added: machinery for making food, fuel, medicine...

Venter's vision is of science solving society's problems, whether those are related to climate change, food shortages, or ill health. He believes about the power of technology to change things; he is confident, for instance, about the ability of humans to safely and precisely manipulate nature. He also mobilises a version of synthetic biology which understands biological systems as something that can be divided into parts and redesigned, a notion of the field which not everyone shares.[38] The future that he is describing, and thereby also performing, is one that is reliant on technology rather than, say, systemic change or behavioural shifts to solve social problems. This future is not necessarily a good or bad thing, but it is just one possibility amongst other, less visible, trajectories. Celebrity scientists therefore play an important role in promoting particular visions and expectations. Their fame can allow them to bring one version of the future to wider public notice.

We mentioned earlier that many working in synthetic biology have been explicit about including social and ethical considerations into the development of the field. Such discussions, however, can take many forms. We have included a case study about the J Craig Venter Institute in a grey box above because we think it is one of the more spectacular examples of how promises of sustainability and solutions to social problems are being used to market particular kinds of research.

Expectations and interests

The question of who benefits from particular expectations and visions brings us to the final aspect of scientific futures we want to explore. What kinds of interests are entangled with future visions and promises?

We have argued that visions should not be understood as straightforward projections of where science and technology are headed. They can be seen as rhetorical constructs: they tell a story—that the future can be a particular way—which, if persuasive enough, is meant to prompt action in the present, such as investment in a certain technological field or interest in and support for it. This does not mean that such visions are not normatively and epistemically well-founded or that it is not a good idea to support the vision and provide the resources asked for. Understanding scientific claim-making as rhetorical does not mean it is necessarily empty or manipulative—it just means that it is communication which is intended to convince someone of something.[39] In this case, visions of scientific findings and products are generally designed to persuade audiences that a particular field deserves more resources.

But this raises the question of exactly how cynical we should be about the promises and visions that scientists (and others) produce about the future of research. Are expectations just another way for researchers and technologists to sell an idea and thus further their own interests?

The answer to this question will, of course, vary from case to case. There are certainly some scientists who produce overblown visions in order to try and gain funding or credibility or respect—but there are many others who actively try to do the opposite, dampening down what they see as 'hype'. We can also nuance the question by taking into account that interests do not necessarily have to be tied to individuals. In a 1998 study of the development of a new membrane technology, Harro van Lente and Arie Rip described those who created expectations as 'promise champions'. Such champions were not speaking on behalf of their own interests specifically; rather, they were 'speaking in favour of a technology'.[40] Promise champions are not necessarily acting to gather as many resources as they can for their own use. Rather such champions may wholeheartedly believe in the potential of their field and simply wish to further it as best they can. We have no reason to believe that promise champions and vision pushers do not themselves believe what they say about their expectations.

Indeed, promise champions do not have to be individuals at all.[41] We have already seen, in Chapters 3 and 5, that organisations and other kinds of collectives are increasingly important in science. As strategic, application-driven research has risen, universities and research organisations—and, most importantly, their communication—have become more corporatised. Such organisations also have interests in producing and promoting particular visions and expectations. Universities might therefore promote particular expectations which align with their research strengths or develop visions around areas into which they want to expand. Similarly, organisations such as learned societies or consultancies will create expectations, driven by their own interests or by that of their clients[42]; more diffusely, any of these can be picked up by the media and, through the use of standardised news frames and tropes, develop into specific kinds of expectations about 'breakthroughs', 'cures' or 'risks'. Science communication professionals in museums or science centres who run events like festivals may also focus on, and create public communication about, particular technologies or visions because they see them as especially interesting or important.

The point here is that we can explore the question of interests without needing to resort to stereotypes about hype or resource-hungry, overpromising scientists. We have seen, in Chapter 3, that it is important to move away from the assumption that science communication is produced by individuals; here we need to apply this to research on expectations and futures. It is important, for instance, to trace the power and effects of expectations not just in public but on science as well. How do promise champions become convinced of the value of a particular area of

Consuming Expectations: Selling Stem Cell Therapies

Excitement about stem cells first burst into public and scientific consciousness in the late 1990s, with the publication of an article in *Science* about a technique for deriving stable embryonic stem cell lines.[43] Almost immediately came the expectation that medical breakthroughs—using stem cells' ability to develop into other cell types, and therefore to regenerate damaged tissue—were imminent: 'We have all heard', reads a patient handbook produced by the measured and careful International Society for Stem Cell Research, 'about the extraordinary promise that stem cell research holds for the treatment of a wide range of diseases and conditions'.[44] But scientific research and clinical trials are slow. It is not yet clear for which diseases stem cells can and should be used as therapies, and what effects their use might have.[45]

Many patients with degenerative diseases are aware of the visions and expectations circulating around stem cell treatments and are not content to wait for mainstream medical science to catch up. In 2015, Australian Ian Callaghan told his story to local news: diagnosed with a fast-developing form of MS, he was travelling to Singapore for a stem cell treatment costing some €125,000 and not available in his home country.[46] 'I could die from the treatment', he told the reporter, 'and Australian doctors think that's too risky … [but] patients should be ultimately in charge of their own health'.[47] For Ian, living with his disease was not an option: he would rather take a high-risk treatment than experience what he believed was not 'much of a life. You're alive but you're not living'. The funding for his trip was being raised by friends and family via a kickstarter-style donation website (help-our-mate-fight-ms.net).[48]

Ian's story fits with research that has been done on stem cell tourism: the practice of travelling abroad to access stem cell treatments that are not licensed—generally because they are considered unproven or unsafe—in one's home country. Like Ian, users of experimental treatments see themselves as active consumers, able and willing to weigh up the risks and benefits of stem cell therapy for themselves, rather than needing to rely on the healthcare system to do this for them.[49] They are realistic not just about the dangers of what they are doing but also about what improvement they might expect. Users, write the authors of one study of stem cell tourists, 'were not expecting miracles from their treatments but rather small, yet to them significant improvements'.[50] Being able to negotiate expectations was therefore important to their self-identity. They were not people who uncritically believed everything that was said about stem cell therapies, but 'active agents who have at least some potential to control their future through current actions'.[51] Just as consumers of science communication are generally not passive, these consumers of promises and hope were similarly nuanced in engaging with this very particular form of science communication.

scientific research and start acting upon this conviction? How do expectations travel between science and the public, and how are they modulated and changed as different kinds of groups or individuals take them up? And how do they travel into policy, becoming the basis for decisions on funding or strategy, or move from country to country? The internationalisation of visions about particular research fields seems especially interesting. Emerging technologies such as nanotechnology or synthetic biology become something that multiple countries are interested in very rapidly. How does this take place, and expectations travel?

How should we study and communicate expectations?

Overall this chapter has suggested that science communication research needs to pay more attention to how public communication is entangled with innovation. We have argued that innovation cannot be understood without considering the role of communication, both in terms of how emerging technologies and new scientific fields are imagined by developers and users, and the way in which promises and visions are built around these technologies and fields. Science communication research, we have suggested, should think more about how public communication interacts with the construction (and resourcing) of different kinds of scientific futures.

In closing we want to think more about expectations and visions as normative devices, and particularly about our own role, as science communication scholars and practitioners, in dealing with these normativities. The context for this is concerns—often expressed by scientists themselves—about the public production of optimistic stories about future technologies. The media has been seen as particularly problematic in this regard, and as at times uncriticially 'selling science' to the public.[52] Others have suggested that unrestrained optimism can result in disappointment when expectations are not (easily or immediately) met, which will ultimately threaten both investors and potential users of a new technology.[53] From this perspective, technological hype risks eroding trust in science and, in the longer term, damaging the relationship between science and society.

First of all, we think that we should pay more attention to how these promises and expectations are actually interpreted and consumed by users, publics, and patients. As our short example on the consumption of stem cell therapies shows, patients might well chose to consume promissory technologies without being blind to the many uncertainties associated with them. Patients who choose to follow experimental treatments might do so simply because they want to see themselves as active and to follow even a small hope of improvement. In such cases, personal values such as choice, taking control, or betting on chance may be fundamental for how they want to live their lives.[54] At the same time, we think there is more to discover about this and would like to see much more scholarship on the consumption of different forms of expectations.

Second, we think it is unfair to blame the media or other actors for over-selling science. As we have seen, scientists and scientific organisations themselves play a crucial part in producing the visions that science media may take up: these days, in competitive and marketised university systems, strategic promising is integral to research. Promises and visions are in many contexts simply part of 'doing science',[55] just another resource for trying to define and shape one's research programme. This also means that it is likely that visions and expectations—from breakthrough stem cell therapies to personal fabricators—are here to stay. While there is pressure on scientific funding, and where competition is based around strategic usefulness to society, researchers and policy makers will construct futures to help argue their case.

Again, however, we should not see this as necessarily manipulative or dangerous. It is important to remember that public discussion cannot be controlled by specific actors. Expectations remain tricky and unstable: it is not possible, even for their creators, to control how they are told and how they travel. Certain actors, such as scientists, entrepreneurs or policymakers, can try to generate support and reduce uncertainty by telling specific stories, but they are only ever coauthors of what are ultimately public stories about science and technology. It is difficult even for researchers to assess the probability and plausibility of their expectations, and there are plenty of examples of visions and promises being rejected or ignored.

As science communicators and thinkers about science communication, how should we deal with expectations and their performative effects?[56] On the one hand, visions are crucial for mobilising resources; on the other, it is clear that such visions have to be assessed and evaluated against each other. And expectations are potent, in that they are performative and—however far-fetched some may think them to be—have real effects in the world today. 'Technological futures', writes Harro van Lente,

> are powerful. When something is defined as a promise, action is demanded […] that which starts off as a possibility can turn into a technical promise and hereafter serve as a demand which has to be met and a necessity which technologists have to work on and others have to support.[57]

As we think about expectations and visions in public science communication, there are a number of questions we think science communicators need to explore. This is particularly important as, with the rise of professionalised science communication, press officers, museum professionals, science writers and others increasingly act as an interface between the visions of scientists and public audiences. Practitioners have a key role to play in reflecting upon what visions should be communicated and how they should be presented. What is the balance between a constructive use of visions to create better futures, and a problematic and unproductive entrapment in certain kinds of technological dream? What should science communication's role be in tempering visions with other imaginations of futures, and how can we identify such competing futures? These questions are particularly important because this task of weighing up visions should not be something that is left to scientists or policymakers or science communicators alone. Visions and expectations are not just the business of scientists and scientific organisations, but something that affects our shared future. We all have the right and the responsibility to interrogate them.

Notes

1. https://www.gov.uk/government/news/over-60-million-for-synthetic-biology.
2. https://europeanspallationsource.se/article/european-commission-establishes-ess-european-research-infrastructure-consortium.
3. We know that the audiences of science communication do not uncritically accept what they are told. They bring other knowledges and experiences, including ideas about the trustworthiness—or not—of scientific organisations, scientists, and policymakers when weighing up scientific promises. See, e.g. Kerr A, Cunningham-Burley S, and Amos A (1998) The new genetics and health: Mobilizing lay expertise. *Public Understanding of Science* 7(1): 41–60.
4. Some of the content in this chapter builds on Horst M (2013) Bør vi forvente os en syntesebiologisk fremtid? In: Schiølin K and Riis S (eds), *Nye Spørgsmål Om Teknikken*, Aarhus Universitetsforlag, pp. 285–302.
5. Mulkay M (1993) Rhetorics of hope and fear in the great embryo debate. *Social Studies of Science* 23(4): 721–742.
6. p. 726, ibid.
7. p. 728, ibid. Mulkay argues that, however powerful it is, the rhetoric of fear is actually subordinate to the rhetoric of hope. It is the latter that tends to be the default when talking about technoscientific futures. Public discourse is generally optimistic about the outcomes of science—it takes a special case, like embryo research, to call forth the rhetoric of fear.
8. See http://syntheticbiology.org.
9. https://www.gov.uk/government/news/over-60-million-for-synthetic-biology.
10. http://www.foe.org/projects/food-and-technology/synthetic-biology#sthash.Dy7yqEXk.OkZmKaJe.dpuf.
11. http://www.raeng.org.uk/publications/reports/synthetic-biology-report.
12. p. 16–17, Rogers EM (1995) *Diffusion of Innovation*. New York: Free Press.
13. Latour B (1987) *Science in Action*. Massachusetts: Harvard University Press.

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7

Images, Spaces, and Emotions: Non-discursive Aspects of Science Communication

This is a story from a few years back—from 2005, to be exact—but one that might still ring true for some forms of science communication. It dates from the height of UK interest in public engagement with science. Science cafes, panel debates, and dialogue events were popping up all over. This particular event was held in a bar in central London; part of a series on drugs, it brought together a set of invited speakers who worked on different aspects of psychiatric research and treatment.

The evening followed what was a typical pattern for these kinds of dialogue events.[1] A facilitator chaired, introducing the expert speakers and allocating them five or so minutes each to give their thoughts on the topic: how beneficial is medication, as opposed to other kinds of treatment, for mental illness? Then the floor was opened up to questions and comments from the 50-strong audience and, as was also the norm, a series of mostly factual questions were asked. How treatable are personality disorders? Can drugs and talking therapies be combined? The speakers gave lengthy and occasionally technical responses, sometimes to the accompaniment of nods, applause, or similarly technical interjections from the audience. The smooth progress of the event was broken, however, as a woman stood up, introduced herself by name, and hesitatingly

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told a story—her story—of debilitating depression, job loss, and everyday reliance on medication. The character of the room changed, becoming marked—suddenly, awkwardly—by a new, intense seriousness: those in the audience watched her or watched their feet, speakers dropped their rather combative demeanour, the space became still. It was with almost palpable relief that the discussion was moved back, by the next speaker, towards more technical details. The confessional moment had been—not wrong, exactly, but awkward, odd, out of place. The woman sat down and did not speak again.

Why is this vignette striking? For us it has become emblematic of an absence from much of the public engagement, and discussion of public engagement, that has taken place over the last decades. The routine, the 'normal' form of the event, that was disrupted by this emotional and personal account was one of carefully controlled and intellectual discussion. The expression of raw emotion and deeply personal experience felt out of place. Anything too intimate, too honest, was self-censored by most participants in at least this instance of science communication—and as a result, the over-riding tone was scientific not spiritual, objective not empassioned, and abstracted rather than tangible. In this event, and others like it, expectations of dialogue as calm, reasoned argument held sway.

To notice this is not necessarily to criticise. Few people actively enjoy shouting matches, passionate arguments, or tearful explanations, and especially not in public life. As we saw in Chapter 2, part of the background to the development of theories of deliberation (and, from there, of public engagement with science) was an ideal of reasoned and equitable debate. Although that ideal has since been criticised, there is much to value about the use of deliberation in public discussion. At the same time, we wonder whether that woman's story, and experiences, might have been relevant to a discussion of the pros and cons of psychiatric medication. Might it have been helpful to stop debating technical possibilities in the abstract for a moment and to reflect on how those possibilities could affect individual lives? Might the nature of deliberation itself be enhanced by an occasional move away from reasoned debate and towards the personal, intimate, and experiential?

This chapter is about these kinds of questions. More generally, it is about the ways in which the practice of science communication tends to overflow the frames that we place on it, whether that is of reasoned argument and deliberation, education, or entertainment. In many ways that is the theme of the whole book: we are interested in how science communication is so much more than the relatively straightforward process of information transfer that it is often viewed as. But in this chapter, these overflowings are made manifest in very tangible ways, through messy emotions, resistant spaces, or badly behaved audiences. It is about the *non-discursive* aspects of science communication, and what noticing these can tell us. It's also, more than some of the other chapters, about the audiences and consumers of science communication. These are often the people who break the frameworks and structures that science communicators like to use—who bring in awkward emotions (like the woman in the event above), refuse to behave in obedient, citizenly ways, or resist the discipline of exhibition layouts, unfriendly buildings, or educative PowerPoints. They are the people who subvert science communication formats and communicators' intentions.

We start the chapter by focusing on images and visualisations before discussing some examples of how materiality, emotions, and subversion and misbehaviour can structure experiences of science communication. What follows is therefore a set of reflections on some aspects of the non-discursive that we have noticed as important when we have developed and participated in science communication. Rather than being comprehensive, the point is to highlight frameworks that allow us to notice aspects of science communication that typically might go under-reported, but which will play a role in the meaning-making that takes place in it.

Images in science communication

In 2010 science blogger Martin Robbins wrote a post called 'This is a news website article about a scientific paper'.[2] He was not, however, breaking science news or even commenting on current research. Instead the piece was a long satire on the format of science news, from the use of puns in the headline to the generic quotes journalists extract from scientists ('*Basically, this is a brief soundbite*,' the scientist will say … '*The existing science is a bit dodgy, whereas my conclusion seems bang on*'.) Right in the middle of the piece, there is a startling image. A dinosaur, in space, wearing a pirate's eye patch, with the word YAKAWOW!!! above it. 'At this point', writes Martin, 'I will include a picture, because our search engine optimisation experts have determined that humans are incapable of reading more than 400 words without one'. The image is subtitled: 'This picture has been optimised by SEO experts to appeal to our key target demographics' (Search engine optimisation, or SEO, involves making sure that a website gets as much visibility in search engines—such as Google or Bing—as possible).

It is not clear exactly what science story the space dinosaur would ever be used to illustrate. But its presence in Robbins' parody (which went on to ignite debate about the quality of online science journalism)[3] makes an important point: no matter what the content is, images, graphics, and visual representations are a vital part of almost any kind of science communication, from news stories to public lectures. Communicators often take it for granted that they will use visuals in their work, and it is standard advice to scientists that they should produce images or graphics to help them explain their research.[4] This ubiquity means that images can often be taken for granted in science communication. We can render them invisible in our experiences or analyses of communication processes, seeing them as something natural—straightforward representations of a piece of scientific knowledge, which enable that knowledge to be communicated more effectively than through text or words, or 'padding' that fills out the space between paragraphs. Robbins' space dinosaur draws the eye exactly because it is not what you expect to find in the middle of a science blog, but if the image had been of cells photographed through a microscope, a galaxy, or a particular natural habitat, most readers would have skimmed over it quite happily.

This taken-for-grantedness ignores the complexity of how visuals are produced and consumed, and grants images an innocence—an objectivity—that they do not actually have. 'Scientific images', writes Rikke Schmidt Kjærgaard, 'are rarely neutral when used in popular contexts'.[5] Their very obviousness—the way in which they can just be there, seemingly straightforward—makes them highly persuasive. There are always different ways of visually representing a particular scientific object or artefact, or of creating charts or graphics, and the format that is chosen thus shows just one (apparently self-evident) truth out of many. This can have powerful effects. Schmidt Kjærgaard suggests that the double helix structure of DNA identified by Watson and Crick has in part caught on as a cultural icon because of its very simplicity: it is instantly comprehensible and makes the representation of DNA easy to understand. 'The public success of the DNA design and idea', she writes, 'was to a large extent due to the visually compelling and sculpturally ideal structure'.[6] Scientific images are also produced within specific scientific cultures, and some of their meaning may be lost as they travel into different contexts. As a result, Jean Trumbo has called for studies of 'visual literacy' alongside scientific literacy in science communication, arguing that there is a need to better understand how public audiences 'read' scientific images.[7]

Noticing images in science communication opens up a range of topics and questions. One area that has been explored, and which overlaps with the previous chapter's discussion of the role of public communication in creating particular technoscientific futures, is that of the imagery around emerging technologies. The grey box that follows, which focuses on visualisations of nanotechnology, shows that images are not just about understanding information but play an important role in how publics develop sense-making around emerging technological possibilities. This is also an area where scholars and practitioners need to consider cross-fertilisation between science communication and fictional accounts such as films, comics, graphic novels, GIFs, and online video and social media imagery. Many people have a large back catalogue of what scientific futures look like from such sources, and this will influence the way in which they decode, interpret and consume science communication visuals.

Representing the Invisible

Nanotechnology involves the manipulation of materials at the nanoscale (10^{-9}m). Like synthetic biology, which we described in Chapter 6, it is surrounded by far-reaching expectations and visions. One US government report from 2000 suggested that the technology will lead to the 'next industrial revolution'.[8] Because of its small scale, however, nanotechnology is very hard to see. Most of it is invisible to normal 'seeing' because its scale is below the wavelength of visible light and because many of the products and technologies that are being promised are not yet in existence. Despite this, however, images of nanotechnology have been an important part of how it has been communicated and presented as a promising technological solution.

Brigitte Nerlich has analysed the way in which so-called 'nanobots' were being depicted in a science image library.[9] This library had 128 images of nanobots, the majority of which were visualisations created by artists. Nerlich studied the way in which these bots were presented and described, and found that—for a new technology—there was a surprising emphasis on familiar and recognisible visual tropes. This 'normality' of nanobots is, she writes, 'enhanced by giving nanobots recognizable shapes, such as bees or wasps or spiders and by letting them perform well-known functions, such as drilling or killing'.[10] In Nerlich's view, images like these of emerging technologies can serve to make them mundane, dampening any concerns about them. They also give the impression that such technologies are already here, by making the 'unfamiliar familiar'.

Other scholars have looked at what happens when laypeople encounter images of nanobots and other potential products of nanotechnology. One group of researchers conducted interviews in which they showed non-scientists two images related to nanotechnology, one of which depicted a nanobot.[11] The responses they got were rather ambivalent: even when the images gave rise to negative associations, people were still hesitant to judge nanotechnology as good or bad. They also found—in line with other studies of public opinion about emerging technologies—that laypeople 'make sense of visualizing nanotechnology by referring back to a specific domain or genre of "science images" they have stored in their memories'.[12] In other words, the new images they were presented with were understood in relation to other images of science that people had seen in the past (maybe from school, or other public communication about science). As we saw in Chapter 2, reception of any kind of information via science communication, whether through images or other means, is never straightforward: people will always bring the knowledge they have already, about that technology or science generally, to bear upon it.

The sociology of images

It is therefore worth science communication researchers spending time unpicking the ways in which visuals are used within public communication. How are such visuals produced? Where do they come from, and how do they travel? How are they read and interpreted by different audiences? The challenge, of course, is the very diversity of the category 'visuals', which includes everything from infographics to 3D visualisations of proteins and photographs of microscope slides. One framework that might assist in exploring these kinds of questions across multiple visual formats is that outlined by Regula Burri in her call for a 'sociology of images'.[13] Burri is clear that images can only be understood as meaningful within social contexts. They are created by people, in particular ways, and are consumed and have effects within social settings. Although of course they hold content in and of themselves, there is also complexity in the activities and processes through which they are made, shared and used. Burri introduces the notion of 'visual logics' to describe how images intersect with social practices, arguing that a visual logic has three key aspects:

> The first dimension—the *visual value*—refers to the non-discursive characteristics of images. In social practice, it becomes important because it allows a simultaneous perception of visual information. The second dimension—the *visual performance*—points to the ways visual signs are composed in an image, in other words, to what is visually represented. The third dimension of an image's visuality—the *visual persuasiveness*—underlines both the importance of visual information in communication and the rhetorical power of images.[14]

By visual value, Burri means the capacity of images to be taken in all at once, at times by multiple people. Unlike reading a text, where (in many writing systems) one has to work one's way through from left to right and top to bottom, one can gain a sense of the entirety of an image in an instant. We might say, then, that visual value is about the specialness of images over discursive communication. What difference does it make to social practices that images have this quality of simultaneity, and how, in science communication, does this affect how they are used?

Visual performance brings us to how images are constructed. Even seemingly 'natural' images, like photographs, are composed, framed, and interpreted. Burri argues that we need to pay attention to the social processes through which images are made and read. What kinds of choices and tacit norms are part of the production of science images for public consumption, and what skills and values are involved in interpreting such images—whether 'correctly' or otherwise? Finally, visual persuasiveness highlights that images are always used to make particular arguments, and to convince audiences of particular things. This persuasive power may come from things such as beauty, elegance or simplicity, as in the double helix example that Schmidt Kjærgaard writes about. But it may also come from an image having the appearance of 'scientificity'. Burri writes about the use of medical images, like radiographs, as an example of this: such images are ‘scientific images and thus viewed as “objective facts” with authoritative power’.[15]

We think Burri’s framework is valuable because it points us to the social situations in which science communication images are used, and the ways in which meanings are made within them. It also helps us to keep in mind the different locations through which such images will travel. A visualisation of a molecule might start as a purely scientific image, used to explain and debate research in the lab, before being published in a journal and ending up in a science story in a newspaper. Images may also be used within different niches of the ecosystem of science communication—mass media stories and public lectures, for instance. It is likely that different norms and practices will apply in these different places: one task for science communication research, then, is to understand these practices better.[16]

Exploring materiality in science communication

There is a tendency in much discussion and analysis of science communication to imagine it as relatively disembodied. As we saw in Chapter 2, it is often theorised as being about information transfer. In this section, we start to think through what we can notice when we stop thinking about science communication in terms of how information travels. What can we discover when we view science communication, in all its many formats, as shaped by its material form?

We will start close to home: the university campus on which we both work. The University of Copenhagen’s South Campus is a set of imposing pale gold concrete cubes linked together by a network of bridges and canals. The site has been under construction for more than 10 years, and is still a building site, but there is a further reason that the campus can feel rather cold and unfriendly: to put it bluntly, it has its back to the street. The central plaza around which the buildings are loosely gathered is exactly that—central. All of the main entrances to the different buildings face this plaza. From the busy roads around the campus what you see are a series of window-pecked walls and, at one point, a very high fence. On the one hand, this is part of efforts to design urban spaces that are not based around cars; on the other, it is interesting to consider what this physical layout connotes in terms of what a university is, and to whom it is accessible. As a passer-by on foot or bike—even as someone looking for a particular department or teaching room—the space feels closed-off and unwelcoming. The building work heightens this effect, such that visitors' experiences are often that the university buildings are hard to access. In contrast with the nearby harbour area (for instance), it is not really a place that you could drift into or hang out in. It is not a *public* space. Even at the occasional open days or public events that take place on the campus the openness feels a little forced and unnatural.

What does this have to do with science communication? On one level, of course, it is a specific example of how one research institution—the University of Copenhagen South Campus—presents itself to the publics that surround it. Scholars of public understanding of science have written about 'institutional body language' and the way it constructs public audiences[17]; here we have such body language writ large in the very buildings and byways that comprise the campus. However unintentionally, and however much the researchers and students who use the site might disagree, this body language is saying: we are secluded and separate. Knowledge is something you have to fight your way in to access, not something you stumble across when you are out for a stroll. The body language of the campus might not be a piece of deliberate, organised science communication, but the physical structures that make up universities and research institutions, as well as their branding and advertising, are nonetheless ways that science is presented to the public.

More generally, this is one example of the importance of physical sites, buildings, and rooms in structuring encounters between science and its publics. The spaces in which these encounters take place are never neutral. They will always have particular connotations and will encourage or discourage particular behaviours. Gerry Stimson has written about this structuring effect, and the need for researchers to notice space and place in their studies of social processes.[18] Too much ethnography, he writes, has been 'logocentric'—focused on words to the exclusion of artefacts, images, or spaces. He gives an example by describing his fieldwork at the UK's General Medical Council (GMC). Interested in the process by which doctors were disciplined by this body, and attending a set of hearings concerning professional misconduct, he was, he says, immediately struck by 'the impact of the room [the GMC Council Chamber] on the participants and visitors'.[19] He describes this Chamber: the oak panelling, the stained glass windows, the marble busts, the leather-topped tables. This, he writes, 'is a room in which serious matters are discussed':

> This is a room that, even when unoccupied, impresses on the visitor a solemn demeanour and subdued speech. When occupied, it retains its solemnity, and speech is now formal, carefully spoken, and a matter for the public record. Visitors in the gallery speak only, if at all, in hushed whispers, for their speech is not part of the proceedings. We know that this is expected of us, and the commissionaires' admonition on entering—'no talking, no eating, no rustling of papers or tapping of pencils, no cameras, no tape-recorders'—is superfluous.[20]

Stimson, familiar with the culture that produced the GMC and its wood-panelled halls, is able to read—interpret—the space he is in. Not only is it a room for 'serious matters' but also one in which he, as a visitor in the public gallery, is not welcome as an active participant. The grandeur of the room is able to very clearly indicate who should have a voice and how. It crushes, or at least renders aberrant, noisy public debate, expressions of support or dissent, or audible commentary on the proceedings. Stimson and others in the public area are visitors. They are not meant to be a part of the GMC's discussions.

The GMC Chamber is an extreme example—a space exactly designed to shore up certain kinds of authority, and to discourage just anyone having their say—and one that might be of limited relevance to the majority of public science communication. (Although, on the other hand, we have certainly attended public lectures, events and workshops held in hallowed halls and oak-panelled university rooms. What are these rooms saying to their occupants about their role in the event?) The key point is that, as we analyse and design different instances of science communication, it is worth noticing where these processes are taking place, and what implications this might have. What difference does it make to hold a science cafe in a pub or in a university cafe? Does science communication happen in public spaces in cities and in villages, or in secluded environments—like the University of Copenhagen's South Campus—which take effort to get into? Do you pay to access it? Is its palette casual, bright, hip, grey, formal, or psychedelic?

Noticing the places and spaces of science communication does not mean only thinking about how different environments might constrain public engagement with scientific knowledge. As Thomas Gieryn has argued, there is always space for the subversion and reinvention of disciplinary buildings and layouts.[21] 'Sociologists could take buildings more seriously', he writes, 'but maybe not too seriously. The play of agency and structure happens as we build: we mould buildings, they mould us, we mould them anew'.[22] In other words, we are not trapped by the structures that surround us. It might be hard to shout and scream and let your views be heard in the public gallery at the GMC, but it is certainly possible. A pub, or university lecture room, or science festival in the heart of the city might invite certain kinds of behaviour (such as learning or informal conversation or attentive listening to authoritative speakers) and discourage others (such as playing games on your phone or talking while others are speaking or being teetotal) but, as science communication practitioners know, there is no way of mandating for these. Users of science communication are always active—and therefore, always capable of rejecting material configurations that seek to direct and guide them.

The affordances of objects, structures, spaces and places

Materiality is not only important with regard to buildings. It is also manifested at smaller, more intimate scales. Different layouts, configurations, and materials change how science communication is experienced, affecting not just how much knowledge is received or learnt but its very content. How someone experiences a particular piece of scientific knowledge—the existence of a force known as gravity, say—will be different depending on whether they read about it in a book, learn about its actions through negotiating an interactive exhibit in a science centre, or watch a theatre production inspired by it (such as art collective Hotel Pro Forma's performance COSMOS+, which uses music, light projections and the spoken word to create 'curiosity about the beauty and many mysteries of the universe').[23]

Researchers in science education have discussed this effect in the context of learning. Science educators are interested, of course, in how to enhance learning, and in what the benefits of different kinds of physical spaces, learning methods, and hands-on activities might be for achieving this. What difference does it make, for instance, if students have the opportunity to do practical experiments as part of their studies? (According to some research, it may just make them more confused about the scientific principles involved—though they do enjoy the activities themselves.[24]) Research in science museums has similarly focused on visitor learning and how this is affected by the choices exhibition developers make, such as how to combine text with objects or lay out an exhibition space. All of this work has highlighted not just how contingent on physical context learning is, but how complex and unpredictable it can be. Scientific content is experienced and interpreted differently not just based on the different material forms through which it is presented, but according to visitors' personal backgrounds and interests and the sociocultural milieu from which they come.[25] Learning, and indeed experiences of the museum more generally, will depend, as John Falk and Lynn Dierking note, on whether you are guiding your 80-year-old grandmother around the museum or dragging your toddlers; on how interested you are in particular topics already; on how crowded the museum is that day; and on whether the museum has put its biggest, most famous objects on display.[26] Learning, they argue, has to be understood as 'free-choice', and educators need to be 'open to a broad range of learning outcomes'.[27] In other words, learning is so complex it is almost impossible to predict if and how it will happen.

For all of these reasons we think it is more helpful to focus not on the potential effects of particular materialities of science communication, and in particular not on efforts towards certain learning outcomes, but on what these material forms *afford*. What possibilities do they offer to their users? What behaviours or experiences do they encourage, and what uses can they be put to? The interesting thing here is that these affordances may well have gone unnoticed by the designers and practitioners of the science communication in question. Users of science communication are often highly skilled at getting what they want—not what practitioners think they should do or experience—out of communication activities and formats, and at working out what particular material configurations can offer them at a particular moment.

As an example of this let us return to the ESOF Science in the City festival mentioned in Chapter 1. One of the reasons Science in the City was interesting to us was that it brought together many different kinds of science communication, involving many different material configurations. As participant observers, we noticed several interesting things about what these different formats could afford visitors to them.

Take the ‘Ocean of Resources’ photo exhibition. It was often easy to feel a little sorry for this project. Consisting of eight large format underwater photos and accompanying text, it was situated on a small patch of grass next to a path linking two parts of the site to each other. Many people simply ignored it as they hurried from one project or activity to another. Some did not realise it was part of the festival at all. As a result, it was never as packed as some of the other projects. At the same time, as we watched how people interacted with ‘Ocean of Resources’ we realised that it offered certain things that other projects, with different locations and material set-ups, could not. Here is an extract from the fieldnotes SRD took as she observed the exhibition, sitting on a damp bench next to it:

> As I'm sitting here the photos do seem to snag a few people who are going past in no hurry—a guy eating a sandwich, a couple discreetly making out (they look, chat, stop and look at each other, hug, kiss, continue looking at the photos). […] As I sit and watch there is still a lot of [foot] traffic along the street—and people do seem to turn their heads and glance at the display. Perhaps no more than that is necessary. It is simply enough that the images add to an impression, a sense of what it is to be here at Science in the City—an overall effect or atmosphere. And the space does offer affordances for those needing time out—I am enjoying being here on the bench, somewhere quieter, tucked out of the way—or for a space where they can linger. Now, again, there is a group of three standing eating and talking and looking at one of the images. It is a space for multi-tasking.

The photos were displayed on four large boards standing parallel to the street, which worked to create an impression of a space that was quieter and more reflective than the rest of the festival. Such a space is useful if you want somewhere to eat a quick lunch (or if you are an ethnographer who wants to sit down for a while). It affords behaviours that are slower, more restful; it also, as noted in the field notes, allows for multi-tasking; absorbing the photos while at the same time talking with your friends, flirting with your partner, or eating a sandwich.

Compare that kind of space and layout with the 'Science Moves' workshop. This was designed as a much more active experience: it was, to start with, a workshop, held a couple of times a day. Participating in it was time-sensitive, so you could not just stumble on it as you could with 'Ocean of Resources'. Once the group was assembled, the workshop started with a warm-up activity involving walking, jumping and occasionally running around the space. The main scientific topic was then introduced. This varied, as it was based on different researchers' current work, but included one workshop that focused on how to understand the movement of prehistoric peoples by studying contemporary landscapes. The topic was subsequently explored through a physical activity—for instance, distributing balls representing raw materials throughout the space, acting as tribes and moving around collecting the balls, and collaborating to build villages. The essential feature was that you were rarely still. Both the knowledge being communicated—ideas about landscapes and materials and traces of previous civilisations, embodied as a material layout of balls and strings of wool—and the recipients of it were constantly active, flung about the space in different ways. The workshop, its organisers told us, aimed to use 'kinesthetic activities' to help enhance both learning and the social experience of participating in science communication.

What did 'Science Moves' afford visitors? On the one hand, it seemed to be viewed as something suitable for children—a way of keeping your kids entertained for an hour or so through involvement in its playful activities. But its constant physical movement also afforded a great deal of pleasure to those who liked to move their bodies. Quite aside from the opportunity to engage with knowledge in a different way, there was enjoyment to be found in using the body differently to how one might expect at a science festival. For some of the students who participated in our research about the Science in the City festival, it was this that was the most striking part of their experience. This is how one participant answered the question 'How did the activity make you feel?':

> Excited, refreshed, getting some extra oxygen in the brain, relaxed afterwards and enjoyed the fact that it was in a dance room, and they had this ballerina practicing structure [a barre on one wall of the studio]. Reminded me I haven't been dancing or moving enough. And it was good to do things in groups.

'The activity', the student commented later, 'reminded me I should do this more often'—meaning, dance about and move. 'Science Moves', then, allowed for very different kinds of behaviours and experiences than 'Ocean of Resources'. Rather than creating a secluded, private space, it encouraged sociality and offered participants the particular pleasure of physical movement. For some participants, it was interesting to think about the scientific content in a new way—to 'use your body to sort of understand something', as one student put it—but for others that was almost a distraction. The key thing the workshop had to offer was the opportunity to run, jump, play, and twist and turn your body in unusual ways.

Neither of these uses of science communication—as a quiet space to hang out and an opportunity to move and dance—are wrong. We are not interested here in being normative. Rather, paying attention to the material affordances of particular instances of science communication seems to us to be an important analytical strategy, and one which can tell us much more about how the users of science communication experience it. It can help us to think about what is going on within science communication beyond a transfer of information.

Consuming Science Communication

The way in which visitors to the Science in the City festival made use of different material layouts for their own purposes, from finding a quiet space to be with your partner to being able to run around and jump, is just one example of how laypeople consume science communication in different ways and to different ends. People make use of the affordances of science communication, both material and social, to meet their personal needs. This may include learning about science, but it may include other needs and desires.

Motivations for participating in science communication are many and various, ranging from having a personal relationship with a speaker at an event to suffering from a particular condition and wanting information about it.[28] One study, focusing on attendees of public engagement events, found what we might call 'cultural' reasons for participation, with an interviewee noting that 'it [the engagement event] is a quite entertaining place to go when I've got a couple of hours to kill midweek'.[29] Sharon Macdonald has explored the way in which visitors to science museums consume the experience of a museum visit and the science that they find there. Looking at a particular gallery at the Science Museum, London, she found that visitors' reasons for attending were often not much to do with 'science' at all; rather, they saw their visit as part of a 'cultural itinerary' whereby they could, for instance, visit a key attraction in the UK capital or nostalgically recreate childhood visits with their own family to the same place.[30] In the same way, she found that their interpretations of the content of the gallery were shaped by their orientations and interests. They were, she writes, 'reconfiguring the exhibition, sometimes in ways unanticipated by, or even explicitly contradicting, the makers'. Such research suggests that people consume science communication in numerous ways linked in with their personal, professional and civic lives. Materiality is one way that science communication can offer particular sets of affordances; affect is another. Science communication may, we can speculate, meet particular emotional needs by helping construct identities, providing social spaces, or offering experiences of wonder or excitement.

Emotions in science communication

Writing about materiality is often also writing about emotion.[31] Once we pay attention, whether as analysts or communicators, to bodies and spaces and objects, it becomes difficult to ignore the kinds of affects that are tied to these.[32] Emotion would seem to be central to thinking on science communication. Reflections on PUS, for instance, often focused on the emotional dimensions of the public to whom science communication is addressed. Are they irrational, over-emotional, and anti-scientific, easily swayed by the manipulations of NGOs and the media into anti-science 'hysteria'?[33] Or, once informed about the 'facts', are they enthusiastic supporters of scientific progress? As Jon Turney wrote in the dog days of PUS, the assumption had generally been that 'to know science is to love it'. One of the motives behind science communication, he noted, had been to 'increase public sympathy for science and scientists'.[34] Much science communication practice continues to focus on engendering positive emotions, such as wonder, delight, interest or excitement. Motivations given by communicators might be to 'inspire' audiences or their own personal pleasure and enjoyment.[35] Most straightforwardly, there is the sense that publics will not make use of science communication if they do not get something positive from it. Science communication has to engender positive affects, or it would not merit any attention.

As we saw in the anecdote that opened this chapter, however, experiences of science communication can overflow expectations of which emotions are appropriate. Communicators and audiences may be keen to promote joy, curiosity or wonder, but the expression of intimate and personal emotions—despair, grief, hope—can feel out of place in discussions about science. In addition, affect generally is often rendered invisible in discussions and analysis of science communication and is rarely studied with the same attention as discourse. Even emotions of enjoyment and pleasure (or boredom and frustration) are rather complex and context-specific. How are they experienced, articulated and modulated in different instances of science communication? What triggers them, and what effects do they have? In particular the rise, in recent years, of overtly entertainment and comedy-oriented science communication formats offers a key opportunity for science communication scholarship to think more about the role of affect. Stand-up science comedy, science slams, science festivals and science-art collaborations all tend to foreground emotion.[36] Experiences of affects should therefore be integral to their study.

The presence and acknowledgement of emotions is thus a further way that the practice of science communication can overflow expectations and models of it, and something else that it would be valuable to notice more in our analyses. We want to offer two brief examples of how this can be done. The first is taken from the work of David Kirby, who researches the relationship between science and entertainment media. Kirby has written about an increasing emphasis on awe and wonder in celebrity science.[37] Wonder, he says, has become ubiquitous in public presentations of science. This is particularly explicit in Brian Cox's work—shows like *Wonders of the Universe* and *Wonders of the Solar System*—but Kirby also finds it in Neil deGrasse Tyson's recent reboot of the TV series originally presented by Carl Sagan in the 1980s, *Cosmos*. There are many scenes in *Cosmos*, says Kirby, 'where deGrasse Tyson reminds us that we need to be humble and stand in awe of nature'.[38] The emphasis is on how amazing the universe is and that our response should be one of wonder.

Kirby explains that this appeal to the wondrous is lifted from religious traditions. Historically, wonder and awe are the theologically correct response to nature from Christians, and there are many similarities with this kind of religious wonder and that expressed by Cox or deGrasse Tyson. *Cosmos*, for instance, used metaphors lifted from religion in explaining DNA or geological records. Kirby sees this as an effort 'to wrest away from the religious community the notion of wonder as a way to frame our relationship to the natural world'[39]— in other words to 'own' wonder as a scientific emotion rather than a religious one. But he also suggests that the wonder expressed by scientific celebrities is not ultimately aimed at nature, or the universe, or the physical world; rather, it is directed at the science and scientists who are able to reveal those wonders. The danger comes, Kirby says, when this is turned into a reverence for, and even worship of, science which ignores the fact that it is both a very human and very uncertain enterprise. 'An overdose of wonder', he writes, 'can lead to disillusionment when science inevitably proves to be fallible'.[40] Kirby's attention to the emotion of wonder therefore highlights one potential danger of trying to elicit unquestioningly positive effects. Wonder might seem to be a natural response to nature and science—but taken in isolation, it may foster expectations about science that can never be met.

A second example of how we might 'follow' particular emotions comes from a visit—described in the grey box that follows—to the Electricity Museum in Lisbon, which is located in a former power station, and the experience of nostalgia that this form of exhibition evoked. As a piece of science communication, the presence of nostalgia might lead us to consider the importance of the intact power station as an 'authentic' space presented for our exploration, and to ask what story this is telling. Noticing nostalgia leads us to think about the temporality of the building—the way that it preserves and celebrates a past in which the power station employed hundreds of people and provided light for an entire city. The nostalgia that the visitor may feel as they start to wander the turbine halls is part of the museum's uniqueness and its appeal. Following that emotion—by thinking about temporality, for example—can bring insight into the museum's nature as a piece of science communication, situating it not only within a framework of learning or even of entertainment but also within larger changes in regional development and in the nature of technological progress itself. It can tell us something about the wider context, and purposes, of at least this example of science communication.

Nostalgia at the Electricity Museum

The Electricity Museum—*Museu da Eletricidade*—in Lisbon is located in a disused power station on the river Tejo. The majority of the space inside is simply the inner trappings of a 1970s power station, cleaned up and with a few panels of interpretative text. As a visitor you walk through the turbine halls, around the condensing chambers, and climb into the boilers. All of the original machinery is still there; you can touch it, walk around it, and pull levers on the control panels. The aim, the museum's website says, is to show the public how the original coal-fired themoelectric plant worked. Visitors can follow the transformation of energy from the arrival of the coal through to the actions of the generators.[41]

Visitors respond to the space differently. Indeed, part of the museum's appeal is that it is so open to different responses. Unlike traditional museum galleries, you are not guided particularly clearly, and it is possible to wander as you want. Children have the opportunity to touch everything and to run around and climb on things. The structure is huge and dramatic, and it is also easy to become entranced by its aesthetics. But another possible response is an overpowering sense of nostalgia, the emotion of somehow being displaced in time. The power station was once productive and busy—it illuminated Lisbon, visitors are told, for 40 years—and it is strange to be surrounded by machinery that once was noisy and active but now is silent and still. This emotional response is heightened by celebratory, black and white photographs of past workers on display and by text that talks about memorialising them and their working conditions. The nostalgia is not just for the power station but for a community and a lost industrial past.

Nostalgia is a paradoxical emotion. In the literature of affect it is generally conceptualised as positive—as something that feels satisfying or pleasurable, helps build a sense of identity, and can foster social connectivity[42]—but the experience of it is not necessarily enjoyable. Indeed, in the past it was categorised as a pathology, a disease from which one might sicken and die.[43] Visiting the Electricity Museum can therefore be something of an ambivalent experience. It is compelling to be able to see and touch machinery that was working before you were born (the plant first opened in 1908), and to experience the scale of the boilers, condensers and cooling chimneys. It is the ultimate in authentic objects and spaces. But nostalgia is not necessarily a comfortable emotion, and the museum can feel rather sad.

Nostalgia can, however, also point us forward in time. The former power plant is now a museum and tourist attraction. Visitors to Lisbon come to a part of the waterfront that they would have avoided when the plant was operating, drawn by the 'heritage industry' and the lure of nostalgia.[44] A display in the museum shows how the waterfront is currently being regenerated and developed, once again becoming a viable part of the city's economic landscape. The celebration and emotionally laden invocation of the past becomes part of the imagination of its future. Seen in these terms, the Electricity Museum is not only, or even not mostly, about explaining how thermoelectric power stations used to work. It is about an experience, and one in which emotions are central.

Boredom and misbehaviour

Following emotions, whether nostalgia or something else, can offer us a tool for analysing the way in which science communication acts in the world. But tracing an affect like nostalgia can also be frustratingly intangible, not least because it can be difficult to get users of science communication to articulate emotional responses they have to it.[45] Emotion-laden behaviours (and misbehaviours) offer another way to examine the experience of science communication beyond information flow. Boredom or a sense of irrelevance, for example, might be identified by observing how users of science communication subvert, disobey or simply ignore its 'correct' use.

There are many examples of the ways that visitors to or consumers of different kinds of science communication surprise—and perhaps sometimes annoy—its practitioners and designers. If people are bored in a lecture or event they may walk out, heckle, or stare at their phones; if written science communication seems uninteresting one can simply stop reading; at a science festival, you can ignore the science and stick to the beer tent.

Installations and exhibitions offer especial affordances for misbehaviour: you can disobey instructions, ignore waymarks that attempt to guide you round a particular route; or vandalise or alter the physical set-up. Such misbehaviours should not necessarily be read as a failure of the communication itself, and shouldn't be dismissed as uninteresting or frustrating—though, of course, as a practitioner it might be hard not to feel that way. Instead, errors, mistakes and misuse can offer insight into the affective worlds of those using a particular piece of science communication.

One example is offered by the installation we developed with a group of colleagues for the ESOF Science in the City festival, mentioned in Chapter 3. This installation was called 'Breaking and Entering: Explore How Science and Society Relate' and sought to create an interactive physical space through which visitors could investigate questions about how science can and should relate to society.[46] The aim was to be dialogic. We wanted to trigger reflection on science and society but also to create space for users' views to be shared with us, each other, and the policymakers who were attending ESOF. To that end the installation featured not only information about different perspectives on the central issue but opportunities to feed back opinions, both digitally and within the structure of the installation itself. As a visitor you could vote about who you thought should take responsibility for the responsible use of science, stretch an elastic band to indicate how you thought risks and benefits should be balanced, and write comments on questions such as 'What are your hopes and fears for the future?'.

The opportunity to write about your personal hopes and fears about the consequences of science offered a particularly good opportunity for visitors to subvert what the installation asked you to do. Fears were to be written on red pieces of card, hopes on green, and both were to be pinned to a network of bamboo canes for public display. In looking at the responses it is clear that some people ignored this framework, or applied it to the realm of the personal rather than that of science and society. Notes on green cards included 'I love my BFF, Thea Gram Ventne, Maja Eva Daneli & Matasja Baggesgaard', 'Håber at møde Justin Bieber og blive gift med ham :)' (*Hope to meet Justin Bieber and get married to him*) and 'Jeg er tørstig' (*I'm thirsty*); notes on red cards included 'I'm afraid of Amanda' and 'I love pizza'.[47]

We have to confess to a certain fondness for such responses. We wanted, of course, people to be given opportunities to think about the relation between science and society, and perhaps to question their assumptions about this. But it also seems to us that in many situations an entirely understandable, indeed thoughtful, use of the installation is not as a space for civic contribution or educational experience but as a means of passing time, joking with friends, or even expressing something personally important (as, perhaps, in the 'BFF'—meaning, best friends forever—note). It is also important to note that such misbehaviours and re-purposings of the installation did not only come from bored teenagers visiting the festival with school groups. While we are open to other kinds of use, the installation ultimately seeks to configure its users as active, engaged, participatory citizens. It asks questions and hopes that visitors will answer them, and that they will contribute to both a digital and physical space of discussion and debate about science, emerging technology, and society. Most importantly, it expects its users to *care* about these kinds of questions—and in the end many visitors, even those who were more overtly 'obedient' than the schoolchildren, did not. If teenagers wrote 'I love pizza' or hid puzzle pieces, then many other visitors simply backed away from the installation's interactive elements or declined to leave comments or suggestions. Many people do not want to be asked to participate or discuss. These refusals of the role the installation puts them in are at least as interesting, and telling, as the pizza comments.

What seems to be misbehaviour, then, can tell us a lot about science communication, including allowing us some access to the affects visitors may be experiencing (boredom, silliness, fun, neutrality, disengagement). Taking an interest in failure and misbehaviour is also the theme of work by STS scholar Mike Michael, who argues that these 'overspillings' can tell us a lot about the frameworks which we use to think about our own practices as analysts of public engagement with science.[48] Michael describes a number of misbehaviours encountered in the context of STS research on public engagement, including the use of focus group discussions by schoolchildren to playfully compete against each other (rather than treating the discussion with the same seriousness as the researchers) and 'distraction', directing attention to other issues than those framed as key by the engagement activity.[49] One further example is so enjoyable it is worth including in full:

> In an interview in the late 1980s on the local risks of ionizing radiation, the participant would only talk about her recent job at Burger King. At the same time, her pitbull terrier was sitting on my feet, and her cat was dragging the tape machine, that had been placed on the floor between us, out of recording range. As such no data, let alone relevant data, were collected. […] Instead of the interview framed as an engagement event that failed to enable a member of the public to raise issues about local ionizing radiation risks, we can begin to think of this as an event in which there was a successful enactment of, among other things, a hybrid of human, dog and cat that disaggregated, and differentiated itself from, another hybrid, the interviewer, his tape machine, and his interview schedule.[50]

In the initial framework this research interview was placed in—'an engagement event that failed to enable a member of the public to raise issues about local ionizing radiation risks'—it was categorically a failure. As Michael says, no data was collected, and the interviewee failed to take up the offer to reflect on a particular issue concerning science and society. It was only later, he says, that he came to question this framework, which was imposed by himself, as interviewer, and by the wider research project of which he was part. Perhaps it was this that was being (implicitly) rejected as the interviewee talked about her job and allowed her pets to disrupt the recording, rather than the interview failing because of 'bad luck' and 'inexperience', as he was told at the time. Indeed, he speculates, perhaps this episode should not be read as an instance of 'failed' citizenship—a citizen refusing to take up their responsibility to contribute to reflections on science and society—but as an instantiation of a different kind of citizenship, one in which relations with nonhuman actors (the pets and the tape recorder) are automatically incorporated and where such assemblages can work together to highlight issues important to them. In this way, the 'failure' of the interview led him to reflect on the assumptions hidden within a particular engagement practice. It disrupted taken-for-granted ideas about what public engagement with science should look like—and thus, Michael argues, mistakes and frustrations and disruptions more generally can be seen as productive, highlighting the frameworks in which we operate and which we often forget to interrogate.

It would be possible to give many other examples of emotions, and emotion-laden behaviours, that work their way into different kinds of science communication. Similarly, we have only offered snapshots and examples of what it might mean for science communication research to notice and analyse different aspects of material culture or of visuals and images. The point of this chapter has not been to be comprehensive, but to highlight that these aspects of public communication are important to the meanings that are constituted around it, by audiences and others. As such, they offer one analytically interesting path for the study of science communication processes and formats. They also start to point us to a wider issue, that of how scientific citizenship is performed through science communication by means of material and affective engagements. Michael suggests, in the anecdote quoted above, that citizenship can be lived out in the rejection of discussion about scientific issues, as well as in public debate or deliberation. It is to these kinds of issues that we turn in the next chapter.

Notes

1. Davies SR (2009) Doing dialogue: Genre and flexibility in public engagement with science. *Science as Culture* 18(4): 397–416.
2. http://www.theguardian.com/science/the-lay-scientist/2010/sep/24/1.
3. http://www.theguardian.com/science/the-lay-scientist/2010/sep/28/science-journalism-spoof.
4. See, Bennett DJ and Jennings RC (2011) *Successful Science Communication: Telling It Like It Is*. Cambridge University Press.
5. p. 343, Schmidt Kjærgaard R (2011) Things to see and do: How scientific images work. In: Bennett DJ and Jennings RC (eds), *Successful Science Communication : Telling It Like It Is*, Cambridge: Cambridge University Press, pp. 332–354.
6. Ibid. See also Nelkin D and Lindee MS (1995) *The DNA Mystique. The Gene as a Cultural Icon*. New York: W.H. Freeman and Company.
7. Trumbo J (1999) Visual literacy and science communication. *Science Communication* 20(4): 409–425.

8. https://www.whitehouse.gov/files/documents/ostp/NSTC%20Reports/NNI2000.pdf.
9. Nerlich B (2008) Powered by imagination: Nanobots at the Science Photo Library. *Science as Culture* 17(3): 269–292.
10. p. 289, ibid.
11. Landau J, Groscurth CR, Wright L, et al. (2009) Visualizing nanotechnology: The impact of visual images on lay American audience associations with nanotechnology. *Public Understanding of Science* 18(3): 325–337.
12. p. 333, ibid.
13. Burri RV (2012) Visual rationalities: Towards a sociology of images. *Current Sociology* 60(1): 45–60.
14. p. 49, ibid.
15. p. 52, ibid.
16. To return to the space dinosaur, that image has rhetorical power exactly because it is so comically meaningless and out of place. It is the opposite of a ‘real’ scientific image, and Robbins has presumably chosen it to make the point that, all too often, science news uses visually striking but irrelevant visuals. (Of course, you already need a certain amount of cultural knowledge to read it in this way—to know what a ‘real’ science picture looks like, for instance.)
17. Irwin A and Wynne B (1996) *Misunderstanding Science? The Public Reconstruction of Science and Technology*. Cambridge: Cambridge University Press.
18. Stimson GV (1986) Place and space in sociological fieldwork. *Sociological Review* 34(3): 641–656.
19. p. 642, ibid.
20. p. 642–3, ibid. Stimson is writing in the mid-1980s; now, the admonition would surely include a reference to mobile phone use.
21. Gieryn TF (2002) What buildings do. *Theory and Society* 31(1): 35–74.
22. p. 65, ibid.
23. http://www.hotelproforma.dk/projects/cosmos/.
24. Abrahams I and Millar R (2008) Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education* 30(14): 1945–1969.
25. Falk JH and Dierking LD (2012) *The Museum Experience Revisited*. Walnut Creek, CA, USA: Left Coast Press.

    Macdonald S (ed.) (2006) *A Companion to Museum Studies. Blackwell Companions in Cultural Studies*. Malden, MA: Blackwell Pub.
26. Falk JH and Dierking LD (2012) *The Museum Experience Revisited*. Walnut Creek, CA, USA: Left Coast Press.

27. p. 329, Falk JH, Dierking LD and Adams M (2011) Living in a Learning Society: Museums and Free-choice learning. In: Macdonald S (ed.), *A Companion to Museum Studies*, Oxford: Wiley-Blackwell, pp. 323–339.
28. Rennie LJ and Williams GF (2006) Adults' learning about science in free-choice settings. *International Journal of Science Education* 28(8): 871–893.
29. Wilkinson C, Dawson E, and Bultitude K (2011) 'Younger people have like more of an imagination, no offence': Participant perspectives on public engagement. *International Journal of Science Education, Part B* 2(1): 43–61.
30. Macdonald S (1995) Consuming science: Public knowledge and the dispersed politics of reception among museum visitors. *Media, Culture and Society* 17(1): 13–29.
31. There has been a wider 'affective turn' in social research which provides resources for thinking about this. At its most basic, this has involved a calling of attention to features of social life outside of the discursive, and thus to the role of the material and emotional. These discussions have also involved distinctions between 'affect' and 'emotion', which we elide here. See: Davies SR (2014) Knowing and loving: Public engagement beyond discourse. *Science & Technology Studies* 27(3): 90–110.

    Gregg M and Seigworth GJ (2010) *The Affect Theory Reader*. Duke University Press.

    Leys R (2011) The turn to affect: A critique. *Critical Inquiry* 37(3): 434–472.

    Wetherell M (2012) *Affect and Emotion: A New Social Science Understanding*. SAGE.
32. Again, we've already seen something of this. The University of Copenhagen's South Campus is, we suggested, 'cold' and unfriendly; spaces like the GMC Council Chamber are intimidating; objects have presence effects that evoke particular emotions. It is very difficult to disentangle materiality from affect.
33. As found in synbio/nanophobia-phobia—the concerns of scientists and policy-makers about 'phobic' publics, which itself amounts to a phobia.

    Marris C (2014) The construction of imaginaries of the public as a threat to synthetic biology. *Science as Culture* 0(0): 1–16.

    Rip A (2006) Folk theories of nanotechnologists. *Science as Culture* 15(4): 349–365.
34. p. 1, Turney J (1998) *To Know Science Is to Love It? Observations from Public Understanding of Science Research*. COPUS.
35. Martin-Sempere MJ, Garzon-Garcia B, and Rey-Rocha J (2008) Scientists' motivation to communicate science and technology to the public: Surveying participants at the Madrid Science Fair. *Public Understanding of Science* 17(3): 349–367.

Davies SR (2013) Constituting public engagement meanings and genealogies of PEST in two U.K. Studies. *Science Communication* 35(6): 687–707.
36. Kaiser D, Durant J, Levenson T, et al. (2014) Report of Findings: September 2013 Workshop. MIT and Culture Kettle. Available from: www.cultureofscienceengagement.net.
37. http://thescienceandentertainmentlab.com/evangelizing-the-cosmos/.
38. Ibid.
39. Ibid.
40. Ibid.
41. http://www.edp.pt/en/sustentabilidade/fundacoes/fundacaoedp/museudaelectricidade/Pages/MuseuElectricidade.aspx.
42. Sedikides C, Wildschut T, Arndt J, et al. (2008) Nostalgia past, present, and future. *Current Directions in Psychological Science* 17(5): 304–307.
43. Ibid.
44. Gregory K and Witcomb A (2007) Beyond nostalgia: the role of affect in generating historical understanding at heritage sites. In: Watson S, MacLeod S and Knell S (eds), *Museum revolutions: how museums change and are changed*, London: Routledge, pp. 263–275.
45. See, for instance, the lengths that the authors of the following study go to in trying to explore emotional responses in a museum: Alelis G, Bobrowicz A, and Ang CS (2013) Exhibiting emotion: Capturing visitors' emotional responses to museum artefacts. In: Marcus A (ed.), *Design, User Experience, and Usability. User Experience in Novel Technological Environments*, Springer Berlin Heidelberg, pp. 429–438.
46. There is more information at www.breaking-entering.dk.
47. MH has discussed these kinds of misbehaviours and appropriations of a previous installation in Horst M (2011) Taking our own medicine: On an experiment in science communication. *Science and Engineering Ethics* 17(4): 801–815.
48. Michael M (2012) 'What are we busy doing?' Engaging the idiot. *Science, Technology & Human Values* 37(5): 528–554.
49. See also: Horst M and Michael M (2011) On the shoulders of idiots: Re-thinking science communication as 'event'. *Science as Culture* 20(3): 283–306.
50. p. 533, Michael M (2012) 'What are we busy doing?' Engaging the idiot. *Science, Technology & Human Values* 37(5): 528–554.

8

Scientific Citizenship: The Role of Science Communication in Democracy

Science communication, we have argued, is not only about how scientific knowledge travels between individuals and groups (science and society, scientists and laypeople, experts and audiences). It is also about organisations, identities, spaces, emotions, careers, futures, and many other aspects of the cultures we live in. Science communication is therefore not something that should be studied as a primarily personal or individual process, but as involving collectives. In this chapter, we take this idea to its logical conclusion and think about science communication in the context of states and their citizens. How does public communication of scientific knowledge relate to scientific citizenship?

Scientific citizenship

What is scientific citizenship? On the one hand, it seems a rather commonsensical notion: we live in technoscientific societies, and therefore our rights and duties as citizens now involve science and technology. This notion was at the heart of thinking behind PUS. Writing in 1989, John Durant asked 'why anyone should care about the public understanding

S.R. Davies, M. Horst, *Science Communication*,
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of science' and answered his own question by saying both that 'science affects everyone's lives, and people need to know about it' and that 'many public policy decisions involve science, and these can only be genuinely democratic if they arise out of informed public debate'.[1] On the other hand, it is not instantly obvious what such scientific citizenship might involve. Even the term 'citizenship' is not easily defined. Leach and Scoones present a summary of some key discussions around it[2]: a *liberal* conception of citizenship emphasises the right of the individual to participate in a political life governed by a more or less benevolent state. *Communitarian* ideals stress the social embeddedness of the citizen such that 'the common good is prioritized over the pursuit of individual interests'. Finally, a *civic republican* perspective 'recognizes a diversity of interests within society and assumes citizens will form factional groups around these'. Taking these differences into account, Leach and Scoones conclude that citizenship revolves around the relationship between the state and its members, and specifically that this relationship should be configured in ways that are focused on inclusivity and political involvement. Adding the term 'scientific' into the mix suggests that not only is scientific knowledge important for the exercise of citizenship, but that citizens can also expect democratic accountability of scientific research.[3]

Research on scientific citizenship has often focused on the different ways in which scientific citizenship can be constituted, and how different actors or organisations frame it. In this line of analysis, scientific citizenship is not something fixed; rather, there's been interest in understanding how notions of citizenship are (implicitly) constructed and used by scientists, policy makers, and laypeople themselves. Citizenship is therefore not something that is static, but is performed differently at different moments and in different contexts. This is illustrated, for instance, in the grey box below, which describes constructions of different forms of citizenship in relation to a medical experiment with gene technology.

Scientific Citizenship in Genetic Therapy

In July 1999, media covered the suspension of a clinical experiment with genetic therapy in Denmark.[4] Safety procedures had been contravened, the clinical protocol for the experiment had not been followed, and patients had been sent to London for treatment in return for large financial donations. On this basis, the experiment was suspended and the doctor in charge, Steen Lindkaer Jensen, resigned. This led to a problem for the authorities: a group of patients had been promised genetic therapy by the doctor and his group, but now they could not receive it due to the suspension of the experiment.

In media coverage of the case, three distinct forms of scientific citizenship were articulated.

In the first articulation, the scientific citizen is a *consumer* of science, with consumer rights. The relation is one of demand and supply, and there is an ethical obligation to meet demand with supply. Danish citizens who become ill have a right to consume research-based health care treatments, even if they are experimental.

In the second articulation, the patients are portrayed as highly vulnerable. They can be willing to do anything in exchange for the hope of a cure, but this will ruin the progress of science, which will only deliver true knowledge if there are systematic, unbiased clinical trials. Scientific citizenship is understood as *communitarian*: the patients have to submit to the wider needs of the medical system.

A third articulation of scientific citizenship did not acknowledge that the doctor in charge had done anything wrong. Lindkaer Jensen was a friend to the patients, willing to act where other doctors, politicians and bureaucrats were letting people die. Patients are understood as being right to take any chance to get better, and as active agents seeking cures where they can find them. The individual patient is portrayed as *isolated* (with only the hero doctor to help), not able to rely on the state or wider social systems.

Philosopher Vilhjálmur Árnason argues that there have been two key themes within research on scientific citizenship.[5] One of these is how current scientific citizenship is shaped by the marketisation of science. This has been a particular theme within studies of new biotechnologies and biological citizenship, where emerging technologies such as biobanks are understood as co-opting national populations with promises of 'health and wealth'.[6] Citizenship here is a passive affair: one donates one's biological resources (such as genetic information) in exchange for the promise of a market-driven, national revenue-boosting bioeconomy. Scientific citizens are not really expected to do anything apart from provide their DNA and act as consumers of the new technologies that result from scientific research. Similarly, STS scholar Joanna Goven described how one consensus conference experiment offered a version of scientific citizenship that was ultimately constrained by its neoliberal framing. Citizens were not allowed to contest the basic principles of this ideology, on which the imagination of technological development under debate was based. It is therefore vital, she writes, for scholars of public engagement with science to 'examine whether the neoliberal context has foreclosed public contestation of key political choices'.[7]

In contrast, Árnason argues that the other key focus has been to emphasise a much more active version of scientific citizenship inspired by deliberative ideals (which we discussed in Chapter 2). This work has argued for greater public participation in science and views citizens, he writes, as 'motivated, informed and able to critically reflect on their society and willing to participate in processes of public deliberation'.[8] It is optimistic about the potential of public engagement and deliberation to create new kinds of knowledge and to help with the governance of science. Here, then, the promotion of scientific citizenship is about enhancing the capacity of citizens for active engagement in scientific governance and ensuring that state institutions and governance processes are responsive to such engagement. Although there has been plenty of critique of the ways in which such engagement is put into practice, this strand of research continues to view scientific citizenship as essentially active. In this approach, scientific citizenship is not something that is imposed on you, but a practice of interrogating and actively engaging with science that you choose to take on.

This emphasis on active scientific citizenship is derived in part from a history of public resistance to particular technologies in which it is very clear that citizens are actively negotiating, and contesting, how science is developing. We covered some of this history in Chapter 2, when we discussed public scientific controversies as part of the backdrop to contemporary science communication. In the introduction to a 2002 edited collection, *Biotechnology: The making of a global controversy*, Bauer and Gaskell write that:

> In the course of its twenty-five-year development: first, biotechnology regularly presented challenges to observers within the public sphere; and, second, these observers at times responded with counter-challenges or resistance that contributed to shape the continued development of biotechnology itself.[9]

The book is an effort to investigate how public counter-challenges—'resistance' to emergent biotechnologies—could influence the life sciences. It draws attention to resistance as an important aspect of public understanding of science. As research has repeatedly shown, public discontent with technology is not just about poor understanding; rather, it serves an important political function, signalling that—in the view of those resisting—there is something wrong with technological development. For Martin Bauer, public resistance to science or technology is therefore functional. Like pain, it signals that 'something is wrong' and that 'urgent attention, elaboration, and response' are required by political authorities.[10] In this way, resistance is seen as beneficial for the entire social system because it contributes to improved technological development. It offers the possibility of institutional, organisational, and social learning in order to create better and more sustainable futures.[11]

The idea that public scepticism or resistance can serve a positive role in scientific citizenship is also found elsewhere. In a report on lay participation in expert advisory committees, Stilgoe and colleagues summarise their ideas in a front-page quotation: 'The challenge is to embrace different forms of expertise, to see them as a resource rather than a burden[12]'. Such thinking emphasises that scientific expertise is not all-encompassing or self-sufficient. It does not cover all of the kinds of knowledge that are important for technological development, and therefore should be supplemented with other perspectives, even (or especially) if those perspectives resist the values, interpretations or predictions of technoscience. An important argument for engaging citizens in discussions of scientific and technological development has thus been the idea that it will ultimately benefit this development (what Daniel Fiorino has called the substantive argument for public participation).[13] Public resistance and scepticism can provide crucial information about the values and preferences of citizens, users, and consumers. Integration of these perspectives into sociotechnical development is therefore important in terms of both legitimacy and efficiency, and public criticism and debate is a *resource*, rather than a problem. Resistance is simply one way that scientific citizens may get involved in the governance of science. Formal public participation is another.

Scientific citizenship and citizen science

Scientific citizenship may therefore be expressed through public activism and resistance, formalised public participation in scientific decision-making, or a more passive co-option into an understanding of the citizen as a consumer of technoscientific products. Most recently the notion of 'citizen science', in which laypeople are able to directly participate in scientific research, has also risen to prominence. Although the term 'citizen science' has been around for some time—and was the specific focus of a 1995 book, *Citizen Science,* by Alan Irwin—its meaning has shifted over this period. Originally used in Irwin's book to evoke a 'science which assists the needs and concerns of citizens' and which might be carried out by laypeople drawing on their own knowledge and concerns,[14] citizen science today takes a number of different forms. Some use the term to refer to activist-driven, grassroots research. Gwen Ottinger, for instance, describes research carried out by social movement and civil society groups—such as 'bucket monitoring' of air quality—as citizen science, viewing this as a way in which citizens can draw attention to issues they care about but which may be ignored by institutional science.[15]

In many citizen science projects, however, the emphasis is more on the needs of science and scientists than on citizens' concerns. For ecologist Jonathan Silvertown, a citizen scientist 'is a volunteer who collects and/or processes data as part of a scientific enquiry'[16]. Such activities might include looking through images from the Hubble telescope to classify galaxies, monitoring the wildlife in your garden, or reporting on the state of your health during the flu season.[17] In these contexts, citizen science is about harnessing the enthusiasm, time and energy of interested non-scientists. Although amateur naturalists and astronomers have existed for as long as their professional counterparts, citizen science projects offer them an opportunity to contribute to the development of scientific knowledge stamped with the authority of 'real' science. Citizen science may also refer to projects that build on public participation and engagement, using techniques taken from deliberation or dialogue to enable laypeople to set priorities for, and directly participate in, the practice and agenda-setting of science.

Citizen science is therefore highly diverse.[18] Teresa Schäfer and Barbara Kieslinger suggest that projects and activities which use this label can be categorised according to two axes. One charts who are the key knowledge producers within the project: is it professional scientists (with citizens acting as data gatherers or assistants), or is it citizens who define and answer the research questions? The second moves from the focus being on answering scientific questions to intervening in particular real-world systems (trying to improve air quality, for example, or preserve a certain natural environment). The version of citizenship that may be mobilised in any particular citizen science project, then, may vary from simply collecting data under close instruction to developing original scientific research that seeks to meet particular needs. As such, citizen science offers one example of the fact that what it means to be a 'scientific citizen' is contingent on circumstance. Another is that when laypeople are asked to debate their role in governing new technologies they often say that this depends on the nature of the technology in question. How actively they want to engage with shaping scientific priorities and directions is related to their thinking on the technology's political, personal and economic salience.[19] Any instance where science interacts with society is likely to involve implicit assumptions about things like how science should be governed, the role of the state, and how non-scientists should be involved, and these assumptions will vary from case to case.

Within both theoretical and empirical accounts, scientific citizenship is something that is not stable or fixed. It can be passive or active, resistant or collaborative, affectless or passionate. As we saw in the previous chapter, it will also be produced in conjunction with particular emotions and material configurations. Citizenship will be affective and embodied as well as discursive. We would therefore argue that a broad understanding of the concept of scientific citizenship is most productive. To us the term designates the constitution of a meaningful relationship, focused on inclusion through political involvement or collective decision-making, between citizens and collective entities (such as the state or the science). Exercising scientific citizenship thus covers more than deliberative participation. Scientific citizenship is instead produced and negotiated within any space in which science is collectively encountered and its governance or direction debated. It is more about a general orientation to inclusion and democratic decision-making than a fixed set of participatory practices. In short, scientific citizenship is about how we co-exist and act together in the contemporary world.[20]

Science communication offers many ways of establishing relationships between citizens and science that can form the basis of such inclusion and political involvement. We believe it offers opportunities to develop practices of citizenship that are active as well as passive, critical as well as appreciative, and outward looking as well as focused on personal experience. This is important because of the sheer numbers of people who engage with science communication. To take the UK as an example, in 2014, some two-thirds of the population watched programmes including science on TV, while over 3 million people visited London's Science Museum.[21] Many, many people encounter scientific knowledge through science communication, and articulations of scientific citizenship will be shaped by these encounters. One challenge for science communication research is to explore how science communication might contribute to active forms of scientific citizenship, as well as to personal projects of enjoyment or education. In what follows we offer three different ideas as to how this might be done. We draw on aspects of political and social theory that have intrigued and stimulated us, and suggest ways in which they might be used as resources for thinking about science communication.

Science communication as capacity building

The consumption of science communication is often an informal and personal activity. If we consider the formats and activities present within ecosystems of science communication in modern knowledge societies, many of them seem to involve public consumption of scientific knowledge in rather private, personalised ways: reading science magazines, attending a science festival, visiting a sci-art exhibition, looking at a university webpage. Unlike, say, being a member of a citizens' jury or consensus conference, these kinds of activities rarely have links to formal government or scientific policymaking. Although state institutions may choose to fund science communication activities such as science cafes or museums, there are only occasionally opportunities for participants in those activities to question, comment on, or impact those state institutions.[22] Participants (and especially lay participants) are effectively separated from the institutions of governance even as they take part in activities that might be government funded or supported. Because of this, it is easy to see science communication activities as promoting a rather passive form of scientific citizenship.[23]

But this is a rather limited notion of citizenship—one in which a good citizen needs to participate *directly* in governance (through deliberative processes, for instance, or by lobbying for causes they believe in). In contrast, and using the notion of 'civic capacity', many theorists of democracy have argued that plenty of other activities—including participation in voluntary organisations (like helping out at a charity shop), social groups (being part of a bowling team), or local administration (being on your apartment building's residents committee)—are valuable in democratic societies. Civic capacity, says public policy scholar Kelly Campbell Rawlings, involves 'the development of certain skills, knowledge, and efficacy … that make [citizens] more inclined towards and capable of continued participation'.[24] By being involved in civic life, citizens may experience personal effects—such as a more clearly defined sense of identity or purpose—or may gain a better understanding of politics and public life. They may be motivated towards particular actions they feel are in the public good, be equipped or empowered to get more directly involved in politics, or develop skills, such as debate or administration, that enable them to have a voice in contexts in which they were previously silenced. They may also forge connections with like-minded individuals or find networks through which their concerns can be brought to wider attention.

Rather than aiming for a direct impact on science policy and seeing scientific citizenship as needing to involve active participation in democratic decision-making, we can understand citizenship as a capacity which can be nurtured through all kinds of different activities. Here we are in line with Leach and Scoones, who end their discussion of science and citizenship by arguing that the practice of citizenship is 'also a learning process that creates and enhances citizenship capabilities'.[25] In studying science communication, we therefore might consider how involvement in science communication enhances particular civic capacities. For instance, running a science cafe might help develop skills and networks that allow you to be a more effective political actor; reading science news may alert you to issues about which you want to protest or debate; attending a debate at a science museum could train you as a deliberator and empower you to make your opinion heard.[26] There is scope for science communication to be understood as a practice through which scientific citizens are developed. At the very least (as the original arguments for PUS would have it), citizens can become informed and perhaps empowered to bring their voice to other, more formal, debates and discussions.

Understanding science communication as something that may develop the civic capacities of citizens introduces a new frame for both analysis and practice. It encourages us to be more concerned with the wider impacts of participation in science communication. While studies of the impacts of engagement with science communication often focus on things such as learning, attitudes towards science, or interest in finding out more about a particular field, reframing science communication as capacity-building suggests we might also want to investigate changes in audiences' civic and political lives.[27] Do those who organise and participate in science communication view it as a resource for their public lives, and if so, how are these civic capacities developed with regard to science? This further relates to the view, emphasised in cultural theory (and discussed in Chaps. 1 and 7), that consumption is always an active process of meaning-making, never something that is passive or straightforward. Reading a popular science book, attending a public lecture, or engaging in activism on a technoscientific issue may all contribute to the collective interrogation and discussion of science that we think comprises scientific citizenship. One challenge for science communication scholarship is thus to parse out the ways in which this occurs.

Futurescape City Tours

The Futurescape City Tours (FCT) project is one example of science communication that seeks to build capacity for scientific citizenship. FCT was led by Arizona State University's Center for Nanotechnology in Society (with funding from the US National Science Foundation), and, when it was first carried out in 2013, involved a large-scale, national deliberation on the use of emerging technologies in urban environments. The project aimed to develop new methods to deliberate technological futures. It drew on thinking from deliberative theory and sought to correct some of the problems inherent in much public engagement on science. For instance, the FCT deliberative process began with an orientation session in which citizen participants could voice their interests and concerns, and these were then used to shape the rest of the process, rather than particular issues being pre-selected and imposed on the discussion regardless of citizens' interests. It also used methods that went beyond the discursive, asking participants to walk around their cities and to use photography to document what they noticed as they did this. The project, which was initially carried out in six cities across the US, developed a guidebook so that the method could be used in other places and contexts: possible users (the guide suggests) might be a local council, urban planners, or a science museum.[28]

A FCT has three stages. In the first, interested citizens are invited to meet together and share some of their thoughts and concerns about the city they live in (the *orientation*). The second stage is the *tour*, in which, based on the discussions in the orientation, participants are guided around a number of key locations (which might be anything from canals to farmers markets or university laboratories) and meet relevant experts and stakeholders. As they do so they are asked to record their impressions by taking photos: the aim is to encourage a different way of looking at the city, and to use photography to reflect on its past, present and future. Finally, the *deliberation* session involves an examination and discussion of the photographs that participants have taken, which are used to provoke debate about the directions the city is developing in and how participants feel about this. At the end, they are encouraged to continue their involvement in investigating and debating the issues that have arisen.

The FCT project is therefore an interesting resource for those interested in carrying out science communication or public deliberation, offering some new ideas on how to do these things. In the context of this chapter, however, it is particularly striking that the organisers of the project are ambivalent about its use with regard to policy. Certainly, it could be used to inform decision making, for instance in urban planning. But Cynthia Selin—the lead on the FCT project—and her colleagues also see it as a means of building capacity for scientific citizenship. FCT, and other forms of engagement like it, are valuable, in other words, if they help equip participants for communal life generally—not only if they have discrete and identifiable effects on political processes.[29]

A systemic approach to deliberation

Thinking about science communication as a means of capacity-building for scientific citizenship also dovetails with recent deliberative theory. As we discussed in Chapter 2, deliberative theorists have modelled and then put into practice mechanisms of governance that act as an addition to representative democracy by directly involving citizens in discussions on policy issues and decisions. In these activities—formats have ranged from consensus conferences on scientific issues to large-scale citizens assemblies or small deliberative workshops—the key aim has been to enable *deliberation* as a mode of interaction, where deliberation is discussion that is free, reasoned, and equitable.[30] Another concern has been to ensure the legitimacy and accountability of a deliberative process, for instance by assembling a 'representative' sample of a wider population as deliberators.

One recent development in deliberative theory relates closely to an understanding of science communication as building capacity for scientific citizenship. This work, which explores the notion of a 'deliberative society', suggests that deliberation should be conceptualised not as taking place within discrete 'mini-public' formats—such as the consensus conferences or deliberative workshops mentioned above—but at the level of whole societies. This approach, put forward by political theorists Jane Mansbridge and John Parkinson,[31] requires a change in perspective. Rather than designing one-off formats for deliberation, or examining particular examples of deliberative processes for how they match up to aims of fairness, legitimacy, and impact on policy, the focus becomes how deliberation is achieved throughout societies as a whole—how different moments of deliberation are articulated in different contexts, and how these connect. Deliberation, which can often be talked about as a kind of mythical panacea for social and political conflict, is now framed as something that is less a single, perfect moment of interaction and more an ecosystem of many flawed and incomplete moments.

Mansbridge and Parkinson and the others who have written about this systemic approach to deliberation are still committed to a model of democracy in which deliberation is key. They still think citizens should deliberate and that their participation in deliberative debate leads to better political outcomes. But their work takes the burden of this off of individual deliberative processes, which can rarely live up to the standards placed on them. No one moment of deliberation, wherever that occurs, should have to be perfectly representative, perfectly fair, or perfectly effective. These capacities should instead be spread throughout a deliberative system as a whole, where this system is understood as diverse with regard to formats and spaces but unified around a particular issue (say, healthcare reform or research priorities in nanotechnology). Importantly, in this model, moments of deliberation may take place in all kinds of different sites throughout a society, not just in formal deliberative processes or in parliamentary debate. 'A map of nodes in the deliberative system', Mansbridge and her co-authors write, 'would reveal many nodes, with multiple forms of communication among them'.[32] They continue by listing some of these nodes—a long list, but one that it is worth quoting in full here as it gives a flavour of just how complex such a network of deliberation may be:

> Those nodes would include nation state bodies at different levels of government and with their different legislative houses, administrative agencies, the military, and the staffs of all of these; international bodies at different levels and their staffs; multinational corporations and local businesses; epistemic communities; foundations; political parties and factions within those parties; party campaigns and other partisan forums; religious bodies; schools; universities with their departments, fields, and disciplinary associations; unions, interest groups, voluntary associations and non-governmental organizations (NGOs) both ad hoc and long-standing; social movements with both their enclaves and their broader participation; the media including the internet, blogs, social media, interactive media, books, magazines, newspapers, film, and television; informal talk among politically active or less active individuals whether powerful or marginalized; and forms of subjugated and local knowledge that rarely surface for access by others without some opening in the deliberative system.[33]

Thinking of deliberation as an ecosystem rather than the product of a single process or a forum therefore gives political theorists a much more generous vision of where productive, deliberative talk may take place. Just as with thinking on civic capacity, it enables us to think about citizenship as something that can be performed in many different kinds of spaces.

'Deliberative moments' (to use Parkinson's language) are all valuable, valid means of acting as a citizen, whether they occur at the kitchen table, as NGOs lobby governments, or in parliamentary debate.

In the context of science and science communication, a systemic approach to deliberation again allows us to think about active scientific citizenship as dispersed throughout all kinds of spaces and situations, and as taking place outside as well as inside of formal participatory processes or policy decision-making. Mansbridge and Parkinson are rather generous in what they allow to be a deliberative moment: these should be discussions that 'involve matters of common concern and have a practical orientation' (by the latter they mean oriented towards some variant of the question: 'what is to be done?').[34] Such interactions will occur in many instances of science communication: we can imagine such discussions taking place between visitors to a museum gallery, at a dialogue event, in the comments below an online article, or as a family discuss a health information leaflet they have received in the post. The notion of deliberation as an ecosystem thus opens up new ways of noticing and valuing moments in which scientific citizenship may be performed within the production and consumption of science communication.

This systemic approach to deliberation again gives us a new frame through which to imagine and analyse science communication. Moments of consumption and production can be studied as parts of a wider ecosystem, not just of diverse science communication formats but of a network of political debate on a particular technoscientific issue. If we are concerned with the question of how and when science communication nurtures scientific citizenship, Mansbridge and Parkinson's work gives us one tool for analysing this. We might take, for instance, a single issue—nanotechnology, or fracking, or new genetic technologies—and follow this issue to track where it is being deliberated, and in what ways. What science communication activities are supporting such deliberation, how do moments of deliberation connect to one another, and what is lacking within this ecosystem of debate? By reflecting on such questions, practitioners interested in supporting scientific citizenship can gain inspiration for the kinds of formats and debates that might aid societal deliberation. Similarly, this framework gives scholars a way of studying science communication as a part of democratic society by allowing them to investigate how 'matters of common concern' with 'a practical orientation'[35] are articulated within instances of science communication. Are science communication activities concerned with 'what is to be done' about scientific topics, or do they close down, rather than open up, moments of deliberation?[36]

Scientists as Citizens

Scientists are also citizens, and the idea of scientific citizenship has also been applied to their activities. What are scientists' responsibilities as citizens of contemporary knowledge societies? One answer to this question has emphasised the need to open up scientific research through processes of 'responsible innovation'. 'Using processes of foresight, public engagement and interdisciplinary collaboration', writes Jack Stilgoe, 'Responsible Innovation asks scientists, funders and regulators to reflect' on 'the products, processes and purposes of their research'.[37]

Some of our research has involved talking to scientists to try and understand whether (and how) they felt they were responsible to the societies that funded them.[38] We asked them, for instance, what they thought it meant to behave 'responsibly', and how this affected their everyday work. We were particularly interested in whether they'd heard about calls (such as the one above) for scientists to engage in dialogue and let their scientific priorities be shaped by public values, as well as how they interpreted and put into practice such calls.

Most scientists we spoke to hadn't heard about these policy discussions.[39] But this didn't mean that they didn't have quite strong personal commitments to carrying out what they saw as the 'right' kind of science, and behaving responsibly in their research. In some ways, they had rather similar concerns to the policy makers and social scientists who argue for the need for scientific responsibility—but there was a difference in the scale at which they saw this responsibility being enacted. Calls for responsible innovation or public deliberation tend to focus on societies as a whole, or perhaps particular disciplines or technologies: science should be responsive to society; controversial technologies should be publically debated; science policy decisions should be aided by public engagement. But these kinds of policy-driven debates seemed rather abstract to the scientists we spoke to. Instead, they saw their responsibilities as focused on the research groups that they managed (we talked to established scientists working at the 'Principal Investigator' level, who had their own labs or groups staffed by students, post-docs and other technical and scientific staff). Most scientists felt that their primary responsibility was to look after the group and the people who worked in it. By taking care of these people—for instance, by helping them with their careers, supporting them through the ups and downs of research, and ensuring they had the training and experience they needed—they would ensure that their other key responsibility was met: the group would produce good science. Potentially, this science would have useful impacts on society, leading to new technologies or particularly important kinds of knowledge.

At the same time, many scientists did also talk about having a duty to communicate their research to the public. 'It's their knowledge, right?' one told us, explaining that as his research was funded by the taxpayer he felt it needed to be publicly accessible. Most of those we spoke to had taken part in different science communication and outreach activities and felt that it was at least theoretically important to do so. So scientists do feel that they have responsibilities to society, particularly as recipients of public funds—it's just that those responsibilities are experienced as vague and peripheral compared to the more urgent task of looking after the people and science they are directly responsible for.

The dynamics of power

The final line of thought we want to suggest for thinking about science communication and citizenship relates to a central theme in STS scholarship: power, and how it is negotiated. We do not understand power as something static. Instead, we think that scientific citizenship needs to be understood as a fluid capacity, one that is continually in progress and which is negotiated moment by moment. Power is one aspect of this: the ways that users of science communication are told to 'behave' and how they resist or 'misbehave', how actors have voices within the structure and content of communication, and how roles are or are not ascribed authority and credibility. But configurations and regimes are continuously in flux. Power is a temporary achievement, and one that is constantly under negotiation.[40]

This understanding of scientific citizenship is perhaps less a research agenda and more a style of thought. It is about acknowledging the complexity and contingency of any instance of science communication. At the same time, it is an important addition to any thinking about scientific citizenship. Power *is* at issue within interactions between science, technology and society. We therefore need to make sure that questions of power do not vanish from our efforts to analyse science communication.

Power has been an implicit theme of much STS research on science and society. Concerns about democratisation stem from the sense that science has had too much power, and too little accountability, in many societies. Not only this, but many scholars have pointed out that there are various interests at stake in the promotion or sidelining of particular forms and views of scientific knowledge. We see this very concretely in controversies over big business funding of science communication. There have been protests and interventions in museum galleries sponsored by the oil industry[41] and science fairs with ties to arms manufacturers.[42] When science communication comes with corporate branding, can you be sure of its content? Thinking about science in society thus needs to acknowledge that different actors may use science to shore up their authority or to promote their own interests—and that science communication may well be part of that. The science policy scholar Andy Stirling has been particularly concerned with these questions of power and control: even in the age of participation and public engagement, he argues, agency is constantly being siphoned away from publics and fixed in already powerful actors (like corporations) or, even worse, simply attributed to technology itself through implicit models of technological determinism (technology takes on a 'life of its own', and is essentially ungovernable).[43] There are always power dynamics at work in participatory and deliberative processes. '[I]ncumbent interests', writes Stirling, of public participation in science, 'by definition enjoy privileged economic, cultural, and institutional positions … it is typically difficult to exclude the possibility that design, conduct, or interpretation of participatory appraisal are subject to implicit, but potentially powerful, conditioning pressures'.[44]

Power is at stake within science communication and in the articulation of scientific citizenship, then, and there are important questions to be asked about how it is expressed and negotiated. This is a complex issue. According to Stirling, power 'may often simply operate through unconscious anticipation of possible actions by powerful actors',[45] and may therefore consist not of force or coercion but of a much vaguer desire to please those we view as powerful. One question researchers of science communication should ask is: what interests are threatened or supported in different instances of science communication? How, in practice, is power articulated and resisted in forms such as science writing, face-to-face events, or museums? But it is also important to see power, and the dynamics around it, not as a straightforward matter of imposition and resistance but as a fluid *process*. Power is not simply present, but is always produced, and its actions and effects are not necessarily under the control of individual actors. It is this aspect of power that brings us again to an understanding of scientific citizenship as dynamic rather than fixed.

This also builds on the work of Mike Michael, and others, who have emphasised the emergent nature of science communication. Just as Michael has argued that, in science communication, 'science' and 'the public' are not discrete sites but should be seen as fundamentally interconnected, taking the form of heterogeneous, rhizomic interactions (see Chapter 2),[46] he has also suggested that this complexity is temporal as well as spatial. Actors involved in science communication are not stable, but in a process of becoming; their involvement in that communication will change it into something slightly different. Hence the emphasis, in STS, on science and publics as *co-produced* by science communication. They are not fixed categories but take their nature from their involvement with each other. Michael has used the notion of 'event' as a way of expressing this. The event 'is characterised by the fact that the interactions of its constitutive elements change those elements'.[47] Those elements—the consumers, producers, organisers, objects, and materials of science communication—are not already-fixed entities which happen to come together in a particular configuration within science communication; rather, they 'become together', taking on slightly different characteristics (or perhaps being produced from scratch) as a result of their entanglements.

Where does this leave us? The point is not that we need to deconstruct every moment of the science communication that we study, or that we can never talk about power as focused in particular actors or sites. Rather, it is to encourage us to keep in the back of our minds a version of science communication and the power that is worked out through it as processual and dynamic. Notions such as the event help us to remember to notice the unexpected, rather than letting ourselves be constrained by a methodological approach or a set of theoretical assumptions. Scientific citizenship, whether that is performed through participating in dialogue events, running a science cafe, or talking about scientific topics over lunch, will be unstable, appearing different depending on the context and the affordances of a situation. As an analytical tool this therefore encourages us to be aware of the contingencies of any moment of science communication practice, and the changing form that active scientific citizenship may take.

To return to the ESOF Science in the City festival, we might imagine a university scientist wandering through the event. At one moment she might be carrying out a demo at a stand run by her department: she seems to be in control of her audience as she explains her science and instructs volunteers, but she is also aware that a PR officer from her faculty is watching and wants to make a good impression on him. At another moment, she visits another stand, reading about research in a different discipline and thinking about how it relates to her concerns about the government's stance on environmental pollution. And at yet another moment she goes into a workshop run by activists and sees them working with hacked, low-tech versions of the laboratory equipment she also uses in her research, but following their own interests and purposes rather than those of institutional science. How she exercises scientific citizenship, and the power that she resists and takes on, is therefore constantly in flux. Drawing questions of power into our analyses of science communication can help us notice these kinds of dynamics and understand how scientific citizenship may be articulated and expressed at different moments.

Sponsorship, PR, and the Big Bang Fair

Investigating power can lead us to look at the role of money and special interests in science communication. The UK's Big Bang Fair is an annual event, first run in 2009. It is, its website says, 'the largest celebration of science, technology, engineering and maths (STEM) for young people in the UK'. In 2015, some 70,000 visitors attended, many as part of a school group. It takes place in a cavernous convention centre and features everything from live science shows—explosions, explosions, and more explosions—to a woman-oriented 'STEMettes' hackathon. A large part of its content is similar to a traditional convention: visitors can browse stands and stalls hosted by a diverse mix of institutions (universities, learned societies, the UK Army), businesses (Siemens, L'Oréal), and more homespun science communication groups and projects (maths buskers, something called the Rowland Emmett Society, which seeks to preserve the work of the designer of the *Chitty Chitty Bang Bang* car). The website talks about demonstrating 'how exciting engineering and science can be, as well as highlighting the career possibilities that exist for young people with science, technology, engineering and maths backgrounds'.[48]

There are similar science fairs and festivals all over the world encouraging young people to get involved in science and technology. But in recent years the Big Bang Fair has become more and more controversial, at least within the community of UK science communication practitioners. There are a number of reasons for this. Some groups commented that it had become too expensive for them to participate—the fair was free for visitors, but there was a fee to run a stand which was often prohibitive if you were, for instance, a university or non-profit group with no dedicated funding for PR.[49] In 2014, the researcher and activist Hamza Hamouchene also started a petition[50] calling for the Fair to cut its ties to arms manufacturers. Companies such as BAE, Rolls-Royce and Doosan were key sponsors of, and very present at, the Big Bang Fair. Hamouchenen and others argued that they were provided with a platform to promote their activities without any space for debate about the way they used science and technology (including ethical and human rights breaches in their activities).[51] Finally, others argued that the event was, as it became larger and more professional, now led by PR and branding rather than science communication or education per se. 'PR-led science communication is always partial', wrote science communication researcher Alice Bell in the Guardian, after visiting the 2014 Fair.[52] 'Whether talking to a university, a learned society, a research council, an engineering firm or the armed forces, I felt spun'.

These controversies are fascinating for a number of reasons. The Fair demonstrates the degree to which science communication is becoming professionalised—both the Fair itself and the activities it hosts are generally run by a cadre of professional, full-time communicators, alongside a second tier of carefully organised volunteers with a STEM background—as well as the way in which it is entangled with PR for businesses, universities, disciplines or professions. But it also brings to the surface the degree to which power is at stake in science and science communication. Critics of the Big Bang Fair's approach pointed out that it seems to be in thrall to the views and interests of elites. In accepting so much funding from big business, it runs the risk of cleaving to their perspective on science, presenting an imagination of the aims and possibilities of STEM that is 'mainly determined by narrow powerful interests such as the largest industrial corporations and the military', as Stuart Parkinson, the Director of Scientists for Global Responsibility, has written.[53] On the other hand, as STS scholar Beverley Gibbs pointed out, these groups *are* some of the largest funders of science and technology research: science has always been driven by industrial and military interests, so maybe the Fair is just giving school students a realistic sense of who they're likely to be working for if they train in STEM subjects.[54] In other words, it's not just the Big Bang Fair that is in thrall to the power of big business and government—it's all of science.

Performing scientific citizenship through science communication

We have taken scientific citizenship to designate the relationship between a state and its citizens in the context of science, and suggested that the relationship should be inclusive, open, and interactive. Citizens should not only be prepared to engage with, but also be able to influence, the progress of technoscientific development in the states of which they are members. But we have argued that this process of engagement and influence might be established in many ways. Scientific citizenship does not necessarily have to involve formal governance mechanisms, such as voting in elections or taking part in deliberative policy-making processes, though of course these things remain important. It doesn't have to look especially 'political'. Instead, we have suggested that scientific citizenship is distributed throughout society, and that it can be performed through various forms of science communication. Even science communication formats that look leisure or entertainment-oriented—reading a science magazine, running a science cafe, visiting a museum—can be experiences that are used in one's engagement with civic life.

We also concluded by focusing on power. This is important: it is a key reason for discussing the notion of citizenship at all. Science communication, we think, should aim to *empower* citizens. It can and should equip them to perform citizenship—whether that involves deliberating new technology, protest and resistance, or understanding state funding of science. However much we want people to engage with science and technology, there are often good reasons for them not to do so. They might feel that it is not relevant to them, that they have more pressing concerns, or that it is simply pointless for them to try and influence science policy or agenda-setting. This is why public controversies and resistance to science remain so important: these are instances where laypeople do actively engage, aiming to influence the state's position on a particular scientific issue. Science communication research, we think, can only gain from paying attention to such instances and to other ways that citizenship is or is not expressed and nurtured within public communication.

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9

Deficit and Dialogue: Reframing Science Communication Research and Practice

Science communication can take many forms. It may involve universities trying to promote their brand, harried parents taking their families to a science event, efforts to enable laypeople to participate in science policymaking, researchers giving public lectures at learned institutions, or social media storms around scientists' public missteps. Science communication is present in multiple places in our societies, and it is as rich and variegated as that frequency and multiplicity would suggest. Taken together, it is a riot of colour, strategies, emotions, sites, visions, objects, and meaning-making.

This richness of science communication—that it takes numerous different forms, many of which deserve more attention in future scholarship—has been one of our key themes throughout the book. Another has been its complexity. We have argued that science communication is much more than the effort to make difficult things simple, or the transmission of scientific knowledge to non-scientist audiences. There is always more going on around science communication than someone understanding a scientific message or not: identities and wider meanings are always at stake. Science communication may involve emotions such as interest and wonder, or the experience of learning something new, but

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it may also help constitute one's identity as a scientific expert, develop a career as a communication professional whose vocation it is to recruit students to science, or cement social relations between a group of friends who together choose to opt out of the role of attentive audience. Science communication is about science, certainly, but it is also about who we are, whether 'we' means scientists, universities, whole societies, or other kinds of group.

One thing we would like readers to take from this book is the multi-faceted nature of this thing we call science communication. We want this richness to influence our thinking about science communication forms and formats, and producers and consumers, and the way we study them. Science communication is not a linear narrative or something that can be modelled in a diagram with a couple of arrows: it is a jungle, full of colour and smells and different kinds of beast and strange things lurking in the shadows. Or, as we have suggested, it is an ecosystem, where there are many and various forms of life, interacting with each other through multiple means. We have also suggested that no single analytical or theoretical approach can do justice to this diversity. No one methodological lens can be used to look at every kind of science communication from university PR to science theatre or science blogging. Instead, scholarship of science communication needs to draw on different disciplinary and conceptual traditions and resources. In this book we have tended to draw most from STS, organisational theory, and political science, but this reflects our own backgrounds and inclinations and should not be seen as definitive. Just as we need to make sure our vision of science communication includes all the different forms it takes, and all the different actors involved, we need to enlarge our toolkit of the resources we use to study these.

Key themes and ideas

The rest of this chapter offers a more reflexive discussion about scholarship on science communication and the kinds of future discussions that we would like to take part in. Before we do this we want to recap the ideas that have been particularly important in the preceding chapters.

The first key idea, developed in the initial two chapters, has already been summarised in the paragraphs that start this chapter. Essentially, this is that there is a lot more going on in science communication than we might think. Contemporary practice is shaped by multiple histories and contexts. Communication is always more complex than the transfer of information.

The second idea is that we need to move away from thinking about individual scientists, representing themselves as individuals, as the key actors in the production of science communication. Chapter 3 suggested that scientists always act as representatives of particular collectives when they participate in science communication. Their communication is rarely just about transferring knowledge, but about their identities as representatives of disciplines or of science as a whole, their relationships with universities and other research organisations, and the multiple cultures of science they may feel allegiance to. In Chapter 4 we explored the professionalisation of science communication, noting that professional communicators are on the rise inside and outside of research organisations. This professionalisation should be a topic of study in and of itself: by moving away from a model in which scientists are the primary producers of science communication, we will be able to notice burgeoning industries of science communication, the norms and values of the wider science communication community, and the many actors outside of universities and university scientists now involved in science communication.

The third key idea has been that the changing nature of knowledge production is re-shaping, and being re-shaped by, science communication. This is, of course, one driver behind the professionalisation of science communication: universities increasingly delegate communication tasks to specialised professionals, while the sense that we are now living in a 'knowledge society' has led to heightened governmental demand for scientifically literate publics and a steady supply of trainee scientists. Chapters 5 and 6 considered the way in which the marketisation of public research and the development of 'academic capitalism' has affected both the kinds of stories that are told in science communication and the way in which that communication is organised. Research organisations now need to develop a strong brand and clear messaging, and increasingly use strategies—and professionals—from corporate communication to do so. On the flip side, and discussed in Chapter 6, the stories that are told about science act to create visions and expectations about future societies and work to shape the present by doing so. Science communication is often innovation communication: it describes, and is therefore part of making real, new technologies, emerging lines of research, and imaginations of future products and the people that use them. As we have seen throughout the book, science communication is not innocent, but helps constitute our societies and our roles as citizens within them.

The fourth idea, which first appears in Chapter 2 and is developed further in Chapter 7, is that we need to pay more attention to the non-discursive within science communication. Communication, we argued, is the constant, interpretative production of meaning. It is something that is embodied, and that is as reliant on material infrastructures and networks as it is on language. In the context of science communication this means that we need to think more about the role of images, spaces, objects, and emotions in structuring experiences of communication. By focusing on talk and text we run the risk of missing many of the meanings that develop within instances of science communication—including things such as boredom, misbehaviour and unauthorised uses of communication products. These may be interpreted as 'failure', but offer important insight into the complex ways in which science communication is used by both its producers and consumers. Noticing the non-discursive can help us identify what is at stake in different instances of communication, for instance by drawing our attention to social processes such as identity construction or the way in which science communication may be used to meet particular emotional needs.

Our final theme has been democracy. In arguing for an understanding of science communication as a rich and diverse ecosystem, we are in many ways arguing for an expanded vision of it, one which can acknowledge the very different diverse purposes and uses that particular instances of communication might have. But that does not mean we want to abandon normativity altogether or are only interested in analysing science communication as an aesthetic experience or an organisational problem. In Chapter 9 we suggested that science communication has an important role to play in scientific citizenship. If the distribution of goods and wealth was a key focus for political struggle in industrial societies,[1] the distribution of, control over, and ability to use technoscientific knowledge can be seen as a key political struggle in a knowledge society. Science communication is thus a crucial tool for inclusion and for ensuring that the ability to understand, evaluate, control and use technoscientific knowledge is shared throughout society. Although scientific citizenship may be expressed in many different ways, it is important to view science communication as a part of this, and as something that can play a role in wider dynamics of public concern, resistance, and appropriations of scientific knowledge.

The deficit to dialogue narrative

In at least one way, we have tried to write this book in a non-traditional way: we started the first chapter by presenting our conclusion, which was that science communication should be analysed as a cultural phenomenon. Chapters 2–8 were an attempt to flesh out what such an approach might look like in practice and to explore different conceptual resources that might help us notice moments of consumption, regulation, representation, production and identity-building. In the same way, this concluding chapter is not an effort to draw all of the previous chapters together. Rather what we will offer are some thoughts about the way in which science communication should move forward as a field. In doing this we want to take our point of departure in the 'deficit to dialogue' narrative we introduced in Chapter 2 as one aspect of the recent history of science communication.

As Brian Trench has argued, this narrative has been a foundational story used in many ways by people in the field to give an account of what the field is. It has been used to produce identities as science communication scholars and practitioners, just as it has been used as a description of the normative foundation for production and regulation of science communication. It is a triumphal story; one of progress and enlightened development. Science communication, Trench writes:

> has been telling a story of its own development, repeatedly and almost uniformly, for almost a decade. The story is a straightforward one: science

> communication used to be conducted according to a 'deficit model', as one-way communication from experts with knowledge to publics without it; it is now carried out on a 'dialogue model' that engages publics in two-way communication and draws on their own information and experiences.[2]

The story of science communication's move from deficit to dialogue has thus been used as an influential, and convenient, shorthand for thinking on public communication of science in scholarship, teaching, and wider communication about the field (e.g., to policy makers). In writing this book we have, however, made efforts to push this narrative into the background for much of the time. In this final chapter, we want to offer some reflections on why this is. The intention of this discussion is to open up scholarly thinking and to point to the need for fresh analyses, new concepts, and other forms of modelling and theorising. While 'deficit to dialogue' as a historical description and normative frame might have served as a useful tool in the professionalisation and coherence of science communication as an academic field, we think that it now imposes restrictions on how this field can develop. In arguing this we are building on the work of many others who have noted the problems with 'deficit to dialogue' as an explanatory device for the study of science communication, including Mike Michael, Brian Trench, Alan Irwin, Massimiano Bucchi, and Ulrike Felt. We are, then, using the work of these and other scholars to continue suggesting alternative ways of talking about our field.

In what follows we will try to flesh out some of these limitations and point to ways of thinking that we think are more fruitful. We want to make it clear that our critical reflections are not directed at particular subjects, authors or schools of thought, but rather are a way of refreshing and opening up storytelling about our field. They are reflections on our own use of ideas about deficit and dialogue as much as anyone's. The more we have thought about this story the less useful we have found it. We would therefore like to draw attention to ways of going beyond this narrative in order to invite readers to consider new avenues for practice and scholarship in science communication.

Acknowledging diverse histories of science communication

First, using deficit to dialogue as a historical account vastly simplifies, by exclusion, all that took place before the 1980s 'beginning' of this narrative. In other words there is a tendency to elide the historical heritage of the field by excluding the extensive *prehistory* of different forms of science communication that took place before 1985 (when the Bodmer report on Public Understanding of Science was published by the Royal Society). This misses important context in terms of both the histories of diverse formats of science communication and older ways of imagining the relationship between science and society.

Science communication has a long history. As we described in Chapter 2, some notion of 'the public' has always been implicit to the scientific process. Relations with public interlocutors have been a key means for scientists to construct a stable professional identity[3]: even as the UK's Royal Society was being set up, early scientists argued that it was important for their work to be open to public witness (though, given the time and place, 'public' meant white, male, and of the gentleman class). Overt efforts at improving public awareness and understanding of scientific knowledge similarly have a long history, from Victorian Mechanics' Institutes and educational pamphlets to the activities of 'visible scientists' such as Richard Feynman, J. Robert Oppenheimer or, today, Susan Greenfield.[4] This prehistory is not confined to what would become understood as PUS activities. Instances of dialogue or participation also abound, from the use of early evolutionary theory by working class political radicals[5] to the emergence of science shops (centres where laypeople can commission or request research from scientific institutions such as universities) across 1970s Europe.[6]

When we think about science communication, then, we need to keep in mind that it is a space influenced by centuries of thinking about science, society, and democracy (as we highlighted in Chapter 2). We should resist the temptation to think of it as something that is new or isolated from wider historical developments. Citizen science, for instance, is currently being praised for its ability to democratise science through engaging citizens in research, as well as being a 'free' source of analytical or empirical labour or a hitherto untapped source of creativity. But this enthusiasm often overlooks the fact that there is a long history to amateur or bottom-up forms of research. Citizens have long participated as volunteers in research (e.g., as birdwatchers) or engaged in their own scientific investigations (e.g., through cutting-edge plant-breeding).[7] Ignoring the history of science communication means that we run the risk of missing patterns, trends, and cycles that may occur over long periods of time, or of reinventing the wheel when we analyse 'new' formats or trends.

Histories of science communication are also culturally located. Understanding them will help us to grasp the nuances of science communication practice and to see how formats and ideas travel (or not). One example is the development of the participatory consensus conference model[8] by the Danish Board of Technology (DBT; *Teknologi-Rådet* in Danish) in the 1980s. When other European and North American countries became interested in participatory and deliberative methods in the 2000s, the DBT's activities were often used as a model for what dialogue on science could look like. However, these activities were based on a particular, deeply entrenched, cultural tradition in Denmark which values egalitarianism, homogeneity, consensus and anti-elitism. At the time, there was little consideration of how such methods could be transplanted to other cultural contexts which might have less historical focus on egalitarianism and consensus,[9] and in practice it was not easy to pick up the consensus conference method and simply move it to another cultural context. The crucial point here is that cultures are diverse and complex. While some aspects of a culture are conducive to particular objectives and formats of science communication, others might be more challenging. If we want to use the past of science communication to understand its future, we need to have a comprehensive understanding of this history and the diverse cultures it represents.

Acknowledging the ecosystem of science communication (research)

Second, the 'deficit to dialogue' narrative gives a highly *partial* history of science communication. It tends to dichotomise the field—to split it into two polar opposites, of deficit and dialogic communication—rather than allowing for an understanding of science communication as an ecosystem with many different nodes, each of which may be fit for different purposes. As an analytical tool the narrative has been very useful for one kind of discussion, that of challenging the idea that in public communication scientists should always talk and non-scientists should always listen and learn. However, by emphasising the dichotomy between 'deficit' and 'dialogue', this history represents science communication as taking either the form of 'PUS'—public lectures and the like—or of dialogue (and specifically participatory processes such as consensus conferences). It largely ignores the role of science communication formats outside of these categories, including, perhaps most significantly, the mass media. Science in the news, on TV, and in popular science magazines and books have their own histories and traditions; it is important to include these as we think about the ecosystem of science communication and how it is articulated in the present. Similarly, the deficit to dialogue story tends to focus on working scientists as communicators of science. It was scientists, after all, who were the targets of the Bodmer Report and other calls to boost public understanding. This renders rather less visible the other actors involved, such as museum professionals, university PR officers, or science correspondents. We miss a large part of this ecosystem if we continue to use analytical tools that, based on this narrative, lead us to focus on particular formats and actors over others.

A related issue is that the deficit to dialogue narrative has a tendency to distribute the field into two camps of people. In one are those who work to set up deliberative exercises and try to engage the public in dialogue. In the other camp are all the others: scientists who want to teach high-school students about science in order to attract them to a scientific education; science journalists who want to explain the latest revelations in quantum physics in order to sustain their media's reputation for science coverage; museum curators who want their exhibitions to educate and entertain visitors about the wonders of the universe; scholars of public perception and attitudes to science. Conflating all of these ambitions and practices into one distinction between deficit and dialogue is obviously not helpful. Rather, we need to study each of these sets of practices in their own right. Similarly, there has been a tendency for the field to be distributed quite sharply into quantitative and qualitative research practices and ambitions. While this is not simply a result of the deficit to dialogue narrative, such storytelling certainly has not helped. We think future scholarship should incorporate much more collaboration between different traditions. As Martin Bauer and colleagues have written, identifying 'the deficit model of the public with survey research *per se*, and for that matter critical enquiry with qualitative protocols, is fallacious and not useful beyond temporary rhetoric'.[10] In our own work, which largely takes place within qualitative traditions, we routinely use quantitative studies carried out by our colleagues in this field for teaching, research, and public communication of research. Just as different forms of science communication meet different purposes at different moments, so do different forms of research.

Acknowledging diverse cultures of science communication

We also need to be aware that the deficit to dialogue narrative speaks to a very specific *national context*, that of the UK. It is here that developments towards participatory governance of science have been most pronounced (though by no means complete or completely accepted), and where the language of dialogue and engagement has most influenced the practice of science communication. Other countries and regions may have been affected by similar trends, to varying degrees, but, as noted above, they also have their own histories and imaginations of science communication.

Science communication is a global phenomenon. Governmental support for public communication of science seems to be on the rise around the world, and there is evidence that research in the field is on the increase. Anecdotally, there were 'more PhD projects in science communication under way in late 2013 than were completed in the two preceding decades'.[11] But the rise of science communication is not homogeneous. Just as science itself looks slightly different when it is practiced in different regions or national contexts,[12] science communication will always be inflected by the cultures in which it is performed. It is therefore extremely important not to apply a descriptive and normative narrative developed in one national context to the field as a whole.

What does science communication look like around the world? In Denmark, something of the reverse move to the UK-centric narrative has taken place, with public participation in science policy at its peak in the 1980s and 1990s and falling away in later years. Most recently, the norm has been an expectation that science should be responsive to industry, aiding society by contributing to economic growth, alongside a PUS-style emphasis on creating a scientifically literate citizenry.[13] Research in Austria has suggested both that the country is, in contrast with other European countries, a relative latecomer to the promotion of public engagement and participation and that these tools have been embraced rather unenthusiastically by both policymakers and laypeople.[14] In the USA, although there has been interest in public engagement,[15] the notion has never become mainstream in the way that it has in some European countries.

The 2014 edition of the *Handbook of Public Communication of Science and Technology* helps widen this picture further by including accounts from five 'emerging centres of science communication'.[16] Brian Trench and Massimiano Bucchi, the editors of the *Handbook*, make it clear that UK and Northern European-centric histories of science communication are not being straightforwardly replicated in other countries—although, of course, some of the ideas of the 'deficit to dialogue' history are picked up and used in other places. In Turkey, for instance, Trench and Bucchi (writing with Turkish scholar Gultekin Cakmakci) note that there have been challenges due to the rapid turnover of political leaders: the Minister for Education changed some five times in one decade, with each individual having different policies concerning popularisation of science. Some were enthusiastic about dialogue and participation; others favoured more 'deficit' approaches. In Argentina, science journalism is becoming increasingly specialised and professionalised, with media organisations appointing more specialist science reporters—a very different situation to the USA, for instance, where communication scholar Sharon Dunwoody has described science writers as 'imperilled'.[17] Science communication is frequently tied to national economic transitions and hopes for new technological industries. Trench and Bucchi, with Arko Olesk and Bankole Falade, describe Estonia's boom in information technologies since the millennium and Nigeria's desire to enable economic growth through the 'rapid diffusion of science and technology'[18]; in both cases, this had led to the need to boost public interest in science and recruit students into tech-related fields.

Trench and Bucchi conclude their reflections by referring to a large European survey of the status of science and society.[19] This categorised different countries into three classes—consolidated, developing and fragile—with regard to the status of science communication, according to factors such as how institutionalised science communication is or the degree of public interest in science. (Countries in the first category included Italy and Belgium; Austria, Switzerland, and Latvia fell into the second; the final category included Israel, Croatia, and the Czech Republic.) One thing, they write, is 'inescapable':

> the supposed turn from deficit approaches to dialogue—however valid or not it may be as an observation of regions with longer traditions of institutionalised science communication—does not apply in regions where the science communication culture is, in the terms of the European mapping mentioned above, 'developing' or 'fragile'.[20]

In other words, all countries will have their own cultures of science communication. Although these may include elements of 'deficit' and 'dialogue' approaches, they are unlikely to look similar to the archetypal UK-based story. What we would like to see in future scholarship is much more attention to the various national and regional stories and cultures and the way in which these interrelate with specific formats, ambitions and experiences of science communication.

Acknowledging the multiplicity of science communication

Fourth, it is misleading to think about the history of recent science communication, even in the UK, as a smooth *linear progression* from one form (one-way dissemination) to another (interactive dialogue). In practice, these two formats, and many more that do not tidily fall into the categories of deficit or dialogue, have always co-existed and continue to do so today. This point is made by Alan Irwin in a discussion of different 'orders' of thinking about science and society.[21] Both deficit and dialogue-style communication, Irwin argues, are manifestations of broader imaginations of what scientific governance should look like. 'First-order' thinking, for instance, which Irwin links to the use of the deficit model in science communication, can be traced to a 'culture of modernity', one shaped by the enlightenment thinking we discussed in Chapter 2. Within such cultures, scientific and technical expertise is highly valued, and the state is concerned with making rational choices based on that expertise. Scientific governance is top-down; the public's role is as appreciative recipient of what science has to offer. In contrast, 'second-order' thinking involves modes of governance, scientific, and otherwise, that emphasise deliberation and participation from as many different kinds of actors as possible. But these orders of thinking appear concurrently, not one after the other. Irwin writes that:

> …the situation in most national and local contexts is of these different orders being mixed up (or churned) together. The deficit model coexists with talk of dialogue and engagement. While some organisations and individuals look for quick and easy solutions to communication problems, others have begun to reflect on the inherent limitations, contextualities and conditionalities of both deficit and dialogue. Importantly, not all parties will agree on any particular categorisation: what one party might view as 'engagement' can often be seen as top-down communication by another (especially if disappointed with the outcome).[22]

In practice, then, the landscape of science communication has always been rather more diverse than talk of 'deficit to dialogue' might suggest. There was dialogue and participation in the days of PUS, and there continues to be plenty of deficit model inspired communication today. In addition, as Irwin notes, the lines between these two formats are not always clear. One person's engagement may be another's PUS. Again, this points us to the heterogeneity of current science communication practice. We should expect different approaches, and different implied notions of scientific governance and the relation between science and society, to be 'churned' together, to the extent that they may not always be that easy to distinguish.

One example of this is the way in which the deliberative formats developed by the DBT have travelled around the world. Although the format appears to be the same, in practice consensus conferences are implemented in different ways in different places. They are capable not only of generating deliberation and dialogue but also more deficit-style dissemination or emerging networks of collaboration.[23] One 2009 project led by DBT, World Wide Views (WWV) on Global Warming, was implemented all over the world. A group of Australian scholars, part of the Australian project team, have reflected on their experiences of trying to carry out the same deliberative process around the globe.[24] Challenges included the WWV method of working with 100 citizens in each country, however large it is (such that China, population 1.3 billion, and Denmark, population 6 million, have the same number of participants), or the fact that countries with multiple national languages have to choose one to carry out the process in, inevitably excluding citizens from others. They also point to the importance of often unnoticed cultural factors in structuring experiences of deliberation. As a result, it is not as straightforward to transfer deliberative formats across countries as it might appear, even with standardised questions or structures. Consider, they write,

> the challenges of open discussion in societies with fundamental power imbalances, such as unequal gender relations, or countries where political debate is not condoned, and where questioning the status quo could be dangerous for participants.

Deliberative public engagement exercises therefore do not always deliver deliberation, but rather overflow in many ways, potentially reinforcing or performing the same power balances, acts of exclusion and deficit style communication that they were originally designed to combat. These overflowings indicate, at the micro-level, the ways in which different modes of scientific governance are entangled with each other. The same process can at one moment be a deliberative event to one actor but a stifling experience of top-down communication to another. In such situations it is not useful to simply conclude that the efforts were a failure because they did not fully live up to the ideal of deliberation. It is more interesting, we would suggest, to explore the entanglements between different forms of science communication, and the modes of governance they imply, than to focus on any one particular ideal of what science communication should look like. Moving away from a linear understanding of our field—deficit to dialogue—will enable us to better study the identities, social and regulatory structures, cultural values, and systems of consumption that are produced within instances of science communication. It will help us to see that communication processes do not necessarily need to be one thing or the other.

Acknowledging wider social, political and economic dynamics

Finally, the deficit to dialogue narrative of science communication also presents itself as a history *in isolation*—one portrayed as internal to science and its attendant popularisers. There is little sense of wider political dynamics. These wider contexts are again, however, essential to how we understand the ways in which science communication is imagined, funded, and carried out. In the context of the UK, for instance, the politics of the New Labour Government were instrumental in allowing notions of participation onto government agendas and in shaping it once it arrived there. As Celia Davies and her colleagues chart when writing about public participation in NHS policy, the rise of participation in science and in medicine was inextricably linked to the UK's New Labour Government (which came to power in 1997) and to their vision of the state.[25] Similarly, 1980s anxieties concerning PUS stemmed at least in part from scientific concerns about a hostile political and public view of science (as expressed in Thatcher era funding cuts).[26] Public scientific controversies, such as those around biotechnology or nuclear power, have historically raised political and scientific anxieties about the science–society relationship, and led to calls for more (or different kinds of) science communication.[27]

More centrally, the practice of public engagement with science around the world has itself been implicitly shaped by neoliberal thought, such that 'citizens' become 'consumers' and participation is understood as a form of market research or, indeed, as a form of market creation. Participation may be viewed as a means of raising awareness of technologies so as to ensure their uptake.[28] Joanna Goven has suggested, in her analysis of a New Zealand consensus conference, that this political-economic context was the key. Although it was never made explicit within the course of the conference, it shaped the content provided, the options given and the discussion that took place.[29] We see something similar in the content of science communication at sites such as ESOF or the Big Bang Fair, which may assume that science is, ultimately, primarily to be carried out in order to produce economic growth or to boost national productivity. Science communication may seek to inspire young people to study science under the assumption that this will lead them to seek scientific or technical careers and that such careers will be good for national competitiveness. Here science communication is shaped by political regimes which emphasise values of market competition and the usefulness of technoscience to growth. In the same way, we argued (in Chapter 5) that one of the wider dynamics crucial to a comprehensive understanding of contemporary science communication is the changing landscape of knowledge production. As research organisations come to see themselves as acting in a competitive marketplace, they adopt corporate communication strategies, often focused on controlling communication flows in order to preserve and increase brand value. Both science and science communication are thus shaped by prevailing economic winds, and will reflect the political contexts and assumptions they are located within.

The point here is that science communication does not take place in a vacuum. It does not develop only according to its own terms of reference—for instance by recognising the need for a shift from 'deficit' to 'dialogue'. It emerges in response to particular political and economic concerns or dynamics and is shaped by those. As we have said throughout this book, it is not, and never has been, just about telling people about science; instead, within that telling (whatever form that takes) are implied worlds of politics and economics and society. In this sense, science communication is never innocent. It always brings with it something more than the science that is apparently at stake.

In conclusion

And so we come to the end. We hope, if nothing else, that this book has given our readers food for thought. Even if you disagree with us we are quite happy with that response: our aim has always been to start a conversation around the study of science communication, and to provoke continued reflections on its research and practice. Because—and perhaps we should have said this more clearly, and more often, throughout the book—we love science communication. We love seeing people get excited about science and watching scientists light up as they explain what they do. We love watching the intricacies of university politics and the way that this structures public communication. We love seeing people who are passionately engaged in scientific issues get angry about the way in which science is used, funded or thrust upon us, and we love it when audiences show their agency by rejecting communication or making their boredom clear. We love science podcasts and dialogue events and book clubs and TV interviews and university open days. Because science is interesting, and public meaning-making around it is (to us) even more so. What more can we suggest, in closing, than that we should continue thinking about science communication in its many different aspects in many different ways?

Notes

1. We are here paraphrasing Ulrich Beck, who made the argument in relation to the change from industrial society to risk society. Our focus is slightly different than Beck's, although risk is certainly an important part of the scientific knowledge we talk about. See Beck U (1992) *Risk Society*. London: Sage Publications.
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