The science communication environment: biotechnology researchers' discourse on communication

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I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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Abstract

Communication is problematic for biotechnology because biotechnology uses or changes life processes, which leads us to question ourselves and our definitions of life — it is controversial. Yet, communication is crucial for engagement and understanding among research scientists and the wider community. This thesis examined the communication beliefs, attitudes and practices of researchers at the National Institute for Cellular Biotechnology (NICB) in Ireland, using semi-structured, face-to-face interviews with 73 research scientists. The ensuing discourse was used to gain an understanding of participants' positioning in the landscape of the science communication environment and to explore issues surrounding the communication of biotechnology in particular. I found that gender and seniority affect the type and degree of communication that took place. A range of factors had reciprocal influences on the communication of researchers at the NICB, including the institution, the audience(s), pre-existing communication about science in the wider community and the individual's identity as a scientist. I found that research scientists at the NICB communicated about scientific knowledge and constructs, the process and organisation of science, and the impacts of science on individuals and society. This communication was more complex than imagined by any science communication model alone. My argument is that full engagement with the doing of science by scientists and non-scientists occurs when these points are communicated in the science communication environment. I propose a humanist driver that is experienced by individual scientists who aspire to engage in science communication to share meanings and reinforce social ties — a driver that has perhaps been neglected in previous models of science communication. Effective communication in the science communication environment is the key to ensuring that social and policy decisions concerning science can be made under the best possible conditions, with input from everyone.

Chapter 1 Introduction

This thesis sets out to explore the communication of biotechnology by individual research scientists located at the National Institute for Cellular Biotechnology (NICB) in Ireland. I am interested in the researchers' perceptions of communicating biotechnology and how they address the challenge of this complex task. The focus of the thesis is on researchers at the NICB and how they understand, engage with and communicate science.

The communication of science in general and of biotechnology in particular is important for reasons of economic prosperity, enrichment of the political process, intrinsic merit and benefit to society. However, potential clashes between utilitarian and ethical implications of the manipulation and use of life processes mean that the need to communicate biotechnology is urgent, but challenging.

1.1 Communicating biotechnology

Biotechnology in its modern form is relatively new, although it has quickly become established as a mainstream scientific and industrial activity. Biotechnology both attracts and consumes huge financial resources. Its application can be controversial because it manipulates life processes and living organisms. It has the potential to affect anyone and everyone, ranging from developed-country medical/pharmaceutical recipients to developing-country GM food-growing farmers. These are matters of high stakes.

Biotechnology is a site at which communication is problematic precisely because it uses or changes life processes (e.g. genetically modified foods, medical biotechnology), which leads us to question ourselves and our definitions of life — it is controversial, particularly in the context of the Irish culture with its history of rejection of technology in life processes. These are deeply personal perspectives; therefore, it is my contention that the high stakes and self-questioning nature of biotechnological research will have an influence in its communication by the people who do the research. I am going to show this in the thesis by examining participants' communication beliefs, attitudes and practices as these elements of communication inform engagement and understanding among professional scientists and, eventually, the wider community.

The communication of biotechnology by researchers is also likely to be influenced by various factors that make biotechnology a distinctive scientific field. Biotechnology research receives a relatively large proportion of research funding from public and private sources. Biotechnology research has many implications for society, which cannot be predicted, and the science and its implications may not be well understood, even by other biotechnologists. Now and in the future, a wide range of individuals throughout the community will need to know something about biotechnology in order to make life choices.

To address the research problem, I chose to investigate the communication behaviour/practices of NICB researchers and their beliefs and attitudes towards communication. More specifically, I investigated NICB researchers' beliefs and attitudes towards communication about their own work, how they communicated with others in the institute and with other scientists and non-scientists, and the constraints on communication they experienced during the course of their work.

I took into account both the institutionalised formal communication practices that are common to all contemporary scientists, such as getting published in peer-reviewed publications and giving structured oral presentations at scientific conferences, and the less formal (and informal) practices of discussing scientific work with strangers, friends or family during social occasions. It became apparent during the course of the study that this less formal and informal communication did not have an equivalent status in the 'doing of science'; yet in talking about it, participants produced rich accounts reflecting on their daily life.

The scientist–communicator has been somewhat neglected in studies of science communication, which have tended to focus on public understanding of or engagement with science through the media, education, social and opinion-seeking research, and science–society engagement activities. The present study addresses this deficiency by investigating individual scientists and their roles in understanding, engaging with and communicating science.

The present research could be used as a resource for the biotechnology researchers themselves and as a resource for the development of science communication strategies for (and by) scientists in general. In addition, the present research has documented a slice in time for an institute in Ireland in the early 2000s. By doing so, an understanding of formal and informal communication practices among scientists doing science, and their beliefs and attitudes towards such practices, may be better understood. In addition, the conclusions drawn here about biotechnology and communication are potentially transferable to a range of other science communication situations, particularly for new technologies (such as nanotechnology).

1.2 The trajectory of the project

My choice of research problem was influenced by my own experience as a biologist with a second career in science, technical and medical (STM) publishing. This career path led me to an interest in the communication of biotechnological (and other) science, and to seek an avenue to do research in this area.

The NICB came into existence in 2002 as a result of a successful proposal to 'Establish a National Institute for Cellular Biotechnology' to the Programme for Research in Third Level Institutions (PRTLI), which is a funding stream of the Irish Higher Education Authority (HEA). Dublin City University (DCU) was the lead institution in the bid, and the partner institutions were the National University of Ireland, Maynooth, and the Institute of Technology, Tallaght. A multidisciplinary research institute from the beginning, the NICB's seven research programmes (at the time of the present study) included Computer Modelling and Biosciences & Society (BSS), along with the life-sciences-focused cell biology, genomics and cellular pathogen programmes.

I was part of the BSS Research Programme, based in the School of Communications at DCU, which originally consisted of me, another postgraduate student and the program leader. Several more people joined the programme over the four-year period that I was involved. The aim for the BSS was to examine the social implications of biotechnology and promote dialogue between bioscientists and others,[1] as a group of social scientists working alongside natural scientists. Thus, the current project developed along both instrumental and pragmatic lines.

Serendipitously, the BSS emerged at around the same time that I became interested in doing social science research with biotechnology researchers. I am interested in both science communication in general and biotechnology specifically; the move from working in a biology laboratory to STM publishing has enabled me to combine these interests. The current research has also given me the opportunity to contribute to a niche area.

The population of biotechnology researchers at the NICB have been a 'captured' population for the purposes of the present research. The participants were both willing and able to take the time to answer questions posed by a social scientist embedded in their organisation. This was a unique opportunity to examine the communication of science from the perspectives of individual scientists.

1.3 Context and rationale

The theoretical focus of the present study sits in the intersection between the doing of science and the communication of science, and is influenced by the ethnographical studies of Latour and Woolgar (1979) and Charlesworth *et al*. (1989), although they were more concerned with describing scientific organisations and the networks formed within them between people and objects. My concern is to examine the communication by researchers that both influences and is influenced by a (science) communication environment — the mutual interaction of context and process in science communication by scientists.

By examining researchers' accounts of their own communication activities, I have been able to use their discourse as a resource (in the sense of Seale (1998) and Waterton *et al*. (2001)) and to a limited degree as a topic (in the sense of Gilbert and Mulkay (1984 [2003])). This approach was developed alongside the project as it became apparent to me that research on individuals in all their messiness required a methodology extending beyond a purely quantitative approach. It was then a

[1] http://www.nicb.dcu.ie/biosciencessociety.shtml (accessed 18 February 2006).

straightforward matter to use the findings to position the researchers within a (science) communication environment and to investigate some of the interactions between the environment and the researchers' communication.

For example, one characteristic of the communication environment extrinsic to the researchers is the large financial resources associated with biotechnology. It is a reasonable assumption that this association will have an effect on the communication (and other) activities of researchers — this is explored in the thesis as a potential limitation on communication imposed by a competitive environment (i.e. confidentiality agreements, patents). On the other hand, it is also a reasonable assumption that characteristics that are intrinsic to the researchers, such as their willingness or otherwise to communicate about their work, will have an effect on the communication environment — this is explored in the thesis through participants' attitudes towards communicating with different groups in society and what communication they actually do.

The purpose of this concurrent mixed-methods study, then, is to better understand science communication by exploring the relationship between macro-level trends in the communication environment operating on the researchers at the NICB and micro-level details from the point of view of the biotechnology researchers employed within the organisation — the part and the whole. In the study, an interview instrument was used to measure quantitatively the relationship between socio-demographic variables and communication practices, beliefs and attitudes. Using the same instrument, communication behaviour was explored using qualitative semi-structured interview questions. The analysis focuses on relationships between the quantitative and qualitative data elicited during the interviews, and evidence gathered from secondary sources associated with the NICB-specific science communication environment.

1.4 Organisation of the thesis

Chapter 2 describes the viewpoint on science communication used in this thesis and provides critiques of other models. My focus is on individual biotechnology researchers communicating against a background of the 'co-production of the social and the natural' — an idea proposed by Jasanoff (2004a) as a way to organise work in science and technology studies — within a science communication environment.

The exploration of alternative science communication models led me to reject them as insufficient to account for science communication as a whole, but to accept them as sufficient to account for aspects of the science communication environment. I discuss the various models of science communication that have been proposed over the past few decades — including the deficit–dialogue–deference 'continuum' and contextual models — and argue that they can all fit within a science communication environment. I then provide an overview of biotechnology in contemporary society and portray the biotechnologist as an individual communicating.

The methodology chapter (Chapter 3) presents a justification for the specific combination of quantitative and qualitative methodologies used in the present study, with reference to the broad theories discussed in Chapter 2. The participant population is described, along with choices I made during its selection as the study sample.

I give details of the structure and development of the interview instrument, including the following elements: borrowing from a MORI–Wellcome Trust survey *The Role of Scientists in Public Debate* (MORI–WT 2001), and other questions and prompts; justification for the inclusion or exclusion of questions; how responses to the interview instrument were aimed at answering the research questions; and data collection process — how the instrument was used, for example, where the interviews took place, audio taping, transcribing and the development of data files.

I outline the features of the databases that I developed for the purposes of organising the interview data and features of the software I used to analyse them. In the analysis I cross tabulated the data and examined relationships between socio-demographic data, texts and discourses — these data analysis processes are also reported in this chapter. I also explore issues of validity, representation, transferability and personal reflexivity as they pertain to the current project.

The information provided in Chapter 4 serves as a socio-demographic snapshot of the population of the institute at the time of the study — participants' age, sex, position in the institute, research area(s) and qualifications are described. These data both describe the population and are used to inform further analysis in this and later chapters by showing the institutional context and structures within which individual researchers communicate.

I explore the structure and culture of the NICB through an examination of the participants' working week, their funding, professional memberships, whether they engage or have in the past engaged in cooperation at home and abroad, and instrumental aspects of being a researcher in a biotechnology institute. The institution is proposed as a setting for communication.

Chapter 5 proposes audiences as contexts for communication and explores how these audiences are also part of the science communication environment and have an effect on the communication that takes place. Using the 'snapshot' of the NICB population presented in Chapter 4, I put together a picture of audience effects based on responses about the groups the participants thought were the most important to communicate with, and about self-reported communication with a range of formal and informal audiences. Comparisons between the present study and two UK-based surveys are also presented in terms of 'important group' audiences.

Chapter 6 investigates what communication means to researchers at the NICB. It is about participants' willingness to spend time communicating their research, and their perceptions of the potential consequences of communicating. This chapter also explores the participants' perceptions of communication about research in the media and how media coverage of research-related topics may have had an effect on the way they communicate about their research. It places the participants within the science communication environment by showing the effects of the science communication environment on the participants.

Chapter 4 refers to the participants and their communication environment in terms of institutional structures. Chapter 7 also engages with the communication context in which the participants operate; however, in Chapter 7, the context is personalised and becoming, being and aspiring to be a researcher in a biotechnology institute is expressed in terms of participants' professional identities shaping their communication practices.

In Chapter 8 (the concluding chapter), I provide an overview of the findings regarding communication by NICB researchers. The effects of context — both institutional and personal — and the interactions between beliefs and attitudes about communication, communication practices and potential limitations on researchers' communication are discussed. I draw conclusions, reflect on the methodology and provide suggestions for future research.

Chapter 2 Literature review

This chapter is a review of the literature surrounding my research problem, which is to explore the communication of biotechnology by individual research scientists at the National Institute for Cellular Biotechnology (NICB) in Ireland — how they understand, engage with and communicate science — in order to better understand the communication of science as a whole. The empirical work will be examined through the lens of a theoretical approach based on the idea that there exists a ‘science communication environment’, within which scientists making discourse as part of making science. This concept is essentially a combination of van Dijk’s ‘context models’ (van Dijk 1998) and Jasanoff’s ‘co-production’ (Jasanoff 2004a), both of which are elaborated below.

Late night science fiction television, half-remembered school science, medical science ‘breakthroughs’ touted in the press, workplace techno-solutions, so-called naive science practised by children … these are all elements of science communication (consisting of text, discourse and context), and these are just examples with overt science content. If we stop to consider the physics of the television that we are watching or the biology of the plants that are growing in the garden, normally concealed layers of science are revealed. We are immersed in science as a way of thinking about the world.

This way of thinking and all of these elements (and more) make up what may be described as an all-pervasive science communication environment. Just one aspect of this environment — science communication done by scientists in a biotechnology institute about their own work — is the focus of the present thesis. I contend that this type of communication is one part of ‘doing science’. Scientists both communicate and simultaneously do science in other ways (e.g. run experiments, manage grants, create networks of co-workers) within the science communication environment.

This chapter describes overlapping layers of theory, each relevant to a part of the thesis and some relevant to the thesis as a whole. Science communication is an umbrella term that describes a huge variety of communication activities and the context(s) in which they occur, such as public engagement, policy development, peer-reviewed publication, scientific meetings and conferences, and so on.

In the following sections, an account of co-production is given, as a description of the mutual shaping of science and society within which scientists make discourse as part of doing science.

Relevant models of science communication that have been proposed over the previous few decades are described and critiqued. I put forward a more holistic model for thinking about the communication of science, based on the notion of a communication environment. The *science* communication environment is located as a subset within this communication environment.

Next, I examine recent attention to biotechnology as an exemplar of a relatively new science and technology. I then focus on the biotechnologist as an individual communicating within the science communication environment. This is the organizing schema for the empirical work on actual communication beliefs, attitudes and practices as reported by biotechnology researchers.

In the empirical work discussed in the following chapters, I draw attention to biotechnology discourse in the form of text generated within in-depth interviews with biotechnology researchers. Therefore, in the present chapter, I examine the theoretical framework behind my choice of this methodology and some examples where discourse analysis has been used to focus on scientists' discourse in other studies. Finally, I provide a summary of the theoretical elements brought together in the present thesis.

2.1 Co-production of science

One way of looking at the world is that we are all involved in its co-production, as defined by Jasanoff (2004b) — that is, we co-produce '…the world created by us [the social] and the world we imagine to exist beyond our control [the natural]' (p. 21). Jasanoff (2004a) stops short of claiming theory status for co-production, preferring to refer to the concept as an 'idiom' by which a great deal of work in science and technology studies (STS) can be organised, particularly work associated with ‘the interpretive turn in the social sciences, emphasising dimensions of meaning, discourse and textuality’ (p. 4).

I use Jasanoff’s formulation of co-production as a background for the work in the present thesis, because Jasanoff suggests that scientific knowledge does not mirror reality, but embeds and is embedded in the social; also as a critique of realist separations of nature and culture, fact and value (p. 3). It also steers away from an over-commitment to the social because:

> …co-production is symmetrical in that it calls attention to the social dimensions of cognitive commitments and understandings, while at the same time underscoring the epistemic and material correlates of social formations (p. 3).

Over-commitment to the social occurs in, for example, Knorr Cetina’s proposition in *The Manufacture of Knowledge* (Knorr Cetina 1981), that science *is* discourse:

> ‘...first and foremost, the communicative foundation of science constitutes the scientists’ operations as a form of discursive interaction directed at and sustained by the arguments of others’ (p. 14)

Knorr Cetina’s knowledge production is ‘decision laden’ in terms of situated social negotiation (p. 152) and, as such, she argues, must be constructive, and not (at all) descriptive. In a book chapter on social scientific laboratory studies, Knorr Cetina bars ‘reality’ or ‘the natural’ from her constructionist science (Knorr Cetina 1995; pp. 148–149). In my opinion, this conception of how science is done misses something.

Rather, I concur with Hagendijk’s (1990) claims that constructivism allows us to understand the *how*, but not the *why* of science (p. 50). He goes on to suggest that ‘a constructivist understanding of science [can potentially] incorporate questions of continuity and change into its analysis’ (p. 51). I propose that co-production similarly can encompass a constructivist science, along with other conceptions of how science is done.

Co-production has a place for the natural. Technological artefacts are constructed by us — that is undeniable — but constructionism as it has often been conceived in STS (e.g. Knorr Cetina) suggests a negation of the independent existence of the material world. My argument is that although our ideas about the material world are constructed, we should allow for a material basis for these ideas. Put another way, Mukerji (1989) suggests that scientists create ostensive models of the objects of their research (p. 147), with the aim of reformulating (reconstructing, co-producing) these models closer and closer to some underlying reality.

The idiom of co-production does not provide deterministic causal explanations of the ways in which science and technology influence society or vice versa, rather, it has been stated explicitly (by Jasanoff 2004b) in order to:

> …make available resources for thinking systematically about the process of *sense-making* through which human beings come to grips with worlds in which science and technology have become permanent fixtures (p. 38; my emphasis)

Four sites and/or instruments of co-production — pathways along which the process of co-production tends to move — are suggested by Jasanoff (2004b): *identities*, *institutions*, *discourses* and *representations* (p. 38). The focus of the present thesis is on discourses, although identities and institutions are considered to be having an impact on (and in some ways determining) the making of discourses — the pathways are interrelated. From Jasanoff's point of view, making discourses or taking discursive choices means producing new, or appropriating or modifying existing discourses. In this context, the individual scientist may readily be imagined as taking discursive choices strategically to, for example, coin new words, persuade others, link knowledge to practice, shore up authority, standardise, and so on.

Like Lievrouw (1998), I use *discourse* in two senses in the present thesis — as the 'interpersonal exchange of ideas, and as the social formations and relationships that support and are produced by those exchanges' (p. 85). In this sense, the discourse of biotechnology is communication about and within biotechnology and also the associated policy, practice and socioeconomic environment in which biotechnology exists. The biotechnologist both creates the science communication environment by communicating about biotechnology and is him/herself influenced by the environment when communicating.

Making discourses is foregrounded here for two reasons, one theoretical and the other practical. According to van Dijk (1998), discourse has a special status because it alone can be used to ‘express or formulate abstract ideological beliefs, or any other opinion related to such ideologies’ (p. 192). I will discuss below how I think the notion of an ideology of science underlies the primacy of a particular limited conception of science communication — the deficit model.

Then, from a practical standpoint, discourse is a useful ‘way in’ to an analysis of communication by biotechnology researchers. Scientists are, of course, simultaneously involved in making identities, making institutions and making representations (Jasanoff’s other three pathways of co-production). For the purposes of the present research, an empirical study of their discourse is a readily available pathway for social science research.

In the present study, I have focused on the individual scientist and her/his place in and activities in the (science) communication environment. The scientist has been conceived of as wearing multiple hats: being in and making the communication environment, and being tempered by feedback from society informing scientific practice, but also forming scientific practice and society against the backdrop of the co-production of science.

As suggested above, within the idiom of co-production, the logical step from accepting that scientists (along with other ways of doing science) make discourse, is to accept that they operate in a science communication environment — they both contribute to and are embedded in discourse. Whether their engagement with science communication is cognisant or non-cognisant does not affect the *existence* of the science communication environment, only how it is structured for them.

van Dijk (1998) describes the context of discourse (what I would identify as the communication environment) as:

> ...the structured set of all properties of a social situation that are possibly relevant for the production, structures, interpretation and functions of text and talk (p. 209).

He then goes on to suggest that we can only really analyse the context as it appears to the participant — as a context model, a dynamic construction by the language user seeing him/herself and constructing the communication environment. For example:

> ...our model of the recipient (part of the context model) will also influence what we say to him or her, and especially also *how* we do so, for example more or less formally, intimately, politely or authoritatively (p. 212; emphasis in original)

At the risk of conflating the normative and descriptive/analytic dimensions, I would like to suggest that instead of simply existing in the science communication environment, scientists could take on multiple roles in communicating their work. In an ideal science communication environment, all would be cognisant of the environment and the role(s) they and others play.

Formal communication, such as manuscripts published in peer-reviewed journals and seminars given at scientific conferences, are more obviously tied in with the doing of science. Modern science could not happen without these communication activities; therefore, they have been institutionalised. Less formal and informal communication about science — to policy makers, friends and family, or the media — is also part of doing science, although this may not be as obvious. This form of communication is also of interest to me.

2.2 Models maketh the environment

Before discussing the science communication environment in more detail, first I would like to define it by its constituent parts; that is, possible forms of communication within possible contexts. The empirical work in the present study is a legitimate way of studying a part to gain an understanding of the whole — the science communication environment. The idea that science and society are not identical, yet are also not separable, and the implications for the science communication environment concept are also explored.

2.2.1 Science communication models

A great deal of theoretical and practical work has been done in regard to (science) communication models. These may be located within the science communication environment and encompass simple one-way 'Shannon and Weaver'-style imparting of information to a passive recipient and complex multi-way interactive communication where all parties are actively taking part, and everything in between.

When the focus is on a single model of (science) communication, it can be a straightforward matter to show that the model is somehow inappropriate in the real world. For example, a strong criticism of the so-called deficit model is based on the following logic: deficit models imply that the person communicating holds the knowledge (e.g. a scientist) and the person ‘receiving’ the communication has a knowledge deficit (e.g. a non-expert member of the public). If the receiver is given enough information (becomes an informed non-expert) or develops enough knowledge (becomes more like a scientist), then any resistance to the doing of science or to the products of science will disappear — science will be accepted.

However, this scenario does not play out in the real world, as, for example, with agricultural biotechnologies in Europe. Marris *et al*. (2001) examined the views of ‘ordinary citizens’ in five European Union member states in regard to GMOs. They found that although ‘ordinary citizens are largely ignorant of the scientific technicalities of genetic manipulation, and of developments in research, regulation and commercialisation related to GMOs, *this lack of knowledge does not explain their response to agricultural biotechnologies*’ (p. 9, emphasis in original)

Many critiques of science communication models have indeed focused on the one-way deficit model. Sturgis and Allum (2004) suggest that the deficit model and contextualist models of science communication have been associated historically with quantitative and qualitative research methods, respectively, in science communication research. They test hypotheses from both theoretical approaches and argue from their results that knowledge *is* an important determinant of attitude to science (as predicted by the deficit model), but also that things are more complex at the ‘knowledge–attitude interface’ than a simplistic deficit model can explain. They suggest that other important determinants of a person’s attitude towards science include ‘culture, economic factors, social and political values, trust, risk perception, and worldviews’ (Sturgis and Allum 2004; p. 58).

Although these authors do not take the idea as far as I would like to, their results show clearly that the deficit and contextualist models (and theoretical approaches) can be viewed as complementary to each other. It appears then that a focus on single explanatory models is misguided. Instead, the idea of a (science) communication environment might be considered — an environment where communication takes place, which is heterogeneous and can only be described by a plurality of explanatory models.

What about using the deficit model to explain only *some* aspects of science communication, or conceiving of it as *the simplest among many models* for the communication of science? Despite the heavy and ongoing criticisms of this model of science communication, it does (according to Hilgartner [1990], who uses the example of the popularisation of science) serve as a resource in scientists' public discourse, providing a repertoire of rhetorical devices for the interpretation of science to outsiders and a tool for maintaining a hierarchy of expertise (with science at or close to the top). However, as we shall see, even the individual scientist communicating,[2] understands that the deficit model is not fully adequate to explain the communication of science.

If we think about the ideology of science as expressed by van Dijk (1998):

> This ideology of science [a supposed engagement only in the disinterested search for the truth], which tries to conceal its interests and wants its own beliefs to be accepted as truth by those who recognise its power and dominance, is thus hardly different from other ideologies that are developed to achieve hegemony, to legitimate power or to conceal inequality – if only in the domain of knowledge (p. 3).

Then the deficit model of science communication makes sense as a means to achieve hegemony, legitimate power and conceal inequality — it has its uses for scientists and others as a conceptual basis for action. I am not suggesting that this is desirable, just that the deficit model is one coherent way of conceptualising science communication.

Other science communication models have been proposed, many in response to the perceived inadequacies of the deficit model. Some of these have included the context of communication, such as Lievrouw's (1990) three-stage cycle of science communication (conceptualisation, documentation and popularisation), using social representation theory concepts and borrowing from the constructivist tradition.

[2] This is a generalisation for the purposes of the current argument. I do not intend to suggest that 'scientists' are necessarily homogenous in any of their attitudes, beliefs or behaviours; however,

Others have added another layer of science communication that is personal (or relating to the individual as communicator), such as Stocklmayer (2001) and Stocklmayer and Gilbert's (2002) model for personal awareness of science and technology through new experiences and old knowledge, and subsequent engagement of the public, or Burns *et al*. (2003) outcomes view of science communication — use of appropriate means to elicit personal responses to science, including awareness, enjoyment, interest, opinion forming and understanding (AEIOU).

The ONION is an interesting example of an all-inclusive model, which is generally shown as a diagram with concentric and/or overlapping circles (e.g. Clare Matterson, Director of Medicine, Society and History, Wellcome Trust, personal communication, 2005) (Appendix 1). This model is used to visualise a range of science communication activities, from information dissemination (e.g. library resources, television programs) to public impact on research or policy (e.g. committee representation). The ONION resembles my conception of the science communication environment, except that it does not explicitly include the scientist as an individual communicator.

Adding an even more nuanced layer to the science communication model mix, Yearly (2005) proposed three theorems about the public understanding of science (PUS):

- people evaluate institutions and scientists, not just the science
- people have their own knowledge(s)
- scientific knowledge incorporates implicit assumptions about the social world.

These provide something of the perspective of the participant in communication about science who is not a scientist. They (we) look at a larger picture than 'just the facts', we bring personal knowledge to our understanding of science and we (as part of the social world) are assumed to behave, believe and value in certain ways and know some things but not others. They also provide an argument for the inclusion of

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research has shown that scientists in general do *tend* to operate as if they believe the deficit model is the way in which science is always communicated (e.g. Cook *et al*. 2004, Cook 2005).

the scientist–communicator in any model, so that they may be evaluated, exposed to others' knowledges and have assumptions about the social world challenged.

Critiques of specific communication models have tended to focus on effectiveness or outcomes, with the simple one-way deficit model regarded as least effective (and even in some critiques offensive to the 'receiver/audience'). Indeed, it seems *obvious* that complex multi-way interactive models, must be more effective *because* all parties are imagined to be taking part actively. But, as Bauer *et al*. (2007) put it, in their critique of the UK 'GM Nation'[3] public debate:

> In this way, consensus is reached by 'monaud': all 'sides' are talking; but only the public is supposed to listen (p. 86).

Instead of picking apart models that are bound to fail under some circumstances, in my conception of an inclusive science communication environment, each of all possible models is appropriate under at least one and probably more than one circumstance. For example, complex multi-way interactive models may be usefully applied in situations where science and policy meet, and interaction models may be usefully applied in situations where people need to retain information to apply to further study (e.g. in secondary school science classrooms). But a simple one-way deficit model can also be usefully applied if the aim (or what the individual seeks) is simply to be provided with some scientific information.

Other ways of describing the one-way deficit model include linear, diffusion, information dispersal and osmosis; it does not take a huge stretch of the imagination to think of circumstances in which this kind of communication does indeed take place, or even circumstances where we ourselves might want to take, but not give. A common example of this would be the use of the internet for self-diagnosis of health or medical conditions or to gather information about topical science-based legislation.

[3] 'GM Nation: the public debate' was a concerted attempt by the UK government to encourage public debate on genetically modified crops/food in 2003. It was widely criticized for lacking funding and adequate time, and for methodological flaws (Gaskell 2004); and because the public were hardly aware of its existence, for failing to engage with a broad range of people, and because of the provision of poor stimulus material (Barbagallo and Nelson 2005).

Clearly, there are many possible forms (and therefore models) of science communication in many possible contexts. These make up the science communication environment.

2.2.2 The science communication environment

To reiterate, any given science communication model may be appropriate in some situations and inappropriate in others. According to Grin (2000) 'our current age should be one characterised by the recognition that wisdom cannot be defined on the level of generic truth, but rather on sensible judgements to inspire action in particular contexts' (p. 16); therefore, it is more analytically fruitful to regard such models as components of a science communication environment in which scientists (and others) operate in communicating science.

One way of conceptualising the science communication environment is to use Layder's (1997) theory of domains. Layder proposes four domains of social reality — psycho-biography, situated activity, social settings and contextual resources — which shape human activity (e.g. the co-production of science) in relatively autonomous ways through the self, social interaction, social context and institutional settings, respectively. It is the domain 'situated activity' against the background of Layder's other domains that is of interest in the present study, and which can be conceived of as the science communication environment of the individual scientist.

It may seem unreasonable to propose a holistic science communication environment and then focus primarily on one aspect of the environment — represented by Layder's situated activity domain. However, if there is interaction between the domains, then it *is* reasonable to make an approach to the whole through a study of a part. This part is also articulated by Leivrouw (2001) as the personal/relational aspect of the 'information environment' mutually shaped by/with information and communication technologies. In the personal/relational aspect, 'people create and share knowledge and information with others through smaller-scale interpersonal interaction and information seeking activities' (Lievrouw 2001; p. 13). This is another expression of the situation of the individual scientist communicating.

Lievrouw (2001) describes variation in access to information and resources in the 'information environment' that might contribute to social differentiation. In contrast, I will attempt to describe face-to-face social interaction between scientists and others that might lead to increased social cohesion. In the same paper, Lievrouw proposes a circular model for the process of information technology adoption, incorporating a feedback loop and providing a pathway whereby the practices of individuals can have an effect on larger cultural practices. This is, therefore, one pathway through which scientists (and others) may contribute to the science communication environment.

Nevertheless, models consisting of visualised lines and circles can only be parts of the more holistic and inclusive 3-(or more)-dimensional model of science communication that is the science communication environment.

2.2.3 Science and society are not identical

Despite my good intentions, I have been partly describing science communication as something that happens between the scientific and the lay, scientists and non-scientists, or from within the culture of science to public culture. The problem with this conception of science communication is that it assumes that a divide exists between these groups that, in turn, promotes the one-way science communication model to the exclusion of other models. As a social scientist studying science communication, this rather linear thought process is all too easy to slip into. In addition, scientists themselves tend to think about the science communication processes in this way (see Leivrouw 2004; p. 170, quoted below). In fact, I would prefer to acknowledge the ubiquity of this conception (and one of the interesting aspects of studying scientists is to try to understand their ideas about this process), but concurrently acknowledge and explore other possible modes of science communication.

On the other hand, I also agree with Bauer *et al.* (2007) that, although it is impossible to pinpoint where one stops and the other begins, science and society are not identical and:

> ...as long as science and society are not identical, the public's understanding of science as well as the scientists' understanding of the public will continue to be a pressing issue (p. 87).

Thus it is easier to believe six impossible things before breakfast than it is to resolve, in the present study, the conflict between the idea of a science communication environment as all inclusive and the non-identicalness of science and society. The pervasiveness, simplicity and commonsensical nature of a one-way communication of science model is something to be aware of. It is temptingly uncomplicated, but ultimately misleading, and (on its own) is an inadequate conception of the science communication environment. However, it should also be acknowledged as useful, as discussed above.

I would like to think that the science communication environment also includes a 'h' for humanities in the 'public understanding of science and humanities' (PUSH), or a broader understanding of science as 'Wissenschaft': scholarship, or any organised body of knowledge. This bridges the gap between the so-called two cultures (science and humanities), first identified by Snow (1964) and acknowledged by, for example, Aikenhead (2001), who describes science as a culture with its own language and conventional ways of communicating for the purpose of social interaction within the community of scientists. I would prefer to think that these cultures are not exactly separate, but merged, or with a permanent isthmus between them.

Finally, in trying to account for all forms of science communication under a single umbrella term/concept, I am wary of trying to account for too much. Interaction between only a few social variables can bring unanticipated results and, because communication is part of the doing of science, it does itself transform the science communication environment. This means that, although the descriptive power of the concept is high, its predictive power is not, at least not in terms of day-to-day communication by scientists.

2.3 Why communicate biotechnology?

Although the idiom of co-production may be used to organise a range of work in STS and science communication, I am particularly interested examining researchers working in the area of biotechnology and the(ir) communication of biotechnological research.

2.3.1 Constitutive and interactive aspects biotechnology

Returning to Jasanoff's (2004b) formulation of co-production in more detail, she proposes two strands theorising the interplay of society, science and technology (pp. 18–19):

- The **constitutive** (or 'what is'), which focuses on emerging science and technology and society, and its creation and maintenance (e.g. within the research laboratory).
- The **interactive** (or 'how we know about it'), which focuses on factors that may be operating against an extant order, where boundary conflicts are occurring, ideas are being organised and reorganised, and tensions between the natural and the social are common (e.g. within the clinic or the legal system).

Both of these strands are applicable in biotechnology — that is exactly what makes biotechnology an interesting field to study. Although it is relatively new, biotechnology is not too new that we cannot recognise interactive aspects. This is also the case, arguably, for the relatively newer area of nanotechnology, around which there has been a push, at least in the UK, to examine societal issues 'upstream' or *before* major technological applications have been invented. This is an interesting experiment in previewing the social over the natural. I prefer to ground the present work in more concrete phenomena, although certainly there is also a great deal of speculation about 'what could be' in biotechnology.

This is in contrast to Latour's (1987) primary interest in science-in-the-making over ready-made science; ready-made and of less interest to him due to it having been black-boxed. Latour's idea is that accepted scientific theory or ready-made science becomes a black box, such that only the inputs and outputs are of interest, not the internal mechanism or structure. I prefer to work within the idea of a white box, where the internal mechanism is available to view, but cannot be altered.

According to Knorr Cetina (1995), laboratory studies (where the social science researcher immerses herself in the day-to-day working environment of the scientists) arose in STS as a response to the problem of unravelling ‘set’ knowledge (i.e. accepted facts or theories, or Latour’s black boxes). The present study is not a laboratory study; rather, I am interested in making use of scientists ‘making discourse’ (and making discourse about discourse) as a site of the co-production of biotechnology. I am interested in *communication* as part of the making of science, rather than technical and scientific practices (Lynch 1985) or the production of data (Latour & Woolgar 1979). Also, as Mukerji (1989) suggests, ‘directing discourse’ is an important element of the power of science and scientists.

This premise answers Woolgar’s critique (1982) that ‘the social study of science continues [note: this critique was made in 1982] to rely mainly on removed, secondary sources: interviews with scientists, published scientific papers and other documentary evidence’ (p. 482). But, I contend that scientists’ discourse, their communication, is not a ‘removed’ secondary source at all. Perhaps, science-in-the-making cannot be studied *fully* from the perspective of what Woolgar identifies as secondary sources; even interviews with scientists. However, if we accept the idiom of co-production, science-in-the-making must be influencing and being influenced by ready-made science — this mutual interaction makes the social study of science messier perhaps, but possible.

Biotechnology is done by scientists against a background of influences. Therefore, I prefer to take a more holistic view of biotechnology and approach it from the perspective of making discourse. Making discourse is for me a primary source, not a secondary source as Woolgar suggests. An added bonus of the focus on biotechnology and discourse is the relative newness (in-the-making) of biotechnology along with its established significance (white-boxed) — both of these aspects are present in a single study area, accessible through interviews.

2.3.2 Biotechnology busts norms

Braman (2004a,b) and others in the same volume (Lievrouw 2004, May 2004) envisage biotechnology and information technology as meta-technologies. Meta-technologies are flexible and change human capacity. They have an expanding range of inputs and produce a potentially enormous range of outputs. They are more social (requiring much social coordination), complex, autonomous and larger in scale than other technologies, and their complexity, autonomy and scale are of concern to us. Biotechnology is readily recognised as being co-produced with discourse, economics, culture, social processes, the law and power.

Biotechnology has a great deal of power, not least because it has ‘one foot in the academy and the other in the market’ (Leivrouw 2004; p. 146). It can be safely assumed that making discourse in biotechnology is affected by this characteristic/context of power, both in terms of the practices designed to maintain or increase power, and in terms of barriers to making discourse. For example, Merton’s original conception of the norm of free and open exchange (Merton 1973), putting aside for the moment the applicability of such an idealised notion, can only be limited by contemporary manifestations of intellectual property and confidentiality agreements in biotechnology, which are designed to limit the exchange of potentially marketable scientific knowledge.

Leivrouw (2004) suggests that ‘…[there has been a] retreat from publication; publication bias; the erosion of peer review; and growing constraints on informal, interpersonal interaction among researchers’ (p. 147) in biotechnology, due to an increased emphasis on competition and secrecy. Data withholding and the restricted dissemination of research results (Blumenthal *et al*. 1997) and research-related materials (McCain 1991) are consequences of the power of biotechnology. These practices restrict the movement of ideas from private to public science — a previously normative sequence from early- to late-stage research.

McCain wondered, on the basis of her research findings, whether the increasing commercial value of research-related information would lead to change in the prevailing attitude of the scientists she interviewed: that such information ‘should be available to all, with the recognition of the researcher’s right to practice private science’ (p. 511). It might be argued that such an attitude, which reflects Merton’s norm of free and open communication, does not reflect actual practice, particularly in biotechnology.

Are Merton’s norms of communality, disinterestedness, organised scepticism and universalism an appropriate starting point for the study of science communication? They are certainly ideal (and idealised) and perhaps naïve, but it may be that scientists (as opposed to scholars who study science and technology) are in fact influenced by assumptions based on Merton’s norms. If we accept van Dijk’s context models, we must also accept the influence of Mertonian norms in their construction because Mertonian norms are part of the socialisation process for scientists (see Leivrouw’s comment below).

Counter norms have been proposed by Mulkay (1976) — secrecy, commitment, irrationality and personal judgement, and by Mitroff (1974) — solitariness, particularism and organised dogmatism. Perhaps, in biotechnology at least, Mulkay’s counter norm of secrecy is appropriate when considering actual scientific practice. If so, it follows that secrecy must be affecting the communication of biotechnology at all stages of the research process. Leivrouw (2004, p. 170) agrees:

> We are faced with a system of scientific information and communication that is increasingly based on secrecy/solitariness, commitment/particularism, irrationality/organized dogmatism, and personal judgement and interest. This is the case despite the fact that when asked most scientists ascribe to and affirm the traditional [Mertonian] norms as part of their training and practice.

Meadows (1998) also discusses constraints on communication that follow from (perhaps) modern deviation from the norms.

It is beyond the scope of the present work to judge the merits of norms and/or counter norms in science, although their influence on STS should be acknowledged. What is more important here is that what biotechnologists communicate about communication is a fertile and legitimate topic of study. It is of interest that ‘most scientists ascribe to and affirm the traditional norms as part of their training and practice’, even if this cannot be confirmed or denied empirically in a way that is separate from what they *say* they do.

The following passage is taken from Mulkay (1991), which is a loose collection of articles authored or co-authored by Mulkay in the 1970s and 1980s on the sociology of science. One article (‘Replication and mere replication’ [1986]), written with

Nigel Gilbert, describes a study of how a group of scientists talked about the Mertonian norm of replication of experimental results. The authors claim that there is an official view of replication that is the basis for claims that it should (does) happen or does not happen in the normal course of scientific research. However, the authors are not interested in this official view. They are not so much interested in replication as they are in *scientists' discourse about replication* and scientists as skilled negotiators of the meaning of replication as a scientific practice. I have substituted the word 'communication' for the word 'replication' in the passage to show that this approach may be taken for any element of the doing of science.

> When scientists' discourse about **communication** is examined in detail, we find that scientists themselves furnish a much more subtle and intricate account than the supposed 'official view'. While we do not intend to suggest that their accounts will tell us how **communication** really does operate in science, the point of departure must surely be a proper appreciation of the complex, diverse and flexible interpretive work which is routinely carried out by scientists. Our aim here is therefore to begin to document some of the recurrent features of scientists' talk about **communication**; to show that scientists themselves use several conceptions of **communication**; and to begin to show how these apparently diverse conceptions of **communication** can be employed by scientists to portray their own and others' actions (taken from pp. 154–155, emphasis added).

In summary, biotechnology is of interest because it involves both the constituent and the interactive; both science-in-the-making and ready-made science. On a social level, biotechnology, with 'one foot in the academy and the other in the market', with its associated rhetoric of fear and hope ('Frankenstein Food' versus 'cures for disease'), and with its potential to change human capacity, cannot be ignored. Thus, one interesting and legitimate approach to the study of biotechnology is the study of biotechnology researchers' communication.

2.4 Scientists communicating

> People distinguish between knowing something from having experienced it and knowing something secondhand or more abstractly, and they generally give a privileged place to their own experiential knowledge (Gamson 1995: p. 87)

Although Gamson's statement makes sense, it is not possible for everyone to have their own experiential knowledge of biotechnology, or any other sort of science. It is not possible for everyone to have the experience of being a plumber (unless they are a plumber), but many of us will have had experiences of being an interested listener, observer or participant in the plumbing process, particularly in situations that are directly applicable to us.

Face-to-face communication between scientists and others may be second hand or somewhat abstract in regard to biotechnology, but it is not inconceivable that many people who are not biotechnologists are prepared to be interested listeners, observers or participants in communicating biotechnology. Direct face-to-face communication, with minimal mediation, increases the chances of the communicating parties coming to some understanding about one another. For example, Scott (1989) suggests that:

> …most scientists within the life sciences see themselves as a wide range of individuals involved in making observations, putting forward hypotheses and designing experiments… (p. 71)

But also speculates that laypeople might regard scientists as:

> A group of special people who, while they all profess to think the same way, still seem to fight a lot with each other. A group of people who, while they keep telling everybody what marvellous progress they are making, still do not seem to be able to do much about some important problems, no matter how much money they are given… (p. 71)

Presumably scientists would like others generally to think about them in a way that is similar to the way that they think about themselves. This is more likely to happen if everyone talks to one other, rather than relying on information and stereotypes that really are second hand.

In the science communication environment, there is a central place for communication by scientists themselves. I am convinced that a scientist talking about science to non-science (semi-science?) others, including friends, relatives or even casual acquaintances, is a basic and effective form of science communication. This has been neglected by previous conceptions of the communication of science.

2.4.1 Studies of scientists communicating

Not, however, totally neglected. For example, Rier (2003) conducted a series of semi-structured interviews with scientists looking at work setting, publication and scientific responsibility. Rier attempted to position science within society by contributing to the articulation of 'civic science' (i.e. scientists representing science to non-scientists). Using the peer-reviewed publication as the (communication) phenomenon of interest, Rier interviewed toxic exposure epidemiologists about how they perceived media coverage and public consumption of their work.

Interestingly, Rier found that grey literature (e.g. public information brochures, unpublished or limited distribution communication), especially in government science, was regarded as a key dissemination channel where concern for downstream consequences was addressed. That is, grey literature, a genre of science communication that is further downstream (using Hilgartner's [1990] metaphor in which scientific findings, as they are communicated from the researcher to a broader audiences may be seen as floating 'downstream') or closer to non-specialists, was seen by scientists as one of the most useful ways to communicate potential toxic exposure scenarios to the potentially exposed public.

Grey literature is not direct communication by scientists, but it is certainly more accessible to non-scientists (e.g. clinicians, journalists, the public) than scientific peer-reviewed publications, and is perhaps more favourably regarded than a 'mere conversation' in circumstances where human health issues may be critical.

Waterton *et al*. (2001) (and with a slightly different emphasis, Waterton 2005) interviewed environmental scientists in the UK, asking them to reflect on the boundary between science and policy, in order to explore the factors that might limit this reflection (and by corollary its communication to non-science others). These scientists recognised that they adjust their communication practice depending on the audience. One went as far as to categorise his communication according to the audience — fellow scientists, non-scientists and science sponsors (funding agencies).

The point that Waterton *et al*. (2001) make is that the contingent nature of science, which non-scientists rarely hear about (i.e. that science is done by people who are influenced by their personal circumstances), can be (and is) reflected on by scientists and communicated under certain circumstances. The authors suggest that perhaps we should:

> ...actively attempt to stabilise this discourse, to establish it as a valid way of talking about science in the context of society today, and perhaps to 'ground' it in recognisable social–institutional dimensions of modern science (Waterton *et al*. 2001; p. 33)

Otherwise, such reflections can never become part of an explicit public debate and discourse about science.

More recently, Small *et al*. (2008) asked scientists to identify the social and political implications of their work — their approach stemmed from the science itself and the people who (co-)produced it. The answers given by the scientists had to take into account situations where they had previously communicated with non-scientists, or at the very least imagined such situations. They found that scientists described the social and political implications of their work mainly within the context of extrinsic (social) themes (e.g. health, environment, economic, technological), but also extensively within the context of intrinsic or internal (to science) criteria in the 'advancement of science' category: 'simply doing science and advancing knowledge is an important social outcome' (p. 220).

More such work is required to examine this relationship between scientists communicating about science and their reflections on it.

2.4.2 Biotechnology in the public sphere

Best and Kellner (2004) argue that issues of genetics, cloning and stem cell research are 'so important that scientific, political, and moral debate must take place squarely within the public sphere' (p. 222). To this end, they urge scientists to 'enter dialogical relations' with the public to:

- discuss the complexities of their work
- make their positions clear and accessible
- be accountable and responsible (p. 220).

Concurrently public intellectuals and activists should, according to Best and Kellner (2004), 'become educated in biotechnology to engage in debate in the media or public forums on the topics' (p. 220). Dialogical relations are both necessary and everyone's responsibility.

Could this process become institutionalised? It is arguable that the dialogue model of science communication came to prominence with the UK House of Lords *Select Committee on Science and Technology Third Report on Science and Society* in 2000. Certainly this report created a lot of activity in the UK and elsewhere as people attempted to think about science communication from a non-deficit-model standpoint. One of the Summary recommendations of the report is this:

> Direct dialogue with the public should move from being an optional add-on to science-based policy-making and to the activities of research organisations and learned institutions, and should become a normal and integral part of the process (UK House of Lords 2000; p. 3).

Whether or not any process of science has dialogue with the public as a normal and integral component, it sounds like a good idea. Optional add-on or institutionalised process, scientists talking with others about their work can only be socially preferable in the long term.

Elam and Bertilsson (2003) do consider scientists (and non-scientists) as individuals, populating the territories of science and society such that they:

> ...are reimagined in a way that produces a closer identity between the two: between the scientific community and society at large and between the scientist and the individual citizen (p. 4).

In a context of 'post-normal science' (quoting Funtowicz *et al*. [1999], defined as a context where 'facts are uncertain, values in dispute, stakes high, and decisions urgent' [p. 8]), where science is carried out of the laboratory and into society, established facts lose reliability and quality replaces truth as a guiding principle for action. This is particularly the case, they argue, for decision-making processes, where support from all stakeholders is required (p. 9). So, unless scientists take it upon themselves to carry their science out of the laboratory, society as a whole can only do a partial job of assessing its quality.

Sturgis and Allum (2004) mention something else that is an issue for scientists as individuals communicating. Referring to Wynne's (1992) three elements of public understanding of science ('the formal contents of scientific knowledge; the methods and processes of science; and its forms of institutional embedding, patronage, organization and control' p. 58) and Miller's (1998) concept of what constitutes scientific literacy (a vocabulary of basic scientific constructs, and understanding of the process of scientific enquiry, and of the impact of science on individuals and society), a theme emerges.

Unless scientists as individuals take some part in communicating science, it is very likely that only the first of these definitions — scientific knowledge or constructs — will be communicated beyond individuals actually involved in science. How science happens (processes), where science comes from (how it is organised, funded, controlled), and what kinds of impact science has on individuals and society — these are all elements of science that need to be discussed for full engagement with science, yet there is little evidence that scientists do communicate these aspects of science to non-scientists in *formal* contexts.

Taking part in a conversation, according to Sless and Shrensky (2001), is what communication is all about. They suggest that 'all types of communication are variants of conversations between people' (p. 103). Communication is dynamic, depends on the 'between' relationship (there is no such thing as a message, communicator or audience on its own) and can only be described as 'what goes on' in a particular context over a particular period of time. This fits in well with the (science) communication environment concept, although Sless and Shrensky do emphasise direct observation as 'the most important research method to be used in communication research' (p. 104) as a logical conclusion from their pro-conversation stance, so I will take care to justify my own methodology (more on this later).

Obviously biotechnology is firmly in the public sphere (otherwise, how would non-scientists have ever heard of it). What is unclear is the degree of dialogue, whether this provides society with a reasonable basis for policy and other decisions, and how scientists can access and contribute to the public sphere if they wish to do so.

2.4.3 Rhetorical devices for persuasion

Berkencotter and Huckin (1993) describe the process by which two scientists go about getting their scientific paper accepted for publication. The social scientists in this case describe what they see as the contingent and tentative epistemological status of natural scientists' knowledge claims; their social construction and negotiation observed in the revision process (p. 113). However, they describe the natural scientists, in placing the work within an intertext, '[saw] laboratory research and rhetorical activity as distinctly *separate*' (p. 124, emphasis in original) and that the necessity of placing local history (the laboratory) into a narrative framework was 'phoney'.

Rhetorical activity and telling the story of the experiment (in the context of the laboratory) — even within the formality of a research article — was perceived as separate from the research. This perceived separateness is not an unusual attitude for scientists, yet many would also agree that Watson and Crick's (1953) paper on the structure of DNA (for example) used such rhetorical devices to great advantage (see Moore 2000 for a discussion of the importance of rhetoric and writing in science).

What is clear is that many scientists are ambivalent about communication and their research. On the one hand (as described in McClam 2006), concerns with 'the self as a scientist' can constrain one from communicating as freely as one would like to within a formal context. On the other hand, communicating in a specific manner within the culture of science and the genre of the experimental article can also force one into writing more than one might wish (as described in Berkencotter and Huckin 1993). Scientists, of course, are not a homogenous group when it comes to attitudes towards communication.

In reality, as in all boundary struggles over scientific authority and control, 'both scientists and non-scientists employ tools including rhetorics, objects and organizations' (Kelly 2003; p. 343). The subject of Kelly's article is the operation of public bioethics committees (in the US). Kelly suggests that the multiplicity of actors with their multiple interests and attitudes make it impossible for scientists by themselves to fully resolve science questions. Science is not separate from societal interests, so the ultimate rein on communication is therefore not merely internal (e.g. perceptions of self as a scientist) or institutional (e.g. restrictions of scientific genre).

Bauer *et al*. (2007) claim that the science and society paradigm focuses on the deficits of the technical experts, such that:

> The implicit and explicit views of the public held by scientific experts come under scrutiny, they explain part of the trust crisis. False conceptions of the public operate in science policy making and misguide communication efforts of scientific institutions which alienate the public still further (p. 85).

My thesis is probably most closely aligned to the science and society paradigm, as opposed to the science literacy paradigm (from which the deficit model of science communication springs) or even the public understanding of science paradigm (which also puts the onus on the public). I do indeed focus on the scientific experts and partly on whether their perceptions of 'the public' have a negative impact on their communication.

There are numerous examples of scientists communicating persuasively when acting collectively. Krimsky's (1998) organizing thesis is that 'political debates in biotechnology are essentially about control over techno-mythmaking, which [he defines] as the shaping of social expectations through the association with technology of symbolic powers and simple moral virtues' (p. 145). Scientists, according to Krimsky, are just as interested as anyone else in maintaining this control, and sometimes collective action can be an effective way to communicate to persuade (e.g. Mulkay 1995, Krimsky 1991). Even so, individual-to-individual contact is often required in such actions, as can be seen in the following example.

Mulkay (1995) describes attempts by scientists use their authoritative position to reassure and as a consequence effectively lobby the UK parliament about allowing certain sorts of experimentation on human embryos. For the purposes of lobbying, a group of scientists formed a group called PROGRESS; they used personal stories from women who had benefited from assisted human reproduction and they created direct links between parliamentarians and researchers involved in the area.

Whether or not one agrees with the methodology used by the group PROGRESS, it achieved its aims and the individuals involved were certainly within their rights to form the group. Interesting aspects of their method are the use of personal stories and the creation of links between individual scientists and parliamentarians. The personalising of interaction and face-to-face communication is a core tenet of the present thesis, increasing understanding between participants and social cohesion. They also suggested the concept of the ‘pre-embryo’, a term which simultaneously changed one concept associated with human life (that prior to 14 days gestation of the zygote, no human individual exists) and allowed the parliamentarians to align themselves with the ‘obvious’ medical benefits and distance themselves from the ‘emotional’ or ‘ill-considered’ anti-research stance.

Krimsky (1991) also observed a group of scientists attempting to depoliticise an aspect of their science; in this case, human genetic engineering (at the Cold Spring Harbor meeting in 1982: *Gene Therapy: Fact or Fiction*). Their strategies included differentiation between types of genetic engineering (e.g. medical [therapy] vs political [eugenics]) in order to associate their work with the more benign (therapy) type; an attempt was made to reconstruct terminology to have positive connotations; and to claim that the technology is the only possible cure, thereby overcoming any ethical or political barriers.

There is no reason why groups of scientists cannot get together and plan persuasive communication strategies. This is discourse directed towards political change, and in this, scientists are just as interested as any other group to persuade others to their advantage.

2.5 Analysing scientists’ discourse

The theoretical ideas that I have been discussing here: the science communication environment, the co-production of science and the place of communication by the individual scientist, are all ideas that lend themselves to investigation using discourse analysis. An analysis of the discourse of individual biotechnologists can provide details about science communication from the perspective of the individual — perspectives about influences on communication from the people who use communication to do science every (working) day. Who better to talk about encouragement or discouragement, benefits and disbenefits of communication of biotechnology than biotechnologists?

2.5.1 Social intent versus social reality

Burchell (2007) suggests that a discourse approach may be regarded as an analysis of the social intent of the speaker, rather than a reflection of social reality. I would agree with this and also take it even further and argue that a social reality for the speaker is in many senses ‘real’ and that, therefore, discourse may be used as both a topic and a resource as long as the social reality is not taken to be the end of the matter — that is, it is not accepted unproblematically as a total representation of ‘the way things are’.

A persuasive argument from Seale (1998) is that it is not necessary to ‘take sides’. He describes a study where respondents’ accounts gathered via interview were initially treated as a resource for ‘learning about previous events’. Later in the study, events during the interviews came to be treated as a topic of research. Searle argues that positivist theories that take language to be a resource and constructionist theories that look at how language is used to construct reality can happily coexist, provide equally useful insights and a richer understanding of complexity.

2.5.2 Discourse communicates information and supports the social

Gee (2005) proposes that thinking about the purpose of language as ‘communicating information’ is inadequate. He suggests two closely related functions of language as ‘to support the performance of social activities and social identities and to support human affiliation within cultures, social groups, and institutions’ (p. 1).

Waterton *et al*. (2001) note that, during interviews, GM scientists were seen to be actively constructing their identities in relation to wider debates, at a time in the UK when GM was a particularly controversial field and widely reported in the media. The GM scientists (compared to other scientists that were interviewed in the study) tended to be defensive and portrayed themselves in an attractive light, whilst discrediting other elements of the debate.

> ...they felt curiously in touch with public opinion about their research (due to the media coverage of the GM food issue), yet at the same time overwhelmingly cut-off and mistrusted by the public. Some scientists had tried to remedy this sense of isolation - for example by stating their position on GM issues on the world wide web. Others felt incapable of trying to shape a better relationship between themselves and the public (p. 22).

> ...almost everything that the GM scientists said in interview could be related back to the media formulation of the issues (p. 22).

> ...GM scientists, sensitised by media attention, seem to be actively adjusting the way that they employ concepts such as uncertainty and responsibility in their discourse (p. 24).

Conversely, silence might also be said to ‘support the performance of social activities and social identities and to support human affiliation within cultures, social groups, and institutions’. Huckin (2002) defines textual silence as ‘the omission of some piece of information that is pertinent to the topic at hand’ and suggests that, in addition to macro-level silences (which occur when powerful groups exercise hegemony over disempowered groups), there are micro-level silences.

Leaving aside silences of the former sort, which are a logical outcome of the power differential between scientists (as experts with vested interests) and non-scientists, silence of the latter sort, including presuppositional, discreet and manipulative silences, are likely to occur between scientists and non-scientists in the less formal situations that are explored in the present study. Some examples might include:

- presuppositional silences, where the speaker does not state assumed common knowledge — presumably a general problem for non-scientists who do not actually share much of what is assumed to be common knowledge
- discreet silences, where the speaker avoids stating sensitive information — might occur between scientists and non-scientists in discourse around controversial areas of science, but also between scientists if, for example, a confidentiality agreement exists
- manipulative silences, where the speaker deliberately conceals relevant information — even if this never occurs, it would certainly be perceived to be

> occurring, particularly in discourse around controversial areas, for example, in the environmental sciences where there is a potential impact on human health.

The problem then becomes how to use discourse analysis to study silence, which lacks an overt linguistic form. One way is to use self-reporting of behaviour, such as the interview data analysed in the present study.

Clearly, discourse is used/modified/constructed to achieve the aims of the speaker. This is a good example of where discourse as a resource (reflecting social reality for the speaker in a specific context) can, perhaps, be an effective way of getting at communication practices of biotechnologists.

2.5.3 Scientific discourse versus discourse of scientists

Prelli (2001) blurs the line between scientific discourse (in general) and the discourse of scientists by arguing that instead of assuming that science is unique (i.e. founded in nature and logic and best approximating the truth), scientific claims:

> ...are interested, value-laden, and opinionated, as are those adduced in less epistemologically exalted fields of human endeavor (p. 63).

Essentially, what scientists say is what science is, with the caveat, discussed earlier, that we should allow for a material basis for our ideas about the natural world.

This argument may be logically extended to the next point, which is this: if the discourse of science (extent, type, absence/presence etc) depends on the context in which science is done (workplace conditions, public controversy, changing status etc), it follows that science will be constrained by scientists' own beliefs and attitudes (about communication and other issues). Science will be constrained by all of the normal things that influence humanity within a social context.

For example, Hermanowicz (2003) found that the scientists he interviewed expressed self-doubts about their own career progression, which differed depending on their workplace. Stephen (1996) suggested that, if scientists are considered as human capital, then the economics, the reward structure and the growth of science, will all impose constraints. Waterton (2005) found that older scientists claimed to no longer speak freely about their work at conferences, as they claimed they had done in the past, because it gave their competitors, in a more competitive modern scientific world, too much information.

McClam (2006) found constraints on communication associated with how scientists see themselves (identities) when she examined individual scientists' perceptions about what a scientist is. Her work seemed to show that personal perceptions of whether an individual fits in to the culture of science, thinks that science will be his/her career or represents him/herself as a scientist, can all have an effect on his/her ability or willingness to communicate. In addition, McClam's interviewees identified constraints on what is allowable in formal scientific communication (e.g. one interviewee wished that she could say more about the negative implications of logging on forest ecosystems, but realised that she could only say things like 'this has implications for policy and management' [McClam 2006]).

Bazerman (1998) reviews several different perspectives on the role of language in the production of scientific knowledge from the point of view that the authoritative success of scientific representations has suppressed awareness of scientific discourse as a social construction. According to Bazerman, once the social nature of scientific discourse was accepted: Latour (1987) showed an interest in the power implications of each scientific term and concept; Myers (1989, 1990ab, 1991, 1992ab) concentrated on the linguistic and rhetorical means by which academic disagreements are negotiated; and Halliday and Martin (1994) explored the creation of scientific text objects (terms), their abstraction and the relation-building that makes the text concrete, but difficult to unpack.

Bazerman's own interest cuts across these ideas — he posits that structured forums or discursive systems (eg experimental articles, research seminars, the media) locate and create specific meanings for scientific texts. Once a text has been accepted in one of these discursive systems, other layers of meanings are applied simply due to its context.

Obviously there are many different perspectives from which to study discourse. Hall's (1992) denotative and connotative meanings, and the decoding of discourse according to hegemonic, negotiated or oppositional senses; Myer's (1990) texts and the social construction of scientific knowledge; Ortony's (1993) use of metaphor in theory building; and Swale's (2004) genre networks, are just some examples of perspectives taken by researchers over the past couple of decades. Interestingly, all of these perspectives have something to say about theoretical matters analogous to the communication environment view.

All of this shows that scientific discourse is a rich area of research, hence my own interest in the scientist-as-communicator. As described by Waterton *et al*. (2001), weighting interview schedules can oblige scientist–participants to reflect on their practice. In the present study, the practice of interest is the communication of biotechnology and science in general.

2.6 Drivers of science communication

So, what does this mean for the individual scientist communicating about his/her work? One important aspect of modern science — and biotechnology is a good example of this — is that it is competitive, which suggests winners and losers, or at least some form of inequity. In terms of science communication, this means that knowledge, information and communication is viewed within a framework of economic exchange and the maximising of personal advantage, rather than of sharing meanings and reinforcing social ties (Lievrouw 1998; p. 91).

Lievrouw (1998) also introduces the idea of horizontal information inequity, which is a situation where people differ in their access to and use of information, despite similar economic and educational backgrounds; limited interaction between horizontally similar groups leads to limited exposure to diverse types of information. Given the increasing constraints on communication faced by individual scientists, horizontal information inequity is bound to be getting worse in science, but not only in terms of scientific communication — any sort of communication that might occur in an interaction between a scientist and another individual. What is potentially at stake is non-scientists' perceptions of science and scientists' perceptions of society.

Interview-based empirical work suggests that scientists (particularly those who work with controversial technologies or research practices) view non-scientists as 'irrational, subjective, ignorant and easily influenced by the media and [non-government organisations]' (Burchell 2006; see also, for example, Cook *et al*. 2004;

Burchell 2007). However, deliberative and inclusive processes (DIPs; e.g. consensus conferences, citizen juries, focus groups, referendums), which are increasingly being associated with new technologies and scientific practice, require communication across areas of expertise. A change in perceptions may be a long-term proposition, but this is obviously required before DIPs can achieve organisers' aims.

2.6.1 Sociopolitical drivers

Science communication, and specifically communication about biotechnology, is generally thought of as being 'a good thing' due to the potential for widespread (global) consequences of science and technology. The merit of communication about biotechnology is often couched in terms of economic prosperity. Stocklmayer *et al*. 2001 identify five oft-cited benefits of science communication: economic, utilitarian, democratic, cultural and social.

These benefits are commonly discussed in public policy terms from a nationalistic and competitive perspective, where the *products* of biotechnology are the focus. However, when scientists are being exhorted to communicate, a different economic perspective is frequently referred to: that stakeholders (the public, funding bodies, medical charities, research councils) are funding the work and therefore should know what is happening to their money.

The potential for increased economic prosperity also tends to be behind calls for a scientifically educated public and in the encouragement of young people to make their career in science. From a utilitarian perspective, it has been suggested that science might be used more efficiently by the community, and the community might feel more comfortable about the use of science, given better communication. Many policy decisions require at least some element of science, which therefore needs to be communicated effectively for policy makers and other stakeholders to make use of it in a democratic system.

There are also a number of more recently articulated general 'motherhood statement' reasons for communicating science:

- Cultural — linked with the idea that science is not separate from culture; there are no 'two cultures' (Snow 1968 [1993]), no diffusion from one to the other, instead science is seen as a human cultural artefact. Thus, science is intrinsically interesting, not just useful for immediate material benefit.
- Social — linked with the idea that individuals, groups and governments need to make decisions, and decisions must be based on knowledge about current and future possibilities. This is particularly relevant in terms of current or future applications and the ethics of pursuing scientific research. At the same time, this type of communication has the potential to improve social cohesion because a shared understanding in society may develop about science and its role in everyday life.

Work in the study of science communication has explored communication by scientists (e.g. Shen 2006, Charlesworth *et al*. 1989, Gilbert & Mulkay 1984 [2003]) and the communication of biotechnology has also received attention in recent years, generally focused on communication in the media (e.g. Crawley 2007, Cook *et al*. 2006) or on different public communication strategies (e.g. Zorn *et al*. 2006, Katz 2005). In the present study, a combination of these approaches will be used to explore aspects of scientists communicating biotechnology.

2.6.2 Personal drivers

In the previous section, I discussed the mixture of reasons usually cited for the *general* benefits of communicating science, based on those outlined by Stocklmayer *et al*. (2001): economic, utilitarian, democratic, cultural and social. All of these are also relevent to the individual scientist communicating, who is, after all, a member of the community and the wider society. But, why would scientists themselves want to communicate their work? As my interest is to narrow the focus to scientists (biotechnologists) in particular, I will discuss the reasons often cited by individual scientists for getting involved personally in science communication. Of course, the general or overarching reasons overlap with personal reasons, and the personal reasons are often a subset of the general reasons.

A good practice guide commissioned by the (UK) Engineering and Physical Sciences Research Council (PSP 2003), provides six overlapping personal answers to the question ‘why get involved in science communication’. These answers stem from a variable mixture of altruism and personal benefit on behalf of the individual scientist and include:

- the sharing answer — a responsibility to share publicly funded research with the public
- the recruitment answer — a desire to influence students to take up science
- the science and society answer — based on the assumption that a better-informed society can debate matters associated with science more fully
- the pragmatic answer — a requirement attached to funding
- the career answer — one method of career progression
- the personal satisfaction answer — an enjoyable and morale-boosting activity.

In all of these, the individual is contributing to the communication environment within which s/he works. Even if these answers are not exhaustive, they provide both a justification for and an explanation of a desire of the individual scientist to get involved in communicating their work.

This is despite the reality that, for scientists, rewards for communicating can be slight and real costs high (Weigold 2001). This is also despite the norm of allocating scientists little responsibility — unless they are well-established and/or particularly visible publicly — for dealing with anyone outside their immediate sphere(s) of operation. Internal and external (to science) barriers tend to discourage a more cognisant engagement in the communication environment (Shortland & Gregory 1991, Weigold 2001). Internally, examples of barriers include:

- problems associated with the specialised language of science
- widespread belief in the primacy of peer review and the triviality of mass media representations
- a culture of seeking to appear humble and dedicated, with neither the time nor the inclination to self aggrandise.

Externally, examples of barriers include the potential for ‘the public’ and the media to misunderstand or distort findings or get excited about the ‘wrong’ things.

Anecdotal evidence (from the interviews) and other studies (e.g. Cook *et al*. 2004, Peters 1994) suggest that clashes between scientists and the media in regard to norms of practice, or the appropriateness of evidence versus assertions, may have led to the adoption of an attitude of 'opting out' of potentially difficult situations.

However, the science communication environment exists whether the individual (scientist) has cognisant or non-cognisant engagement with it. Prelli (2001)claims that:

> Today, scholars are more apt to assume that science is constructed within a dynamic complex of social processes permeated with human interests, values, and preferences. The actual practices of scientists consist of myriad layers of decision making and judgment down to its logical and empirical core…[scientists'] claims, it turns out, are interested, value-laden, and opinionated, as are those adduced in less epistemologically exalted fields of human endeavour (p. 63).

Scientists communicate in a science communication environment. The aim then is to find out using discourse analysis what a certain group of biotechnologists think about communication and how they interact with the science communication environment.

2.7 Conclusion

In this chapter I have introduced the idiom of co-production according to Jasanoff (2004 ab) and linked it with van Dijk's (1998) context models to position the present thesis within the landscape of the social and the natural in the doing of science.

I have discussed the various models of science communication, with an emphasis on the inadequacies of the so-called deficit model, and proposed a science communication environment, within which a multiplicity of models may be appropriate to explain a wide variety of science communication phenomena. The non-identicalness of science and society as a concept remains in conflict with the holistic nature of the proposed science communication environment; however, I have argued that this ambiguity does not need to be resolved.

Elements that make modern biotechnology a distinctive enterprise have been discussed: its constitutive and interactive aspects, the tension that exists with

Mertonian norms and the emergence of counter norms in this more private style of science making.

I have put forward the communication of science by scientists as an important part of doing science, and have presented other scholarly work in this somewhat neglected area. These studies have investigated the civic scientist, the policy-informing and boundary-working scientist, and the socially reflective scientist. The value of science communication in the public sphere has been discussed and I have given examples of scientists being persuasive in their public communication.

For the purposes of the present study, ‘discourse’ is taken to mean the communication of information and the support of the social — an individual’s social activities and identities. It is clear that constraints on the communication of science by scientists exist, including the limitations imposed by ‘standard’ repertoires, communication contexts and scientific identities. Much of the empirical work in the present thesis engages with the forms of constraints operating on individual scientists communicating. Finally, I have given examples of sociopolitical and personal support for science communication, as I hope to show that both push and pull factors exist in the science communication environment.

Chapter 3 Methodology

Creswell and Plano Clark (2007) have argued for the use of combined methodological approaches in social science research:

> The combination of qualitative and quantitative data provides a more complete picture by noting trends and generalizations as well as in-depth knowledge of participants' perspectives (p. 33).

Given the range of qualitative and quantitative data that I collected during the course of the present study, their argument makes sense. In addition, from the beginning I felt that a single approach would be inadequate to address the complexity of the research problem, as my aim was both to study the participants as individuals communicating and the kinds of communication individual natural science researchers *tend* to do.

Therefore, data were triangulated in order to provide a rich and deep understanding of the area of interest. Different forms of data were gathered and several methods of analysing them were combined, with different emphases depending on the data set, but in a systematic and complementary manner. In this way, I hoped to bring together the trends and generalisations of quantitative research and the details and depth of qualitative research (see also Creswell 1998, 2003). The datasets converged as the results were brought together in the analysis and interpretation. The data were collected at the same time and, as the same individuals participated in my collection of qualitative and quantitative data, neither form was given precedence over the other (e.g. by differential weighting).

This chapter is divided into sections describing the methods I used to choose and describe the pilot and participant populations, develop the interview schedule, collect, organise and represent the data, and analyse the results.

3.1 Research methods and data types

Table 3.1 summarises the methods and the samples used. I conducted 11 pilot interviews in April and May 2003 and 73 interviews for the main study between July

2004 and May 2005. The interview schedule and prompt cards are in Appendixes 2 and 3, respectively.

Table 3.1 Research methods and samples

Method	Time period	Sample
Pilot interviews	April & May 2003	National Centre for Sensor Research biotechnologists (*n* = 11)
Main interviews	July 2004 to May 2005	National Institute for Cellular Biotechnology research scientists (*n* = 73)

Triangulation of the data in the present study is in the sense of making use of 'multiple and different sources…to provide corroborating evidence' (Creswell 1998), rather than in a literal sense. Creswell (2003) uses the term 'mixed methods' for a research strategy that has moved forward from the original conception of triangulation of qualitative and quantitative data sources for the purposes of increasing validity. The present study may, therefore, be described as a concurrent mixed methods study, which uses different forms of data collected during the same time period with the aim of integrating these in the interpretation of overall results (see Creswell 2003; p. 16).

Section 3.6, below, provides a discussion on concepts of validity, representation and transferability associated with the present study.

I chose the interview as a modification of the survey in which, according to de Vaus (2002), the researcher looks at variation in a variable across cases and at other characteristics that are systematically linked with it. Thus, I was interested in two aspects of the interview:

- the ability to gather data to examine systematically naturally occurring variation across the population (which is normally available from survey work)
- linking these data with the qualitative data that can only be gathered in a face-to-face interview.

In addition to the reasons already discussed in the Introduction, other methods of data collection would probably not have provided enough data about *communication* and the participants (Marsh 1979). In effect, one of the main conjectures of the present study — that researcher/participants are themselves an important source of communication about biotechnological research — meant that the only practical way to examine this type of communication in depth was to communicate with the researchers via interviews.

Additional reasons to use interviews, referring to the first of the five general stages in the development and completion of a survey, outlined by Czaja and Blair (1996), are that:

- the entire study population could be encouraged to, and did, respond
- participants needed to see cue cards and response cards to enable greater complexity in the design of the interview schedule
- participants could consult personal records or perform other memory-assisting tasks if required
- written answers to open questions would have created a disincentive to full participation.

Czaja and Blair (1996) discuss several disadvantages of interviews, including cost and time, the limitation of asking threatening or personal questions that are less likely to be answered, and response bias tending towards the socially desirable. Cost and time were not an issue in the present study. Personal questions were dealt with using category answers (e.g. age groups, rather than explicit years since birth). (I also felt that none of the questions were particularly threatening or personal, and this perception was borne out in the piloting process.)

The tendency to over-report socially desirable answers is an acknowledged aspect of the participants' self-reporting of perceptions and behaviour. My aim was to both minimise this and acknowledge it during the analysis and interpretation of the results. I decided to avoid agree–disagree answers because of the related problem of acquiescence, where some people may be predisposed to provide an 'agree' answer (discussed in Schuman & Presser 1996). Agree–disagree responses may be less valid indicators of attitude than forced-choice responses.

3.2 The participant population

As a social scientist engaged in research on the communication of biotechnology, I was in the rare position of being embedded in the research institute I was studying. The National Institute for Cellular Biotechnology (NICB) at the time of the present study was made up of (mainly) natural scientists engaged in research in biotechnology and related areas. I had, for the purposes of my research, nearly unlimited access to a population of biotechnology researchers who were willing to participate. A high proportion of them were also interested in the concept of science communication; some had engaged in science communication in the past, and nearly all of them had at least thought about the things I asked them in the interviews. This meant that my main research sample was conveniently placed and primed for the interviews.

3.2.1 The pilot

However, before I launched into the interviews, it was appropriate to trial in a pilot population the interview schedule, my interview and person-to-person communication techniques, potential interview locations, appropriate language use, technology requirements, and so on.

In April and May 2003, I interviewed 11 participants from the National Centre for Sensor Research (NCSR) at Dublin City University (DCU), with the aim of gathering data about the communication activities and attitudes of a small sample of biotechnology research scientists, and using these data for feedback in the development of the final interview instrument (see Appendix 2 for notes about changes made between the pilot and the final interview schedule).

I used a ‘post-interview’ interview to obtain information about comprehension when pre-testing the interview instrument (Czaja & Blair 1996; p. 97). This consisted of post-interview discussions with participants and asking them about the interview they had just taken part in. Participants were told at the outset that I would be discussing the interview with them at the end. (An additional aim of the pilot was to use the report as documentary materials in my transfer from Masters to PhD status at DCU.)

I chose the NCSR researcher pilot population as a group that would be as close in composition to the target NICB population as possible: both are research centres located at DCU and there is some overlap in the kinds of research done. The NICB is smaller than the NCSR, in terms of both resources and staff, and is less multidisciplinary. To some extent, the NICB competes with the NCSR for resources at DCU and within Ireland.

The results of the pilot were encouraging:

- all participants were willing to engage in the interview process
- lengths of the interviews were consistent
- the process was not too arduous for the participants, myself included
- gaps in data gathering were identified and rectified
- language was reviewed to make the questions clearer to the (mostly) Irish participants.

Following on from the pilot and from feedback I received during the transfer from Masters to PhD, the instrument was tweaked, in order to obtain more information or more pertinent information.

The final interview instrument, which resulted from this pilot work, can be found in Appendix 2.

3.2.2 The participants

The social scientists at the NICB (i.e. from the Biosciences and Society (BSS) Research Programme) and the members of the Computer Modelling Research Programme were excluded from the sample population. This was because I was only interested in people who were either biotechnologists, or perceived to be associated with biotechnology through the NICB (e.g. organic chemists). The participants in the present study were, therefore, members of the following Research Programmes:

- Cellular Differentiation & Tissue Engineering
- Cancer Cell Biology & Drug Resistance
- Bacterial, Fungal & Viral Pathogenicity
- Target Validation & Functional Genomics
- Synthesis & Fermentation.

Members of the NICB are constantly changing, with researchers joining and leaving, so the final interview population can only be considered as a slice in time. The implications of this flux are that I was unable to capture some people in the interview population. For example, one researcher was on sabbatical in Canada during the interview period, although he was still considered to be a member of the NICB and he and I were able to communicate adequately via email. This person was not included in the population for the purposes of interviewing. I had already decided not to modify the questionnaire for telephone or email use (which may have captured people on sabbatical, for example) because the face-to-face contact associated with the interview process and the form of the questions (their order, emphasis etc) was an important element of systematizing the research. Although such modification may have created more data (by capturing more participants), overall, the results would have been less comparable.

I contacted the Senior Administrator of the NICB in order to identify potential participants. In addition, mailing lists already set up for communication with various sections of the NICB were scrutinised so that any new researchers could be identified and linked with their email addresses. Each of the 80 potential participants was sent an email cover letter and invitation to participate (Appendix 4), which was followed up by a telephone call, if necessary, to organize a suitable time to interview.

Some participants were contacted more than once, but all participants who were contacted agreed to take part, unless they were on sabbatical or otherwise unavailable. One participant declined to be audio taped due to personal reasons, but agreed to be interviewed, allowing me to take written notes.

Most NICB researchers interviewed (of a total of 73) were located on campus at DCU (45). There are also two other sites of the NICB: one at the National University of Ireland, Maynooth and the other at the Institute of Technology, Tallaght. At the time of the interviews, there were 14 researchers at Maynooth and 14 researchers at Tallaght, mostly concentrated in the Bacterial, Fungal & Viral Pathogenicity Research Programme.

The participants located at Tallaght and Maynooth were recruited for the present study in a slightly different manner to that described above. As these two sites are rather self-sufficient, in both cases I initially contacted the research leaders to gain access to the sites and to the participants. This meant that the process was more efficient — in Tallaght I interviewed all 14 of the researchers in a single day — but there was less scope for spontaneous talk with the participants due to time constraints. In addition, there was probably less scope for participants to decline to participate, had they wished to do so.

The interviews took place between July 2004 and May 2005, in the offices of the respondents, in my office, or in some neutral quiet room. The mean duration of the interviews was 34 min (max. 65 min, min. 20 min). Each interview was audio recorded (with one exception, noted above) and written notes were taken at the same time for comparative purposes and in case the audio technology failed. Chapter 4 provides information about the population from the perspective of the work environment they operate within.

3.2.3 Biotechnology in Ireland

Ireland is a rich context in which to do this type of research. Economically, Ireland has taken an approach to biotechnology and information and communication technologies (ICTs) that is focused on the notion of a 'knowledge economy' (many other countries have also taken a similar approach; e.g. Singapore, Australia). The knowledge economy approach in Ireland has led to policy actions such as the establishment of partnerships between government and industry (e.g. BioResearch Ireland) to facilitate the commercialisation of academic biotechnological research, and a focus on the development of a significant biotechnology-educated workforce.

In Ireland, over the 7-year period 2000–2006, €2.5 billion was allocated to research, technological development and innovation, of which €310 million was estimated to be going to biotechnologies (Canning 2000). This is a substantial increase on the €46 million allocated to biotechnologies in the 5-year period 1994–1998. In 2002, Ireland announced an approximately €20 million fund for biotechnology companies through BioResearch Ireland, designed to promote cooperation between academia and industry (Lee & Dibner 2005). Overall, Ireland aims to increase gross expenditure on research and development to 2.5% of Gross National Product by 2010, from 1.4% in 2004.[4]

Biotechnology in Ireland represents substantial economic and social capital (Bourdieu 1986).

3.3 The interview instrument

The aim of the interviews was to collect data on the participants and their attitudes, perceptions and practices in relation to communication about their own research and related science and technology. Thus, the interview schedule included questions on:

- socio-demographic variables
- research area and professional practice
- communication activities and attitudes
- sources of information and media coverage
- recent and future communication events.

The complete, final interview instrument can be found in Appendix 2.

Twelve of the questions included in the interview schedule were based on questions asked on the Wellcome Trust-commissioned Market & Opinion Research International (MORI) survey *The Role of Scientists in Public Debate* (MORI–WT

[4] From an Irish Department of Enterprise, Trade and Employment publication – *Building Ireland's Knowledge Economy: The Irish Action Plan for Promoting Investment in R&D to 2010, Report to the Inter Departmental Committee on Science, Technology and Innovation,* available from: http://www.entemp.ie/publications/enterprise/2004/knowledgeeconomy.pdf (last accessed 23 September 2006)

2001).[5] Details of questions that were reproduced exactly from the MORI–WT survey, and those that were modified, split or merged can be found in Appendix 2.

I drew on the MORI–WT survey because the research problems it explored, the definitions of concepts and the measurement questions were similar to those I was developing in the present study (see Section 3.3.1). In addition, the stated aims of the MORI–WT survey in 'seeking to identify and understand how scientists themselves perceive increasing calls for them to become more involved in communicating their research to the public' (MORI–WT 2001; p. 4) also fitted in quite well with my own research aims.

Additional questions were developed in order to tailor the instrument to the needs of the present study, including questions about:

- research area
- membership of professional science organisations
- aspects of working life (particularly time allocated to different activities)
- confidentiality agreements
- future goals
- specific instances of communication with specialist audiences and with non-specialist individuals or audiences.

A question about the participants' willingness to talk about their research to non-specialists in the future, such as schools, interest groups and public meetings was initially included for the purposes of following up and asking those participants who had expressed a willingness to talk to school groups to do so as part of a colleague's project. That project took scientists from the NICB into schools to talk to secondary school students in Transition Year (fourth year) and some in their fifth year. These talks were about motivations, day-to-day work in biotechnology, university entry points and career paths, and biotechnology and society.

[5] Also available for download from http://www.wellcome.ac.uk/doc_WTD003429.html (last accessed 9 April 2006).

As the survey instrument developed beyond the pilot phase, I decided to shift the emphasis of this question. If the participant expressed a reluctance to talk about their research to any of the three groups mentioned, I explored their reluctance by asking them why. In the end, the participants were not followed up for the other project and the responses to this question formed part of the open responses to the present project.

3.3.1 MORI–Wellcome Trust survey

This large-scale Great Britain-wide survey was carried out between December 1999 and March 2000 with (all types of) scientists working under funding from a range of academic, charity and industry sources. As the Wellcome Trust and MORI are well-established organisations, with a great deal of professional experience — particularly MORI in all aspects of survey design — it was a good opportunity to borrow from the format developed for MORI–WT (2001). The questions had already been validated and, although this validation was done with scientists from a range of areas of expertise who were presumably not Irish, this provided a reasonable starting point for the development of the survey for the present study. (The MORI–WT survey was piloted on 17 scientists to test comprehension, appropriateness, flow and language of the questions).

I also discovered that a researcher in South Africa was using the MORI–WT survey as a basis for questioning scientists at the South African Medical Research Council (Gething 2002). After email contact with her, on her advice, I attempted to obtain written permission from MORI or the Wellcome Trust to use the survey in my own project. However, although I spoke to several people involved with the development of the MORI–WT survey, none of whom objected to its use, I did not obtain explicit written permission. My feeling was that this was more from a lack of concern on their part, rather than an implied refusal. I decided to continue using the MORI–WT survey because I had contacted the survey developers and because they had already given permission to the South African research.

The initial aim of repeating part of the MORI–WT survey was to compare the answers given by NICB participants with the answers given by the wider group of scientists surveyed in 1999 and 2000. Some such comparisons have been made in the present study (e.g. see Section 5.4), but the following limitations to comparison due to the composition of the MORI–WT sample population should be given due recognition:

- The survey was done with British scientists, not Irish scientists.
- The participants were drawn from all scientific disciplines, not just biotechnology and related fields.
- A stratified random sample of individual scientists was selected, based on their discipline, and was not a census sample of a particular institute.
- Recording of the open-ended questions was written (by the interviewers), not audio taped and transcribed verbatim.

In addition, caution is required in any comparison because the investigative aims of the two studies (although similar) do differ. In the present study, participants were interviewed by a single interviewer as opposed to a number of interviewers. Although some questions were exactly the same in both surveys, and some were very similar, they could not appear in the same order because the surveys overall were not the same. The development of the interview schedules had different starting points and took different pathways.

Many of the closed questions served as a description of participants' inherent characteristics (e.g. age and sex) and provided 'factual'[6] information about their communication activities. This was used to establish the parameters of the NICB population and the working environment, described in Chapter 4.

Two other surveys of scientists also contributed to the design of the survey instrument, although none as directly as the MORI–WT survey:

- One thousand and eight hundred geneticists and other life scientists across National Institutes of Health-funded universities in the United States were

[6] The inverted commas show that I recognise that the information provided by the participants is self-reported and is therefore their own version, rather than a 'true' reflection of some objective reality; however, apart from errors in recall, there was no reason why the answers would not have been as close to 'factual' as possible. In addition, many of these factual answers could be corroborated by independent means, and in some cases I did so.

surveyed about their information-sharing habits — communication between specialists (Campbell *et al*. 2002)

- Thirty UK biotechnologists working either in the academic or commercial sectors were surveyed about their roles in the production and dissemination of scientific discoveries and the applications of biotechnology — communication with non-specialists (Gunter *et al*. 1999).

Later, in 2005, another survey of UK scientists, was carried out by People, Science & Policy: *Survey of Factors Affecting Science Communication by Scientists and Engineers*, for the Royal Society, Wellcome Trust and the Research Councils UK (PSP 2006). The PSP survey was designed to 'mirror' the results from the MORI–Wellcome Trust survey. The PSP survey did not contribute to the development of the survey instrument in the current study, but the publication of its results allowed me to compare the three surveys for specific common questions and participants' responses (e.g. Section 5.4).

3.3.2 Open and closed questions

The use of both closed and open questions in combination was deemed to be the most appropriate way to gather data in the current study, for a number of reasons. A written questionnaire, without interviewer–interviewee interaction is limited by a reader's understanding of the text. An interviewer can clarify queries. Each interview participant has complex views that are unique to the individual, due to different experiences of being a research scientist in a biotechnology institute. I hoped to capture this complexity through the open questions and associate it with the data gathered using the relatively straightforward closed questions.

Czaja and Blair (1996) recommend the use of closed questions because data from open questions are essentially narratives that must be interpreted and coded (p. 63). Fowler (1995, 2002) acknowledges this justification (lists of answers are more reliable, more easily interpretable and possibly more valid), but justifies the use of open questions because:

- the range of possible answers may exceed those provided in closed-question response options

- some answers cannot take a non-narrative form
- answers cannot be given by chance (i.e. a multiple choice answer could potentially be chosen randomly)
- the reason behind an attitude or behaviour may also be of interest
- systematic information can be gathered about complicated situations.

Fowler also discusses problems with the narrative form of answer (Fowler 1995, pp. 177–179). Such data can be difficult to deal with, it requires reading and coding of answers separate from data collection, and inter and intra-coder reliability may be an issue. He suggests that ‘it is critical to specify as clearly as possible in the question what constitutes an adequate answer’. This I attempted to do in the design of the questions that were unique to the survey instrument for the present study. In addition, during the interviews I provided neutral prompts if I thought that an initial response was inadequate.

As my ideas developed along with the project, so did the methodology, particularly in terms of the forms of the questions used. In fact, I began with a much more quantitative mindset, which emphasised the use of closed questions. Part of the learning process was indeed that some answers that were of interest to me had to take a narrative form (e.g. why did you become a biotechnologist?), that I was interested in the reasons behind attitudes and behaviours (e.g. why do you say that?) and that each person’s situation was complicated (e.g. describing the most recent social situation in which they spoke to a non-specialist about their work).

The act of interviewing also led me to a greater interest in participants’ responses to the open questions — these were where I had the greatest feeling of rapport with the participants and where I felt the more interesting data emerged. As the process of dealing with the data progressed further (as I transcribed the open questions from the interviews and reread them several times), it was clear that a kind of balance had been struck between the quantitative and the qualitative, and that this was appropriate to the current data set.

3.3.3 Relating to the research questions

There were three main areas covered in the interviews corresponding to the project aims and research questions. The first related to the beliefs and attitudes participants' held about communication of their work, the second was about participants' communication practices, and the third explored potential and real limitations on communication.

These three areas are directly associated with the research questions (see Section 1.1), although there is not always a direct 1:1 mapping between the questions in the interview schedule and the areas described here. This is due to the way the questions changed over time, in the initial development of the schedule, during the pilot phase and after the pilot phase. Nevertheless the questions in the schedule can be associated with one (or more) of the areas described above and consequently with the research questions set out in Section 1.1.

The interview schedule (Appendix 2) is divided roughly into demographic/factual questions; research area and professional behaviour; general communication activities and attitudes; sources of information and media coverage; and recent and future communication events.

3.3.5 How the instrument was used

Six questions (12 sub-questions) from each interview were transcribed in full:

- C6a, b and c — confidentiality agreements
- D2a and b — media coverage of five biotechnology-related topics
- E1a and b — important groups to communicate with
- O1 — becoming a biotechnologist
- O2a and b — describing a communication event with a specialist and a non-specialist audience
- O3a and b — doing biotechnology in the future.

Some of the other questions also prompted open-type (narrative style) responses from the participants (e.g. E2 why they might not be willing to talk about their research to certain groups of non-specialists), but these were considered to be codable in a straightforward way; that is, the range of answers fell into pre-defined categories.

I listened to each tape and transcribed the answers to the 12 sub-questions using a simple transcription code developed for the purpose (see Appendix 5 for a description of the code used). During the pilot I identified themes that tended to be linked to the expression of laughter and humour in the participants' answers; therefore, I also included some non-verbal information in the transcripts, such as laughter. This information was later used in the analysis of questions that prompted laughter (see Section 7.1). Where voice levels or accents made audio comprehension impossible, I referred to my written notes.

Spelling and other potential sources of transcription error in the data set were dealt with as I read and re-read the transcripts and the data in the Access database. This data cleaning is an important process in, for example, the construction of word lists in WordSmith, although this program is able to deal with alternative spellings and lexemes. At this point I was not sure how I would be organising and analysing the data, so it was appropriate to keep the spellings, the transcription coding and the extra recorded elements as uniform and consistent as possible.

The remaining participant responses were not transcribed as they were either already coded on the answer sheets (e.g. each participant was coded into one of seven age categories), or could be coded easily at the same tine as the data were being entered into a database. Besides, transcribing the entire interviews would have taken too much time for little increase in quantity or quality of data.

3.3.6 Interview database and analysis

A Microsoft Access database was developed so that data could be entered directly from the written interview records (i.e. the data that had not been transcribed). Potential sources of data entry error were examined, checked against the written records and cleaned if necessary. Once the data were entered in the database, they were manipulated and exported into Microsoft Excel for simple analysis of the responses to the categorical (closed) questions.

For the open questions with narrative responses, WordSmith Tools was used to identify themes by generating lists of words occurring in the text and reporting their frequencies. High-frequency words were then grouped into thematic categories. Further identification of key words included an analysis of their context. This process provided an indication of common words used by participants. These were clustered into common groups (e.g. enjoy and passion) and text in the context of these word clusters was also examined (e.g. 'I really enjoy working out what's going on in an experiment' and 'I'm passionate about the research'). This information was then used with NVivo to analyse the variety of participants' answers, and their commonalities and differences and contexts of use.

In fact, Word Smith Tools was not used in this way for the analysis of the open questions about confidentiality as the text was manageable in NVivo (see below) without the use of the Word Smith software. The methodology described was nevertheless the same: identification of clusters of words relating to themes, then one or several iterations relating these themes to the answers given by the participants — in order to generalise in some instances and particularise in others.

NVivo is a software tool designed to manage qualitative (and some quantitative) data. It enables the researcher to import, sort and analyse text (and other materials, but only text was used in the present study), by linking trends in the data or coding with specific references to words used by research participants. In the present study, each of the open questions was analysed and discussed separately. Later, correlations or associations between responses to all of the questions were explored. Much of this latter analysis was done using Microsoft Excel as I found it easier to link trends in the data with categories of participants.

Taking Lievrouw's (1998) conception of *discourse* as the 'interpersonal exchange of ideas, and as the social formations and relationships that support and are produced by those exchanges' (p. 85), discussed in Section 2.3.2, I used discourse in the present study in the sense of communication about and within biotechnology. That is, participant responses are (some of) the discourse of interest. The tools described above are means of recording, organising and analysing this discourse.

3.4 Comparing three surveys

In 2006, results were published of a survey commissioned by the (UK) Royal Society, Research Councils UK and the Wellcome Trust, which had been carried out by People Science and Policy (PSP 2006). The sampling frame and survey design of the PSP survey was developed in order to 'mirror' the results from the MORI–Wellcome Trust survey published in 2000 (MORI–WT 2001). Many of the questions included in the current NICB interview schedule were based on the MORI–WT survey, but the four questions described in the current section are direct comparisons between the PSP and MORI–WT surveys, and the NICB interviews.

This section describes how the three surveys were compared, where possible, in terms of four questions that were common to all of them. The results of these comparisons are explored in the appropriate sections, dispersed throughout the thesis:

- disadvantages and drawbacks to communicating (Section 5.4.2)
- scientists have a duty and responsibility to communicate (Section 5.4.3)
- funders should help scientists to communicate (Section 5.4.3)
- if you had to communicate your research, which would be the most important group to communicate with and why (Section 6.2.4).

Responses to a question about limitations on engagement with the non-specialist public, which was asked in the PSP survey in 2006, but not in either of the other surveys, are also provided as evidence of restrictions on scientists' communication in general (Section 5.4.3).

Table 3.2 provides a summary of populations, methods and aims of the two UK-based surveys and the current study.

Table 3.2 Population and sampling used in two UK-based surveys of scientists and engineers, and in the current study

	MORI–WT (2001)	**NICB**	**PSP (2006)**
Survey time period	December 1999 to March 2000	July 2004 to May 2005	September 2005 to November 2005
Sex	78% men	45.2% men	65% men
	22% women	54.8% women	34% women (1% no reply)
Age (years)	1% Under 25	21.9% <25	54% under 40
	33% 25–34	49.3% 25–34	44% 40 and over (2% no reply)
	31% 35–44	20.5% 35–44	
	21% 45–54	6.8% 45–54	
	8% 55–59	1.4% 55–59	
	4% 60–64	0% 60+	
	1% 65+		
Working status	97% full-time	98.6% full-time	93% full-time
	3% part-time	1.4% part-time	6% part-time (1% no reply)
Disciplinary groups included	Clinical biomedical, non-clinical biomedical and non-biomedical	Biotechnology, chemistry (see Card B1, Appendix 3 for list)	Clinical, non-clinical biomedical and other (non-biomedical)

	MORI–WT (2001)	NICB	PSP (2006)
Employment function	Research only, research and teaching (teaching only excluded)	Research only, research and teaching (no participants did teaching only)	Research only, research and teaching (teaching only excluded)
Sampling	Random sample of employees at higher education institutions in Great Britain, and research council-funded scientists	Researchers at the NICB (census or enumeration) in Ireland, including postgraduate students	Stratified random sample based on employees at UK higher education institutions and mirroring MORI–WT sample

cont.

Grade	Professor, Director/Assistant Director, Head of Department/Division/School, Reader, Principal Lecturer, Senior Lecturer, Senior Research Fellow/Senior Scientist/Advanced Research Fellow, Research Fellow/Fellow, Researcher/Research Officer, Higher Scientific Officer, Lecturer, Scientific Officer, Assistant Scientific Officer, Senior Research Assistant, Research Associate/Assistant	Senior researcher, researcher, senior lecturer, lecturer, research officer, research assistant, postdoctoral researcher, postgraduate student	Professor, senior researcher, researcher, assistant
Method	Face-to-face structured interview	Face-to-face semi-structured interview	Internet-based structured survey

	MORI–WT (2001)	NICB	PSP (2006)
Aims	To identify and understand how scientists themselves perceive increasing calls for them to become more involved in communicating their research to the public: • their responsibility and preparedness to communicate • benefits and barriers to the public understanding of science • changes required for scientists to take a greater role in science communication.	To examine Irish biotechnology researchers' attitudes and behaviours in regard to communication about their work, constraints on and opportunities for communication, and coverage of biotechnology in the *Irish Times*.	To examine the factors affecting science communication by scientists and provide evidence to support the development of strategies to encourage scientists and engineers to communicate with stakeholders in including the public, policy makers and media.

Various similarities and differences between the two UK surveys and the Irish NICB population have also been described elsewhere (Section 3.3.1). There are many obvious differences between the three studies (Table 3.2):

- one is based in Ireland, the other two are not
- there are more women than men in the Irish population
- the Irish population is generally younger (because it includes postgraduate students)
- very few people work as scientists part time, although there may be a trend towards more part-time work over time, in the non-Irish populations
- disciplinary groups in the Irish population only include biotechnology and chemistry, whereas the non-Irish populations include all types of scientists and engineers
- methods and aims differed between the three studies.

It is nevertheless reasonable to compare the results between the two non-Irish studies as a rough measure of how the populations and their attitudes have changed over time (from 2000 to 2006), and between the three studies in terms of broad results and to reveal potential Irish-specific beliefs and attitudes. In addition, English-speaking European science is roughly comparable in structure and process (and researchers commonly move between the UK and Ireland). It could also be argued that science communication is more prominent in the UK in terms of opportunities and support for scientists, and institutionalised public engagement with science (e.g. Wellcome Trust, British Association for the Advancement of Science, Royal Society).

3.5 The case studies

The interviews provided a complex data set, which I analysed as a whole according to the processes described in Section 3.3. That was one way to ‘cut’ the data — to concentrate on a large number of participants and identify trends and cross-tabulate responses. This method enabled me to retain some of the detail of participant responses using direct quotations.

To provide a different cut of the data, I chose a small number of individuals, based on pre-defined criteria (shown in Table 3.2), and examined and compared their complete responses. The case studies comprised a postgraduate student, a senior researcher and a research assistant, and these 'titles' were used to describe these participants. This method enabled me to examine only a few individuals, but in fine detail and against the background of the analysis described in Section 3.3.

The cut provided by the case studies enabled me, in the sense used by Rabinow and Dan-Cohen (2005), to provide narrative space for the 'native's point of view' — to provide a more complete picture of a small number of participants and, in doing so, to allow their responses to stand alone. The advantage to providing different data cuts was referred to in Section 3.1: different forms of data collected during the same time period may be integrated in the interpretation of overall results. The aim was also to compare the three case studies as they were chosen so that they differed in a range of significant characteristics (Table 3.2), but similar enough to the rest of the participants to be considered 'typical'.

Table 3.3 Case study characteristics

	The student	**The senior researcher**	**The research assistant**
Location	Not at DCU	DCU	DCU
Age (years)	<35	≥35	<35
Sex	Female	Male	Female
Employment function	Research and teaching	Research and teaching	Research only
Qualifications	No PhD	PhD	No PhD

DCU = Dublin City University

3.5 Personal reflexivity

In this section I discuss my role as the 'primary data collection instrument' (Creswell 2003; p. 200) and try to identify the values, assumptions and biases I brought to the present study. I have an undergraduate degree in biology and I have done laboratory and fieldwork in genetics. I have a Masters degree in communication studies, which has enabled me to work in science, technical and medical publishing as an editor. More recently, I have worked as a science writer. I bring to the present project knowledge of what it is like to work in scientific research and in a specific field of science communication.

I talk about my work and I read, write and talk about science because I find it challenging and interesting. This has influenced the present research project, as it can be difficult for me to grasp that people might not want or be able to do the same. I hope I have not been too blinkered in my outlook on the communication of biotechnology by its practitioners — I am concerned that I may have conflated what I think people 'should' do with what people actually do (or say they do). However, most of the interview participants did show a great deal of enthusiasm for their chosen fields and in talking to me.

During the time I was doing this research at DCU, I was also a committee member of the DCU Research Ethics Committee. This led me to reflect on the ethics of my research to a greater degree than I might have otherwise, even though the research is not particularly ethically problematic. Nevertheless, it would be remiss of me not to discuss the issues I considered and how these had an influence on the trajectory of the research. I have already discussed the lack of written permission to use the MORI–Wellcome Trust-derived questions; this is more of a copyright/permissions issue than an ethical one. In some ways the inclusion of the question about participants' willingness to talk to groups of non-scientists in the future, which was originally included as a method of identifying willing participants for a colleague's research project, meant that the purpose of the question was not fully disclosed to the participants. However, the answers were never used to identify participants in the manner that was intended originally and the question was modified for use in the present research.

The one ethical problem I did have during this research, which was not fully resolved, was the recruitment of the participants to the study. This is a personal ethical problem, rather than a systemic one, as I do believe that it had little effect on the participants' ultimate willingness to participate. The head of the NICB was enthusiastic that this study go ahead and influenced participation to some extent, but this type of influence was even more pronounced from the heads of the two non-DCU sites. It is not clear whether all of the participants from the non-DCU sites would have taken part otherwise, but they certainly would not have found it easy to refuse to take part. I was not able to contact these participants directly, so the principals provided me with a list of names and directed the researchers under them to turn up at designated times. In fact, this arrangement suited me well as I was able to get through the interviews very quickly and efficiently, but I did feel uncomfortable with the suggestion of even mild coercion.

I think my interviewing skills improved enormously during the course of the project, but there were a couple of occasions where it was clear that rapport with the participant had not occurred. This caused discomfort for both parties and led to much subsequent reflection on my part. It would have had a direct impact on the nature of the data and should be mentioned here. In these few cases, perhaps the quantitative data obtained from the closed questions was not influenced substantially by this lack of rapport. It is likely that the responds to the open questions were. This is one of the shortcomings of using self-reported data.

Finally, confidentiality was provided to the interview participants, but anonymity could not be. It is certain that any person familiar with the people that were working at the NICB during the interview period would be able, in many cases, to connect what was said in the interviews with the individuals involved. Except where it is not a confidentiality issue, my reporting on the interviews does not name individuals.

The duration of each interview was recorded in most (all except for nine) cases because I thought it would be prudent to check if interview length or date varied with respect to demographic (age, sex, seniority etc.) or other factors. The check was to see whether the interviews were influenced unexpectedly by when or where they took place, and to use interview duration as a rough measure of ‘willingness to take part’ and ‘having something to say’. The check provided some interesting data, which, although strictly ‘results’, were used to feed back into my personal reflection on the project processes. In fact, there was no consistent variation over time; that is, the interviews did not get shorter or longer over the length of the project. Out of a total of 73 interviews, mean interview duration was 34 min (max. 65 min, min.

20 min) and 21 (29%) of the interviews were shorter than 30 min. Seventeen (23%) were 40 min or longer.

Interview duration was influenced to some degree by where the interviews took place. The interviews at Maynooth and Tallaght were strictly timetabled, as discussed above, and therefore shorter. For these interviews, there was no scope to extend the duration if the participant wanted to keep talking. They were a mean of 30.1 and 32.1 min long, respectively. Twelve out of the 21 interviews shorter than 30 min were done at Maynooth and Tallaght.

Men tended to interview for longer than women, with a median 33.5 min compared to 30.5 min, respectively. Twelve out of the 17 interviews that were 40 min or longer were with men.

It did not seem to be the case that more senior participants talked for the longest time, but 19/21 of the shortest interviews were with postgraduate students. Participants without a PhD (mainly postgraduate students and research assistants) tended to give shorter interviews than those with a PhD, medians 29.0 min and 35.0 min, respectively.

Thus the personal reflexivity issue here is that interviews tended to be shorter at Maynooth and Tallaght (for the reasons discussed above), with postgraduate students and with women. For the postgraduate students and women, was this due to my own interview style? Did students talk less because they were under more time pressure, or because they simply had less to say (less experience)? Did I talk more to men or were they more willing to talk to me, or is this some kind of inherent difference in interviews when the interviewee is the opposite sex?

Role-dependent (use of feedback, probing strategies etc) and role-independent (sex, age etc) interviewer effects are discussed in Pedhazur and Pedhazur Schmelkin (1991) and Breakwell *et al.* (2006). Role-dependent effects are certainly an issue in the present study, although I sought to minimize these using the formal structure and prompts of the interview schedule. Characteristics of the interviewer appear to have an effect if the questions are associated with that characteristic (e.g. sex of the interviewer and questions about sexual stereotypes), which is not overtly the case in the current interview schedule (see Appendix 2). It is difficult to pinpoint whether these effects have been an issue during the present study. However, I have tried to consider them in my self-reflection.

As noted in the introduction to this chapter, the methodology for the present study was chosen within constraints, but was intended to incorporate advantages from both quantitative and qualitative methodologies. I could have concentrated more on the discourse of the participants — their stories — rather than on categorizing their responses quantitatively; however, there were several advantages in the approach I took. The quantitative approach allows for systematic collection and analysis of data. The qualitative approach allows for the capture of complexity. It is only the combination of these approaches that allowed me to deal with the data. That said, the study was and still is a learning process and I am not the same person who did a pilot study in 2003.

In Section 3.3.2, I discuss my initial emphasis on the use of closed questions, which developed into a methodology with an emphasis on open questions. This come about so that I could obtain the responses that could only be obtained in a narrative form, responses exploring the reasons behind attitudes and behaviours of the participants and responses that were complex and messy. In addition, I used the case studies to explore in detail three individuals.

The trade off between the methodologies may have played out differently under different circumstances. The methodology I used meant that I could use a semi-structured design, in contrast to the WT–MORI and PSP surveys. However, where the qualitative methodology was probably less than ideal where the rapport I established was poor (as I have mentioned it was in a few cases).

In Chapter 6, I suggest that a ‘new’ question asked by the PSP survey would have been interesting to ask the NICB participants. The question (What is stopping you from getting (more) involved in activities that engage the non-specialist public in science?) meant that participants were encouraged to be more forthcoming in explaining their attitudes and behaviours. In this case, the attitude and behaviour of interest was their prioritization of time. The NICB participants could, within the constraints of the Likert-style question, indicate that they though they did not have enough time to communicate about their work. The PSP participants could take that further and explain the other activities that they did in preference to communicating.

In the present study, the constraints I faced (my own time, resources etc) meant that compromises had to be made — this type of compromise was always made in a considered fashion. The things that I might have done differently in hindsight had to be weighed against the constraints I faced and my previous experience.

3.6 Summary

In this chapter I have described how I went about the empirical research documented in the present thesis. The participant population was available, rather than chosen in the usual sense of a study sample. However, the population's characteristics and availability informed the interview instrument, which I developed from both borrowed and original material, tailored to elicit responses to answer my research questions. The data were cut in different ways to provide a rich picture of the communication attitudes, beliefs and practices of NICB researchers. In hindsight, there are elements of the study I would have done differently, but I took into account as many sources of potential bias and preconception as possible — both personal and associated with the methodology.

Chapter 4 At work — the institution as a setting for communication

This chapter explores institutional aspects of working as a biotechnology researcher at the National Institute for Cellular Biotechnology (NICB) — aspects of the science communication environment — and how they may have an effect on participants' communication.

An aspect of the institutional setting to be explored in this chapter is whether there is any evidence of Lievrouw's (1998) horizontal information inequity among NICB researchers, or of her (2004) general caution about growing constraints on informal interpersonal interaction. Similarly, patents and confidentiality agreements, which are more common in biotechnology than previous scientific fields, may be having the effect posited by Blumenthal *et al*. (1997) that modern science involves the withholding and restricted dissemination of research results. Is this institutionalization having an overall effect such that Mulkay's counternorms are in operation (Mulkay 1976)? On the other hand, it is reasonable to suggest that the institution provides the opportunity to its members to act collectively to communicate persuasively (Krimsky 1991, 1998; Mulkay 1995) and to access and contribute to the public sphere (Stockylmayer *et al*. 2001)

Results are presented in this chapter that provide a snapshot of the NICB participant population, including demographic data and information about the work environment within which biotechnology researchers operate — their day-to-day working week, professional positioning in the field of biotechnology in Ireland and internationally, formal communication, and cooperation with other researchers. The potential effects of confidentiality agreements and patents on communication are also discussed.

These data were collected both to stand alone as a description of the participants' science communication environment, and to inform the analysis presented in later chapters. They document the population of participants, and some of the context and structures within which individuals at the NICB communicate.

4.1 The population

The study population consisted of 73 research scientists, some with additional management and administrative job functions, working at a point in time at the NICB. The bulk of the participants were located at Dublin City University (45/73; 61.6%), but spread out across the campus in different buildings[7] and with a variety of university affiliations (e.g. School of Biotechnology, School of Chemical Sciences). The remaining participants were located at the National University of Ireland, Maynooth (14/73; 19.2%) and the Institute of Technology, Tallaght (14/73; 19.2%). The NICB also had collaborative affiliations with various hospitals in cancer, diabetes, eye disease and microbial disease research.

This population is, for the practical purposes of the present study, a census (i.e. an enumeration or list) of the people working at the NICB during the time period in which the interviews took place, between February 2004 and May 2005, over a total of 16 months. Missing from the census are people who were on sabbatical doing research out of Ireland, and it is possible that potential participants were missed because they were not on one of several lists kept of the people located at the three sites. Surprisingly, there was no central database of NICB staff and students at the time — partly because of their distribution across the three sites, and partly because the students tended to be looked after administratively by the Schools with which they were affiliated.

There was also quite a high degree of fluidity of connection, with some researchers located in the School of Biotechnology. for example, seeming to move in and out of association with the NICB depending on the source of funding for their current research, and the presence or absence of affiliated students. Other researchers were located only temporarily at the NICB, as they were also affiliated with other third-level institutions. Finally, particularly in the case of students, there was constant movement in and out of the NICB at the beginning and end of contracts and study periods.

[7] During the time of the interviews and beyond, a dedicated building was being built for the NICB on the Dublin City University campus. This building was officially opened by Mary Hanafin, the Irish Minister for Education and Science, on 24 October 2006, 17 months after the interviews took place.

Table 4.1 shows the age group distribution of the population. Most of the participants (52/73, 71.2%) were younger than 35 years, which is a greater proportion than in the general scientific and technical workforce in Ireland (57.7% younger than 35 years; 2002 Census data).[8] This may be partially explained by the fact that the NICB is also a teaching institution, whereas the general scientific and technical workforce is located across third-level institutions, government and private industry.

Table 4.1 Age groups (years) of the NICB population (*n* = 73)

	No.	%
<25	16	21.9
25–34	36	49.3
35–44	15	20.5
45–54	5	6.8
55–59	1	1.4
Total	73	

Note: Totals may not equal 100.0% due to rounding error.

Thirty-three of the participants were men (45.2%) and 40 were women (54.8%); a sex ratio of 0.82.

Although women were more numerous overall, they tended to be younger, more junior and less qualified than their male counterparts:

- **Younger** — 77.5% of the women were 34 years of age or younger, compared to 63.6% of the men (Figure 4.1).
- **In more junior positions** — more women were postdoctoral researchers (all six of the postdoctoral researchers were women), research assistants (women : men, 4 : 1) and masters students (14 : 4) and there were more women students in general (19 : 11). More men were lecturers (6 : 2), research coordinators (2 : 1) and PhD students (7 : 5).[9] Of the more senior positions, men held seven out of

[8] Data available from http://www.cso.ie/census/ (last accessed 07 December 2007).
[9] It is DCU policy that students intending to do PhDs are enrolled as masters students for at least a year before they are allowed to 'transfer' to the PhD track. It is possible that a short period of time

11, and the positions of Director and Manager were held by men (at the DCU site), as were the two most senior positions at Tallaght and Maynooth.

- **Less qualified** — 24 women compared to 15 men did not have a PhD, yet PhDs were held by approximately the same number of women as men (16 and 17, respectively) overall. More men than women working at the NICB had held their PhDs for longer than 10 years (10 out of 17), while more women then men working at the NICB had held their PhDs for 10 years or less (12 out of 16).

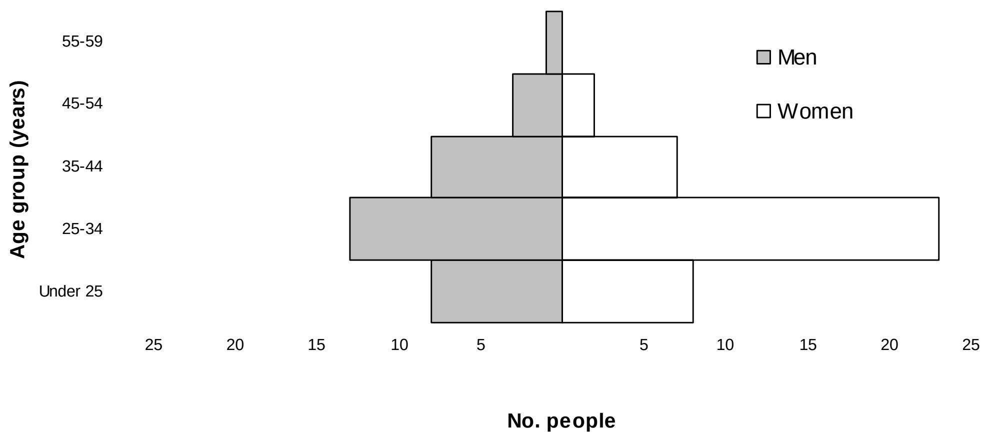

Figure 4.1 Age group and sex of the NICB population (2004–2005)

Figure 4.2 shows the age groups and sex of the occupation category 'Scientific and Technical Occupations' from the 2002 Irish Census of Population.[10]

after these data were gathered, all of the female masters students would have transferred to the PhD track, in which case they would outnumber male PhD students. However, it is interesting that only just over a third of female students were enrolled on the PhD track. Anecdotally, it appeared to be more common for female students to stay on the Masters track until the final year of their study, while male students tended to transfer to the PhD track as soon as possible.

[10] Data available from http://www.cso.ie/census/ (last accessed 07 December 2007).

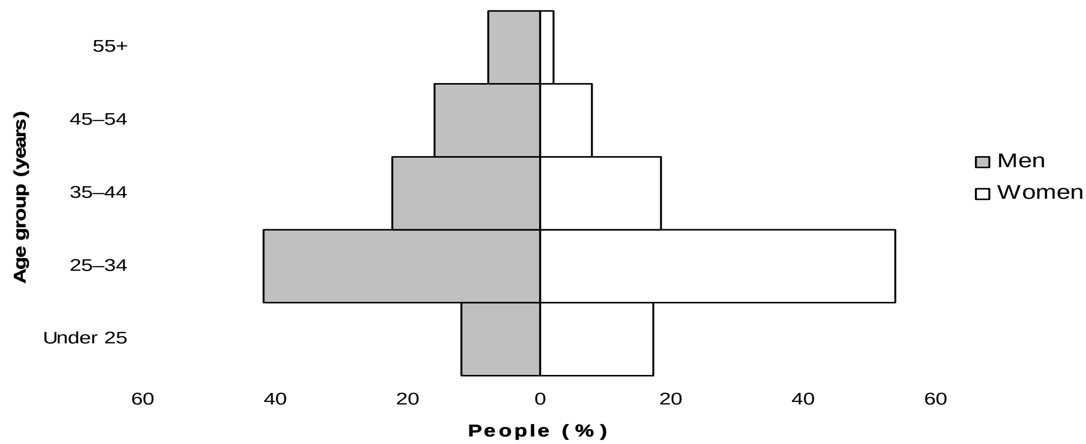

Figure 4.2 Age group and sex in Irish scientific and technical occupations (2002)

Overall the population pyramids in Figures 4.1 and 4.2 look similar, although there is a relatively greater proportion of women in the 25–34 year age group and a relatively greater proportion of men in the under 25 years age group in the NICB population. There are also some women in the 55+ years age group overall in the scientific and technical occupations in Ireland, but not at the NICB (Figure 4.2), which may be accounted for by the small numbers overall in the NICB population (there was only one man in this age group).

It is interesting to compare these with the population pyramid in Figure 4.3, which shows proportions of men and women in each age group across the entire Irish workforce in 2002.[11]

[11] Data available from http://www.cso.ie/census/ (last accessed 07 December 2007).

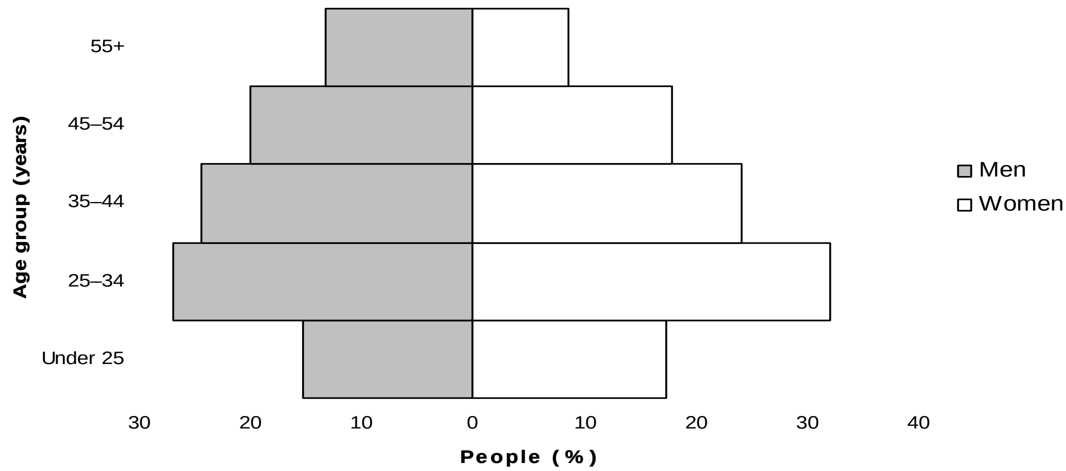

Figure 4.3 Age group and sex across entire Irish workforce (2002)

Figure 4.3 shows a more even spread between men and women and a greater proportion of women than men in the 25–34 year age group in the workforce. No inferences could be made from the NICB data about differences in the number of men and women across the research groups or across the three sites, as the numbers were too small; however, men and women appeared to be evenly distributed.

It is striking, looking at Figures 4.1 and 4.2 against the background of Figure 4.3, that there appears to be a point after training and early experience (i.e. between the ages of 25 and 34) at which many scientists leave the profession. This phenomenon also appears across the workforce (Figure 4.3), but it is much more obvious in both the NICB population and the Irish scientific and technical workforce.

This trend is even more obvious for women — there are fewer older women than there are men in the scientific and technical workforce, but more younger women than younger men. From personal experience and observation, I can speculate that this is due to both push and pull factors. Push factors are specific to the profession (e.g. the lack of career progression opportunities beyond a certain point) and pull factors are workforce or lifestyle options that are not available in the profession (e.g. the ability to work regular hours that are not dependent on short-term funding). This could be a no-win situation for science communication, in that the more experienced in communicating science one becomes, the more likely one is to leave. Also, as will be shown in Section 7.3 and elsewhere in this thesis, women appear to be less likely to communicate in ways that are useful to their career. Perhaps this makes them less likely to be some of the few that do stay in research.

In general, there appears to be a significant amount of institutional pressure on junior researchers, so that self-doubts about career progression Hermanowicz (2003), constraints according to the economics, reward structure and growth of science Stephen (1996), and, especially for women, negative personal perceptions of identity as scientists, the scientific culture and future career prospects McClam (2004) may well be factors in the demographic make up of the NICB and the science and technology workforce in general.

4.2 The working week — time to communicate

This section explores the working week of the participants and notes the different activities that they do, whether these activities involve communication to a greater or lesser degree and how long the participants spend doing them. The issue that is investigated here is whether researchers are more likely to make time for institutionalized (required) communication, or have that time 'blocked out' in their working week. If this is the case, then taking time for the types of communication that are seen as not strictly necessary is less likely to occur.

This series of questions about the participants' working week provides information about day-to-day work, beginning with the number of hours worked. If a participant worked longer than a 40-hour week, they were asked why they worked the 'extra' hours. Information was also gathered about the full or part-time status of the participants, whether they were involved in teaching as well as research, and how tasks were apportioned across the week.

4.2.1 Hours worked

Twenty-nine people worked 40 or fewer hours (Table 4.2); one of them worked part time at 25 hours/week — the only person at the NICB to work less than a full-time week. Eight of these people volunteered information about why they might occasionally work for longer then 40 hours — each said that they did so when they were in the middle of running experiments and doing lab work where equipment could not be left unsupervised: ‘There are always delays...I stay until [the experiments] are finished...fermentations take 12 hours in a day’. One volunteered that s/he, thankfully, no longer did the overtime that had been required as a postdoctoral researcher; another had cut down her hours recently to have a baby.

Table 4.2 Working hours/week, NICB population

Hours	No. people	%
≤30	1	1.4
31–40	28	38.9
41–50	30	41.7
51–60	11	15.3
61–70	1	1.4
≥71	1	1.4
Total	72	

1 case missing data.

Forty-three participants (59.8%) stated that they worked longer than 40 hours per week; a few claimed that they worked up to 70 or 80 hours per week. These very long hours were worked by participants at either end of the work scale — postgraduate students and senior researchers — the former so they could ‘finish up’ their research more quickly and the latter because that is how they managed their workload (i.e. there was more work than could be fit into a 40-hour week). Some less senior researchers also managed their workload in this way.

The tasks that researchers did in their ‘overtime’ hours included running experiments, taking samples and laboratory work, all for the same reasons as discussed above — when working with live material and shared equipment and resources, long-running experiments have to be supervised. Writing, corrections and marking (for teaching staff), reading and using the computer are all tasks that may be done at home in the evenings and many participants included this type of evening work in their estimation of their work hours. One participant was also a Head of School, with the associated commitments to administrative tasks.

At this point in the questioning, none of the participants were negative about the numbers of hours worked. Many of them were practical about ‘doing what needed to be done’ and needing to ‘get ahead’. One participant mentioned his positive feeling of personal ownership of the work and that his wife also worked at the NICB. Another stated that the work was interesting, consisted of regular new projects, and was not physically demanding, so s/he did not mind working the long hours. Participants did not volunteer negative consequences of the number of hours worked, although this was not specifically asked for at this point in the questioning.

Although some laboratory work is done in ‘overtime’ hours, it is in many senses compulsory, unlike communication activities — in a finite number of working hours, it is more likely that the bench work will get done than communication, particularly formal communication such as writing research papers, as this communication depends on there being something to write about. For more junior researchers, it is possible to do bench work and never be involved in the formal communication activities outlined in Section 4.5.

Some participants did report doing communication activities in ‘overtime’ at home in the evenings, including writing. Presumably this includes grant writing, writing up experiments and writing papers for journals and conferences.

4.2.2 Employment function

Thirteen participants (17.8%) were involved in research only and most of these were postgraduate students. Fifty-eight (79.5%) were involved in both teaching and research and two (2.7%) did not think that what they did fit into either of those categories. The latter included both research and the training of NICB staff and outsiders in laboratory techniques used in the institute, and occasional lecturing and working outside the institute. Two of the participants who answered that they did both teaching and research also answered that they provided lectures and training to government and industry. The provision of industry training tended to be done by research assistants without PhDs.

Out of the others who stated that they did both teaching and research, most lectured and the rest demonstrated in laboratory classes (Table 4.3). The bulk of the demonstrating was done by postgraduate students — some lectured occasionally.

Table 4.3 Teaching type, NICB population

	No. people	%
Full-time lecturing	14	25.0
Part-time lecturing	4	7.1
Occasional lecturing	16	28.6
Demonstrating/tutoring	22	39.3
Total	56	100.0

'Other' (not included in the table) were two participants involved in teaching to industry and government.

All full-time lecturers had obtained a PhD five or more years previously. Most full-time lecturers were men (71.4%) and most part-time or occasional lecturers were women (70.0%). Thus, senior participants did most of the higher status teaching activities.

Teaching is a communication-heavy activity, which has the benefit of training the teacher in communicating (e.g. public speaking, use of language that is appropriate to the audience, presenting material that is appropriate for different learning styles). Training that comes from teaching can be transferred to all types of communication activity with all types of audience. If in-house training is included in the count, 60/73 participants did this type of communication.

4.2.3 Breakdown of working week

The participants were asked the question 'In the last normal working week how many hours did you spend:

- in the laboratory doing research
- reading or writing about your (or related) research
- in meetings with colleagues

- teaching/lecturing
- administrative tasks
- other (specify)'.

When this question was drafted, I realized that it may be problematic due to likely differences in an individual's 'normal working week' over the year — research hours, reading or writing about research, attending meetings, teaching and administrative tasks will all be subject to change. However a vaguer 'general working week' would have lost immediacy and freshness in participants' minds. The aim, therefore, was a question that struck a balance between these two extremes, so that I could find out what people did 'last normal week' and for what proportion of their time.

The most problematic part of this question was about teaching or lecturing as this activity is only done during semester. As the interviews ranged over a period of 16 months, some of the 'normal working weeks' were within a semester and some were not. The participants were therefore encouraged to answer this part either in the more general sense as what they would have done, had they been teaching, if they wished, or more explicitly if they had actually been teaching during their last normal working week.

In the laboratory doing research

Sixteen people, all senior, had not done laboratory research in the last normal working week. Some did not normally do laboratory research at all, including senior lecturers, program coordinators, heads of school, the Director and the General Manager of the NICB. Others normally did do laboratory research, notably three research officers, but in the week chosen were busy writing applications for funding or research articles.

Five people had done only a few hours in the laboratory (<10 hours). These were lecturers, who had been teaching, a senior research scientist who had been writing and someone with both university administrative and postgraduate student supervisory responsibilities, who had been working in the laboratory in the latter capacity.

Everyone else (52 people, 71.2%) had been doing laboratory research for between 20 and 60 hours in the previous normal working week. The three people who had done 60 hours in the laboratory were all postgraduate (PhD) students and of the 10 people who had done between 50 and 60 hours in the laboratory, eight were postgraduate students and the other two were postdoctoral researchers.

Reading or writing about research

Eight people had done no reading or writing about research in the previous normal working week, and seven had only done one or two hours. Forty-two people (57.5%) had done 3–10 hours of reading or writing about research. Ten people had done 20 or more hours of reading or writing about research — all of these were senior lecturers and other staff (including the Director), except two postgraduate students who were on the Masters track preparing for transfer to a PhD within a week or so. These last two had done 20 or more hours of reading and writing about research in addition to spending 20–30 hours doing laboratory work.

In meetings

Most people (63, 86.3%) had spent less than 10 hours in meetings with colleagues during their last normal working week. Thirty-six had spent less than 2 hours and 16 had spent no time in meetings. Ten people spent 10 or more hours in meetings and the most senior people, with the heaviest administrative load, had spent between 25 and 35 hours in meetings (a head of school, the Director and the General Manager).

Teaching or lecturing

Fifty-eight people (79.5%) stated that they had done no teaching or lecturing in the last normal working week. Given that only 13 participants said that they were only involved in research (i.e. did no teaching at all; see Section 4.2.2), at least 45 of these people could have, but chose not to, answer this question in the sense of ‘if I had been teaching’ (see discussion above on the ambiguity of this question).

Interestingly, of the 15 people who answered that they had done teaching during the last normal working week, six were from ITT and seven were from NUI Maynooth. The remaining two were from DCU — one a lecturer in the School of Biotechnology (who stated that s/he had done 32 hours of teaching). It may be that the two non-DCU sites were more teaching-centred, but it could also be that the timing of the interviews at these sites coincided with teaching weeks.

Administration

Most people (51, 69.9%) had done fewer then 4 hours a week in their last normal working week on administrative tasks. Of the 10 people who did 10 or more hours in their last normal working week, all were senior (including the Director and the General Manager) and some had roles that were largely administrative (e.g. one head of school had done 56 hours of administrative work).

Other

People tended to answer this question if there were tasks that they did that they thought were not covered by the previous categories. However, two people used this category to provide more detailed descriptions of their working week: a senior research scientists said that s/he had done 8 hours of laboratory work, 16 hours of reading and writing, 8 hours of meetings, 8 hours of administrative work and 20 hours writing grant applications, supervising and planning work with PhD students and collaborating with hospitals; a research officer said that s/he would normally (generally) have done 30–40 hours in the laboratory and 10 hours of reading and writing, but the last normal working week was actually spent doing 10 hours of reading and writing, 10 hours in meetings and 20 hours of administrative work; that is, no work in the laboratory at all.

Tasks that were mentioned and were not covered by the previous categories included (hours spent shown in parentheses):

- working with postgraduate students (3.4 hours averaged over seven people — all of the following were mentioned only once)
- reviewing courses at the academic institution (10)
- being responsible for stores (7)
- liaising with secondary schools (6)
- maintaining computers (5)

- working on a committee to buy equipment (4)
- talking socially about science during lunchtimes (2.5)
- giving and listening to seminars (2)
- coordinating a program with local hospitals (2)
- cleaning and maintenance (2)
- cleaning equipment (1)
- organising heath and safety (1)
- setting up audiovisuals for teaching (1)
- dealing with human resource matters (1).

4.2.4 Communication during the working week

Much of what the participants did during the working week was more or less communication, such as teaching and working with postgraduate students (supervision), reading and writing about research and attending meetings. The bulk of this type of communication was done by senior participants, apart from the reading and writing about research that must have been done by postgraduate students for their theses. It is also true that senior participants did the bulk of the administrative work, which is not considered here to be a communication activity (although obviously some administrative activities involve communication). All of these activities are viewed as legitimate ways of doing science and are institutionalized (required).

The other communication-heavy activities reported by participants — liaison with secondary schools, working on a committee to buy equipment, talking socially about science during lunchtimes, giving and listening to seminars, organizing health and safety and setting up audiovisuals for teaching — are still legitimate ways of doing science, but are not absolutely necessary or institutionalized. These activities are also mainly done by less senior participants.

The assumption that researchers are more likely to allow time in their working week for communication (and non-communication) activities that are institutionalized is borne out by these data. The data also show that extra hours are done if necessary to get all institutionalized activities done. The interesting association following from the evidence that senior participants do more of the institutionalized work, communication and otherwise (apart from bench work, which is mostly done by junior participants), is that more of them are men. Without attempting to provide a causal explanation of this phenomenon, this is corroborating evidence from a different angle (compared with observations from Figures 4.1 to 4.3) that a larger proportion of women than men leave the science and technical workforce after an initial period of training.

These data show that, in science, communication during working hours is mainly legitimate, institutionalized communication — that is communication to peers and other 'friendly' science-interested audiences (e.g. students, funding bodies). It does not appear that biotechnology specifically is an issue in this regular day-to-day workplace communication is an issue for biotechnology specifically. Obviously the communication is about biotechnology, but the same kinds of communication issues occur in all areas of modern science, making this a common landscape for scientists communicating in the science communication environment.

4.3 Institutional incentives to communicate

Whether participants have institutional or financial encouragement to communicate is likely to have an effect on their willingness to do so. Such encouragement might include whether they are located with or are in regular contact with researchers interested in their area of work (from the same or similar field), whether they are members of professional science organisations, what their career background is and which organisations fund them. Part of what it means to be a biotechnology researcher in contemporary science is associated with commercial aspects, such as patents. This section covers a series of questions posed to explore these issues.

4.3.1 Principle and other funding

Sixty-four participants answered the question (What is the principal source of funding for your research?) by first answering 'other' and then listing their principal funding body and other funding bodies as appropriate (Table 4.4). The outcome was, therefore, actually greater detail about funding than originally intended. Only nine people understood and answered this question in the way that was intended, which was to provide a broad overview, categorizing funding sources as European Union, Irish Government, university, industry/private, charity or ‘other’.

Table 4.4 Principal funding sources for NICB research

Funding source	**No. people (*n* = 64)**
NICB	24
Programme for Research in Third-Level Institutions (PRTLI)	19
Higher Education Authority (HEA)	7
Science Foundation Ireland (SFI)	5
Don’t know	4
Irish Research Council for Science, Engineering and Technology (IRCSET)	2
Higher Education and Training Awards Council (HETAC)	1
Enterprise Ireland	1
National Roseacea Society (USA)	1

Table 4.4 should be treated as a simple list as it is difficult to know whether the answer ‘NICB’ means that the person is on a scholarship and so is literally funded by the NICB, or if they do not know the source of funding for the NICB that supports their research. The PRTLI, HEA, SFI, IRCSET, HETAC and Enterprise Ireland are all Irish Government sources (e.g. the PRTLI is an HEA programme). The National Roseacea Society (USA) is a specialist source for a specific piece of research on the skin condition known as roseacea.

Secondary funding bodies identified by the participants included: Enterprise Ireland, HEA, a local Council (paying a postgraduate’s fees), PRTLI, SFI, the Technological

Sector Research Fund, Health Research Board (HRB), Department of Agriculture, hospital, Cancer Research Ireland, and charity and industry sources.

4.3.2 Participants' main research area(s)

Appendices 2 and 3 list the questions and the nine options provided for the participants to choose a description of their main research area.

Fifty-six people answered that their research area was molecular and cellular biology, either solely (10 people), or in combination with one or more of the other categories. This was to be expected, given that the focus of the NICB is 'cellular biotechnology'. Other single main research area answers included plant and animal sciences (1), medicine/diagnostics/therapeutics (2), food/industry (3), pharmacology/pharmacognosy (2) and 'other' (4).

Common combinations of research areas included molecular and cellular biology in combination with:

- genetics
- medicine/diagnostics/therapeutics
- instrumentation/technology (e.g. bioinformatics, biosensors, nanotechnologies).

Only one person answered that their main area was environment/marine (e.g. bioremediation, pollution, risk assessment). 'Other' answers occurred where participants thought that their main research area did not fit into any of the categories. These included molecular work in microbial/fungal pathogens and organic chemistry (synthetic chemistry for medical or clinical purposes).

4.3.3 Member of professional science organisations

This question was posed to find out whether participants were members of professional science organisations. The assumption is that such memberships facilitate communication with others in the same or similar fields of research and with non-specialists. Thirty participants (41.1%) were not members of a professional science organisation. People who were not members tended to be less senior (age groups under 25 and 25–34 years), not yet have a PhD, and be postgraduate students (doing research only).

Table 4.5 lists the professional science organisations with NICB researcher members. As some people were members of more than one professional science organisation, the numbers of memberships exceed the number of people holding them.

Table 4.5 NICB professional science organisation memberships (number of members if >1)

All Ireland Society for Higher Education	European Tissue Culture Collection Society
American Chemical Society (2)	Glioma Invasion Forum
American Mass Spectrometry Society	Institute of Biology of Ireland (3)
American Oil Chemists' Society (2)	Institute of Chemical Engineers
American Society for Microbiology	Institute of Chemistry in Ireland (2)
Animal Cell Technical Industrial Platform	Institute of Food Science and Technology of Ireland (2)
Association of Biotechnology (European)	International Mass Spectrometry Society
Biochemical Society [UK and Ireland] (4)	International Society for the Study of Fats and Lipids
European Biosafety Association	Irish Association for Cancer Research (10)
Bionet (2)	Irish Bioindustries Association
Biotechnology Research Society (DCU School of Biotechnology)	Irish Clinical Oncology Research Group
British Mass Spectrometry Society	Irish Federation of Diabetes
British Mycological Society	Irish Society for Immunology (2)
British Society for Medical Mycology	Irish Mass Spectrometry Society (2)
British Society of Plant Pathology	Irish Research Scientists Association (2)
Diabetes Association	Royal Association of Medicine of Ireland
Diabetes UK	Royal Society of Chemistry (5)
Engineers Ireland	Society for Experimental Biology
European Association for Neurooncology	Society for General Microbiology (12)
European Association for the Study of Diabetes	Society of Chemical Industry
European Biochemistry Organisation	Society of Industrial Microbiologists
European Cystic Fibrosis Society	Society of Medicines Research
European Membrane Society	Various user groups (e.g. DNA arrays)

European Society for Cell and Tissue Culture	

The two most popular organisations with NICB researchers were the Irish Association for Cancer Research and the Society for General Microbiology, with 10 and 12 members, respectively. The Royal Society of Chemistry was also relatively popular (5 members), as was the Biochemical Society (4 members). This means that chemists or biochemists are much more likely to hold memberships as there were fewer of them in the NICB population. Perhaps this is because in these well-established fields, membership is encouraged, or perhaps this is because these researchers are in the minority at the NICB.

The Irish Association for Cancer Research states on its website:[12]

> Our aim is to bring researchers from different disciplines together to share their expertise, latest information [sic] to help promote greater understanding about cancer to ultimately help reduce the burden of cancer.

Communication is a big part of the stated aim of the organisation and members are supported in this communication, at least amongst themselves. There is an image of one of the NICB researchers on the front page of the website.

The Society for General Microbiology is a large organisation based in the UK, but with members from many European countries. The objective of the society is to 'advance the art and science of microbiology', which it does by providing career resources for microbiologists, holding scientific meetings, publishing four monthly journals and one broad interest magazine, providing downloadable materials for use in secondary schools and supporting members in communicating microbiology to young people aged from 5–12 years, older young people and adults.[13]

The Royal Society of Chemistry website states:[14]

> The RSC is the largest organisation in Europe for advancing the chemical sciences. Supported by a worldwide network of members and an international publishing

[12] www.ia-cr.ie (last accessed 11 October 2008)
[13] www.socgenmicrobiol.org.uk (last accessed 11 October 2008)
[14] www.rsc.org (last accessed 11 October 2008)

business, our activities span education, conferences, science policy and the promotion of chemistry to the public.

And the Biochemistry Society[15] 'communicating biochemistry internationally' and 'advancing molecular biosciences' encourages communication via scientific meetings large and small, journal publishing, grants and careers, policy and education activities: 'to provide information and opinion to government and its agencies, schools and universities, and the general public'.

All of these organisations have some kind of communication agenda. They are part of the science communication environment, as well as legitimate outlets for communication exchange. None of them are specific to biotechnology, but perhaps this is because 'biotechnology' is all of the areas covered by these areas. The 30 less senior and younger NICB participants who were not members of professional organisations would certainly benefit from joining, in order to tap into aspects of the science communication environment denied to them. But, perhaps non-membership is due to a lack of finances.

4.3.4 Working in sectors

Like the questions exploring participants' research areas (Section 4.3.2) and whether they had ever worked abroad (Section 4.4.1), the assumption underlying this question (Which of the sectors (Irish Government, university, industry/private, other) would you describe yourself working in in your current research?) is that broader experience in different sectors might predispose participants to communicate about their research.

Most of the participants (62; 84.9%) described themselves as currently working in the third-level sector (not, as some pointed out, the 'university' sector as institutes of technology are not considered to be universities). Two described themselves as working in the Irish Government sector only, two others were a mixture of Irish Government and third-level sectors, and five described themselves as working in a third-level–industry collaboration.

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[15] www.biochemistry.org (last accessed 11 October 2008)

Thirty-nine people (53.4%) had only ever worked in the third-level sector. Twenty-four had worked in both the third-level and industry sectors, two had worked in both the third-level and government sectors, two had worked in the third-level, industry and government sectors, and four had worked in a sector described as ‘other’, for example, the Canadian Government. One person had only ever worked for the Irish Government and one had worked for both the Irish Government and industry.

4.3.5 Patents

Research-related patents, like confidentiality agreements (see Section 4.6.1), have the potential to limit communication activities while patent applicants are waiting for approval or rejection. However, as patents are specific to the invention or discovery, it might be argued that they only constrain communication about a small proportion of the actual work done by researchers.

Thirteen participants (17.8%) had applied for a patent and eight of these had been successful. Most people who had applied for patents were men (8/13), as were those that had applied and had also been successful (5/8). Successful applicants all had PhDs and had held them for five (3 people), six (4 people) or seven years (1 person). Pending or unsuccessful applicants (the question did not distinguish between these options) tended to be less qualified — without a PhD or only 2 years into their PhD. Answers could refer to an individual or group application.

Only a small number of participants had applied for patents overall and a small number had been successful – presumably these participants no longer had constraints on communicating their research in the area of the patent. However, the process can take many months or several years, during which time they would have been subject to constraints.

4.4 Communication through cooperation

Cooperation requires communication. The assumptions explored in this section are that cooperating with researchers across fields and disciplines, both scientific and non-scientific, and being exposed to different cultures may somehow predispose researchers to communicate, or at least provide them with the skills to do so more effectively.

It could be argued that the culture of science is somewhat universal, but it is, of course, embedded in the culture of the hosting society. This section examines participants' previous opportunities to work outside of Ireland and documents their normal levels of contact with researchers from their own and other disciplines. It can be seen in the following sections that slightly over half the participants had never worked abroad and, although cooperation was generally thought desirable, little cooperation had taken place with researchers (or others) outside fields of research close to the participants' field.

4.4.1 Working outside Ireland

Forty-two people (57.5%) had never worked outside of the Republic of Ireland.[16] Thirty-one (42.5%) had worked in 46 different placements in Europe and around the world, including:

- Europe — France, Germany, Hungary, Northern Ireland, Slovenia, Sweden, Switzerland, Great Britain and Yugoslavia[17]
- North and South America — Argentina, Canada, the United States and Uruguay
- Australia, India, Japan and Kuwait.

For participants who had spent time abroad, placements had been for a median of 14 months. Only seven postgraduate students had spent time abroad and these generally had not stayed longer than 8 months (one had spent 30 months, but had come to his/her postgraduate study after some years of work). Five out of the six postdoctoral researchers had spent time in research abroad, three in the United Kingdom (for 12, 60 and 120 months).

The longest periods of time were spent in the United Kingdom, Japan, Canada, Australia and Switzerland and the shortest periods of time were spent in Uruguay,

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[16] I have made the assumption, based on institutional governance, that Northern Ireland is more like the United Kingdom in terms of its model of academic research organization; therefore, it is distinguished from the Republic of Ireland here.
[17] The Federal Republic of Yugoslavia (when it existed).

Sweden, Hungary, the United States and Yugoslavia. Twelve placements were in the United States and nine in the United Kingdom (out of a total of 41 placements).

The Director of the NICB had spent months at a time in Europe and weeks at a time in the United States, but was not more specific than this. His data are not included in the descriptions above.

4.4.2 Cooperative research

Participants were asked whether they had taken part in cooperative research with people in fields other than their own (cross-referenced to Card B1, see Appendix 3), in other scientific disciplines and/or in non-scientific disciplines.

Nineteen people had not done cooperative research with any of the three groups provided. Two of these people were senior (a senior lecturer and a research officer); the rest were postgraduate students or postdoctoral researchers. As expected, close cooperation with scientists in fields other than their own tended to be with people doing research in fields close to their own. Thirty-eight participants (52.1%) identified their collaborators in fields on Card B1; the same list that participants had been asked to choose from when describing their own research (see Section 4.3.2).

The most popular type of close collaboration was either molecular and cellular biology, medicine/diagnostic/therapeutics or pharmacology/pharmacognosy, or a combination of these, with food/industry (e.g. industrial microbiology, neutraceuticals, food/beverage processes). Cooperative research was also done with people working with medical devices and surgical glue used in humans (which did not fit into the categories on Card B1). Two participants answered ‘no’ to this question, but commented that they would be doing so in the future.

Thirty-two participants (43.8%) had done cooperative research with people in other scientific disciplines, either with chemists or they were themselves chemists (26/32); with physicists (5/32); or with computing experts (2/32), who were more commonly categorized as from *non-scientific* disciplines (see below). Also mentioned were clinicians, materials scientists (optics) and petrologists; this last a collaboration with a NICB chemist, which occurred during previous work.

Some participants included comments about the ‘other disciplines’ part of the question; paraphrased below:

- There may not be direct collaboration with scientists from other scientific disciplines because the material might be handed over for others to do different work on, with no direct association or contact between individuals.
- More collaboration with other disciplines is desirable.
- Computing is interdisciplinary.

Only 12 participants (16.4%) stated that they had taken part in cooperative research with people from non-scientific disciplines, including computing experts, engineers, statisticians, business people in industry, lawyers, educators, ethicists and researchers from the BioSciences and Society research group. This last could, in theory, be all of the participants, since they were participating in my research project; however, only one participant thought that this was the case though, and he was referring to research done with another BSS colleague on biotechnology in schools.

For researchers who had worked outside Ireland and in other cooperative research, the assumption is that communication across cultures, other science and non-science disciplines, or even other laboratories, which may have their own cultures, is beneficial. The researchers were aware of the thrust of this question and indicated that they too thought collaboration was desirable, although this was couched in terms of benefit from a research perspective, rather than a communication perspective.

4.5 Formal communication activities

The theme of this Section is communication that is *required* of biotechnology researchers, with an emphasis on more formal modes of communication, such as disseminating information about research for funding organisations, attending scientific conferences and submitting manuscripts to peer-reviewed journals. This type of communication is perceived as a strong component of ‘doing science’ and, perhaps as a consequence, there was no evidence of the participants being forced onto rhetorical activity that they objected to (as found by Berkencotter and Huckin 1993).

Section 4.5.4 (communication relating to public policy), although placed here under the umbrella of formal communication activities, was actually perceived differently by the participants. That is, they mainly either thought of this kind of communication as something that would be done by senior researchers and management (i.e. the Director), or they would do it themselves, but only due to a specific (and out of the ordinary) request.

4.5.1 Disseminating information about research for funding organisations

Section 4.3.1 lists the organisations that funded research at the NICB at the time of the interviews, according to the participants. The Irish Government provided the bulk of the funding — only one or two sources were charities or private industry, and no funding appeared to come from the European Union.

Participants were asked to choose from a list the types of dissemination *required* by the funding bodies (Table 4.6). The six types of dissemination that were required most often by funding bodies were all formal and for specialist audiences. Presentations and articles for non-specialists and web-published material were not commonly required.

Table 4.6 Information dissemination required by funding bodies

Dissemination type	No. participants	% (*n* = 72)
Written progress reports	63	87.5
Oral presentations for specialists	39	54.2
Thesis/dissertation	32	44.4
Written articles for specialists	31	43.1
Written end-of-grant reports	22	30.6
Written abstracts	21	29.2
Oral presentations for non-specialists	10	13.9
Written articles for non-specialists	8	11.1
Web publication	7	9.7

One missing data point.

Interestingly, 10 postgraduate students did not answer ‘thesis/dissertation’ when asked this question. This may be explained by the wording of the question: dissemination that is required by the funding body, as opposed to a thesis/dissertation being a requirement of the award of a postgraduate degree. Some non-postgraduate students did answer ‘thesis/dissertation’ — these were mainly lecturers, senior lecturers and other researchers involved in the supervision of postgraduate students. It makes sense that they would be more attuned to this requirement of funding as they would be responsible for the funding requirements being met by their students.

Participants answered ‘other’ when they thought that the funding bodies required them to do dissemination that was not covered under the categories provided, or when they wanted to volunteer other related information. Two postgraduate students volunteered that they were required to provide 3-month progress reports to their supervisors as part of being funded. One supervisor of postgraduate students stated that funders required PhD theses to be produced, for which s/he was in part responsible. One participant pointed out that the topics of research projects funded by the HEA were all available on the HEA website as a form of dissemination, although it was not a requirement for the participant, but a practice of the HEA (see below for a discussion about this communication).

Three participants responded that, in addition to their own dissemination requirements, other dissemination was done on their behalf or on behalf of the research project. For example, the principal investigator might write abstracts and give presentations to specialists and non-specialists about the research done by a team — this work was required of the principal investigator. In another case, the participant was a research assistant and was not required to disseminate information because this was the job of the laboratory manager (again, on behalf of the research project).

Only nine participants reported that they were not required by their funding bodies to produce written progress reports. Two had replied ‘other’ only. Four were postgraduate students (required to produce a thesis/dissertation), who were also required to provide written articles and give oral presentations for specialists. One person was required to produce an end-of-grant report only. The other two were required to produce oral presentations for specialists, and so on.

The General Manager of the NICB was the only person who said that funding bodies required all of the types of dissemination listed, presumably because of his management and reporting role, and being a contact person within the NICB and with other organisations. Six people stated that they did at least two of the three non-specialist dissemination types. The people who claimed that they were required to do at least one of the three non-specialist dissemination types were a mixture of junior and senior researchers, although all of the senior staff were represented: the Director, the General Manager, heads of schools and senior researchers.

Although most funding bodies required written progress reports and/or oral presentations for specialists, other than this formal (doing science) type of communication, very little funder-directed communication was required (Table 4.6). Interestingly, it is more likely that the National Roseacea Society, than larger more general funding bodies, would require the dissemination of research results, perhaps because such results would have the potential to be immediately applicable to the human health issue for which they were funded.

Perhaps it is the shorter distance between the bench and bedside for human health-targeted research that encourages communication. For example, the only document I was able to find that seemed to be targeted to the wider community, which was also an example of funder-initiated communication about research by an Irish funding body, was the HRB's *A Picture of Health* series. This is a glossy annual booklet containing vignettes about researchers and their area of research. One such is quoted below:[18]

> **Lung cancer: The puzzle that is bcl-xL**
>
> Dr Carmel Daly, Prof Martin Clynes and PhD student Isabella Bray (National Cell & Tissue Culture Centre, DCU) are trying to find out how some cancer cells become resistant to chemotherapy drugs
>
> Cell suicide, a highly regulated process which scientists call apoptosis, plays an important role in our body's healthy development, but also in many diseases. Several drugs now exploit apoptosis, notably chemotherapy drugs which work by persuading cancer cells to commit suicide. Unfortunately, cancer cells can become resistant to these drugs, usually by producing more of some gene that blocks apoptosis and prevent the cells dying. One such gene is called bcl-xL, and our group previously discovered that chemo-resistant lung cancer cells over-express this anti-apoptotic gene. This made us wonder: if we turned down this gene, would the cells become sensitive again to chemotherapy drugs?
>
> To explore bcl-xL's role in drug-resistance, we devised two ways of turning down the gene which would hamper the production of bcl-xL protein. Both methods worked effectively in test tubes as measured by the absence of precursors to the bcl-xL protein. To our amazement, however, when we attempted the same thing in lung cancer cells, we saw, if anything, an increase in bcl-xL protein levels. Perhaps bcl-xL is so vital, a cell will not let us interfere with its production? Or perhaps, if you do interfere, the cell compensates in some other way? Clearly, we need to know more about bcl-xL. One possible next step is to use gene-chip technology to look not just at bcl-xL, but at several apoptosis genes simultaneously.

The use of the phrases 'our group' and 'made us wonder' suggests that this piece was written by one of the researchers. Later on in the *A Picture of Health* series (e.g. in the booklet published in 2006), it is acknowledged on the copyright page that the text is written by a well-known Irish science communicator; however, it is clear from

[18] HRB (2004). *A Picture of Health: A Selection of Irish Health Research 2004*:, available from the

the text that she has interviewed the researchers. This type of publicly accessible direct communication by researchers is rare.

4.5.2 Attending scientific conferences

Participants were asked whether they had attended any scientific conferences in the past year. If so, they were asked to list the conferences and state whether they had presented a poster or given an oral presentation.

Only 13 people (17.8%) had not attended a scientific conference within the previous year. These were postgraduate students (4), research assistants (2), research officers (3), lecturers (3) and the Director of Quality Promotion — an administrative non-science job requiring a great deal of commitment and time away from the NICB.

Twenty-seven (37.0%) attended scientific conferences in Ireland only and the rest (33, 45.2%) attended scientific conferences in and out of Ireland.

A total of 147 conference attendances took place over the previous year, with:

- 29 papers presented (19.7% of attendances)
- 52 posters presented (35.4% of attendances)
- 66 nothing presented (44.9% of attendances).

It was more common (38/60) for people to have attended one or two conferences over the previous year than more than two (22/60). Five people attended five or more conferences over the previous year. Two of these were postgraduate students who either presented posters or did not present at all. One research officer presented one poster, but attended six conferences. At the other end of the scale, one senior research scientist attended seven conferences and presented a paper at six of them.

Attending scientific conferences is a communication activity that is an integral part of doing science, and junior researchers are generally encouraged to take part. In the biosciences, poster presentations are often seen as a way for junior researchers to present their work if they do not have enough material for an oral presentation or as a lower-status alternative to an oral presentation. Sometimes senior researchers will do

HRB publications webpage (www.hrb.ie). Last accessed 18 September 2008.

an oral presentation, but take along posters of other work being done by a research group.

4.5.3 Manuscripts submitted to peer-reviewed journals

Participants were asked whether they had submitted any manuscripts to peer-reviewed journals in the past year as first author or as co-author and, if so, to list the journals and state whether their paper had been accepted or not.

Thirty-one people (42.5%) had submitted at least one manuscript to a peer-reviewed journal as a first or co-author in the previous year. Broken down (an individual may have submitted more than once) there were:

- 17 first author submissions (23.3% of people)
- 14 co-author submissions (19.2% of people)
- 11 first author and co-author submissions by the same individuals (15.1% of people).

Table 4.7 shows the journals to which first-author articles were submitted, the outcome of submission, the journal impact factor (where available) and the median impact factor(s) for the subject field(s) to which the journal belongs.[19]

[19] The impact factor is a measure of citations to a journal and is often used as a proxy measure for the importance of a journal to a field of science or social science. This use is controversial because the measure applies only to journals, not individual articles or individual scientists. A journal should only be ranked with journals in the same subject area. Despite these issues, the impact factor is a relatively objective measure and is widely accepted.
The median impact factor of has been included here for comparison as it is only valid to compare impact factors of journals within subject areas (e.g. *Anticancer Research* and the *British Journal of Cancer* are both oncology journals); not across subject areas (e.g. a crystallography journal and an oncology journal). There are 171 subject categories in the science edition of *Journal Citation Reports* and some journals may fall into more than one of these.

Table 4.7 Journals to which articles were submitted by first author

	Published	Rejected	In press	Impact factor (2006)[1]	Subject area(s)	Median impact factor(s) (2006)
Acta Crystallographica (Section C)	1	–	–	0.896	Crystallography	1.467
An unspecified Irish journal	1	–	–	N/A	N/A	N/A
Angewandte Chemie International	–	–	1	10.232	Chemistry, multidisciplinary	0.984
Anticancer Research	3	–	–	1.479	Oncology	2.396
Archive for Organic Chemistry (ARKIVOC)	1	–	–	0.800	Chemistry, organic	1.894
Bioorganic & Medicinal Chemistry	–	–	1	2.624	Biochemistry & molecular biology Chemistry, medicinal Chemistry, organic	2.476 1.636 1.894
Biotechnology Letters	1	–	–	1.134	Biotechnology & applied microbiology	1.938
British Journal of Cancer	1	–	–	4.459	Oncology	2.396
Cancer Genomics and Proteomics[2]	–	–	1	N/A	N/A	N/A
Chemistry/biochemisty[3]	–	–	1	N/A	N/A	N/A
Cytotechnology	1	–	–	0.464	Biotechnology & applied microbiology Cell biology	1.938 2.949
Fungal Genetics and Biology	1	–	–	3.121	Genetics & heredity Mycology	2.552 1.574
Glycobiology	1	–	–	3.668	Biochemistry & Molecular biology	2.476
Inorganic Chemistry	–	–	1	1.787	Chemistry, inorganic	1.402

Communications					& nuclear	
International Journal of Cancer	1	–	–	4.693	Oncology	2.396
Journal of Medical Microbiology	1	–	–	2.180	Microbiology	2.221
Journal of Membrane Science	–	–	1	3.442	Engineering, chemical Polymer science	0.656 0.969
Journal of Organometallic Chemistry	1	–	–	2.332	Chemistry, inorganic & nuclear Chemistry, organic	1.402 1.894
Journal of Pharmacy and Pharmacology	1	–	–	1.533	Pharmacology & pharmacy	1.987
Separation and Purification Technology	–	–	1	2.497	Engineering, chemical	0.656
Transplantation Proceedings	3	–	–	0.962	Immunology Surgery Transplantation	2.513 1.139 2.297
Total submissions	18	0	7			

– = outcome did not occur; N/A = information not available.

1. Impact factor and median impact factor have been taken from 2006 data as these are calculated with a 2-year time lag.

2. The journal *Cancer Genomics and Proteomics* began publication in 2004, so the impact factor would not have been calculated until 2007.

3. Unknown journal.

Source: Thomson Scientific (2006) *Journal Citation Reports*, Thomson Scientific: Philadelphia.

None of the first-author submissions had been rejected (although the articles with 'in press status could have been rejected subsequently). The long lead-time for some of the journals explains the in-press status of seven of the articles, and it was not recorded when in the previous year the articles had been submitted.

Three postgraduate students had submitted papers as first author in the previous year, although one was still in press. All of these students were in the process of transferring from the Masters to PhD track and publication was seen as one route to a successful transfer. Four (out of a total of six) postdoctoral researchers had submitted papers as first author in the previous year. One article was still in press. The remainder were senior staff — five lecturers, four research officers and a senior research scientist. Only senior staff had submitted more than one manuscript over the previous year as first author.

For the first author submissions, there was a mixture of journal impact factors being higher, approximately equal to or lower than the median impact factors for each subject area (Table 4.7). Journals in the chemistry subject areas, with the exception of *Archive for Organic Chemistry (ARKIVOC)*, all have higher impact factors than the median for their subject areas. Journals that had been submitted to successfully more than once, that is, *Anticancer Research* and *Transplantation Proceedings*, had lower impact factors than the subject area median.

Table 4.8 shows the journals to which co-author articles were submitted, the outcome of submission, the journal impact factor (where available) and the median impact factor(s) for the subject field(s) to which the journal belongs.

Table 4.8 Journals to which articles were submitted by co-authors

	Published	Rejected	In press	Impact factor (2006)[1]	Subject area(s)	Median impact factor(s) (2006)
Acta Crystallographica (Section C)[2]	2	–	–	0.896	Crystallography	1.467
Analytical Chimica Acta	1	–	–	2.894	Chemistry, analytical	1.427
Anticancer Research	2	–	–	1.479	Oncology	2.396
Biochemistry	–	–	1	3.633	Biochemistry & molecular biology	2.476
Biological Chemistry	1	–	–	2.752	Biochemistry & molecular biology	2.476
Bioremediation	–	1	–	N/A	N/A	N/A
Biosensors & Bioelectronics	1	–	–	4.132	Biophysics Biotechnology & applied microbiology Chemistry, analytical Electrochemistry Nanoscience & nanotechnology	2.332 1.938 1.427 1.611 1.543
British Journal of Cancer	–	–	1	4.459	Oncology	2.396
Chemical Communications	1	–	–	4.521	Chemistry, multidisciplinary	0.984
Diabetologia	–	–	1	5.247	Endocrinology & metabolism	2.442
FEMS Immunology & Medical Microbiology	–	1	–	2.281	Immunology Infectious diseases Microbiology	2.513 2.330 2.221
Fungal Genetics and Biology	1	–	–	3.121	Genetics & heredity Mycology	2.552 1.574
Infection and Immunity	–	1	1	4.004	Immunology infectious diseases	2.513 2.330
Infectious Disease[3]	1	–	–	N/A	N/A	N/A
International Journal of Cancer	3	–	–	4.693	Oncology	2.396
Journal of Microbiological Methods	2	–	1	2.442	Biochemical research methods Microbiology	2.452 2.221
Journal of	–	–	1	2.332	Chemistry, inorganic & nuclear	1.402

Organometallic Chemistry					Chemistry, organic	1.894
Journal of Pharmacy and Pharmacology	–	–	1	1.533	Pharmacology & pharmacy	1.987
Journal of Supramolecular Chemistry	–	–	1	1.861	Chemistry, multidisciplinary	0.984
Journal of the American Society of Brewing Chemists	1	–	–	1.077	Biotechnology & applied microbiology Food science & technology	1.938 0.857
Journal of Virology	1	–	–	5.341	Virology	2.783
Microbial Ecology	1	–	–	2.332	Ecology Marine & freshwater biology Microbiology	1.462 1.196 2.221
Miscellaneous[4]	12	1	2	N/A	N/A	N/A
Molecular and Cellular Biology	1	–	–	6.773	Biochemistry & molecular biology Cell biology	2.476 2.949
Organic Letters	–	–	1	4.659	Chemistry, organic	1.894
Solid State Ionics	–	–	1	2.190	Chemistry, physical Physics, condensed matter	1.778 1.343
Tetrahedron	–	–	1	2.817	Chemistry, organic	1.894
Total submissions	31	4	13			

– = outcome did not occur; N/A = information not available.

1. Impact factor and median impact factor have been taken from 2006 data as these are calculated with a 2-year time lag.

2. Section C is assumed here

3. Not clear whether this is the Journal of Infectious Diseases or the International Journal of Infectious Diseases

4. Miscellaneous includes '10 to 12' unspecified journal submissions from one individual (shown as 10 published articles), and five unspecified journals.

Source: Thomson Scientific (2006) *Journal Citation Reports*, Thomson Scientific: Philadelphia.

Three postgraduate students had submitted papers as co-author in the previous year — one had submitted two (one in press, one accepted) and the other two had submitted one each (one accepted and one in press) — as had four (out of a total of six) postdoctoral researchers — one had two papers published and the other three had a paper in press. It was quite common for supervisors and principal investigators to be co-author (or 'last' author) in the submissions of more junior researchers and the large number of senior researchers as co-authors probably reflects this. Two rejected papers were submitted by a lecturer as co-author.

Co-author submissions tended to be to journals with higher or much higher impact factors than the subject area medians (by approximately 2:1). Four rejections were reported, one was from a high impact factor journal, one from a low impact factor journal and for the other two, the associated information was not available.

Journals that were submitted to as co-author in the chemistry subject area were again high impact factor, relative to the median subject area impact factors.

Like attending scientific conferences, submitting manuscripts to peer-reviewed journals is an integral part of doing science. As such, it is done to a greater extent by more senior researchers and the junior researchers have a kind of apprentice role, which is shown by the order of authors.

4.5.4 Communication relating to public policy

Participants were asked whether they had ever contributed to a response by their institution to a government advisory body or a parliamentary committee, given oral evidence to a parliamentary committee or any other activity relating to public policy associated with their research.

Independently of the inclusion of this question in the interview schedule, the Director of the NICB (in July 2003) requested that all NICB staff and students write and speak to their local TD (Teachta Dála, or member of parliament) and discuss the importance of funding for the NICB. The idea was to get as many people as possible approaching politicians about science, particularly NICB, funding because the universities could not be expected to make the case, given their other commitments.[20] Many people did this and then mentioned it in response to this question in the interview.

Forty-six (63.0%) had not contributed to public policy in any of the suggested or self-reported ways mentioned. Thirty-three (45.2%) of these were postgraduate students or postdoctoral researchers; in fact, none of the six postdoctoral researchers had ever contributed to public policy. Two people, one a lecturer and one a postgraduate student in the third year of his/her PhD answered 'don't know'.

Fourteen (19.2%) had contributed to a response by the NICB to a government advisory body or parliamentary committee – two of these were postgraduate students and the rest were senior (the General Manager, lecturers, senior researchers etc).

Only one person had given oral evidence to a parliamentary committee, and that was when s/he worked in the UK, to a UK parliamentary committee. Given that this question originated from the MORI–WT survey, it seems that this activity is more common in the UK. Perhaps direct dialogue with the public is becoming normalized in the UK at least (UK House of Lords 2000).

Nearly everyone who responded with 'other' (21, 28.8%) was referring to writing a letter to their TD, at the Director's request (17, 23.3%). This is nearly a quarter of the NICB researchers who managed to engage with the policy process, albeit in a self-interested way.

Most notably, the Director himself replied 'other' with the explanation that he had given written submissions to government policy documents but *not* usually on behalf of the institution — more in a private capacity to air his views on the use of human embryonic stem cells. As an example available in the public domain, in August 2004, the Director wrote an article in *Studies* (a Jesuit periodical) that urged the government to reject research involving the destruction of human embryos. Earlier in November 2003, the *Irish Independent* published his letter in the Letters to the Editor section:

> I am writing, as one of the few scientists in Ireland involved in stem cell research, to ask that the Government should oppose allocation of EU funding for research involving the use of human embryonic stem cells. A decision will be taken in the next week, and several countries including Italy, Germany and Portugal, will oppose funding for such research. Ireland should support them...

[20] The Director acknowledged that his request was unusual, but argued that although scientists prefer doing science to doing politics, their reticence does not go unnoticed when it comes to political approaches about research funding in Ireland.

As a well-known communicator about science from a Catholic perspective, the Director was often heard in the non-scientific press and policy circles in Ireland. Perhaps this is what inspired him to request that NICB staff and students write and speak to their local TD in regard to funding. Nearly a quarter did so, which is a significant minority. It would be interesting to follow up on this activity in the future — did it inspire people to take their own initiative in engaging with public policy and communicating about science.

4.6 Confidentiality

The participants were asked whether they thought confidentiality agreements (CAs) had an effect on talking about their work with other specialists and with non-specialists (see Appendix 2). The issues explored in this section cut across the themes of 'private science' and the potential constraints this mode of science places on scientists' communication, both within science and with non-scientists.

4.6.1 Confidentiality agreements

Twenty-five participants responded that they definitely did not operate under a CA associated with current or recent research. The other participants answered that an explicit (official or signed) agreement existed, that a tacit (unspoken or verbally directed) agreement existed, or that they didn't know if an agreement existed (Table 4.9).

Table 4.9 Participants operating under a confidentiality agreement

	No.	%
No	25	34.7
Yes (explicit)	34	45.8
Yes (tacit)	12	16.7
Don't know	2	2.8
Total	73	100.0

Answer: no

Three participants, apart from responding 'no', also added 'not that they were aware of'. This could imply that they were answering 'don't know', but equally the 'don't know' responses could be grouped with either the 'no' responses, as one of the two participants who responded 'don't know' went on to say that 'currently in the research that we're doing there's nothing, as far as I know, that's supposed to be confidential', or the 'yes (tacit)' responses: 'It's kind of automatic not to go spreading it or anything'.

One 'no' participant added that s/he knew someone who had experienced a CA, and there was nothing like the formality of that CA at the NICB.

One participant answered 'no', but then conceded that there was an implied level of confidentiality at the NICB, but not the same as a CA that s/he had experienced 'in industry', which had been very strict.

Thus it seems that participants were answering 'no' either because they genuinely believed that they were not (and probably were not) operating under a CA or because, based on their observations/experience of what constitutes a 'proper' (formal or strict) CA, they had not experienced that kind of CA at the NICB.[21]

Answer: yes (explicit)

One participant responded 'yes (explicit)', describing a general CA for those who worked in 'the Centre':[22]

> ...your information, I suppose it would be owned by [the Centre], but ... we're still told we can still talk ... we can present stuff ... we actually do sign a confidentiality

[21] The data to provide a definitive answer as to which participants did operate under an official CA (probably signed as part of their contract) was not collected at the time of the interviews, and would now be impossible to obtain from records. As this series of questions was to explore their communication and constraints, it is perhaps a moot point (i.e. their perceptions would guide their behaviour, 'true' or not). In addition, many of the participants (i.e. postgraduate students) would not have had a contract, although intellectual property associated with their work would automatically belong to the third-level institution in which they were working, unless alternative arrangements had been made.

[22] 'The Centre' was a common way to describe the group that were a part of, or came from, the National Cell and Tissue Culture Centre (NCTCC), which was established as a BioResearch Ireland centre of excellence for animal cell biotechnology in 1987, and had since been subsumed by the NICB.

> agreement, but I mean, I presume that's because we would work on and off with clinical researchers...

No one else described this agreement specifically.

Another participant claimed that s/he couldn't remember what was in the CA that s/he had signed.

Six of the participants specified that CAs only apply to parts of the research — the parts 'with companies' — because 'otherwise you wouldn't get access to [the] information', and in cases of collaborative research with commercial enterprises, but not with other academics.

Answer: yes (tacit)

Five respondents who responded 'yes (tacit)' explained their answer as a common sense outcome of needing to keep unpublished work confidential, and that this reaction was either self-imposed or directed by (presumably) someone in a senior position. Three respondents argued strongly that their work *belongs* to the NICB, one of these in terms of patents held by the NICB, or that everyone should exercise discretion as an employee of the NICB.

Associations with demographic data

Table 4.10 shows a breakdown of answers according to sex. A greater proportion of women stated that they did not operate under a CA.

Table 4.10 Participants operating under a confidentiality agreement by sex

	Yes (explicit)	Yes (tacit)	No	Don't know
Men	63.6%	24.2%	12.1%	0.0%
Women	32.5%	20.0%	42.5%	5.0%

Thus, a greater proportion of men stated that they did operate under a CA, and when the 'yes' results are pooled — explicit plus tacit — nearly 90% of men compared to approximately 50% of women stated that they operated under a CA.

Taken at face value, these results might be explained by noting that a greater proportion of women were postgraduate students or in other relatively low-status positions (i.e. younger, more junior and less qualified). This explanation makes the reasonable assumption that the presence of a CA implies relative importance and higher-status positions — ones that deal with clinical research or with patentable materials.

Taken from the perspective of the male participants, it might be that men are more aware of or concerned with confidentiality, or are more concerned with claiming under interview conditions that their work is associated with a CA.

Taken from the perspective of the female participants, the corollary is that women may be less aware of or concerned with confidentiality, or less concerned with stating this under interview conditions. Perhaps women talk about their work with less concern about the potential consequences of breaching confidentiality. Perhaps they do talk about their work without breaching confidentiality, but do not recognize this ability in themselves.

In terms of age, there was a relatively even spread of answers across the age groups. In terms of time since completion of their PhD, nearly all (9/10) participants who had received their PhD between 5 and 10 years ago stated that they operated under an explicit CA. A greater proportion of those doing research only (83.3%) compared to those doing both research and teaching (63.8%) stated that they operated under an explicit or tacit CA. When the three participants who replied ‘other’ to the questions about employment function are included (who all worked in ‘research only’-type positions), the proportion of participants doing research only who stated that they operated under an explicit or tacit CA rises to 86.7%.

4.6.2 Talking research with other biotechnology researchers

Participants were asked about their thoughts and attitudes in regard to how CAs might affect how they talk about their research with other biotechnology researchers. Clearly, CAs are tailored to prevent this from happening — other biotechnology researchers are the most likely people to be able to understand and take advantage of a breach of confidentiality. It is relevant, therefore, to explore this in terms of constraints or lack of constraints, and the meanings and practical effects that CAs might have on NICB researchers.

Constraints — competitors, commerce and sensitive information

In talking about their research with other biotechnology researchers, participants felt constrained by CAs in terms of being aware of competitors and competition, the effects of commerce and the withholding of sensitive information.

With people perceived to be competitors, participants stated that they were more conscious about what they said; holding back information in case a competitor laboratory was 'sharper', meaning that they might 'nab your idea'. Thus, they would not tell other biotechnology researchers exactly what they were doing, wouldn't go into detail, wouldn't talk freely, particularly at specific times, such as just before publication, would be guarded in speech, sometimes afraid of what they might say, and would present only limited information

The way that participants would talk about their research would depend on the audience — its vested interests, specialties and the same or different sort of expertise. Particularly with novel work, 'they wouldn't normally give ideas out'. One person related a cautionary tale: 'I did talk openly about something [to another biotechnology researcher] and I saw similar work, with their name [on it] ... they'd be better known [in science] ... it was only by accident I was at the conference'.

One participant expressed problems with timing in terms of publishing and getting a patent — s/he would consider publishing about the *activity* of a compound, but would reserve a description of the *properties* of the compound for a patent application. This approach precludes a competitor from piecing the information together. Similarly, with verbal communication, s/he might tell another biotechnology researcher about the activity of a novel compound, but would never tell anyone about its properties because 'they would want to make [it]'.

Fortunately, there is a point beyond which it becomes acceptable to talk about novel research, once a patent has been organized or sufficient research done: 'then it opens up and we can properly talk about it to anybody...you can talk and discuss an awful lot without the thing...you can be very collaborative [still]'.

Constraints became even more pertinent when the research was associated with commercial interests — a company, a specific product or even the nature of a grant. Sometimes the object of study is commercially available (such as a cell line) and any associated novel discoveries would be treated as confidential in terms of competition. From a practical perspective: ‘if you’re not capable of keeping information confidential, people won’t collaborate with you’ and ‘it is kind of common sense...you wouldn’t divulge any kind of sensitive information’.

Several researchers mentioned that they had been trained from the beginning (e.g. when one was an early researcher under the direction of Archport) to never mention the name of the company or certain things about the research, or to stop at a certain point in the conversation. People learnt to clarify when working with a compound whether it was acceptable to mention the name of the company. This training appeared to carry through so that other researchers at the NICB would not even try to talk about certain work with each other — instead a common in-joke was: ‘if I tell you I’ll have to kill you’. Several participants used a similar phrase with me during the interviews.

The usual constraints required by a company sponsoring or part-sponsoring research were that the name of the company or the name of a company-supplied compound would not be mentioned. This was particularly the case in drugs development. In addition, an agreement might include the vetting of papers or presentations before they were disseminated to other biotechnology researchers. Such CAs might extend beyond the completion of the research:

> ...well that research that I conducted in industry [I can’t talk about], because it’s still under confidentiality agreement, I am allowed to talk about any work that has been published in patent form or in peer reviewed journal form...

Such caution led some researchers to express frustration. One was adamant that CAs benefit only industry and not the advance of (cancer) research. CAs stop the dissemination of ideas. Her/his ideal solution was that ‘there should be a clause whereby you can talk about your research without people trying to steal ideas’ — not a solution that would work in practice.

Another participant did not see commercial interests as necessarily detrimental to information exchange about science or unreasonable, and associated confidentiality with daily life and normal human relationships:

> ...[CAs are] sometimes seen as a negative thing...[but they're] not a major stumbling block to the free flow of information in terms of intellectual exchange. [CAs] generally refer to the kind of very specific sets of facts, which maybe somebody might want to patent or publish and until they do, it's reasonable. In normal human relationships when we tell [someone] something in confidence, there is generally a reason and you don't pass it on as part of...ordinary living. Sometimes [confidentiality is] seen as a kind of a big bad wolf, but it's generally not...

A positive reaction was that CAs made life easier because one could be upfront at the beginning of a conversation about not being able to mention a company or a specific product, and then not have to worry about it.

Mostly though, there was ambivalence in participants' thoughts about CAs: 'I don't give too much away, but I don't like having to do that'.

Dealing with limitations if they exist

Some of the ways that participants dealt with constraints were related in the previous section. Participants also dealt with limitations in other ways. Many participants mentioned that CAs do not interfere with explaining the science. The research can be talked about in general terms or even quite specific terms as long as nothing confidential is mentioned. The details could be left out to give the audience a general picture of the science and to make the research activity understandable.

> You'd still be able to talk about your general area of research, particularly with someone you're interested in collaborating with.

Importantly, although one participant said that s/he would never mention very recent or original results to another biotechnology researcher, it was quite acceptable, and occasionally necessary, to discuss scientific problems in order to address them. It was always acceptable to talk about research once it had been published and was therefore in the public domain.

CAs do not interfere with researchers talking about cell lines developed within the NICB, because only NICB researchers would have access to such products. One participant suggested, therefore, that the CA had no effect at all on talking about her/his current research. Many participants thought that CAs had no effect on talking to other researchers as long as the other researchers were also in the Centre. One young researcher said that s/he would always feel fine to talk about research within the Centre and would rely on her/his supervisor to vet a presentation or publication to be disseminated outside the Centre.

It was generally agreed that CAs can limit communication with other biotechnology researchers. Although many participants stated that this was not a problem for them (as discussed above), others found the situation frustrating and difficult at least sometimes. Some participants were concerned that the dissemination of ideas was probably being curtailed, and that information of public or research interest was not being communicated that perhaps should be.

For one participant, it was difficult to identify with the possibility of others being interested enough in the work to want to appropriate it, let alone listen to more than 5 minutes at a very light level 'mentioned in passing'.

One participant wanted to say that all of her/his research was built up from talking to people; however, there had been times when this was not the most appropriate attitude to take and s/he had 'got into trouble' for doing so.

Many participants would never mention specific aspects of their research, particularly recent or original research. They would always be guarded and careful when operating under a CA. There was a kind of indoctrination to behave in this way in some cases. Nearly all of the participants used a variant of the phrase 'not too may details' and 'only talking in broad terms' when talking about communicating about their research under a CA. This is even more pertinent when talking with non-specialists about their research, however for different reasons (see Section 4.6.3).

4.6.3 Talking research with non-specialists

Participants were asked to share their thoughts and attitudes in regard to how CAs might affect how they talk about their research with non-specialists. Unlike other biotechnologists, non-specialists are presumably not a threat, particularly not in regard to confidentiality of research — non-specialists are the least likely people to understand and take advantage of a breach of confidentiality. However, it is interesting to explore the potential effect of CAs from this perspective. The order of the interview schedule meant that this question was asked immediately following the 'talking with biotechnology researchers' question, meaning that it was still fresh in participants' minds.

In fact, there were two mutually exclusive responses to this question: 'it's the same' (i.e. the same constraints hold as when talking to other biotechnology researchers) and 'CAs have no effect on talking to non-specialists' because participants would only be talking in broad terms to non-specialists anyway and a CA would not apply. Many of the responses were couched in terms of aspects of non-specialist audience ('them'), rather than aspects of the research or the CA itself.

CAs place the same constraints on communication with non-specialists

A small number of participants pointed out that from a purely legal perspective, research that is going to be patented or published cannot be spoken about to anyone. Any disclosures effectively compromise intellectual property, particularly of patents, and thus 'if you disclose too much information ... it might affect your patent later on down the line'. The same rules apply when talking to specialists or non-specialists: 'we wouldn't be able to go into the details of the name of the company, the nature of the drug or what it was active against', 'it's still confidential and is not meant to be passed on'.

In addition, you can never know if the person is or is not a specialist or has some connection with specialists:

> ... it depends on [how the] conversation comes up and who is a non-specialist. You can talk about it to anybody if you know they have no idea, but you should be wary. [You can't] know if they have a scientific background and are from another group.

CAs have no effect on communication with non-specialists

Nearly everyone commented that they would be very unlikely to be facing a competitor when communicating with a non-specialist and would only be talking about their research in very broad terms anyway, that is, not specific enough to be proscribed by a CA.

Viewing non-specialists as non-competitors means that they:

- are unlikely to work out the significant, CA-related, parts of the research
- will not be asking questions pertinent to CA-related information
- will not be part of a network of professional information dissemination.

Non-specialists are therefore relatively 'safe' and many participants felt that they could be less careful in what they were saying. One participant suggested that people can be identified as competitors quickly.

The 'broad terms' of communication with non-specialists refers to the type of communication normally required of the participants when talking about their research in this context, which is in less detail, as shown in the following quotes:

- 'I can describe activities without having to mention drugs, which will often confuse the issue anyway'
- '...you wouldn't go into details anyway ... you would just try to make it as understandable as possible'
- 'I would certainly not be getting down to the level of details relevant to confidentiality'
- 'the only reason I would even skirt around [talking about] confidential work would be to look for advice on techniques and work-related advice [and] there would be no call for me to have that kind of conversation with a non-specialist'.

The detail generally avoided is alluded to by the kinds of less detailed information a participant might talk about with a non-specialist:

> ...you're probably just going over the basics of it, of what you do...up to now we have been working on differentiation, so, you'd explain about how cells [differentiate] — the basics of it — and you wouldn't have to discuss in [more

> detail]. If you start going on talking about particular genes or things like that, you can see their eyes glazing over ... but they're usually very interested just in the basics of how the thing is developed and what's known about it — that's kind of interesting, you know?

As in this quote, there were a range of characteristics attributed to non-specialists that were mentioned by the participants to explain the level of communication normally required. These attributes appear to be based on previous experiences, are not always flattering and tend to fall into one of three types:

- they wouldn't understand the research anyway ('have a low level of understanding')
- they are not interested in the research ('their eyes glaze over')
- they have preconceived (negative) ideas about the research.

In relation to this last point, one participant said that s/he would be very careful talking with non-specialists anyway, CA or no CA, because of the (controversial) nature of the research — particularly in a (then current) context of organ retention scandals in Ireland.[23]

Finally, a participant commented, in somewhat wistful tones, that non-specialists would be interested in his/her research if it could be explained to them. Another thought that the biggest problem faced by scientists talking to non-specialists (referring to him/herself) was not the leaking of confidential information, but the ingrained use of jargon, 'of words that over the years, you don't even realize that they are jargon because you've got so conditioned to using them'. Perhaps this partly explains the three general characteristics attributed to non-specialists listed above — this person has recognized communication can only take place with effort from all parties.

[23] Up until 1999 in Ireland, nearly 14 000 pituitary glands gathered during postmortem examinations were supplied to drug companies to make products without the consent of next of kin.

4.7 Summary

The evidence provided in this chapter shows clearly that the participants' work environment — the institutional part of their communication environment — affected their communication.

If, as Berkencotter and Huckin (1993) suggest, scientists see rhetorical activity and laboratory work as distinct and separate activities, it is easy to see that even formal communication, which is a necessary part of the doing of science, might have a lower priority in the busy working week.

Teaching satisfies two of the PSP (2003) personal drivers for communicating — the recruitment answer, as science students become scientists, and the career answer, as academic science is weighted towards a mixture of teaching and research.

Most participants considered themselves to be working in the field of molecular and cellular biology — even some of the chemists. This is a fairly homogeneous situation, but nevertheless Lievrouw's (1998) horizontal information inequity may be occurring (see Section 4.5 for the types of formal communication practices occurring between the researchers and their close colleagues).

Clearly, professional science organisations are set up to communicate science in a variety of ways. Most participants were members of at least one professional science organisation, but it was notable that it tended to be the less senior participants — students and others without PhDs —who were not members. Membership of these societies is a semi-institutionalized way of reducing Leivrouw's (1998) horizontal information inequity; however, it is clear that not all researchers have taken up memberships.

The PSP (2003) pragmatic answer as a driver to communicate, that is, communication as a requirement attached to funding, has been addressed here. This driver was a factor in the participants' communication, but does not appear to be a very strong motivation for these researchers during the study period. Besides written progress reports, not a great deal of communication was required by the funding bodies as a stipulation of receiving the funding, and often it was done by a few on behalf of others. The bench work of science is commonly done by more junior researchers and the communication aspects of doing science by more senior researchers, although it is of course to the advantage of junior researchers looking to further their careers to at least take part in the communication aspects of the science.

By communicating to their local TDs about funding for the NICB, it could be argued that the individual researchers at the NICB did manage to communicate persuasively by acting collectively (Krimsky 1991, 1998; Mulkay 1995). The Director, with his policy comments, was providing society with a reasonable basis (in his own terms) for policy decisions in this area. This is one way in which scientists can access and contribute to the public sphere (e.g. Stockylmayer *et al*. 2001).

Patents, to some degree, are associated with 'private science' with one foot in the academy and the other in the market (Leivrouw 2004, McCain 1991). It would be interesting to see whether the number of patent applications had increased over time at the NICB to mirror this trend towards private science.

In the NICB, a CA might apply to a company name, the name of a company-supplied cell line, the products of the research (its properties) or all of these. Approximately two-thirds of participants operated under a confidentiality agreement (CA) or as if they were under a CA for the purposes of proscribing communication. More men self-selected into this majority group than women. Reported early training in this type of behavior associated with confidentiality means that it is a normal part of doing science for many. Indeed, the fact that CAs exist supports the assertion of Blumenthal *et al*. (1997) that modern science involves the withholding and restricted dissemination of research results. This outcome results from a 'commonsense reaction' to the need to keep unpublished work confidential, to ideas that the work is 'owned' by the NICB and relationships with commercial partners need to be protected.

The participants indicated that CAs do place constraints on talking to other biotechnology researchers, but these sorts of constraints are commonly self-imposed even when CAs are absent. This is because it makes sense in biotechnology to keep a tight reign on intellectual property associated with research. Once intellectual property is in the public domain, through publication or patenting, the research can be communicated without restraint. Some researchers expressed frustration, believing that CAs can curtail important dissemination in science, but most were either positive or ambivalent about the effects of CAs on information exchange with other biotechnologists.

Sunder Rajan (2006) suggests that the biosciences are taking more corporate forms and contexts, but:

> …the corporatization of the life sciences has simultaneously been rapid and hegemonic on the one hand, and contingent and contested on the other, setting up what [Sunder Rajan calls] a *frictioned* terrain on which these emergences take shape (p. 4, emphasis in original)

How can the communication of biotechnology not be frictioned as well for the NICB participants? Sunder Rajan also investigates the coproduction of biosciences with political economic regimes, arguing that the life sciences and capitalism are coproduced. He does not argue that capitalism has been the *cause* of biosciences emerging in certain ways, but does argue that biosciences are *overdetermined* by capitalist political economic structures within which they emerge (overdeterminism is a contextual but not a causal relationship) — the idea is that captalism disproportionaltely sets the stage for biosciences. As communication is a part of doing science, so it seems capitalism overdetermines communication about biotechnology, at least at the NICB.

Leivrouw (2004) suggests that there are growing constraints on informal interpersonal interaction among researchers and this does seem to be the case at the NICB. Some researchers did claim that they could still talk amongst themselves about all of the research except clinical research, and others said that they would never mention particular details of their research. Perhaps this mode of operation is ingrained enough that it does not impose constraints in the sense suggested by Leivrouw — rather Huckin's (2002) 'discreet silences' (see Section 2.6.2) allow researchers to ignore that part of the research that they feel is covered under a CA and interact as normal when communicating the other parts. Otherwise, awkwardness could be avoided by the use of the common in-joke 'if I tell you I'll have to kill you'.

Legally, any disclosures of intellectual property are proscribed under a CA and some participants were concerned with this. However, in practice, most participants thought that this constraint usually applies only to other biotechnology researchers. Non-scientists are unlikely to be competitors and, anyway, these NICB participants reported that they tended to talk about their research only in very broad terms to non-specialists. This means that communication with non-specialists does not usually include specific information that would be proscribed by a CA.

There was a small amount of evidence that at least a few participants thought the public to be irrational, subjective, ignorant and easily influenced (as in Burchell 2006, 2007; Cook *et al* 2004), but the presence of a CA might have constrained their communication with non-specialists anyway. Certainly, some participants would feel constrained to talk to non-specialists due to the nature of the research (but more on this in Section 6.4).

Overall, this is an argument for the operation of at least one of Mulkay's counternorms — secrecy — as opposed to Merton's norm of communality (Mulkay 1976). As indicated from the responses of the participants, they were trained from the beginning to never mention the name of the company or certain things about the research, or to stop at a certain point in the conversation. They learnt to clarify when working with a compound whether it was acceptable to mention the name of the company.

In conclusion, the women at the NICB were younger, more junior and less qualified than the men. This is significant in terms of institutional career pressure and the formulation of an identity as a scientist. Seniority and gender also matter in formal communication activities, teaching, belonging to professional science organisations, patent applications and confidentiality agreements. This type of communication is a significant aspect of 'doing science'.

NICB researchers did not see themselves as cooperating a great deal with other researchers, even though they believed that it was desirable to do so. Perhaps there was little institutional opportunity afforded them. It may be that Lievrouw's horizontal information inequity is an issue within the NICB, despite the homogeneity of research interests and membership of professional science organisations.

Some participants contributed to public policy in an ad hoc fashion. Nevertheless, potentially persuasive communication was achieved by those participants who acted collectively in contacting their TD. There is opportunity, which is sometimes taken up by NICB researchers, to access and contribute to the public sphere in Ireland in regard tot heir work and its social and ethical implications.

Attitudes towards the constraints imposed by CAs varied across the NICB population, although clearly they had an effect on communication practices in terms of withholding information and restrictions on disseminations of science. Participants also reported some constraints on informal interpersonal interaction.

The NICB researchers were mainly molecular and cellular biologists, and a high proportion of them were 'red' biotechnologists; that is, pharmaceutical or medical biotechnologists as opposed to green (agricultural) or white (industrial) biotechnologists, although there would be some overlap with the latter at the NICB, as it subsumed the NCTCC, which had a focus on cell and tissue culturing. A significant minority of NICB researchers had worked across the third-level and industrial sectors in their research. This industry familiarity is possibly an unusual feature of biotechnology compared with other biosciences — chemistry and biochemistry are more likely candidates for an industry focus.

Awareness of industry, coupled with the influence of commercialization that requires confidentiality agreements and patents, is a feature of biotechnology research. This probably makes a difference in communication within the culture of science as a whole — that is, it is in the interest of all scientists to curb their own communication activities in certain formal communication situations — but particularly so in biotechnology.

The communication activities of the Director were significantly different to those of everyone else interviewed during this study. The Director engaged wholeheartedly with the science communication environment (often in innovative ways, such as the TD-campaign), particularly *because* his topic of communication was 'red' biotechnology. For some communication activities, his role as a well-known Catholic commentator meant that he occasionally wished to distance himself from the institution as a setting, commenting privately and not on behalf of the institution.

Surely, this is an unachievable aim for the communication of biotechnology in the Irish science communication environment.

Paula and Birrur (2006) talk about 'white' (industrial) biotechnology, which also forms a significant part of the NICB's research, and suggest that the business-to-business character of white biotechnology is perhaps what has insulated scientists, industrialists and policy makers from public opinion. They argue that social acceptance of biotechnology (and I suggest the subsequent ease of communication of biotechnology by researchers) is to a great extent dependent on the presence of '(a) a (perceived) benefit to consumers, under acceptable risk, (b) adherence to key moral values regarding human and non-human life, and (c) trust in the governance of the technology' (p. 257). Both red and white biotechnology, as practiced at the NICB, have perceived benefits for consumers (with acceptable risk) and adhere to key moral values in existence in Ireland, particularly due to the presence of the NICB's Director.

Chapter 5 The audience as a context for communication

It is my contention that audiences, like institutional contexts and structures, are an important part of the make up of the science communication environment.

The variety of themes of Small *et al*. (2007), and drivers of Stocklmayer *et al*. (2001) and PSP (2003), provide a range of reasons for scientists communicating with a diverse range of audiences. This chapter examines whether the participants' communication is within the framework of economic exchange and the maximizing of personal advantage, or whether other frameworks are apparent in the participants' communication.

This chapter explores aspects of audiences for communication by National Institute for Cellular Biotechnology (NICB) researchers, and how these various audiences are also part of the science communication environment and have an effect on the communication that takes place. Drawing on the 'snapshot' of the NICB population presented in Chapter 4, I put together a picture of audience effects based on responses about the groups the participants thought were the most important to communicate with, and about self-reported communication with a range of formal and informal audiences. Comparisons between the present study and two UK-based surveys are also presented in terms of 'important group' audiences.

5.1 Important audience groups

The participants were encouraged to speculate about the most important group for them to communicate with and why. This question was also asked in the WT–MORI survey (MORI–WT 2001) (see Question E1a and b in Appendix 2). The issue explored in this section is not necessarily about participants identifying the audience that they feel most comfortable communicating with, but the audience that they believe they should communicate with. Thus, the two-part question was phrased so as to overcome the problem of asking the participants to self-report on their communication if they had never actually communicated (i.e. 'if you had to communicate...', rather than 'when you communicated...'). Responses will, therefore, include both hypothetical and actual audience groups.

5.1.1 Groups that are important

Table 5.1 lists the groups identified by the participants. Only one person, a younger woman, could not identify a group with which to communicate her research and its social and ethical implications with (Table 5.1). The group identified by approximately one-third of participants as the most important was colleagues in the scientific community. This group was identified by nearly the same proportion of men to women as was in the total population (approx. 0.8). The next-most likely group to be identified was patients/patient groups or people who would benefit from or benefit others by knowing about the research. Interestingly, twice as many women as men identified this group as important, for a ratio of men to women of 0.5. The general public was identified as important by a relatively large proportion of participants — relatively more men than women (ratio 1.0). Although the numbers are small and should be viewed with caution, it is also interesting to note that more men than women identified funding groups as important groups to communicate with — four times as many.

Table 5.1 Important groups to communicate with

	Men	Women	Total
Colleagues/peers/scientific community	11	14	25
Patients/patient groups/users/doctors	6	12	18
General public	6	6	12
Funding groups	4	1	5
Students/schools	1	3	4
Irish Council for Bioethics	2	1	3
Industry/business	1	1	2
Policy makers	2	0	2
Media	0	1	1
No idea	0	1	1
	33	40	73

Different age groups did not necessarily identify one group over another, except that people identifying the 'colleagues in the scientific community' group as important tended to be younger (21/25 were in the two youngest age groups). This makes sense, given the high priority placed on communicating with colleagues by younger researchers for supervision and career purposes, and also perhaps reflects their relative lack of experience communicating with other groups.

On the surface women seem to be more interested in communicating altruistic aspects of their research and men in communicating less altruistic and more career-oriented aspects (this is explored in more detail in the next section, where responses explaining why the groups are important are shown). However, patient groups also fund research and, as is shown in the next section, funding opportunities might be pursued in a variety of ways.

5.1.2 Why identified groups are important

The participants answered the 'why they considered the identified groups they communicate with as important' question with a mixture of answers ranging from 'because communication with group X will be of benefit to group X' to 'because communication with group X will be of benefit to me' (Table 5.2).

Table 5.2 Why these groups are important to communicate with

	No.	%
It is relevant to them	21	28.8
It is clinically useful (and they could use it)	11	15.1
To pursue funding opportunities	9	12.3
They would validate my work and provide feedback	8	11.0
The ethical and societal implications are important	7	9.6
To gain support for or promote science	6	8.2
It may be of interest to them/be of interest generally	6	8.2
They can make my work ready for dissemination	4	5.5
Don't know	1	1.4
Total	73	100.1

Note: Total % is greater than 100 due to rounding error.

The 'because it will be of benefit to group X' type of answers, which were most common, may be seen from two complementary points of view. First, biotechnology is a technology-focused science, which implies the application of scientific knowledge for practical purposes or finding technological solution to human problems. Therefore, it may be assumed that people doing biotechnology have practical applications in mind and, as many of the implications of the research done with the NICB were associated with human health, these may be of benefit to patient and health care groups.

Second, the kind of altruism implied by these answers is a common theme throughout many of the open responses to the questions (e.g. because the bacterial work has implications for people with cystic fibrosis). People like to give the impression that their work, they themselves and the organisations they belong to are socially desirable.

The 'because communication with the group will be of benefit to me' type of answers were less common, but no less practical in the sense that pursuit of funding, validation of one's work and the use of individuals and organisations for the communication of one's work are all important aspects of doing science.

The in-between answers had a broader remit — they appeared to be about the benefits of communicating to society. These included the importance of social and ethical implications of their work to society, the importance of science in society, the wish to promote or gain support for science and the potential interest in science that could be satisfied in society with such communication.

5.1.3 Characteristics of audience groups

The groups identified as finding the research relevant were colleagues, other scientists, peers, the scientific community, and to a lesser extent business and industry. Business and industry for commercial purposes, and colleagues sometimes as a kind of default because other groups 'would not be interested':

- '[my research] doesn't have large implications for society'
- '[my research] has no social and ethical implications'
- 'it's really just chemistry'
- 'it doesn't have an impact on people's daily lives'
- '[the research] is too specialized to be interesting to the public'.

Often these phrases were coupled with the reference to a participant's research potentially having more relevance to non-colleagues in the future.

If the participants referred to their colleagues and it was not in the 'default' way described above, they reasoned that their colleagues would be interested because their colleagues would be most interested in the products of their research. For example, the compounds that they were working on were at a late stage and therefore important. In addition, according to one participant, the 'normal procedure' in terms of communicating was to 'start within and work outwards'.

As expected the groups reported as most likely to find the research clinically useful were:

- doctors, hospitals and health care workers
- patients or users of products
- professional societies that support people with or research on specific diseases (e.g. cancer, cystic fibrosis).

The research in many of these cases had direct implications for human health or health care. The link between these groups and their interest in biotechnology is straightforward. For example, a project on biofilms that form on the inside of tubes surgically inserted into patient's chests (plastic cardiac arteries), or a project on bacterial infections common in people with cystic fibrosis with implications for health workers in hospitals.

Nine participants reported that they would pursue funding opportunities with business and industry, funding bodies and policy makers. Again, the reasons for choosing this particular group were straightforward. Communication was seen as a way to build a profile with these groups so as to increase the potential for receiving funding. The pursuit of funding was also linked with a desire to explain the work because the potential implications were not yet understood by these groups or because the work had been unexpectedly productive. One participant could not explain why s/he chose funding bodies as the most important group beyond the fact that they were the first group to come to mind.

Participants who sought validation of or feedback about their research did so from colleagues, other scientists, peers and the scientific community. These participants were mainly postgraduate students. Their responses were associated with the process of being a postgraduate student learning a scientific specialty, requiring mentors and disseminating for the purposes of career progression. Peer review was important to one of these participants, who conceded that the media or the general public would be an important group to communicate with only after peer review.

Some postgraduate students and the Director of the NICB, thought that the general public and the Irish Council for Bioethics were important groups to communicate with. The ICB were chosen because they ‘are an open-minded government [appointed] group and would therefore deal with [the implications] properly’ and because they were established to do this kind of job.

One respondent chose the general public as the most important group to communicate with because s/he was using an animal model (i.e. doing research on animals). However, it was not clear whether s/he thought that people should know about the research in order to make up their own minds about using animals in research, or that it was a duty to let people know that animal models were being used, or if s/he was implying that there are social and ethical implications to using animals in research, or all of these. The Director of the NICB also chose the general public:

> ...because in the biotechnology area, the implications are for the wider society. The debate should be as wide as possible. [We] could target [specific groups], but everyone should be aware.

Secondary school students, schools and undergraduate students were identified by some participants as groups that are important to communicate with for the purposes of promoting science as a subject of study or a career option. In fact, if these groups were identified by a participant, it was always in association with the support and promotion of science.

The general public was also a group identified as important in the context of support and promotion of science:

> ...science needs to have awareness and be supported...[communication] sparks an interest in science so young people take up science and take an interest...

One participant thought that the social and ethical side of his/her research was important to communicate to the general public because of the ‘bad press’ that biotechnology had received with issues such as cloning.

Some participants thought that others could potentially have a general interest in their research — the ‘others’ identified in these cases was always the non-specialist general public. Some participants responded in this way because they thought that their research was not ‘aimed at a specific group’, it wouldn’t be an ‘advantage to any group treatments or cures’, or conversely, if the research did refer to a treatment for a widespread skin disorder, it could potentially be of interest to everyone.

The general public had a ‘right to know’, according to some participants — they needed to ‘explain the implications’ of the research, particularly if it involved new techniques, new applications or the donation of human materials. In this sense, the general public was seen by some as the ultimate recipient of the research: ‘[they are] what we’re trying to do the work for’.

Colleagues, other scientists, peers and the scientific community, or the media, were candidate groups for making some participants’ research ready for dissemination. In this sense, the colleagues were seen as intermediaries ‘because [we] can’t go straight from lab research to the national newspapers...[we] don’t want to shock people’, and the media were seen as ‘a channel to outline the social and ethical or economic benefits of one’s work or the impact of the work’.

5.1.4 Comparison between surveys

Table 5.3 shows the more common responses given by participants in the MORI–WT, NICB and PSP surveys/interviews about the groups they communicate with (or would communicate with if they had to) and why they think such communication is important or easy.

Although a related but different question was asked in the PSP survey in 2006, with a list of groups provided, rather than open responses allowed, the responses still provide an indication of the types of groups a scientist might expect to communicate with. However, a factor in the PSP survey (see Table 5.3) is that the question is asking for a response about the group with whom respondents would feel most comfortable communicating.

Table 5.3 ‘If you had to communicate your research...’ compared across two UK-based surveys of scientists and engineers, and the current study

MORI–Wellcome Trust (MORI–WT 2001)	**National Institute for Cellular Biotechnology (NICB 2004)**	**People, Science & Policy (PSP 2006)**
If you had to communicate your research and its social and ethical implications, who do you think would be the most important group to communicate with?	*If you had to communicate your research and its social and ethical implications, who do you think would be the most important group to communicate with?*	*Which of these groups do you find it easiest to talk with about your research findings??*
17% My peers/colleagues/fellow scientists/researchers	34.2% Colleagues/other scientists/peers/scientific community	29% Industry / business community
17% General public/everyone/tax payers	16.4% Non-scientific public/general public	29% Popular science journalists (e.g. on New Scientist)
13% Government/politicians/policy makers	11.0% Patients/users of products	23% Schools and school teachers
10% Industry	8.2% Doctors/hospital and health care workers	22% Young people in schools
10% Students/graduates/schoolchildren	6.8% Funders	21% The non-specialist public
8% Financiers/funding bodies	5.5% Secondary school students/schools/undergrads	20% Patients / patient groups
8% People who will be directly affected (e.g patients, horse owners)	etc	etc
etc		
Why?	**Why?**	**Why?**
13% They provide the funding/pay my salary/ will secure funding	28.8% It is relevant to them	24% They want to know / are most interested / put in effort
10% They can pass information on to the general	15.1% Clinical usefulness	21% We speak the same language / they are most like me

public/present info onto a wider audience	12.3% Funding opportunities	/ they understand me
9% To raise awareness/improve peoples knowledge of science	11.0% They would validate my work/provide feedback	17% My work is most relevant to them / to what they do
8% It is most relevant to them/research is related to them	9.6% To explore the ethical and societal implications	5% My own experience
8% It would be useful to them/they would use it	8.2% Science needs support/promotion of science	4% The networks / contacts / opportunities are already in place
8% They will understand it/no-one else will understand it	8.2% They may be interested/general interest	3% Not valid
etc	etc	3% They're the most fun / it's most rewarding
		3% There is no one difficult group / easy group / I like talking to anyone / no-one
		etc

Note: The response 'funding institutions' and subsequently, why: 'they provide my funding' was not an option in PSP 2006.

Although the difference between the two non-Irish surveys for these two questions are marked, it is interesting to note that ‘industry or the business community’ is an important group for both populations of participants, as are school teachers and students, the non-specialist public and people who might be directly affected by the research, for example, patient groups.

The ‘why’ part of the question for the MORI–WT survey participants (Table 5.3) includes a mixture of self-interest and interest in the identified groups’ use of the science, with raising awareness or improving people’s understanding of science a minor factor. The ‘why do I find it easiest to talk to that group’ part of the question for the PSP survey is more to do with the receptivity of the audience.

The NICB participant responses are very similar to the MORI–WT participant responses. Both Irish and non-Irish participants ranked colleagues/other scientists/peers/scientific community first in the list of important groups to communicate their research and its social and ethical implications with, although a greater proportion of the Irish participants chose this group. The non-scientific public/general public was the second-ranked group by Irish and non-Irish, and both participant populations included patients/users of products, funding bodies and students/schools as important groups.

Policy makers and industry were two groups important to the non-Irish participant population. These were mentioned by the Irish participants, but only by 3/73 and 2/73 people, respectively. The Irish participants thought that doctors/hospital and health care workers were an important group, which probably reflects the type of research commonly done at the NICB specifically related to human health (cancer, diabetes, fungal pathogens etc); the non-Irish participant population included scientists from a wide range of disciplines, including those not associated with human health.

In terms of why they chose those groups, the Irish participants cited relevance to and clinical usefulness for the group over funding opportunities and the validation of their own work. They were also mindful of communicating the ethical and societal implications of their research, along with the sense of science needing to be promoted and garnering interest. The non-Irish participants were more concerned with what communication would mean to themselves — securing funding and getting their research disseminated more widely — over the requirements of the groups.

5.2 Specialist audiences

The participants were asked to remember an instance where they communicated with a specialist audience in a more formal manner, such as published written material or a conference presentation or poster, about their research. This section explores the reciprocal effect of specialist audiences on the communication attitudes, beliefs and practices of the participants.

The responses to this question were prompted and are grouped into sections, describing the:

- audiences for this type of communication, when and where it was done and how it came about
- topic of communication and the stage of research reached at the time
- reaction and feedback received from the audience and self-reported communication ability.

There were seven participants who did not or could not answer this question. Four of them were postgraduate students who had not yet had an opportunity to communicate in this way. The other three included two lecturers who, perhaps, had little time for anything but teaching, and one senior scientist. The lack of an answer from the senior scientist was not expected — communication with specialist audiences is part of 'doing science' at this high level. It was not clear from the data collected why this would be the case.

5.2.1 Specialist audience, time and location, and initiation

Participants were asked to identify the audience for their specialist communication, where it took place and how it came about that they were communicating in that instance.

Specialist audiences

More than two-thirds of participants nominated scientists working in the same area or NICB colleagues as the audience for the last time they engaged in specialist communication. The category ‘scientists working in the same area’ included scientists, postgraduates, undergraduates, staff; a range of specialists: clinicians and oncologists, medicinal chemists, pathologists, environmental scientists, mass spectrometry specialists, anti-microbial peptides specialists; and also peer reviewers if the participants were referring to the peer-review process in submitting journal articles.

Many participants who nominated the NICB as the audience were referring to an open day held to bring together all of the researchers from the three locations. This occurred once during the study period and was an opportunity for participants to see what others in the institute were researching. Also present at the open day were people from government and the Higher Education Authority (funders). In addition to this NICB-wide day, there were one or two internal seminars for chemists seeking to explain their research to biologists. The NICB audience also included ‘Centre’ colleagues and the more generic ‘colleagues at work’.

Some participants nominated their ‘own group’ as the audience, which did not necessarily fit with the larger NICB category as it referred to smaller laboratory, departmental or research group-based communication. There were also open days held at non-DCU locations — these were included in the ‘own group’ category as they were not NICB-wide open days. Conversely the category ‘the scientific community’ referred to a wider group of scientists not necessarily working in the same area as the participant.

Business or industry was a category referred to by a few participants who seemed to be specializing in research producing products that were potentially commercially lucrative — the General Manager nominated this category as his most recent and presumably most common specialist audience; he explained this type of communication as ‘both sides having specialist scientists talking to each other’, with himself acting as the NICB facilitator.

Three postgraduate students nominated ‘lecturers’ and ‘fourth year undergraduates’, who are certainly on their way to becoming specialists, as the audience for specialist communication.

Time and location of specialist communication

Approximately four-fifths of the participants spoke about communicating with a specialist audience some time within the last year — some within the previous few weeks or days.

These instances of communication were most likely to occur within Ireland, either at the home education institution of the participant, or within another Irish educational institution. When they did occur outside Ireland, participants were referring to speaking or presenting posters at scientific conferences in the UK, the US, Denmark, Greece and Italy.

The initiation of specialist communication

Conferences were the most enthusiastically recalled communication events by participants — for oral presentations, posters, or occasionally for networking purposes only.

> I...had completed a body of work on that subject, gotten some lovely results on it [and] we were interested in starting up a transcriptional research unit in the Centre, so we thought it would be a good idea if I went over [to the conference] and got some experience in the kind of research that’s out there in transcription...as well, the opportunity to publish at [the organisation] it’s a great opportunity. You just apply, you register and then you say whether you’re going to be speaking or just presenting a poster or neither…[I found out about it] from the web. I’m actually on their mailing list now, they send me [notices about] every transcription conference going…

Of the people who spoke about a conference as their specialist communication event, 22 applied to go, commonly by submitting an abstract, and seven people were invited to speak. People giving oral presentations often have the registration fee waived and conference attendance is part of career progression, so the presentation of work is strongly encouraged.

> I actually kind of approached them [to talk to them about my poster] more than anything, I mean you know really when you are at these conferences I think you need to draw attention to your work if you don't get an oral presentation.

However, communicating the work at conferences is not always a straightforward proposition:

> [The] NICB don't get oral presentations at [conferences held by organisation X] because of political reasons ... there'd been a lot of submissions [and] a huge group went, but I think there are deeper politics. [Perhaps] the NICB [is] a threat. It's personality, it's people who are afraid to give up their positions or who have their career as their primary interest [as opposed to the research]...

Many participants described either the NICB open day or an internal seminar series within their research group as their specialist communication event. Participants felt an obligation to attend the former, but also a desire to disseminate information across disciplines within the NICB, and there was a turn-taking type of organisation for the latter. Overlapping with these was required reporting on completed or ongoing research and communication to fulfill funding obligations. However, in all of these situations, getting feedback on the research was just as or more important to participants as treating the communication as a required personal learning experience. In some cases, it was an opportunity to meet face-to-face with collaborators:

> ...when you are encouraged to take part it's good, but it is also nice to see the other faces. Sometimes I get a packet of compounds in the post from [another researcher] and it's nice to actually be able to say 'yeah, I have those compounds and I've tested them' and we can shake hands and say 'thinks very much we're interested in this'...[that's] a reasonably decent section in my own PhD thesis, so I like to be able to collaborate between the different disciplines and actually see them and say 'yes, OK, this is what we're doing' and 'yes, we're doing this' and 'yes, thanks for those compounds' and 'we can test those for you'.

Only four people described a *written* specialist communication event — submitting a journal article for peer review or publishing research findings — this type of communication was typically self-initiated. Sometimes a paper was submitted to a journal, rejected, and then re-submitted to a different journal (e.g. a journal within an allied discipline). One person described a process of identifying a gap in research and aiming to fill it, which resulted in publishable research *owned* by the researchers:

> ...it was a technique that we developed in the lab, a novel technique for image analysis. We wanted to do particular work on the organism I work with and we found, we did a little search, found that there was nothing out there and then went and developed our own technique to do it, so [it was a] self-contained bit of work. It's a technique that I've used right throughout my own work, it's probably the core of what I do, and once we developed it, we were happy with validating the system, it worked perfectly...we decided not to share it, but keep it for ourselves, so that's what we did. [We] wrote it up, published it...

Another participant relates how s/he was brought in to 'finish off' a paper:

> ...I was helping to write it as I was second author on that paper [which] needed to be re-submitted on the basis of new work carried out. I'd recently returned from a lab in [X] and I had a number of ideas and I'd got all the experience in the kind of area that the journal was looking for to finish off the paper, so I was pulled in and asked to help. I did the work to help people get it up to the standards that they wanted.

Participants also described specialist communication between themselves and other members of professional organisations, postgraduates and potential industrial collaborators — all part of being an academic scientist — and, in one case, as a job seeker in response to a job advertisement in the newspaper.

5.2.2 Topic and stage in research

Participants were asked to state what they talked about during their specialist communication event and to describe the stage they were at in their research or in the research that they talked about during the specialist communication.

Topic of specialist communication

Table 5.4 provides a list of specific topics relayed by participants as the subject(s) of their communication. These are presumably abridgements of the original topics, as they were provided in the context of an interview situation. During the interviews, there was a tendency towards laughter when specific topics were stated, along with a sense of gentle disbelief (e.g. 'do you [really] *want* the title of it?') that someone (me as the interviewer and non-specialists as a general rule) might want to know the specific topic and not a more general overview.

Table 5.4 Specialist communication topics

5-fluoro-uracil, used for chemotherapy	diabetes	microbes to treat waste
a model system	disease targets	model for invasive metastatic cancer
a specific cancer, invading and spreading	drug resistance	molecular biology
alternatives for antibiotics	fluro pyrimidines	molecular cancer research
anti-metastatic agents	functional foods	multiple drug resistance
anti-microbial peptides	gene control	natural or synthetic molecules
apoptosis	gene knockout	neuro-oncology work
Aspergillus fumigatus	generic markers	P53 (a gene)
breast cancer	identification of potential genes	pharmaceuticals
breast cancer cells	insect immune system	probiotics
c-DNA and micro-arrays	lung cancer	proteomic
chemotherapy drugs	lung cell differentiation	synthetic organic chemistry
chemotherapy resistant cell lines	macrobiotics	transcriptional regulation in lung cancer
conjugated linoleic acid	microarrays	translational regulation of differentiation

The topics in Table 5.4 came up in participants' answers when they did not simply answer the question 'what did you talk/write about?' with the more generic 'my work', 'our work', 'recent or current research' and so on. Thirty people answered in this specific manner, the other 36 (66 people in total answered this question) answered more generically, including 'a technical problem I was having' and 'different [projects or areas of research]'.

A complex picture of the participants' motivations for specialist communication emerged when participants answered this question, even though it was intended only to identify the topic of their communication, including:

- passing on specialist knowledge so that the group could design better experiments and improve the infrastructure available at the NICB

- allowing other specialists to ask questions (e.g. ‘how did you find that?’)
- getting ideas from other specialists about methodology
- fitting the research within the broader context of the scientific goals of the NICB, its commercial approach and policies regarding intellectual property
- encouraging new and reinforcing existing collaboration (receiving antibodies from other NICB people to work on)
- identifying potential niches for further collaboration and networking
- discussing and attempting to resolve a specific problem.

These motivations suggest a give-and-take with specialist communication that may not be as apparent in their non-specialist communication. This communication is on the dialogue end of the science communication model spectrum. Only occasionally did participants talk solely about communication as simple dissemination:

> ...the work that I’ve been doing, the experiments that I’ve done, the methods, the results and then a discussion...

But, even in this case, there was also a question session at the end. Specialist communication for these participants is more than simply about the topics set out in Table 5.5. The communication also seeks to achieve a range of outcomes in terms of the ‘doing of science’.

Stage in research

When asked at what stage their research was at the time of the communication event, participants’ answers fell pretty evenly across the five categories: ongoing; early, middle and late stage; and finished. Although the first category is timeless and the others refer to specific time periods, all of the categories were somewhat amorphous as they were self-reported (i.e. to some extent what was early to one person might be late to another). In addition ‘finished’ might mean the completion of the entire research project, or of only part of the research project (the part that was talked about), while the rest was ongoing or beginning.

‘Ongoing’ was often used as a category when the research did not have a beginning or end:

> It's always ongoing because we're always moving, and so, you know, we maybe find answers, but we keep moving on there isn't a natural start/stop cycle...

5.2.3 Reaction, feedback and communication ability

Participants were asked to talk about the kind of reaction they thought their audience had, whether they received any feedback (and if it was useful) and to assess their own communication abilities in that situation.

Reactions

Words and phrases used in participants' responses to the reactions they elicited were categorized as follows:

- positive — interested, positive, helpful, asked questions, gave praise, agreed, reacted well, discussed solutions to problems, contacted [the participant] afterwards, wanted to collaborate (led to collaboration), encouraged the research (doctors), saw potential for commercialization
- moderately positive — medium interest, not too many questions, mostly favorable, no groundbreaking reactions but they had some suggestions, half knew what I was talking about half did not, pretty well I suppose
- unknown — don't know, hard to say, hard to know, posters are difficult to gauge interest in
- negative with reasons — not a lot of interest in the poster, my time was too short, it was late on a Friday afternoon so their minds were elsewhere
- negative — there was silence, there were no suggestions when I prompted them.

Most of the participants' answers (58/66) could be categorized as positive (51/66) or qualified positive (7/66). These kinds of formal communication events were mostly oral presentations and tended to lead the audience into showing their interest by asking questions and making encouraging comments, all indicative of a dialogue model of science communciation:

> Yeah, they reacted very well...I can sometimes tell how well a talk is going down by the questions that you get, so just to talk about that presentation, the questions I got were leading on from things I brought up in the presentation, it wasn't like

> clarification or anything like that, so I was confident that at least people had asked the questions, had followed me so far as I presented and then, a few people asked for copies of it as well, afterwards, so I thought it went down pretty well…

Saying that there were 'loads of questions' implied a positive reaction by itself.

Some communication with specialist audiences referred to by the participants was by poster. These are generally placed in a common area of a conference, in approximately A2 or larger format, and follow an 'abstract, introduction, methods, results, conclusions, further work' type of structure. Participants are expected to stand by their poster during set periods, and the audience may or may not come and ask questions or discuss the research.

There can be difficulties communicating using the poster — there may be lots of posters within a confined space, all covering different research areas, and there may be too little time to read them properly.

> ...posters are kind of a passive way of looking at nice pictures during the coffee break. Very few people, I'd imagine, have any [uptake], even the judges of the poster review panel don't have time to read them in depth. The nature of the work is completely different across the board...three institutions, all presenting different work, some of which is developing compounds, some of which is anti-fungal compounds, like pathogens, others who work in cell lines and cancer, it's completely different. You walk by, you take a flick through the handbook during somebody's talk or somebody could say: 'let's go and take a look at that', but as to how much you actually absorb, it's probably very minimal.

This is much more on the deficit end of the science communication model spectrum. There were more negative than positive reactions gauged by participants for people reading and discussing posters; however, overall participants only identified negative reactions to posters in 3/66 cases and unknown reactions in 5/66 cases.

Feedback

Fifty-five out of 66 participants either received or expected to receive (if they had submitted a manuscript for peer review) feedback from the specialist communication event. Ten participants did not receive feedback and one participant was not clear in his/her answer.

Interestingly, a participant's general attitude influenced whether they felt that they had 'received feedback'. For example, if the audience had asked questions for the purposes of clarification, then some participants thought that the questions alone constituted feedback, while others did not. Eleven participants had received feedback, but did not consider it to be useful.

The following is an example where a participant had received feedback that they thought was useful:

> ...definitely [useful] yes, I think my thesis, my final thesis will be different because of the feedback I got in the conference. I think it focused my mind in a certain way...to actually see it physically and to actually physically talk to people [about] what they were doing, it focuses you. I think it was important for the research...

The following is an example of feedback that was deemed not useful by the participant:

> No, it was not [useful]...apart from your colleagues, your immediate colleagues [saying] 'yeah that was good', 'well done', [I got] no major feedback, although my supervisor said it was good.

Again, the general attitude of some was a 'glass half full' and others a 'glass half empty', the former associated with the dialogue end and the latter with the deficit end of the science communication model spectrum.

Participants found feedback to be useful if it was:

- was critical in a constructive way
- commented on the future direction of their research
- resulted in some kind of collaboration (e.g. the exchange of compounds for testing), networking outcome, contact with industry, or follow-up work in another laboratory
- involved suggestions about experiments that could be done, new methods or solutions to problems; ideas that the participant may not have thought of before.

If the people giving the feedback talked about how they might apply the methods to their own research, this was also considered to be useful because it both provided reassurance that the participants were doing research that was on track and invoked excitement that the research might be something novel.

Some participants reported mixed feedback — some useful and some not, about the same communication — and some participants reported that the talk or poster was not really the communication event, rather the conversations that they had afterwards were where they exchanged feedback or developed networks.

For those who had given oral or poster presentations, the questions asked by the audience were all important:

> ...if you are asked questions, then it starts you questioning your work. Also, it shows you that you've held people's attention well...
>
> ...people asked lots of questions and they were positive...
>
> ...they asked lots of good questions...this [stage] is when the peer-reviewed publications start coming out...

For participants who had submitted a manuscript for peer review, the feedback from the reviewers was all important: 'the peer reviewers give feedback so that the paper is publishable'.

Significantly, some participants thought that the feedback from formal communication with specialists was 'always useful', that it led to positive change in research practice and that it increased participants' status in the scientific community: 'I no longer felt that people were looking down on me'. Presumably the latter applied when the communication was successful.

Ability to communicate

In the specialist communication situation, 46/66 participants thought that they had communicated well and 12/66 thought that their communication ability was 'adequate, average, could be better, fair, not too bad, OK or reasonable'. Six participants had communicated 'not as well as they would have liked' and two participants did not respond in a comprehensible manner for the purposes of the present study.

Where more information was provided by participants who thought that they had communicated ‘adequately’, their ambivalence tended to be due to a lack of confidence or nervousness about communicating. Pragmatically, one participant said that s/he ‘got the facts across’, implying that this adequacy could be improved, and another that s/he ‘needs more practice’.

All of the participants who thought that their own communication ability was inadequate (6/66) also talked about a lack of confidence and/or an overwhelming nervousness about public speaking:

> I don’t like public speaking, [it is] a phobia...
>
> I get quite nervous about it.
>
> I don’t like presenting work...most people don’t. I’m not comfortable with that kind of public speaking and stuff...I suppose because [I] don’t do it often enough...
>
> I’ve very little experience and I’m a bit nervous.
>
> I hate speaking in public cause I get very stammery [so despite the good feedback and overall good outcome] I think they felt sorry for me...I knew what I was trying to say, it’s just, it was coming out kind of strange, but eventually I did get the point across...
>
> It’s nerve wracking, even more so when it’s your own work.

It is interesting that no one who gave a poster presentation or who referred to written specialist communication described their own communication as inadequate. Perhaps this is due to the more concrete ‘written down’ nature of these kinds of communication.

Where more information was provided by participants who thought that they communicated well, reasons included aspects of:

- the audience (‘it is targeted’, ‘they are experts’, ‘I have no problem with peers’, ‘they looked a bit nervous of me to be honest’)
- the situation (‘relaxed’, ‘one-to-one’, ‘followed a familiar format’)
- themselves:
  - overcoming nerves (‘despite the nerves’, ‘once I start I’m fine’)

- preparing well (‘training in public speaking’, ‘practice in schools’)
- experience (‘I’ve had some experience and I’m improving’, ‘I’ve given presentations to people who have English as a second language’)

- their attitude (‘that person was once like me’, ‘I know what I’m talking about’).

5.3 Non-specialist audiences

The participants were asked to remember an instance where they communicated with a non-specialist audience, such as to relatives at Christmas, at the pub, or to a school or college audience, about their research. This section explores the reciprocal effect of non-specialist audiences on the communication attitudes, beliefs and practices of the participants.

The responses to this question were prompted and are grouped into sections describing the:

- audiences for this type of communication, when and where it was done and how it came about
- topic of communication and the stage of research reached at the time
- reaction and feedback received from the audience and self-reported communication ability.

Three participants did not answer this question as it was presented. They included a postgraduate student who had only just started his/her PhD, a senior lecturer who claimed that s/he had never had people ask about his/her work in social situations, and a research assistant who was also a postgraduate student, and who also did not answer the specialist audience question.

> ...if it were friends who were scientists I would go into details of what I was trying to do or new techniques that I was using or new technology we were getting in, but to someone who isn’t a scientist, ah, no I wouldn’t...

Participants tended to use a looser conception of ‘their research’ in responding to this question, compared with responding to the specialist audience question. The responses, therefore, included instances of communication with non-specialists about science in general, biotechnology or chemistry in general, social and ethical aspects of science and science policy, institutional organisation, along with communication specifically about aspects of their own research.

If, like Sturgis and Alum (2004), we bring together Wynne's (1992) elements of the public understanding of science and Miller's (1998) concept of what constitutes scientific literacy, we can suggest four points to be covered in the communication of science:

- scientific knowledge and constructs
- how science happens (process)
- where science comes from (how it is organized, funded, controlled)
- what kinds of impacts science has on individuals and society.

I have argued in Chapter 2 that deficit models can encompass the communication of scientific knowledge and constructs and, to a degree, the processes of science, but for full engagement in a science communication environment (in *doing* science), the last two of these points need to be communicated as well. From the results discussed in the present section, it is apparent that all of these points are discussed with non-specialists by the NICB population. It might even be the case that the first two points are minor parts of the kind of face-to-face social communication about science that is described here.

5.3.1 Non-specialist audiences, location and time, and initiation

Participants were asked to identify the audience for their non-specialist communication, where it took place and how it came about that they were communicating in that instance.

Non-specialist audiences

Fifty-eight out of the seventy reported non-specialist communication events were with family, friends or girlfriends/boyfriends. This included partners, parents, siblings, cousins, uncles and aunts, grandparents and in-laws; friends; and boyfriends/girlfriends, but did not include participants' adult children.

The rest were with acquaintances (e.g. housemates, the colleague of a partner) (6/70), students or teachers (5/70), and one instance was with a journalist.

Location and time

Twelve participants responded to this prompt in such a way that their answer could not be categorized clearly. Forty-nine out of 70 answered that the non-specialist communication had occurred within the previous eight weeks, commonly (26/70) within the previous few days or on the previous weekend. It appears that non-specialist communication is typically more current in the minds of the participants compared with specialist communication, possibly because of its less formal and sometimes spontaneous nature, but also because it happens quite often.

Three participants were not clear about where the communication had taken place. Eight out of 70 participants referred to non-specialist communication that had taken place in their institution or workplace (at DCU, Tallagh, Maynooth or 'in the School'). Casual meetings or 'at home' were common places for non-specialist communication to occur (45/70). This makes sense if most of the communication occurred with family and friends. Parties, pubs and funerals were less common places for the communication to occur (14/70).

Initiation of non-specialist communication

In 49/70 cases, the non-specialist communication was initiated by the other person or people. Also prompted from the outside, in 2/70 cases the initiation was mutual ('it just came up', 'we were exchanging problems we were having'), in 5/70 it was organized by the institution, either as lectures to the public, information sessions for health care workers or for the Merville Lay Seminars, and in one case the form of initiation could not be discerned from the data.

In 5/70 cases the non-specialist communication event was prompted by media representations of science:

> ...well they're both very interested in what I do and they like to see, you know, the articles in the newspapers that mention me, those kind of things, but they would always ask me what's happening, sometimes I can brush them off <laughs> and other times I can't...

> I believe we'd been talking about transplants, lung transplants, because there [had] been [a well-known case where someone with cystic fibrosis died as a result of not getting a lung transplant, so we were talking about him.

Self-initiation of non-specialist communication was reported in 8/70 cases. This involved the participants either bringing up the topic themselves, talking about it and getting the audience interested enough to reciprocate, or volunteering to talk to school audiences.

Participants were sometimes actively sought out by the other person — one by a journalist; another by a friend in the insurance business:

> He rang me, you know, he called me. He's in the insurance business and he was going to be doing business for a biotech company, so he wanted to know the, the low-down, or buzz words...I mean, he wanted to go into the meeting knowing that 'this was a key area' and 'that was a key area', and all that sort of stuff.

A number of participants were possibly actively sought out due to their perceived knowledge of a human health issue, typically cancer:

> ...it was probably talking about somebody having cancer...it just would have been mentioned, it would have come up in general...it wasn't me talking about my job, it was actually somebody else talking about maybe somebody they knew having the disease and then just asking me about what I did, knowing [that I worked in biosciences]. It would have been brought up by them and not by me.

...but also diabetes and infection:

> A friend of the family had somebody who was seriously ill at the time, with an infection. Lots of the information they were getting from doctors was conflicting and I could give some clarity to it, you know, what was going on, and why they were doing what they were doing...I think they approached me particularly for that reason.

This initiation by 'the other' for the purposes of talking about human health and business in biotechnology points to a strong interest by non-specialists in communicating about science when they perceive it to be in their interest and/or have some impact on themselves or people they know.

Mainly, non-specialist communication events were initiated by people simply asking how participants' work was going. This was commonly a concern for a participant's personal wellbeing ('she asked me how I was going', 'he asked me about my day at work') — a normal part of the human condition. Sometimes initiation was a pretext for asking questions about a human health issue (e.g. cancer, diabetes) and occasionally more of an imposition than the audience realized:

> ...if you have to talk to a non-scientific audience all the time, you just kind of get asked to explain it again and again...what might take two minutes will take an hour or three hours, whatever, to explain something that's really very fundamental and you'd have to go back over it again and it kind of dilutes your enthusiasm for it as well. The amount of times you have to tell people and the gloss comes off it a little bit. [I don't like to talk] to people abut my work, because I just get sidetracked, like, especially [with] non-scientists. I don't mind so much [with] scientists, because people have agreed to go over it and ask me questions on it. I would have very close friends that are in the same field, so that's not a problem, because they know exactly what I'm working on, whereas, like, non-scientists, they would just be very labor intensive, and I would be very frustrated dealing with somebody like that...

The quote above is one of the few instances where a participant admitted to actively disliking talking to non-specialists about the research. This general dislike is despite the well wishing and concern that s/he felt was the motivation behind the person initiating this particular non-specialist communication event and the somewhat useful feedback s/he received, which s/he thought was motivational in nature.

However, most participants did not mind communicating with non-specialists and many talked about making the communication to non-specialists as interesting as possible, for example:

> The title of the [organized talk was] 'Protecting against viral diseases', so it was viral disease that I talked about. I tried to talk about some of the sexy ones, you know, like Ebola and the gory ones and then slip in the less, ah, photogenic, but equally problematic ones...

5.3.2 Topic and stage in research

Participants were asked to state what they talked about during their non-specialist communication event and to describe the stage they were at in their research, or in the research that they talked about during the non-specialist communication event.

Topics of non-specialist communication

Compared with the topics of specialist communication shown in Table 5.4, the topics of non-specialist communication reported by the participants (Table 5.5) are less about the science (e.g. DNA chips [DNA microarrays], microbiology and bacteriology) than they are about how the science is placed in the world — its products (agriculture, alternatives to antibiotics), negative and positive implications (in vitro fertilization and embryonic stem cells), economic issues (patents), human health issues (blood product contamination, biopsy, disease during pregnancy, cancer, cystic fibrosis) and societal issues (the Commission for Assisted Human Reproduction report). There are also common elements to the two lists (*Aspergillus fumigatus*, alternatives to antibiotics, chemotherapy, microarrays), but these are specifically, except the latter, associated with human health.

Table 5.5 Non-specialist communication topics

agriculture	cancer	lung cancer
AIDS	chemotherapy	lung cancer prevalence
alternatives to antibiotics (but not acupuncture)	Commission for Assisted Human Reproduction report	lung cancer survival rates
animal model, *Galleria mellonella*	cystic fibrosis	microbiology and bacteriology
Aspergillus, A. fumigatus	design of novel protease inhibitors and peptides	new developments
bacteria	disease during pregnancy	NICB
basic research	DNA chips (DNA microarrays)	parvovirus B19
biomarkers	evolutionary biology	patents
biopsy	fungal strains	proteomics
biotechnology	human neutrophils	software
blood product contaminant	immunising rabbits	stem cells
brewing industry	in vitro fertilisation and embryonic stem cells	

Forty out of 70 participants answered specifically (Table 5.5) and with a range of emphases about their own progress or lack of it, the people and work in the laboratory and the NICB as a whole, funding, science policy, science education, human health and disease and how their work relates to this. Participants also reported talking about science in the media or in books, a dog with cancer, software for proteomics (to an information technology specialist), and current politics. Overall, this kind of communication is common to most people. We all talk about the people we work with, the organisation we work for, how we are going at work, whether there is any money in it, and politics and education as they intersect with our work. Less common perhaps is for work to have such large implications for human health.

A common and usually good-humored gripe, particularly associated with communicating with older family members (parents, uncles and aunts), was the need for participants to explain what it is that they did and the sense they had that the family member would never understand:

> She didn’t know what I did and I had t explain that. I don’t think she got it, but…<laughs> She tells her friends that I wear a lab coat and deal with fungal strains.

> Usually they want to try and find out what I’m doing to tell their friends, because when they try to think of biotechnology, they never seem to get the name right...they want me to explain what it is I do, so that they remember that, so I try to tell them exactly what it is because they can never remember [the word] ‘biotechnology’ <laughs>

> I get asked the same question every single time that I go up there <laughs> ‘what exactly is it that you do?’ [I reply] “I come here every whatever and the same question the whole time, I answer the same question” <laughs>. [Apart from the question] ‘what exactly is it you do?’ you get the ‘so, have you saved the world yet?’ <laughs> that kind of thing...

For the participant who had previously been involved in the Merville Lay Seminars, there was an acknowledgement of the difficulty for some areas of science to be communicated to non-specialists at all:

> My PhD research in diabetes was an easier topic to try and talk about in lay terms than some of the other topics. I found that to be the case with a lot of those seminars. The pharmacology students have a much easier time than some of the biochemists, because enzyme kinetics <laughs>...people can't relate to enzyme kinetics. They can relate to the words: ‘cardiac research’ and ‘cancer research’, so they mightn't be necessarily understanding your area of research, but they do know the buzz words.

Generally, participants showed good humor and self-depreciation in identifying the topic that they communicated with non-specialists. This good humor is a feature of them talking about non-specialist communication overall. There were 23 instances of laughter answering this question regarding the topic they communicated about in non-specialist communication, compared with seven instances for the specialist communication, and this laughter was also associated with participants not really believing that I might want them to provide me with the specialist topic as shown by the following quotes (for the specialist communication answers, see also Section 5.3.2):

> ...the work within our group on…do you want this kind of specific um, 'the translational regulation of differentiation' <laughs> that's the general title <both laugh> I'd have to go back and get the specific title for you <laughs>...

> ...'using fluro pyrimidines to induce differentiation in lung cancer cell lines' <laughs> in lung cancers using chemo drugs, basically...

> ...do you want the title of it? <laughs> it was called: the 'involvement of P53 (which is my gene of interest) in multiple drug resistance in lung cancer'...

An exploration on humor and laughter can be found in Section 7.1.2, which explores participants' laughter at the question of their original motivations for becoming a biotechnologist.

Thirty participants answered in a generic way. The topics in Table 5.5 came up in participants' answers when they did not simply answer the question 'what did you talk/write about?' with the generic 'what I do', 'what I work on', 'its importance', 'hopes for it', 'general progress', 'the project', or for postgraduates, the ubiquitous 'what is the topic of your PhD, when are you going to finish and what are you going to do afterwards?'

Stage in research

Participants categorized their non-specialist communication into communication about their own work (in which case there were the same subcategories as discussed in the specialist communication in Section 5.3.2) or communication that was associated somehow with biotechnology or science, but was not about their own work.

For communication about their own work (51/70), participants' communication was not distributed evenly across the five categories (ongoing, early, middle, late and finished) as it was in the specialist communication. Rather, most (28/51) communicated about ongoing work, 11/51 communicated about work that was in the middle stage, 8/51 about work that was in a late stage, and only 3/51 and 1/51 about work that was in the early stages or finished work, respectively. Five out of 70 did not answer the question in a way that the data could be used.

Fourteen out of 70 participants responded to this question by talking about a communication event that was about research or science or biotechnology, but was not about their own work specifically. Sometimes the communication was more generally about science: '...it was sort of bigger picture stuff than that; not as specialized [as my own research]...'

Often the participant had some pertinent or peripheral knowledge about a human health issue (e.g. cancer), and that was what they communicated about:

> ...not directly my own work, as my own work wouldn't be so much in skin cancer, but [I talked about] what I knew about it...

> ...what they were very much interested in [is] how it affects people in treatments, you know, I mean they were interested in the technology side of it, and find it fascinating, but it would take too long to talk to them [about that]. They were really interested in, you know, cures for people, I mean that's what people want to know, it's like if you are working in diabetes and cancer: 'is there a treatment', 'is there a cure'? You know, that's, that's what they are interested in.

One participant was a kind of 'general hand' at the NICB, so did not have a research project of his/her own. S/he did, however, identify him/herself with the cancer research:

> I don't have a particular research project. My job is just to help out the, all the different research projects. [However] I work in cancer research, so the last time I talked about what I would do on a day-to-day basis...well, a couple or three of the projects that I do are on cancer cells...

It is clear that for the specialist communication event described by the participants, the subject was defined narrowly because the communication event was initiated in order to address the specific subject of the research done by the participants. Thus, in specialist communication, they communicated about different stages of the research to a nearly equal degree (Section 5.3.2), meaning that they communicated as required during any stage of the research. With the non-specialist communication, however, as in everyday informal conversations in general, the topic could range more widely. The participants communicated about middle-stage or ongoing work to a large degree, not so much about early, late or finished work. It seems that, when given a 'choice', participants tended to talk about their work that was current.

5.3.3 Reactions, feedback and communication ability

Participants were asked to talk about the kind of reaction they thought the audience had, whether they received any feedback and if it was useful, and to assess their own communication abilities in that situation.

Reactions

Words and phrases used in participants' responses to the reactions they elicited were categorized as follows (four participants did not answer this question):

- positive — shocked and impressed, interested, encouraged and took heart in what we are doing, learned something they didn't know, delighted in their son, asked pertinent questions, very interested and I get excited explaining it, became sympathetic to the situation of someone with the disease, understood because they've asked a question since
- somewhat positive — sought clarification, nodded but did not reach an understanding, I worked to make it understandable, they 'got' what I was doing, they were skeptical about the efficacy of the research, they were interested (but they don't know what I do, but only because I gave a general talk, but I 'dumbed it down', but I was careful in what I said, but only because I didn't get technical, but I kept it very basic)
- neutral or a mixture of positive and negative — allowed me to talk, receptive but bewildered, didn't really react, looked to be awake but didn't have any questions
- bewildered — had blank expressions and scratched their heads, confused
- unsatisfactory answer — 'I hope I gave some clarity'.

Positive reactions often seemed to be associated with the research being human health-related or because the participants were 'helping people'. The kinds of questions asked by the audience during positive non-specialist communication as reported by the participants were generally for clarification; the audience sought to understand the research. This is different to the kinds of questions asked during positive specialist communication, which were considered to be part of the communication/interaction itself (the number of questions was positively associated with a ‘positive’ reaction) and used as a communication tool by the audience. Questions for clarification, on the other hand, had less positive associations during specialist communication.

Most of the participants’ answers (49/69) could be categorized as positive (35/69) or somewhat positive (14/69). These are fewer positive answers than for specialist communication (Section 5.3.3), but they are again mostly positive: ‘very positively, I mean, you know, he, he finds this whole thing very interesting...’ and ‘I think they think I’m going to get the Nobel Prize or something: “it sounds brilliant, so it does!”’

Nine out of 69 participants thought that their audience’s reaction was neutral or a mixture of positive and negative:

> ...two of them very positively, one not particularly positively ... he just wasn’t interested in listening to the story. He didn’t think it was nonsense, he just wasn’t interested. But you get that a lot, certain people are quite interested in science and some just, you know, they just, it annoys them that you talk about it...

Three participants thought that their audience was bewildered and nothing else: ‘...they drew blank expressions and scratched their heads’.

Four participants thought that the reaction of the audience was negative:

> Oh, god, they didn’t agree with what I was doing because it was bunny rabbits [that I was doing research on].

> He didn’t agree with what I said he’s got his own ideas and what he’s read [about cancer]...

> [There’s a] lack of interest...they switch off...

> ...this particular person seemed to be tired of people telling him that smoking is bad for you. He didn’t seem to understand that second-hand smoke is dangerous...it killed the conversation.

So apart from these very few negative reactions, and some where there was a confused lack of understanding, it seems that participants’ responses about non-specialist communication were generally positive and that audience reactions were generally positive.

Some participants felt like they were ‘dumbing down’ their communication, which may have made the event less enjoyable for themselves, which makes it a negative reaction from themselves, rather than from the audience:

> ...its terrible, but I tried to dumb it down a little bit. I was trying to explain it to them because you can’t launch into exactly what you do, so generally what I say is, ah, try and explain to them is that, ah, I produce a chemo drug and once you mention chemo, that’s the magic word for them. There’s no point in telling them that I produce an antibiotic which has anti-tumour properties, they just won’t understand that. So I try to explain that I produce a chemo drug, which then, hopefully will be taken by a toxicologist to test against cancer cells, and eventually it’ll be given to an oncologist to be tested in a hospital situation, and that they understand. If you explain to them what you do [in terms of] how your particular part fits in the overall grand scheme of things, it is a lot easier for them to understand what you do.

The participant is honestly assessing what it is s/he can communicate with the audience by putting her/his work into context from bench to bedside. A similar process of communication with non-specialists was more positively described by another participant, who acknowledges his/her own jargon-using tendencies in communication of this sort:

> Well they seemed to, you know, have those faces on that say ‘yeah, yeah, it makes sense to some degree’ and then you lose them every so often, and then you bring them back into it, you know. Sometimes you have a bad habit, you start using technical terms, and you realise ‘whoops, I’d better go back…’

There can be a high level of self-awareness in communicating research to non-specialists.

Feedback

Approximately half of the participants (33/70) thought that they had not received feedback during the non-specialist communication event. Where this was elaborated on, participants said that the audience had wished them well, or were sympathetic or generally supportive, but the outcome tended to be the generation of more questions. In these cases, the questions themselves were not considered to be the feedback, as they often were in specialist communication events, instead there were questions that remained unanswered, could not be answered or were social in nature. These, for most, were not feedback.

This finding is interesting in light of the arguments for the superiority of the dialogue model. When the participants felt that the communication was not really a dialogue, they were dissatisfied. Perhaps they were looking for evaluation, exposure to others' knowledge and to have their assumptions challenged — an argument that I borrowed from Yearly (2005) to argue for the inclusion of the scientist–communicator the mix of science communication models that make up the science communication environment.

Feedback was defined by one of these participants as the audience being able to 'give me ideas on how to progress'. For this participant, a non-specialist audience could not do this. Two of the 'no feedback' participants went so far as to say that the audience 'wouldn't dare' and 'wouldn't have the confidence' to give them feedback.

Thirty-four out of 70 participants thought that they had received feedback and three did not give a meaningful answer for the purposes of the current study. Three of those that thought that they had received feedback thought that it was not useful. Of the three, one said that the audience was 'trying to understand', which for the participant was not useful. Yet many other participants viewed the audience's attempts to try to understand as a catalyst for them to modify their language or delivery, or to think about their research differently — they cast their experiences in a more positive light:

> It's useful actually, because it gives me a chance to kind of re-think 'why am I doing this' and how to explain something to a non-scientific audience. It actually helps...because you have to get it down to a not-be-too-patronizing level that other people understand and enjoy...

One person thought that the feedback was useful because the audience was someone who had actually taken the drug that they were working on, during cancer treatment, and that discussion brought home the reality of cancer drug side-effects:

> I think the only feedback was that a drug which I work with in the lab [which I normally] talk about at conferences and in presentations [her reaction made me see] the reality of it. I actually talked to her about the initial experience of taking that

> drug and all the rest, and [although] it's not the worst of them by far (well [it is] up there in the top field of not being nasty), but it opened my eyes to just how nasty [the drugs] can be, the side effects...

This is a prime example of feedback/communication that does all of the things Yearly (2005) suggests: evaluates, exposes and challenges. This participant was clearly positive about the experience.

Some participants used non-specialist communication to actively seek non-specialist feedback that they know is going to be useful for them in refining their communication overall:

> I find it useful to talk to family members because it does allow one to gauge the understanding that people have without any kind, there being any kind of force or anything around it, or anybody trying to be artificial. It allows one to gauge things that they find most interesting —the topics and the areas — so if I'm explaining something to a [different] non-specialist person, I often try and think 'how would I say this to my parents or to my brother or sisters'...I use them as a kind of model...

Ability to communicate

During the non-specialist communication event, 63/70 respondents thought that they had communicated well, 2/70 thought that they had not communicated well and 5/70 were undecided or ambivalent about their communication abilities in that situation. It appears that a similar proportion of participants thought that they had communicated well to both specialists and on-specialists, but in the non-specialist communication, there were also participants who were unsure. This type of communication can be less straightforward and more difficult to gauge.

Only one each of the 'unsure' and 'not well' participants provided further information about the communication event. The unsure participant said:

> I can simplify it to a degree, but I think the sort of stuff we do is very difficult to simplify enough for someone non-scientific...they couldn't really follow it...

The participant who thought that s/he had not communicated well said:

> I think when you're talking to somebody, now, you tend to, you don't want to sound like, <laughs> I don't know, you, you don't want to sound like, you know when you

> start talking in scientific terms and they don't know what you're talking about...I try to simplify it and it's quite hard.

At least for these two participants, the problem lies in their perception that the research needs to be simplified in order to be understood by the audience and that they find this task difficult.

Where participants thought that they had communicated well and had provided further information, their answers could be grouped in two ways associated with them or with the audience:

- the participant was open and 'willing to be told otherwise', found it interesting to communicate with non-specialists, or was prepared to suffer some frustration and rise to the challenge of communicating
- there was some aspect of the audience that made it easier ('my dad catches on quick', 'my mum does have a bit of an understanding', 'she's a little bit into it, you know, and has heard about it').

Even when they had communicated well, participants differed as to whether they thought communicating with specialist or non-specialist audiences is easier:

> ...for me to explain things to a non-scientific person is more difficult...I would much prefer to talk to peers than actually have to try and explain something to someone who doesn't really have an idea...

...but, from another:

> [...it is] probably a lot easier to communicate to non-professionals than specialists.

5.4 Summary

In this chapter I have shown that the audience is a significant part of the science communication environment, whether it is carefully chosen, formally recognized as an aspect of doing science, or exists as a result of social interactions with friends and family.

Colleagues/peers/scientific community, patients/patient groups/users/doctors, general public and funding groups — by choosing a 'most important group' audience, the participants also provided an indication of their perceptions of the social and political implications of their work. Small *et al*. (2007) found that scientists described the social and political implications of their work within extrinsic themes — in this case, it seemed that women tended to choose health and men tended to choose economic themes.

Perhaps this is associated with the findings described in Chapter 4 around confidentiality agreements (CAs), where I speculated that it might be that men are more aware of or concerned with confidentiality — this concern, like the CAs, is at least partly to do with economic themes and the maximizing of personal advantage (Lievrouw 1998). Thus, the association between biotechnology and economics (or Sunder Rajan's [2006] capitalist political economic structures overdetermining the biosciences) is creating friction in communication by researchers. Additionally, perhaps it is associated with the types of communication that are more common in women. If, as Alan Irwin (2004) suggests in his discussion on public consultation regarding the biosciences, 'the public believe advances in human health represent the biggest benefit to arise from scientific developments' (p. 299), this may well be what these women are tapping into in their communication .

All of the sociopolitical (Stocklmayer *et al*. 2001) and personal drivers (PSP 2003) for science communication are represented in the answers to this 'important groups' question, even the pragmatic answer, that is, as a requirement attached to funding, if the term 'requirement' is imagined in a broad sense.

Both sides of Lievrouw's (1998) coin are shown in these responses, that is, that modern science communication is viewed within a framework of economic exchange and the maximizing of personal advantage (funding), compared with previous framings of sharing meanings and reinforcing social ties (health). Obviously, framings are less straightforward, more messy, than might be predicted. Lievrouw's becomes less pertinent when the more detailed responses are considered.

There is no direct mapping in a one-to-one fashion between the important group and the more detailed responses shown here. For example, although five people identified funding groups as the most important group to communicate with, nine people gave the answer 'to pursue funding opportunities', meaning that funding opportunities might be pursued in ways other than directly with funding bodies. These responses show even more emphasis on the extrinsic themes proposed by Small *et al*. (2007) and the drivers for communication identified by Stocklmayer *et al*. (2001) and PSP (2003).

The Irish participants were interested in talking about the relevance of their research to the group and in communicating its ethical and societal implications — humanistic considerations — although they were also interested in promoting science more widely. The Irish participants might also all be described as red and white biotechnologists at the NICB, in contrast to the non-Irish participants who were drawn from a wide spectrum of science disciplines. Are Irish biotechnologists more humanistic than non-Irish non-biotechnologist scientists? Unfortunately, analysis of the data can not answer this question definitively; however, there was a stronger trend, with the non-Irish participants, towards Lievrouw's economic exchange and the maximizing of personal advantage.

Specialist audiences were commonly close, institutionally and geographically, and reported specialist communication events were recalled from within the last year or more recently. Many participants talked enthusiastically about presenting their work at conferences. Although they were often obliged to communicate to specialists, there was little resentment — it seemed to be a normal part of being a scientist. Getting feedback from other specialists on the research was important to participants and this could occur at any stage in the research. All of this is unsurprising because it is common to science in general.

The participants were not specifically questioned about models of communication, but specialist communication seemed to be recognized as far more complex than simple dissemination. Spontaneous discussion on specialist communication painted a picture of strong interaction, involving the giving and receiving of information and methods, and the development of connections between researchers. Most participants thought that audience reactions were positive for specialist communication. Where it was perceived as negative, this tended to be explained by the difficulties of the communication process (e.g. problems with posters as a medium of communication), rather than a problem with the science.

Most participants thought that they'd received feedback during the specialist communication event, or afterwards, and that it was useful in some way. Most participants thought that they had communicated well or adequately. Nervousness was given as the reason for inadequate communication, and positive attitudes towards their own work and themselves was associated with a feeling that participants had communicated well.

It is clear that this type of communication, whether self-initiated or required, or a mixture of both, is a fundamental part of doing science. In this communication, there is no need for researchers to use communication forms that are accessible to non-scientists, such as Rier (2003) found with the toxicologists he interviewed.

As is suggested in Waterton *et al*. (2001) and Waterton (2005), the participants were able to communicate the contingent nature of their science under certain circumstances (e.g. to me, as quoted above). It is also clear that the doing of science that is laboratory work, the doing of science that is this kind of formal communication to specialists and the doing of science that is the networking and political aspects of belonging to professional societies are all influenced by the prevailing circumstances.

Three participants responded that they had never communicated to non-specialists, yet the 69 responses to this set of questions paints a picture of typical communication — day-to-day communication — that all of us do. It is only the *implications* of the work or the perceived *difficulty in understanding or enabling understanding* that makes this communication different from an accountant; for example, talking about their work in a social situation. For biotechnologists, where the implications of the research are potentially far reaching, much speculated on (but ultimately unknown), and who face difficulties in enabling understanding due to the novelty of concepts and the newness of the technology, these must be the biggest stumbling blocks for communicating their work to non-specialists.

Compared with communication with specialists, communication with non-specialists included a broader range of possible topics. More of the same specifically science-related topics were included, as well as topics that explored how the science is placed in the social world and its implications. Topics associated with human health were common, and these were generally positive experiences in terms of audience reaction, even if they were just about information dissemination. Family and friends were communicated with during ‘casual meetings or at home’, mainly, and were commonly initiated by the family member or friend as a ‘how are you going’ type of question. The events that participants talked about were relatively recent and current.

The participants often laughed when this question was asked (about communication with non-specialists) and/or during their responses. This was good natured laughter about the difficulty of communicating with non-specialists or the typical and sometimes frustrating questions they were commonly asked by non-specialists. However, some of it is also likely to be nervous laughter, as it was clear that some participants were unsure about their abilities in regard to this type of communication (laughter in the interviews is explored in more detail in Section 7.1). In contrast, when reflecting on the specialist communication events, participants were relatively clear about when they thought they had not communicated well.

Finally, just as in their reflections on the specialist communication (Section 5.3.3), participants’ own attitudes appeared to influence whether they felt that they had received feedback and, if so, whether the feedback was useful. Questions — commonly regarded as feedback in themselves during the specialist communication events — were less likely to be regarded as feedback in the non-specialist communication events.

Reasons for or outcomes of communicating with such a diverse range of audiences may be categorized into the themes of Small *et al*. (2007), and the drivers of Stocklmayer *et al*. (2001) and PSP (2003). There is a small amount of evidence from this relatively small-scale study of underlying trends towards Lievrouw’s (1998) modern science communication framework of economic exchange and the maximizing of personal advantage — particularly when responses from the Irish participants were compared with the non-Irish survey participant responses. However, as I will suggest in later chapters, there is even more evidence for a humanistic element in the NICB participants’ motivations for the communication of their work. Perhaps modern biotechnology does provide greater *opportunities* to accept and exploit Lievrouw’s framework because of its association with commercially important products. This does not mean that such opportunities are salient to the individual scientist. Perhaps, as Sunder Rajan (2006) suggests, capitalism overdetermines the biosciences, but this does not necessarily filter down to influence individual scientists communicating about their work; although as suggested above, it may have an influence in specific areas to do with CAs and maximizing personal advantage.

There are some interesting findings in the present chapter that point towards the participants themselves wanting to engage in communication at a variety of points in the science communication environment, in communication with specialists and non-specialists. There is some evidence that they do so — evidence that the science communication environment is an appropriate umbrella under which many styles of science communication can co-exist.

Chapter 6 Consequences for the individual — communication practices, perceived advantages and constraints

There is strong evidence in the present chapter that participants' communication is affected by the presence of biotechnology-related topics in the public sphere.

This chapter explores a range of a range of sociopolitical and personal drivers for science communication (Stockylmayer *et al*. 2001, PSP 2003) in terms of participants' willingness to spend time communicating their research, and their perceptions of the potential consequences of communicating. That is, are these drivers part of the participants' willingness to communicate and what constraints are operating on them? This chapter also explores the participants' perceptions of communication about research in the media and how media coverage of research-related topics may have had an effect on the way they communicate about their research. In addition, it explores whether NICB-related research is being communicated in the media, to address Best and Kellner's (2004) proposal that public intellectuals and activists should educate themselves about science. Finally, this chapter explores whether, as Hilgartner (1990) suggested, the participants use the deficit model as a resource in their discourse about communication.

These interview questions were developed based partly on some of the multiple choice questions asked in the MORI–Wellcome Trust survey of UK scientists in 2000 (MORI–WT 2001), with the aim of comparing the results of the survey with the results of the interviews in the current study (and with the acknowledgement that the populations are likely to differ in many ways; see Sections 3.3.1 for methodological issues). Serendipitously, some similar questions were also asked in a large-scale UK survey of scientists and engineers *Factors Affecting Science Communication by Scientists and Engineers*, which was commissioned by the Royal Society and the Wellcome Trust in 2005 (PSP 2006). One of the aims of the PSP survey was to 'complement' the MORI–WT survey, which had been done at the earlier time point (PSP 2006; p. 5). Sections 6.2.2 and 6.2.3 provide results of the current study compared with results of the two surveys of UK scientists.

6.1 Communication practices

The theme of this section is about how often researchers talk about their work with everyone from close colleagues to researchers outside the organisation, how long they might spend doing other kinds of communication activities (e.g. with schools, with media outlets) and whether they would be keen to communicate with various groups of non-specialists in the future. The idea explored here is that any number of sociopolitical (Stocklmayer *et al*. 2001) or personal (PSP 2003) drivers may operate on scientists to encourage communication, but if they lack the time or willingness to do so, such encouragement can have little effect. To some extent, Section 6.2.2, which addresses potential disadvantages to scientists' communication, is also about constraints.

6.1.1 Frequency of talking about research

Participants were asked how often they talked about their research with:

- colleagues within their own laboratory or research group
- colleagues within their organisation
- individuals from research groups affiliated with their organisation
- other researchers.

During the initial interviews, I decided to ask the participants to define what they meant by 'your organisation'. This change was an unexpected, but necessary, means of pinpointing what participants meant when they were answering this question. It yielded some interesting results in itself. This links in with the material in Chapter 4 about institutional setting as it shows that participants' perceptions of their own work setting can be as individual as they are.

What do you consider to be 'your organisation'?

Interestingly, only 18 people (24.7%) considered 'their organisation' to refer to the NICB (Table 6.1). Only one of these, a lecturer, was located outside DCU at Tallaght — all of the other researchers at Tallaght and at Maynooth considered their organisation to be their local college; the laboratories or departments that they worked in daily.

Table 6.1 What 'your organisation' means to NICB researchers

	No.	%
NICB	18	24.7
Maynooth	14	19.2
NCTCC	14	19.2
Tallaght	13	17.8
Dublin City University (DCU)	3	4.1
School of Chemical Sciences (at DCU)	5	6.8
School of Biotechnology (at DCU)	6	8.2

The three people who considered their organisation to be DCU were the Director of Quality Promotion (his main job was an administrative one with the university), a research assistant and a head of school.

Researchers who considered the Schools of Biotechnology and Chemical Sciences to be 'their organisations' were either postgraduate students or lecturers working day-to-day in those schools.

The National Cell and Tissue Culture Centre (NCTCC) was set up in 1987 as a centre of excellence for animal cell biotechnology. Researchers commonly referred to the NCTCC as 'the Centre'. As someone not in the organisation, the status of the NCTCC seemed ambiguous to me (I was never clear whether it was still officially in operation or not, even after many enquiries), but closely aligned with (within) the NICB. Research at the NCTCC was in a variety of animal cell biotechnology areas (e.g. multi-drug resistance, monoclonal and polyclonal antibody resistance). It had links to clinical research groups in the cancer units of five Dublin hospitals. One of its key objectives was to commercialize its research through patenting and its close links with Irish and international companies.[24] Fourteen participants thought of 'their organisation' as the NCTCC.

It is clear that 'NICB researchers' are not a homogenous group, even in terms of the organisation they feel that they belong to. This is probably an additional factor in the institution as a setting for communication (explored in Chapter 4) because, for example, people affiliated with the Centre (the NCTCC) were more likely to operate under constraints on communication imposed by confidentiality agreements (see Section 4.6.1 for a quote where this is explicitly stated). In contrast, participants associated with the educational aspects of the third-level institutions, mainly postgraduate students or lecturers in the Schools, would be more likely to associate communication with education — this suggests that they would be more likely to communicate about their work to non-NICB people, but that this communication would be less detailed than the kind of communication avoided by CA-constrained participants associated with the Centre.

This lack of homogeneity probably also means a lack of common purpose in communication of research, which is not necessarily a bad thing if it brings a greater variety of communication to the public sphere. However, a common purpose could encourage a greater amount of communication, and this appears to have been lacking at the NICB during the study period. It might be speculated that biotechnology in the context of the NICB, where many participants did not consider themselves to be 'biotechnologists' (Section 7.1), is a fraught area for communication because it has emerged in a piecemeal fashion with a variety of conceptions about what it actually is.

Frequency of communication?

Table 6.2 gives a breakdown of how often participants talked to various colleagues and others about their work.

[24] http://www.dcu.ie/~nctcc/index.htm (last accessed 10 January 2008).

Table 6.2 How often participants talked about their research

	Several times a week	Once a week	Once a month	Several times a year	Once a year or less often	Never
Colleague in their laboratory or research group	68	3	2	0	0	0
Colleague within their organisations	39	20	8	3	1	2
An individual from a research group affiliated with their organisation	10	16	16	13	10	8
Another researcher	2	8	21	16	17	9

Only the General Manager of the NICB stated that he talked to all of the colleague and researcher categories several times a week. Everyone else talked to their colleagues and other researchers to varying degrees. Most, but not all, participants reported speaking progressively less frequently along the top-to-bottom scale of Table 6.2. For example, for some, speaking to ‘another researcher’ occurred more frequently than speaking to an individual from a research group affiliated with their organization (once a year or less often cf. never, respectively). These two colleague categories were the most commonly unaligned along the top-to-bottom continuum — in 14 cases — meaning that these participants talked less frequently to an individual from a research group affiliated with their organisation than they did to another researcher.

Taking into account the results in the previous section, at least some of these answers must have meant that participants were less likely to talk to another ‘part’ of the NICB than they were to talk to someone who happens to do research in their area of expertise. This makes sense, particularly for participants located at Tallaght and Maynooth (and considering those locations to be ‘their organisation’) as it might be more likely for them to run into someone from a laboratory down the hall than someone from DCU.

One postgraduate (a second-year PhD student) stated that s/he never spoke to colleagues or other researchers outside the laboratory or research group. It was more common for women (13) than men (6) to answer ‘never’ to any of the colleague and other researcher categories.

There did not appear to be any differences between researchers at Tallaght, Maynooth and those in Dublin in terms of how often they spoke to colleagues or other researchers. Nor did there appear to be any difference between NCTCC researchers and the rest of the NICB, although this might be expected, given their group affiliation. It is surprising that any participants answered ‘never’ when asked how often they talked about their research with a colleague within their organisation, as even the most junior postgraduate student is supervised (but perhaps, to them, a supervisor is not considered to be a colleague). These results are further evidence for communication activities within this particular institute lacking a common purpose. There were, during the study period, a few attempts at bringing all of the researchers together, but these specific meetings or ‘days’ seemed to do little to coordinate this piecemeal institutionalized communication overall.

6.1.2 Spending time communicating

Participants were asked whether they had spent any time on communication activities (from a list on Card C2, Appendix 3) in the past year and, if so, how long they had spent on the activity, including preparation time. Table 6.3 provides an overview of the communication activities and the overall time spent doing and preparing for them across the NICB population.

Table 6.3 Estimated hours spent on communication activities, NICB

	No. people	Total (hours)	Mean (hours)	Median (hours)	Range (hours)
Presenting at scientific conferences for scientific professionals	37	1637.0	44.2	24	2–240
Submitting manuscripts to peer-reviewed journals	28	5103.0	182.3	110	5–640
Writing and presenting research grant proposals	28	3602.0	128.6	100	4–432
Participating in open days for the general public	26	490.5	18.9	16	0.5–80
Talking at schools or colleges	23	589.5	25.6	10	2–240*
Presenting at public conferences, other than scientific conferences for scientific professionals	19	338.5	17.8	16	0.5–40
Speaking at non-scientific academic conferences	10	139.0	13.9	8	2–40
Talking to or writing for national newspapers	7	35.0	5.0	8	1–8
Speaking at public meetings	5	42.0	8.4	8	2–20
Talking to or writing for the popular science press (e.g. *New Scientist*)	5	60.5	12.1	16	0.5–24
Talking to TV or radio journalists or speaking on TV or radio	5	22.5	4.5	3	0.5–8
Talking to or writing for local newspapers	3	17.0	5.7	8	1–8

Mean and median provided as the distributions are skewed and the median provides an indication as to positive or negative skew.

*One person spent 240 h talking to schools or colleges, but described it as six lots of 40 h.

Five people answered that they had done 'none of these things' — these were four postgraduate students and a research assistant. 'Other' answers included: doing the communications course organised by the BioSciences and Society research group

(Section 1.2), providing training to IDA Ireland (the Irish Industrial Development Agency) and companies, and giving a lecture on proteomics to fourth year Masters students in the Centre (the NCTCC).

Everyone else had done at least some of these activities.

Formal communication directly associated with research

The first three rows in Table 6.3 can be considered to be formal communication that is directly associated with the participants' research work — the doing of science (as was found in Chapter 5). All three activities are an expected and required part of being an academic researcher, and grant writing is crucial to maintaining current and developing future research projects.

Although more people had presented at conferences for scientific professionals than any other activity listed (37, 50.7%), only approximately half to one week was spent on this activity over the entire previous year (17 by men and 20 by women) In contrast, 28 manuscripts were submitted to peer-reviewed journals (discrepancies between these numbers and numbers in Section 4.5.3 are due to multiple submissions by the same individual, or missing cases) and 28 research grant proposals were written or presented, taking people approximately 2.5–4.5 weeks and 2.5–3.5 weeks, respectively, over the previous year. These two communication activities are clearly the most time consuming of the activities listed. The fact that a large amount of time could be taken to pursue these activities clearly make them an integral part of doing science.

It was quite common for the same individuals to have both submitted manuscripts to peer-reviewed journals and written and research grant proposals (18 times), and these individuals were senior (with the exception of two postdoctoral researchers). Two out of the nine participants who had been involved with grant writing/presenting only were postgraduate students — quite probably working on the same grant as they were from the same laboratory in Maynooth. It was more common for junior researchers and postgraduate students to be involved in submitting manuscripts only (6/11). This is because this activity is in their career interests and publication reflects well on the laboratory as a whole — however, it also means that these most junior scientists are less likely to be communicating in other ways.

Out of 28 cases where research grants proposals were submitted, 18 (64.3%) were done by men, and, out of 28 cases where manuscripts were submitted, 16 (55.2%) were done by men. This may be explained by the association between the greater number of men in senior positions and these activities tending to be done by senior NICB staff.

These findings are unsurprising as they reflect activities that are done across the sciences (including the social sciences) and the division of labour between senior and junior.

Formal communication promoting the research to potential scientists

The fourth and fifth rows of Table 6.3 (participating in open days for the general public and talking at schools or colleges) describe communication with non-scientists, but with a ‘promotional’ flavour — there are potential and future scientists in open day, school and college audiences (the PSP 2003 recruitment answer).

This kind of communication is not insignificant in recruiting students. As can be seen in later chapters, many of the participants (albeit already interested in science) were recruited in this way. Scientists know that this works. Biotechnology, being a relatively new field, is even more appealing to potential scientists. Thus, even though this kind of communication is not generally thought of as a formal part of doing science it is either tolerated or actively encouraged, even in younger more inexperienced participants.

Communication with non-scientific academia, media and the public

The remaining rows in Table 6.3 describe a mixture of communication, with non-scientific academia, the media and the public. None of these activities are formal in the sense of being a requirement of scientific or academic work. Few people had done these activities, and when they had done so, they had typically spent a day or less over the previous year.

Most of the people who stated that they hade been involved in ‘presenting at public conferences, other than scientific conferences for scientific professionals’ were senior (12/19) — those that were not senior appeared to be using this description for the NICB open day. The other activities in this group (the final four rows in Table 6.3) were done by participants in senior positions, and the three media-related activities were done by the Director and the Manager and a few other senior staff. Consequently, most of the media activities were done by men, apart from the notable exception of a lecturer at Tallaght.

For science communication in general, such limited communication with non-scientific academia, the media and the public is problematic. In Ireland, which is a relatively small country, biotechnology is a fraught area. If communication with the public sphere is being done mainly by the ‘older guard’, then it will be limited by their attitudes and biases.

6.1.3 Talk about research with groups of non-specialists in the future

This question provided a measure of willingness of participants to talk about their work with different groups of non-specialists, organized by the BSS. If they stated that they were not willing to talk about their research with groups of non-specialists in the future, I asked them why (allowing open answers).

The groups were these: schools, interest groups, public meetings and other. Out of a possible 292 answers (four questions and 73 participants), most (201, 68.8%) were positive. Nearly all participants stated that they were willing to do this with school groups (68/73) and interest groups (68/73). Fewer participants were willing to do this at public meetings (47/73).

Eighteen participants gave a range of ‘other’ responses. Six of them wanted to mention that they would be prepared to talk to *any* non-specialist group, although one of these thought that their research ‘was not the most interesting’ and another would only do so under supervision, unless it was a specific familiar subject area. (Fifteen people responded with ‘yes’ to the three categories provided and the ‘other’ prompt, but without a definition of ‘other’, meaning that 9/15 answered in the sense that they would be prepared to do other talking with non-specialists in general.)

Five stated that they would be willing with academics, undergraduates and industry professionals — some already did so or had done so. Four stated that they would with patient groups and hospice staff where their work was relevant (e.g. in order to allay concerns about the effects of drugs). Two would with politicians and policy makers with the aim of increasing understanding of biotechnology in Ireland: 'We rarely see a politician standing up and talking about science'. One person said that they would be willing to talk to funding bodies.

Two people, both postgraduate PhD students from Maynooth, were not prepared to talk to any non-specialist group in the future. Unfortunately, neither gave a reason for their attitude towards these activities.

Thirty-six participants were recorded as answering the 'why (not)' question, although 11 of these actually supplied a response even though they had said 'yes' to the three non-specialist groups provided in the list — these 11 responses were to clarify a point about speaking to groups of non-specialists, and included:

- the structures to do so are often not in place
- doing so was contingent on a confidentiality agreement
- they would not mind doing so, but they would not actively seek it out
- they already did so (e.g. in hospitals or schools)
- if public meetings did arise (unlikely according to one participant), situations could be problematic due to:
  - unanticipated questions from ill-informed people who 'believe all sorts of things'
  - a lack of self-confidence in talking about non-specialty areas
  - public speaking nerves
  - the wish to avoid controversial topics (e.g. setting up incinerators — a controversial topic in Ireland)
  - the unknown agendas of meeting participants
  - the potential to be too confrontational and to 'serve no one's purposes'.

One of the 11 suggested positively that:

> ... [I] wouldn't be against talking to anyone really ... I seem to talk about it all the time, every time I meet at a cousin's wedding or meet the relations. I'm getting used to it.

The remaining 25 people who answered the 'why not' question in response to prompting after they had answered 'no' to one or more of the non-specialist groups mainly did not want to be involved in public meetings for the following reasons:[25]

- lack of confidence about public speaking and a wish to keep a low profile
- fear that their research would be perceived as controversial or would be questioned, putting them in a defensive position
- unwillingness to be involved in giving the research a 'bad name' (i.e. if a debate occurred)
- lack of confidence about speaking on ethical and moral issues
- reluctance to speak with an audience that is
  - uninterested and inattentive
  - polarised or emotional
  - composed of sufferers and/or their carers (for health-related topics).

Many could not see that their research might be a topic of a public meeting, even peripherally. Participants with this attitude did not think that there were any 'issues' that might arise from their work — showing that they assumed that a public meeting would only be held if such issues arose (and not that there might be other reasons to be involved in a public meeting).

Some did not want to talk to schools because:

- school students might not be able to understand the research
- school students might not be interested

[25] 'Public meetings' and 'interest groups' have been combined here as no one answered 'interest groups' separately from 'public meetings'.

- they felt nervous presenting to an audience, unless it was composed of younger children
- they might need to simplify the research inappropriately.

Most of the 28 participants who said ‘no’ to speaking with one or more of the non-specialist groups were women (16/28) and junior (19/28). Twice as many senior men as senior women (6:3) said ‘no’ to speaking with one or more of the non-specialist groups, and these men were more senior (i.e. senior research officers cf. research officers). Everyone from Maynooth who said ‘no’ (7 people) was a postgraduate student (6/7) or a postdoctoral researcher (1/7).

Willingness to communicate to groups tended to be strong across the participant population for conventional groups, such as school groups and interest groups, less so for ‘potentially hazardous’ public meetings. The lack of structure to do so and institutional constraints on communicating (e.g. CAs) were less of an issue than were concerns with self-confidence and fears about the audience. It is clear that a small amount of training in communication and in public understanding of science for scientists would go a long way in translating this stated willingness to communicate into real ability to do so.

6.2 Pros and cons of communicating

This theme is about perceived (and prompted) personal disadvantages or advantages to communicating about research to the public, and about whether participants agreed or disagreed with a series of questions about scientists’ duty and responsibility to communicate, and potential constraints on or assistance with communicating. Again, the idea explored here is that any number of sociopolitical (Stocklmayer *et al*. 2001) or personal (PSP 2003) drivers may operate on scientists to encourage communication, but if they perceive little reward for communicating and too high personal costs (Weigold 2001), such encouragement can have little effect.

6.2.1 Personal benefits of communicating research to the public

Participants were asked to look at a list of personal benefits (see Card C4, Appendix 3) and state which, if any, they saw in communicating their research and its implications to the public. Table 6.4 provides an overview of the answers given.

Table 6.4 Personal benefits in communicating research and its implications to the public

	No. people	%
Advancing the role of science	56	76.7
Opportunity for others to contact me for collaborative/other purposes	56	76.7
Gives me experience in communicating	55	75.3
Attracts possible funding	55	75.3
It advances my career	40	54.8
Gets my name known	34	46.6

Every participant answered positively regarding at least one of the options (i.e. no one responded with ‘none of these’ or ‘don’t know’). ‘Other’ benefits were volunteered by 11 participants. These included:

- learning from the process and getting good ideas
- satisfying a personal interest in people
- enjoying the process and personal satisfaction
- promoting the NICB
- talking about lung cancer research to friends who smoked (humanistic)
- raising awareness of science for the public and removing barriers.

One participant combined several of these answers by stating that s/he enjoyed raising the awareness of the complexity and usefulness of science (and biotechnology in particular) when people, especially young potential scientists, showed an interest.

As a proportion of the total number of women, 85.0% replied that a personal benefit was that it ‘gives me experience in communicating’ (cf. 63.5% of the total number of men who answered in this way) and 60.0% that ‘it advances my career’ (cf. 48.5% of the total number of men who answered in this way). Only ‘advancing the role of science’ was answered proportionally more by men (78.8%) than women (75.0%). Eighteen people answered positively to all of the options provided.

The drivers proposed by Stocklymayer *et al*. (2001) and PSP (2003) are in evidence here, although I would like to propose an additional driver, which is not really covered by the utilitarian or science and society drivers, that is, the humanistic driver. ‘Humanist’ is defined as seeking rational ways of solving human problems and behaving as a responsible and progressive intellectual being. Such a motivation for communication by individual scientists is not strictly about *personal* benefit to the individual communicating, although many of the participants did see it this way.

It was evident in Chapter 5 that many of the approaches from non-scientists to participants to communicate about biotechnology (particularly human health research) were responded to from a wish to provide reassurance and compassion to others. Many of the participants did consider their work to involve responsibility to others. It may be the case that biotechnology is an area of research where this attitude is more common — certainly it seems to be the case in researchers communicating biotechnology. This will be discussed further in Chapter 8.

6.2.2 Personal disadvantages of communicating research to the public

Participants were asked to look at a list of personal disadvantages (see Card C5, Appendix 3) and state which, if any, they saw in communicating their research and its impactions to the public. Table 6.5 provides an overview of the answers given.

Table 6.5 Personal disadvantages in communicating research and its implications to the public

	No. people	%
Takes time/takes too much time	36	49.3
Feel nervous about talking to the public	29	39.7
Don't feel adequately trained/equipped	18	24.7
I might feel forced to take a particular stance	17	23.3
None of these	12	16.4
Could be bad for my career	6	8.2

No one answered 'don't know; to this question. 'Other' disadvantages were volunteered by four (5.5%) of participants. These included:

- being misquoted in the media and the spin of sound bites
- communication not being worthwhile due to the group dynamics (not clear which group is referred to here)
- answering incorrectly and/or being judged by others based on misunderstanding and miscommunication.

A higher proportion of women than men thought that communicating research and its implications to the public 'takes time/takes too much time' (52.5% cf. 42.5%, respectively) and 'feel nervous about talking to the public' (47.5% cf. 30.3%, respectively). For the other answers, the numbers are too small to draw any conclusions about sex differences, although there was a similar trend for 'don't feel adequately trained/equipped' and the opposite trend (a higher proportion of men than women) for 'I might feel forced to take a particular stance', 'none of these' and 'could be bad for my career'.

The Director of the NICB, who arguably had done more of this sort of communication than other staff thought that it 'takes time/takes too much time' as expected, given his demanding job, but interestingly, perhaps because of his stance on controversial issues, also 'felt nervous about talking to the public' and that it ‘could be bad for [his] career’. Neither of which stopped him from doing it. Fewer disadvantages of communicating were perceived by the participants than benefits, as a whole.

Table 6.6 shows a breakdown of responses given by participants in the MORI–WT, NICB and PSP surveys/interviews to questions about the disadvantages or drawbacks to communicating with the (non-specialist) public. Both non-Irish survey participant populations responded commonly with the attitude that there are no disadvantages or drawbacks to communicating with the public.

Table 6.6 Disadvantages and drawbacks in communicating compared across two UK-based surveys of scientists and engineers, and the current study

MORI–WT (2001)	NICB (2004)	PSP (2006)
What PERSONAL disadvantages, if any, do you see in communicating your research and its implications to the public? 38% No disadvantages 23% Takes time/Takes too much time 8% Mis-representation of information 7% Risk from animal rights/extremist groups 7% Misunderstanding of information/misinterpretation of information etc	**What PERSONAL disadvantages, if any, do you see in communicating your research and its implications to the public?** 49.3% Takes time/takes too much time 39.7% Feel nervous about talking to the public 24.7% Don't feel adequately trained/equipped 23.3% I might feel forced to take a particular stance 16.4% None of these 8.2% Could be bad for my career etc	**Looking at the list below, what do you think is the main drawback to scientists and engineers generally engaging with the non-specialist public?** 29% It takes up time that is better used on research 27% There are no drawbacks to engaging with any of these groups 19% It can send out the wrong messages 10% It makes them a target 3% It takes up time that is better used on other, non-research, activities etc.

Where disadvantages were admitted, they commonly cited the excessive amount of time required and the danger of becoming a target. This last was a disadvantage specific to the non-Irish participant populations, presumably linked with animal rights and other groups perceived as extremist and dangerous and much more active in the UK. The risk of information being misrepresented or misinterpreted during communication was also cited as a disadvantage by both non-Irish participant populations.

The NICB participants were more likely to acknowledge that there *are* disadvantages to communicating with the public. They also felt that excessive time is required for such communication. The Irish participants admitted to feeling nervous about talking to the public and inadequately trained or equipped to do so — neither of these issues was as pertinent to the MORI–WT participants (who were asked exactly the same question and provided with the same list of possible responses), nor to the PSP participants (who were not actually provided with these as response options, but could volunteer this under the 'Other' option).

These differences between the NICB participant populations and the other populations surveyed could be cultural or systemic; that is, Irish scientists are less self-confident in general and have less time in their working day to consider non-required communication, but the UK scientists have the added perception of extreme reactions from interest groups. It could be that biotechnology itself is the factor that makes NICB participants more aware of the disadvantages of communicating. Frankly, if the Director worries about the effect of communication on his well-established career, then it would be shortsighted for others in the NICB not to feel the same way.

A new question was asked in the PSP survey, which would have been interesting to ask the NICB participants: 'What is stopping you from getting (more) involved in activities that engage the non-specialist public in science? (Please mark all that apply)'. The responses provide some self-reported evidence of limitations on engagement for scientists in general:

- 64% I need to spend more time on my research
- 43% I need to spend more time getting funding for my research
- 34% I would have to do it in my own time
- 24% I need to spend more time on administration
- 23% I need to spend more time teaching
- 22% I am too junior.

It is clear that most of the PSP respondents were concerned with the amount of time required for engagement and the need to prioritize their own time in other ways (the top two answers meaning more time on activities associated more strongly with doing science). This result complements the common articulation by Irish and non-Irish scientist populations that time is a strong limiting factor on communication and/or engagement with non-specialists about science. This is not a reflection on communication about biotechnology per se, but about communicating about science in general.

6.2.3 Statements about communication

Participants were asked about their degree of agreement, Likert-style (Card C7, Appendix 3, with a set of statements about duty, responsibility, constraints and assistance for communication (Box 6.1).

Box 6.1 Statements about communication

Duty and responsibility

- (A) Scientists have a duty to communicate their research and its implications to the non-specialist public
- (C) Scientists should report on any social and ethical implications of their work when they publish their research findings
- (D) Scientists have a responsibility to communicate the social and ethical implications of their research to policy-makers

Constraints

- (B) I would like to spend more time than I do communicating the implications of my research to non-specialist audiences
- (E) The day-to-day requirements of my job leave me with too little time to carry out my research
- (H) Scientists should publish findings only when they are peer -reviewed
- (I) The day-to-day requirements of my job leave me with too little time to communicate the implications of my research to others

Assistance

- (F) Funders of scientific research should help scientists to communicate research findings and their social and ethical implications to the non-specialist public
- (G) Scientists should obtain assistance from professional communicators when communicating their findings to the non-specialist public

Letters in parentheses refer to the original order of the questions.

Duty and responsibility compared across two UK surveys and the present study

Table 6.7 provides an overview of NICB participants' answers to the four statements relating to duty and responsibility (Box 6.1).

Table 6.7 Attitudes towards duty and responsibility in communicating (no. people)

	Strongly agree	Tend to agree	Neither agree nor disagree	Tend to disagree	Strongly disagree	Don't know/no opinion
Scientists have a duty to communicate their research and its implications to the non-specialist public	32	29	6	5	1	0
Scientists should report on any social and ethical implications of their work when they publish their research findings	23	34	8	8	0	0
Scientists have a responsibility to communicate the social and ethical implications of their research to policy-makers	30	34	4	4	1	0

Participants had a positive attitude towards communicating their work to the non-specialist public (83.6% tended to agree or strongly agreed, 8.2% tended to disagree or strongly disagreed), and towards reporting on social and ethical implications when publishing (78.1% tended to agree or strongly agreed, 11.0% tended to disagree or strongly disagreed) and to policy makers (87.7% tended to agree or strongly agreed, 6.8% tended to disagree or strongly disagreed).

Some comments were recorded when participants could not or did not want to answer the questions within the constraints of the Likert scale and the statements provided. Regarding a duty to communicate to the non-specialist public, one person wanted to emphasize that it is ‘important that this is done, especially because biology is a part of everyday life’, another that their neutral answer was because it ‘depends on the research’. It could be speculated that biotechnology is an influence on duty and responsibility to communicate — that it is both part of everyday life and that it is changing life/society.

For reporting on the social and ethical implications of their research when publishing, one person said that they answered ‘tend to disagree’ for peer reviewed publishing, but would have answered ‘strongly agree’ for non-peer-reviewed publishing. Another commented that journals now commonly ask about ethical approval for research. The question caused one participant to pause and suggest that it might not be the scientists’ place to comment — ‘society should know enough to see the ethics involved’. Another commented that a lack of training in ethics means that scientists may not be competent to report in this way.

Why would someone tend to disagree that they should report on the social and ethical implications of their work when publishing in a peer-reviewed journal, but strongly agree when publishing in a non-peer-reviewed format? It could be that their perception of the peer-review process is that it precludes speculation on the social and ethical implications of the science — that is, there is no place for such speculation and reviewers might be influenced into rejecting manuscripts that include it. Perhaps, because journals do already ask about ethics approvals, it is unnecessary to report on social and ethical implications when it comes to peer-reviewed publishing (if so, this is a rather narrow definition of social and ethical implications).

Whatever the individual’s reasoning, the converse — that is it important to report on the social and ethical implications of their work in non-peer-reviewed formats — is of interest in considering the communication of science. Is it that these formats are ‘the correct place’ for such reporting, or is it that more reporting of this sort ‘should’ be seen in these formats, or both? For biotechnology, such reporting is about society rather than the science. This is a clearly imposed separation between what is considered appropriate to science (peer review) and society (non-peer review), and must limit the kinds of communication that are possible.

For reporting on the social and ethical implications of their research to policy makers, one participant who answered ‘strongly disagree’ (i.e. that scientists should not report such implications to policy makers) commented that, because policy makers are non-scientists, they can be inefficient and ‘tie things up’ — another clear separation between science and society. Another said that s/he had changed the answer from ‘neither agree nor disagree’ to ‘tend to agree’ due to the word ‘responsibility’ in the statement — in this case, perhaps the feeling of responsibility to policy making overrode her/his ambivalence towards the reporting.

Table 6.8 provides a breakdown of responses given by participants in the MORI–WT, NICB and PSP surveys/interviews to a group of statements about scientists’ duty and responsibility to communicate the results of their research and its social and ethical implications to non-specialists. The PSP question is an amalgam of the two questions asked in the MORI–WT and NICB interviews as it introduces the concepts of ‘moral duty’ (rather than ‘duty’ or ‘responsibility’) and ‘engaging’ (rather than ‘communicating’), but refers to the non-specialist public (rather than ‘non-specialist public’ and ‘policy makers’). It is, therefore, impossible to tease out the effect of these changes in the questions; so only general inferences have been made.

Table 6.8 Duty and responsibility to communicate compared across two UK-based surveys of scientists and engineers, and the current study

MORI–WT (2001)	NICB	PSP (2006)
Scientists have a duty to communicate their research and its implications to the nonspecialist public 45% strongly agree 39% agree 8% neither agree nor disagree 6% disagree 1% strongly disagree *% don't know **Scientists have a responsibility to communicate the social and ethical implications of their research to policy-makers** 54% strongly agree 37% agree 4% neither agree nor disagree 3% disagree 1% strongly disagree 1% don't know	**Scientists have a duty to communicate their research and its implications to the non-specialist public** 43.8% strongly agree 39.7% agree 8.2% neither agree nor disagree 6.8% disagree 1.4% strongly disagree 0.0% don't know **Scientists have a responsibility to communicate the social and ethical implications of their research to policy-makers** 41.1% strongly agree 46.6% agree 5.5% neither agree nor disagree 5.5% disagree 1.4% strongly disagree 0.0% don't know	**Scientists have a moral duty to engage with the non-specialist public about the social and ethical implications of their research** 20% strongly agree 49% agree 14% neither agree nor disagree 12% disagree 2% strongly disagree 2% don't know

*Numbers too small for meaningful inclusion.

The first is not related to the responses, but is a comment on the change in attitude within the science communication field over the first half of the 2000s, from 'communication with' to 'engagement with' non-specialists.

Overall, the MORI–WT participants agreed more with the statements and their agreement tended to be stronger. The PSP participants were more likely to be neutral or disagree. Perhaps the phrase ‘moral duty’ increases the strength of the imperative and ‘engage’ implies more than ‘communicate’ — these two factors could have influenced the PSP participants’ responses.

Comparing the MORI–WT and NICB population participants, there was very similar and strong agreement with the ‘duty to the non-specialist public’ statement, less so with the ‘responsibility to policy makers’ statement. For the latter statement, NICB participants were more likely to be either neutral or to disagree. Perhaps, as suggested elsewhere, the structures in place in the UK (compared with Ireland) in regard to engaging with the policy process make the difference here.

Constraints compared across surveys and the present study

Table 6.9 provides an overview of participants’ answers to the four statements relating to constraints on communication.

Table 6.9 Attitudes towards constraints on communication (no. people)

	Strongly agree	Tend to agree	Neither agree nor disagree	Tend to disagree	Strongly disagree	Don't know/no opinion
I would like to spend more time than I do communicating the implications of my research to non-specialist audiences	7	29	23	11	1	2
The day-to-day requirements of my job leave me with too little time to carry out my research*	9	18	9	24	11	1
Scientists should publish findings only when they are peer-reviewed	36	23	1	10	2	1
The day-to-day requirements of my job leave me with too little time to communicate the implications of my research to others**	7	21	23	14	5	1

*1 missing data point; ** 2 missing data points.

There was a tendency to agree with the statement about spending more time communicating their research to non-specialists (49.3% of participants), but a reasonable proportion had a neutral attitude (31.5%). Comments included: ‘don’t necessarily want to’ and ‘in theory yes, but would prefer to do the work’. This shows the ambivalence towards science communicating that is not generally considered to be part of the doing of science.

Participants were more evenly distributed but tended to disagree (47.9%) rather than agree (37.0%) that the day-to-day requirements of their job left them with too little time to carry out their research. The Director of the NICB felt that he could not answer this question because he was not actually doing research at the bench. This is a literal interpretation of the statement, which no other participants considered, even though it was relatively common for senior staff not to be directly involved in research at the bench. One person commented that an answer of ‘neither agree nor disagree’ actually meant ‘sometimes’ in regard to this statement.

Participants had a positive attitude towards the statement that scientists should publish findings only when they are peer-reviewed (87.7%). however, this statement produced the greatest number of comments as participants struggled with competing justifications for their attitudes (Box 6.2). Only a small proportion (1.4%) of participants was neutral about this statement.

It is clear from the range of statements shown n Box 6.2 that participants’ attitudes towards peer review are ambivalent — there is a trade off between the ‘gold standard’ of peer review (although some were also ambivalent about whether peer review is a gold standard) and the need to communicate the science quickly or for people to have access to results quickly. I believe that these attitudes are becoming more common among scientists in general — for the purposes of science communication, a relaxation of attitudes towards peer review provides an opportunity for a greater volume of communication to take place, but this would be associated with a perceived reduction in quality.

Box 6.2 Comments about the statement: ‘Scientists should publish findings only when they are peer-reviewed’

Ambivalence

Novel science must be peer reviewed, but information should also go out to the public via the media, but be ‘censored properly’.

Communication about research without peer review means that mistakes can get through; however, research needs to be communicated to the public.

Not all research needs to be peer reviewed — there are times when small groups need to talk about their research and times when research should be put ‘out there’.

Publishing without peer review ‘is scary’.

Type of publication

Non-peer-reviewed publications can be a useful way for students and new researchers to get their work ‘out there’, as a form of practice in a non-threatening format and to help build confidence.

Even book chapters are peer reviewed if it is considered in a broad sense.

Other forms of publication, such as posters and short commentaries, are also important.

People have no access to peer-reviewed material and are therefore vulnerable to the rubbish on the internet when they are looking up information about, for example, a disease. Some level of control over internet (science and health) content is desirable, but unlikely to occur).

Problems with peer review

Peer review is not the ‘be all and end all’. Science can be talked about outside of peer review. Just because people are peers, does not mean that they know everything

Peer review can not take other work into context, can be biased and takes a long time.

Although strong agreement is the unconsidered response to the statement, something might be ‘true’ but still not acceptable to journals because it is not the accepted opinion.

Length of time

Peer review takes a long time; up to 2 years to publication. It can take too long, which means that some research does not get published at all.

The length of time peer review takes can ‘back up research’. Although it can stop results that are not OK, it is not always necessary.

Like the first statement in this section, participants had a tendency to agree with the statement about job requirements leaving them with too little time to communicate the implications of their research to others (38.4%), but a nearly equal proportion of participants were neutral about this statement (31.5%) and a reasonable proportion disagreed (26.0%).

Comments about job requirements leaving them with too little time to communicate the implications of their research to others included that ‘it depends on the audience’ and ‘it is a requirement in the Centre that staff do reports and informal presentations’ (so thee activities must to be fit in somehow, although that means that working hours are very long). The two people who did not provide a Likert response to this statement made the comments that that act of publishing means that the information is ‘out there already’ and that they would ‘not be unwilling’ to communicate further, but it is difficult to do so (presumably agreeing with the statement, but not prepared to provide a Likert scale answer).

Assistance compared across surveys and the present study

Table 6.10 provides an overview of participants’ answers to the two statements relating to assistance on communicating.

Table 6.10 Attitudes towards assistance for communicating (no. people)

	Strongly agree	Tend to agree	Neither agree nor disagree	Tend to disagree	Strongly disagree	Don't know/no opinion
Funders of scientific research should help scientists to communicate research findings and their social and ethical implications to the non-specialist public	23	34	8	7	1	0
Scientists should obtain assistance from professional communicators when communicating their findings to the non-specialist public*	35	28	8	0	1	0

*1 missing data point.

There was a strong tendency for people to agree with the statements about funders helping scientists to communicate research (78.1%) and scientists obtaining assistance from professional communicators (86.3%). However, one comment that applied to both statements is that 'it is good to have [assistance], but not if it is prescriptive'. This statement was in reference to the introduction of bias to science communication, where the person or organisation providing the assistance might have their own agenda.

A comment on assistance from funders suggested that assistance in communication might be difficult to provide if the funding came from multiple sources. The participant was also concerned with the possibility that funders might have some level of control over the communication because of vested interests. Again, the introduction of bias is an issue for individuals' communication about their own research.

One person who did not want to respond to the statement about scientists seeking assistance from professional communicators commented that an answer:

> ... would depend on ‘spin’ and on an individual’s skills. People who are good at it should do it. [Assistance] could be detrimental otherwise. We need the best people or at least those better than average [to communicate].

Another person, who had responded with ‘neither agree nor disagree’ suggested that a professional communicator still needs to be educated about the research, so the communication is only as good as the third party. Another person agreed: ‘it depends on the communicator’. Clearly, the provision third-party assistance, funding or training for communication is a double-edged sword for the NICB participants, but most would accept it if potential prescription or proscription were minimized.

Table 6.11 provides a breakdown of responses given by participants in the MORI–WT, NICB and PSP surveys/interviews to a statement about whether funders of scientific research should help scientists to communicate with the non-specialist public. (Note: The PSP survey did not refer to the communication as about research findings and their social and ethical implications.)

Table 6.11 'Funders should help scientists' compared across two UK-based surveys of scientists and engineers, and the current study

MORI–WT (2001)	**NICB (2004)**	**PSP (2006)**
Funders of scientific research should help scientists to communicate research findings and their social and ethical implications to the nonspecialist public 39% strongly agree 45% agree 9% neither agree nor disagree 5% disagree 1% strongly disagree 1% don't know	**Funders of scientific research should help scientists to communicate research findings and their social and ethical implications to the non-specialist public** 31.5% strongly agree 46.6% agree 11.0% neither agree nor disagree 9.6% disagree 1.4% strongly disagree 0.0% don't know	**Funders of scientific research should help scientists to communicate with the non-specialist public** 16% strongly agree 54% agree 17% neither agree nor disagree 7% disagree 1% strongly disagree 3% don't know

Most of the two non-Irish survey participants either agreed or strongly agreed with the statement, but the PSP population had a more neutral attitude. This could be explained by a general change in attitude over time (6 years) in the UK and/or the lack of specific mention of 'research findings and their social and ethical implications' in the question (meaning that perhaps PSP participants were less likely to think that funders should help with science communication *in general*).

There was a general similarity between the MORI–WT participants and the NICB participants in that most agreed or strongly agreed with the statement. The Irish population was slightly more neutral, and slightly fewer participants strongly agreed and slightly more participants disagreed. Thus, the Irish participants were slightly less likely to think that help with communication should be a role for funders. This could simply be due their being used to a funding environment that is less conducive to providing assistance with communication.

6.3 Mediated communication with non-specialists

The theme of this section is mediated communication with non-specialists, as opposed to non-mediated or face-to-face communication, which is explored elsewhere (Chapter 5). These questions investigate whether peer-reviewed articles published by the participants have been mentioned in non-specialist media and whether they themselves or their work have been the subject of a media story. In addition, I look at participants' ideas about how non-specialists gain information about scientific research (in essence, which media outlets participants think non-specialists use).

Here the idea being explored is that biotechnology in the media might have consequences for scientists in terms of their willingness to communicate. In addition, scientists' perceptions of the sources non-scientists use might have consequences for willingness to access and contribute to the public sphere. Best and Kellner (2004) suggest that public intellectuals and activists have a responsibility to become educated in biotechnology; a difficult task if the material is not readily available.

6.3.1 Specialist media

Thirty-four participants (46.6%) had never been published in peer-reviewed journals as first or co-author. Of those who had been published, 20 (27.4%) had published 1 to 10 articles, 14 (19.2%) had published 11 to 30 articles and five had published more than 30 articles (6.8%). All participants who had published 11 or more articles were senior, apart from two postdoctoral researchers who had published between 11 and 30 articles (i.e. not more than 30). This makes sense, given requirements for senior and postdoctoral researchers to 'publish or perish'.

Twelve participants had seen at least one of their articles (or the research that it referred to) mentioned in the non-specialist media. Three of these were postdoctoral researchers, perhaps reflecting the 'cutting edge' nature of their research. Of the 12, eight were from the '1 to 10 articles published in peer-reviewed journals' category, three were from the 11 to 30 articles category, and one was from the more than 30 articles category. It is difficult to tell whether this rate of mention in the non-specialist media is comparable to the rate in general across science in Ireland, but 12 out of 34 participants had seen at least one of their articles or the research that it referred to mentioned in the non-specialist media. It seems that information about the scientific knowledge and constructs of biotechnology, at the NICB at least, were in the public sphere. In addition, it did seem that novelty or newness of the research rated it a mention, rather than sheer volume.

The Director of the NICB answered 'none' to this question, possibly due to his interpretation of the question, which was more literal than the other participants (i.e. none of the articles that he had published in peer reviewed journals had been *directly mentioned* in the non-specialist media). (The next section may capture this information.) In retrospect, possible responses to the intent of this question were probably limited by the narrow focus of peer-reviewed journal articles.

6.3.2 Media coverage

This question explored participants' satisfaction with media coverage if their work had been the source of subject of a media story (differing from Section 6.3.1, which was about *publications* appearing in the non-specialist media). Card D3 (Appendix 3) lists the satisfaction categories provided to the participants. Eighteen participants (24.7%) answered that they or their work had been the subject of a media story — more than once for some individuals. (Some individuals would also be mentioning the same media story and the same research as they would have been in collaboration.)

People tended to be either very satisfied (8/18) or satisfied (9/18) with the coverage they received. One person was neither satisfied nor dissatisfied. One person commented they were satisfied with coverage in one instance, but not in another (referring to two media stories about different research issues). Another commented that they were satisfied with the newspaper coverage in the *Independent*, but not the coverage in the *Irish Times* (referring to the same research), because the *Irish Times* coverage included a statement that another member of the research team gave to the journalists that might have provided the audience with 'false hope' — a common fear for communication about human health issues.

Clearly, satisfaction with media coverage is contingent on a variety of factors — the research itself, the media outlet and the framing of the story — however, none of the participants mentioned that dissatisfaction would stop them from being involved with a media story about their work in the future.

6.3.3 Sources of science information for non-specialists

The intention of asking this question was to get information about participants' attitudes towards mass media use by the non-specialist public, but of course the participants themselves are to a degree 'the non-specialist public' for science that is outside their broad area (e.g. physics for a biologist). Therefore, it could be argued that their answers reflect their attitudes towards media use by others, but based on their own experiences. The types of media were provided on Card D1 (Appendix 3). An overview of participants' answers is shown in Table 6.12.

Table 6.12 Participants' beliefs about where non-specialists obtain information about scientific research and its social and ethical implications

	No. people	%
Television documentaries and current affairs programmes	63	86.3
National newspapers	60	82.2
Television news	58	79.5
The internet/websites	56	76.7
Radio documentaries and current affairs programmes	52	71.2
Information published by campaigning groups (e.g. on environment and health)	48	65.8
General interest magazines e.g. women's or men's magazines	47	64.4
Information published by charities (e.g Cancer Research Ireland, Irish Heart Foundation)	40	54.8
Local newspapers	39	53.4
Radio news	30	41.1
Television dramas and films (e.g. soaps, fiction films)	27	37.0
The 'popular' science press (e.g. *New Scientist*)	19	26.0
Computer magazines (e.g. *Computer Weekly*)	12	16.4
Museums	4	5.5
Radio dramas	2	2.7
Scientific journals	1	1.4

It would be interesting to see if the order of the sources in Table 6.12 has changed since the study period. It appears that the participants thought that non-specialists generally obtain their information from 'straight' news, current affairs and documentary media sources. I suspect that the internet/websites category would be further up the list even just a few years after the study period. Certainly, this would be a more likely source for Best and Kellner's (2004) public intellectuals and activists. The implications for communicating science, particularly biotechnology as a contested area, are that the speed of web-based publication and the lack of quality control have changed the media landscape and drawn the information available to everyone with connection even further away from the peer-review process.

None of the participants answered ‘don’t know’ or ‘none of these’. Three people answered and defined ‘other’ sources of information as word of mouth (which can be good or bad according to the General Manager of the NICB) and other people, such as family, scientists (especially for health-related opinions) and second-level teachers.

In terms of the number of categories chosen, which ranged from 1 to 14 (no one chose all of the 17 possible categories and Table 6.12 only shows 16 as the ‘other’ category is not included), more women than men chose between 5 and 9 categories, while more men than women chose between 9 and 13 categories. Perhaps this means that, in this case, men use (and think others use) a wider range of information sources than women do. The least popular information sources — radio dramas and scientific journals — were chosen by postgraduate students. It is not clear whether this is because they lacked experience in picturing others’ media use or because they themselves sourced information in these ways, or both.

6.4 Media effects on communicating

This theme is about coverage of biotechnology-related topics in the media and the potential effects on communication by researchers. The topics presented to the participants were animal or human cloning, assisted reproductive technology, genetically modified (GM) foods, stem cell research and funding for biotechnology. It covers participants’ perceptions of the potential effects of the communication of these topics on the science communication environment.

Like the previous section, the idea being explored here is that biotechnology in the media might have consequences for scientists in terms of their willingness to communicate. Here, however, the participants’ points of view are explored as they link more or less controversial biotechnology-related topics in the media with their own likelihood of communicating. The intention was to capture their attitudes towards controversy in biotechnology in the public sphere.

In addition, because the participants were able to respond with concrete instances of communication in mind, it was an opportunity to explore the communication in terms of a variety of science communication models. Did the participants use the deficit model as a resource in their discourse as Hilgartner (1990) suggests, or to achieve hegemony, legitimate power and conceal inequality as van Dijk (1998) proposes?

None of the demographic variables described in Chapter 4 appeared to be associated with the types of responses given. There were distinct categories of answers about the likelihood of participants communicating:

- coverage of *all* topics increased the likelihood
- coverage of *all topics except stem cell research*, increased the likelihood
- coverage of most of the topics *reduced* the likelihood.

Coverage about the topic 'funding for biotechnology' was, in general, perceived differently than coverage of the other topics.

Although none of the categories were associated significantly with age, sex or seniority, there seemed to be two distinct seniority-related 'camps' in the 'coverage of all topics increased the likelihood' category. Only junior researchers were in the 'coverage of most topics reduced the likelihood' category.

6.4.1 Coverage of all topics increased the likelihood of talking about research with non-specialists

Fourteen people said that *all* of the suggested topics made them more likely to talk about their research with non-specialists. This answer seems to stem simply from the idea that biotechnology in the public sphere means that there are more opportunities to talk about biotechnology-related research, whether it is self-initiated or not.

In response to prompting about whether they themselves would initiate a conversation about their research, the more junior researchers in this group responded that they would never initiate such conversations; however, as it would be more likely that conversations about the topics would happen if prompted by the media, they would be keen to join in. This response seemed to be due to shyness or self-perceived inadequacies. For example, one person said that s/he would be more likely to say to people that s/he is a scientist if any of the topics came up in conversation, but added, after a long pause: ‘not that know what I’m talking about’.

The junior researchers wanted to make people understand the science, correct misconceptions and what they saw as propaganda, and allay fears:

> ...people are more afraid of what they don’t know as opposed to the actual reality of it. The problem is they’re hearing horror stories in the news, you know, the newspapers and TV, so they actually don’t get the good side of it.

One wanted to ‘educate’ non-specialists with what s/he knew about the topics.

The senior researchers, in contrast, wanted to initiate conversations about the topics and were experienced in fielding questions by non-specialists who knew that they were scientists. To them, a greater awareness of the science and a greater availability of information in the community (‘their primary source is the media’) mean more opportunities for these participants to communicate about their research — one said s/he would ‘talk about [the topics] weekly’.

The stated motivations behind the senior researchers’ communication included a need to communicate more, to create better-informed coverage, to communicate so that there was a better understanding of what the benefits of the research are, and to have a dialogue:

> I kind of want to give them a better idea of what an actual scientist thinks...I would say ‘OK, why do you think that’ and discuss it with people, rather than just have them get the wrong idea from the press, or maybe [information that is] too one-sided...

The senior researchers also thought that there was a lot of misinformation and scare tactics used in the media. Their attitudes towards non-specialists were that they thought ‘the public are genuinely interested in understanding...in what the benefits are...in treatment options and food safety’. One acknowledged non-specialists’ knowledge:

> I think, given the coverage in the media [that] certainly there'd be an interest, a heightened awareness and a heightened level of information [about these science-related topics in the community]. So I don't think I would be speaking to people who are completely ignorant. They might know more than I do, so, you know, I would feel it was my duty as a scientist to offer an opinion.

Thus, the senior researchers were more open to dialogue with non-specialists, more proactive about initiating it and, importantly, did not think that non-specialists needed to be educated, but listened to and engaged with: 'a lot of scientists have realised that part of the perceptions that people may wrongly have about a lot of these [topics] are the responsibility of the scientist'. This is not merely providing information to people with a science information deficit. When one senior researcher was asked whether the topics came up in conversations s/he had with non-specialists, s/he laughingly replied:

> ...yes, all of them...even at home or with family. My parents wouldn't be from scientific backgrounds at all, but they would have read or heard something, you know, or relations, friends who don't work in [science], generally suggest that we're cloning everybody, but if that was the case, we wouldn't be working such long hours!

One senior researcher thought that scientists '…have a big responsibility to communicate their findings, their research, with all the implications that entails to the public and nothing should get in the way of that'. This attitude went with what at first seems to be a classic deficit model outlook — 'the more they know about science the more accepting they will be':

> I think that if, if the ordinary person in the street knew the kind of research we are doing, then they wouldn't oppose it. There are very few mad scientists out there trying to do bad things with their research. The biggest problem I think in the public understanding of science is public fear of science. I've even [experienced] examples of that in my own working life. Ordinary people feel they have no control over scientific research and I think that the more they know, the happier they'll be with what we were doing.

However, this statement is more complex than a simple deficit model. The researcher is concerned both with non-specialists finding out that scientists are *people* attempting to do beneficial research and with non-specialists gaining more control over research. The statement 'the more they know, the happier they'll be' is not just about the 'facts' of the research, but includes the doing of science, the setting within which science is done and reciprocal responsibilities in the doing of science.

The trend was that if a participant thought that the presence of the biotechnology-related topics in the public sphere would make them more likely to talk about their research, and they were junior, then they did use the deficit model as a resource in their discourse (Hilgartner 1990). They wanted to *make people understand* the science, *educate them*, *correct their misconceptions*, and *allay their fears*. If they were senior, however, they thought that non-specialists should be listened to and engaged with — that everyone, themselves included, should take some responsibility. It is clear that this science communication occurred across the spectrum of science communication models.

6.4.2 Stem cell research is a challenging topic

Coverage of stem cell science was one topic in the media that participants who were otherwise keen to talk about their research shied away from or found strongly challenging. Again, this attitude was not merely about non-specialists knowing the 'facts' of the research, but also how it happens, where is comes from and what kinds of impacts science has on individuals and society (Sturgis and Allum 2004):

> ...it's shocking the poor level of knowledge and understanding [in the community] and I'm not talking about technical knowledge, but just even a lack of knowledge about what kind of research is permissible in our society. People have asked me absurd questions to the extent of 'do we do experiments on babies in the womb?' and this kind of thing. [That person] thought that we did [do such research], so when you hear things like that you become quite frightened for the future of science, because there are prevailing attitudes out there that are going uncorrected.

There was also comment from one researcher that s/he differentiated between talking about stem cell research and the other topics because stem cell research was an issue of particular concern to the Director of the NICB. This attitude was not necessarily because s/he agreed or disagreed with the views of the Director, more that it was safer not to engage in talking about stem cell research because of its controversial nature. As s/he was unlikely to do that kind of research in the future, s/he did not perceive this self-restraint as a problem.

Another researcher did not want to talk about stem cell research with non-specialists because s/he believed that hype about stem cell treatments creates false hope:

> ...stem cell research I think is a very thorny area at the moment. I really feel that science has pushed it as too much of a potential treatment. I actually think scientists have extrapolated grossly from very preliminary, provisional findings, and there certainly is no treatment there in the next two decades. So, that would make me less likely [to talk about my research with non-specialists], although my research wouldn't directly involve that anyway. I'd be less likely to discuss it [and this attitude is about] giving false hope.

Many researchers were wary and anxious about the idea that, while communicating, they or other researchers might be giving sufferers or carers false hope. As the previous quote suggests, this caution could be strong enough to limit their own communication, even if their research was unrelated.

The idea behind my asking these questions was that topics that are controversial (and stem cell sciences are a much more controversial topic in Ireland than GM foods) might constrain scientists in talking about their work. This seems to be the case with a significant minority of NICB scientists, although their explanations for this outcome vary. In this way, the communication of biotechnology is challenging, more so than more 'conventional' areas of science.

6.4.3 Coverage of all topics reduced the likelihood of talking about research with non-specialists

All of the five participants who fell into this category were junior and all of them had a lot to say about their motivations for not wanting to talk about their research with non-specialists in response to the topics being covered in the media.

The person with the most to say was concerned with people's ulterior motives (generally people that commented in the media on these issues). S/he wanted to see less randomness, more control, over how the topics were commented on in the media. This attitude made him/her less likely to talk about his/her research because s/he was concerned that s/he would be misinterpreted, that people would take what s/he said the wrong way. This participant was keen on the intervention of communication specialists to assist in the communication of research. However s/he did respond with ‘more likely’ for GM foods because:

> ...that’s probably because of my own personal belief on the matter. I feel that it’s the pharmaceutical companies, like Monsanto and that, that have put pressure on [this topic] and I don’t think there is enough known. There have already been a lot of activities which possibly shouldn’t have happened and people weren’t informed about it and [yet] things went forward. I think it’s time maybe to, not stop it, but just discuss it more widely.

This is an issue with the control of science. This participant’s main concern was that claims are made for findings (e.g. about cancer drugs) that are not supportable scientifically, yet scientists give each other awards and attract a great deal of funding to the research. S/he told a story of a pharmaceutical company that approached a cancer action group, encouraging the group to influence the approval of a drug that was only effective in a small number of patients:

> ...it created false hope. I think there can be a problem in the general media with emotive responses or a desire for something to work. When, very often, you have to just stand back and say ‘no, there is absolutely no evidence for it’. [Otherwise the coverage] creates false hope.

This researcher was describing the influences that scientists themselves can have on the communication environment and on society.

This theme of false hope emerged in a variety of places in the interviews. It was obviously much on the mind of the participants, mainly due to their research being to do with human health and a humanist wish to do the right thing. Fear of giving false hope would work both as a driver and a disincentive to communication. However, its ubiquity in the participants’ responses does point to it being a driver to *thinking* about the communication process.

Another participant pointed out that none of the topics were within his/her field of research and:

> ...any information that I communicate is, could be, overshadowed by my own personal preferences, which is a dangerous thing. [I think] people should make up their own minds and try to be presented with the information and then make a decision, even though I would probably feel strongly one way or the other about certain issues. It boils down to the fact as well that, not only is it very difficult to communicate my own work to non-scientists, it is very difficult to communicate work that isn't my own work, because I could be saying something that is wrong. [I] might advise that person to one direction or the other [and a problem that eventuated] could be through my own fault.

This participant also thought that GM foods are easier to talk about with non-specialists because they have been in the media for a long time and people are familiar with them. This was from the perspective that the modification of plants is more tangible to non-specialists than molecular work (e.g. injecting cytoplasm).

One participant replied that all of the topics would make him/her less likely to talk about his/her research:

> Media coverage has been quite negative and, therefore, the public don't have an open view because they've just seen one side of the question. Even though some programmes tend to try and give a balanced approach, I do find that the people who are against these particular topics are more vocal and seem to get more air time than those for [the research].

S/he also thought that science communication in general was difficult:

> I think sometimes that scientists are, well we're not very good at communicating to the general public, and therefore when you sit down and you try to tell people what you do, it's hard to bring it down. [For example], I just assume that people know what an amino acid is [but] and they mightn't know what a protein is, so to try and get to at that level for communication purposes, it can be difficult.

The constraints on communication spoken about in this section are mainly about taking a precautionary approach because one might make a mistake and say the wrong thing. In addition, the concept of false hope comes into play; so the precaution here is not just about making a mistake of fact, but also making a mistake of degree of advocacy. Media coverage is considered to be sensationalist, negative or one-sided, which compounds the problem for these participants. This is strong evidence for the science communication environment having an effect on participants' communication, as is the claim that GM foods is a media topic that is *easier* to talk about because it has been debated in the public sphere for a longer period of time.

6.4.4 Funding for biotechnology topic is treated differently

Twelve people answered ‘no difference’ to all media topics *except* funding for biotechnology. These participants tended to go on to say that the answer of ‘no difference’ was due to the topics being unrelated to their research area and their not knowing enough about them — presumably this meant that they did not communicate in a more general sense about science or about biotechnology-related science, but only about their own field, if at all.

The topic of funding, though, was of concern to these participants because it is in their own interest and the interests of their field of work to secure funding — funding supports their day-to-day existence and the participants considered that the research they were involved in was worthwhile and worthy of continued funding:

> Funding project proposals and all the rest of it by and large is a political process. Politics is the people. If you can influence the grass roots, given that, for instance, PRTLI is 3 years [and the] NICB [got] 34 million and there was only 100 people working in it [less]. It’s very hard to see where 34 million is going amongst 100 people. We don’t have any lobbying power, but if people understand what we do and the benefits of we do, if each of those 100 people talks to 10 people, that makes 1000. That’s why I’m saying that. Just trying to put forward to people the message that what we do is actually worthwhile.

This clearly covers all of the points of science communication (Sturgis and Allum 2004) — scientific knowledge and constructs, processes, organisation, funding, control and impacts. As I argued in Chapter 2, this is an example of scientists employing rhetoric to influence the science communication environment, in this case the ‘benefits of what we do’ are just as important to communicate as the ‘what we do’ part. Again, this is not merely providing information where a perceived deficit exists.

Another participant thought that funding needs to be discussed openly so that people understand *why* it is happening. As discussed in Section 3.2.3, the Irish government has allocated large resources to biotechnology so that, in the words of one of the participants, Ireland has the potential to be an 'international centre for biotechnology, comparable with Singapore'. This same participant thought that scientists do not talk about this enough. S/he was making a conscious effort to do so, in an attempt to influence the retention of highly trained Irish researchers:

> Because basically conditions are quite good at the moment, there is money, whereas a number of years ago there certainly wasn't...we've always been able to teach people to [train them] to a high standard in Ireland, but the subsequent postdoc training, you've needed to go abroad to further yourself. But that doesn't need to be the case now because major researchers from abroad are coming here, so you can work in international standard labs. I think that maybe in a couple of years' time, Ireland will be considered [to be of an] international standard, but the perception and the actual are two different things.

In other words, because there has been such an increase in biotechnology in Ireland, if there is an opportunity to talk about it, you should take it — to boost the profile of biotechnology in Ireland through discussing its benefits, as discussed above.

Two participants responded with the opposite. They both thought that media coverage of all of the topics *except* funding would make them more likely to discuss their research with non-specialists. This was surprising, but seemed to be due to the idea from one that no 'lay people' would be interested in who is 'paying my wage' and from the other that based on anecdotal evidence that the subject of funding had *never* come up in discussions that/he had been involved in.

Six more participants responded with 'more likely' to all of the other topics, but 'no difference' to the funding topic. Their reasoning seemed to be similar to the two participants discussed above, namely:

- funding is not of particular interest to the general public
- non-scientists seem to think that science funds itself
- non-scientists are not aware of where biotechnology gets funding from
- people are not really bothered about funding.
- nobody I know cares about funding for biotechnology
- I'm more likely to talk about funding with peers

- I’m not really interested.

Except for the last two, these answers are all about participants’ perceptions of ignorance and a lack of interest in non-scientists about funding for biotechnology. The first group, the ‘benefits-communicating’ group, thought that they could or should communicate about their research, particularly its benefits, in order to secure funding, while the second group justifies a lack of communication by citing this ignorance and lack of interest shown by non-scientists. It could be argued that these groups are both using the deficit model as a resource in their discourse (Hilgartner 1990), because they all think that a deficit exists.

6.5 Summary

The present chapter explored a range of sociopolitical and personal drivers for science communication, (Stockylmayer *et al*. 2001, PSP 2003). I found that the most common communication activities were, unsurprisingly, those that are traditionally associated with the doing of science (e.g. publishing manuscripts in peer-reviewed journals). Senior participants did more communication and more of the communication that was relatively formal in context, but not traditionally associated with the doing of science (e.g. speaking at non-scientific academic conferences). This division of labour was common across the NICB — clearly the proposed drivers operate to different degrees under different circumstances.

However, there was a lack of common purpose in communication across the NICB, whose members mainly identified themselves with the Centre or the School they were associated with, rather than the NICB. As I have commented elsewhere, the organisation may have become more homogenous in this sense once the purpose-built facilities were in place, but this did not occur during the course of this study. In terms of communication, there would have been a distinct set of consequences for the individual, depending on where s/he was placed within the organisation. People from ‘the Centre’ would be concerned with confidentiality, while people from the Schools would be concerned with communication as education.

Across the NICB, there was a preoccupation with self-confidence, fear about potential audience reactions and public speaking nerves for participants contemplating communication with less conventional groups (e.g. at public meetings). Other constraints operating on communication included a lack of time and funding, and ambivalence towards themselves communicating (although communicating was considered to be a 'good thing' in general). This is despite a general agreement that the disadvantages to communication are less numerous than the advantages. Also, nearly everyone agreed that they have a duty and responsibility to communicate. this means that although there might be a will, there is often not a way for scientists to communicate — this a comment about science in general, rather than biotechnology in particular.

Best and Kellner's (2004) proposed that public intellectuals and activists have a responsibility to become educated in biotechnology, and suggested that this would be a difficult feat if the material (and willingness of scientists) is not available for them to do so. However, what seemed like a fairly large proportion of participants had actually seen at least one of their peer reviewed articles or the research that it referred to mentioned in the non-specialist media (the magnitude of this could be checked against data from the wider science and technological workforce, but not in the present study). I also speculated that it is becoming more and more likely that the primary source for information about biotechnology for non-specialists is the internet.

Peer review itself is no longer seen as straightforward for more of the participants — perhaps it never was, but it is only more recently that it has begun to be talked about in the terms described here. The trade off between the 'gold standard' of peer review and the need to communicate or access information in a timely manner is one that many participants had already considered before the interviews. Also of influence perhaps is the breakdown of the traditional idea of a separation between science and society (although this is obviously still present for some). As Franklin (2004) notes, the cloning debate:

> …is about society, not technological systems. Many people who have no scientific training whatsoever may well know a great deal about what society is, how they think it should be, and how people treat one another (p. 256)

I explored communication in terms of a variety of science communication models, concentrating on whether the participants used the deficit model as a resource in their discourse as Hilgartner (1990) suggested. I found that they did use the deficit model as a resource, but that this was less straightforward for senior researchers than it was for junior researchers. All of the participants appeared to choose from a variety of models in their discourse about communication. For example, some of the participants who were wary about communicating with stem cell sciences as a topic of media attention felt this way because they thought claims about the science might present sufferers and their carers with false hope (deficit model in the sense of a potential underestimation of people's ability to engage and make their own judgments), while others felt this way simply because the science has controversial connotations (and they were wary of being part of the debate/dialogue).

According to Gaull and Yeeton Woo (1996), biotechnology has huge potential for the production of false hope, because no one yet understands the implications of biotechnology and inflated claims are commonly used to boost chances of getting a part of the lucrative research pie. In 1996, at a symposium on consumer issues in biotechnology, they saw fit to publish a paper titled: 'Biotechnology and society: we scientists have responsibilities too'. Wariness about communicating false hope did not seem to transform into a unwillingness to communicate at all in the NICB participants, just into an awareness of the complexity of communicating.

This chapter explored the consequences for the individual in communicating; a big issue for a thesis that is focused on the individual researcher communicating biotechnology. The next chapter explores the professional identities of these individuals and how this might have an effect on communication practices.

Chapter 7 Professional identities and communication practices

Becoming, being and aspiring to continue to be a researcher in a biotechnology institute in the future involve crucial points of communication with and by individual researchers in the science communication environment. Communication is influenced by participants' motivations in becoming researchers, their current achievements and future aspirations in research — their professional identities.

The present chapter explores the interaction between participants' professional identities, communication practices and the science communication environment. I wanted to examine the influence of the science communication environment on the identities of the NICB researchers (what motivated them to become scientists), the influence of their identities as researchers on their communication practices, shown using case studies, and the potential influence of identity building on future aspirations. Other scholars have claimed that a scientist's perception of his/her identity will influence communication practice, cultural comfort and aspirations for the future (McClam 2004, Hermanowicz 2003). In addition to using the interview data to explore these themes, I adopted a case study approach by selecting three individuals for a more in-depth analysis across the entire interview.

7.1 Motivations to become a scientist in a biotechnology institute

This section explores participants' personal motivations for becoming a biotechnologist, or scientist, in a biotechnology research institute. The two aims of this part of the interview were to provide the context in which the person became a scientist and to examine the original communication about science that motivated them to move towards this work. Becoming and being a researcher is a significant investment of personal time and effort. Sometimes, as will be shown in the present section, this path begins with the effect of an 'original motivator' during secondary school or in the home environment. Sometimes factors that are intrinsic to the individual set them on their path.

Not surprisingly, participants talked with enthusiasm about their chosen field, which made for effective communication during the interviews. Section 7.1.1 explores the original motivations for taking up science, mainly biology and biotechnology, but sometimes chemistry, and Section 7.1.2 explores the places in the interviews where the participants laughed, often with enthusiasm coupled with unprompted talk about their motivations. Section 7.1.3 explores media accounts with science content — fictional and non-fictional — which motivated some participants to take up science.

7.1.1 Why become a scientist?

Participants were prompted to talk about the original motivations for becoming a research scientist in a biotechnology institute. The participants' immediate reaction to the prompting was recorded, along with follow-up (commonly unprompted) comments. In terms of immediate reactions:

- 44 were motivated by an interest in science in general or chemistry or biology in particular
- 20 enjoyed, liked, loved or had a passion for (and wanted to do) science (in general or chemistry or biology in particular)
- 4 thought that they had brains that 'looked for logic' or 'could relate to the non-abstract nature of science' and 'did well' as a consequence.

Thus, a large proportion of the participants (68 out of 73, or approx. 93%) responded that they were motivated in the first place by what could be described as inherent factors — their own interest, emotional attachment or aptitude. They were 'scientist types'. It might be speculated that this did not necessarily make them communicating types (or even science communicating types), although during the interviews at least, most were adept at communicating their attitudes to doing the science.

In terms of outside influences, only two participants claimed at this point that they were motivated to become a biotechnologist by an inspiring science teacher or by a career guidance teacher,[26] and only two thought that they had taken the path due

[26] Such a teacher, it could be argued, would have been responding to an inherent interest and aptitude of the student, for example: 'I hadn't heard about biotechnology until a lady in our school, a career guidance teacher, said, "hey did you ever hear of biotechnology? I know you like maths, you like your

either to chance or in a roundabout way. One did not answer the question in a meaningful way for this part of the analysis.

Secondary reactions or follow-up comments about participants' motivations for becoming a research scientist in a biotechnology institute largely reiterated the motivations cited in the first instance, but it was more common at this point, than in the initial responses, for participants to say that they found science easy to learn or that they were good at it and 'you enjoy the things you are good at'. Three other motivations were commonly cited in follow-up comments:

- The sciences, particularly biology, were compared favorably against the alternatives, such as languages, business or commerce, or the arts, because the work is 'unique', it is 'your own', is 'hands-on' and 'important', and you may be involved with 'new developments'.
- There was some acknowledgement that biotechnology, at a time when many of the participants were in secondary school or doing their undergraduate degrees, seemed to be an exciting new career prospect, an area where 'things were happening', and that there was more of a chance of getting a job due to explicit links with industry.
- The opportunity afforded by biotechnology, as with all research into human health issues, to help people, and to be involved in the development of 'new technology to improve either the world or human health or the environment' was an important consideration for some: 'cancer affects a lot of people, it is a devastating disease'.

None of these is specifically linked with a desire or an aptitude to communicate about the research. The uniqueness of biotechnology for the participants, stemmed from it being a new area, linked explicitly with industry (and hence good future prospects) and associated with the desire to improve the human condition.

Slightly more than half of the participants mentioned that they had *always* had an interest in science (as far as they could remember or from a very young age), a

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science, you like your computers. I've just heard of this thing called biotechnology that kind of pulls all of them together"'.

tendency that was linked with wanting to ‘know how things work’ and being interested in the natural world or the world around them.

A mixture of inherent aptitude and external drivers motivated the NICB researchers to become scientists. It might be speculated that the inherent aptitude of a research scientist does not necessarily include a desire or aptitude for communication, particularly the less formal and informal communication explored in the present thesis. This point is considered in more detail in Section 7.3, where participants’ future aspirations, including leaving science, are examined.

7.1.2 Laughing at being a biotechnologist

Although it was not my intention to analyze non-verbal cues systematically in this study, I found that laughter was an obvious indicator that something was going on with the participants in particular areas: the idea of being a biotechnologist, their inspirations to take up science as a career and the sheer enjoyment of doing science.

Slightly more than half the participants were hesitant or laughed at the first part of this question (‘do you consider yourself to be a biotechnologist’ and ‘why did you become a biotechnologist [or other type of scientist identified in the first part of the question]?’) or during their response. This hesitancy and laughter appeared to be about the *concept* of being a biotechnologist (or generalist, or chemist, or ‘not really a biotechnologist’). Perhaps my attempt to categorize them made them uncomfortable.

> …um, we do an awful lot of collaboration with a biotech lab, but my work, I would describe more as cellular biology or immunology.
>
> Strictly I’m an organic chemist, so, I mean we make drugs, so…the sector I’m in is obviously biotechnology and biopharmaceuticals, but…
>
> um, I don’t actually do any biotech, biotechnology <laughs> I’m just more the chemistry side, providing samples for biotechnologists.
>
> More of an immunologist…
>
> um, it’s kind of not exactly biotechnology, but like, you know, pharmacy-related biotechnology, but they are all related.

> …yeah, I do [consider myself to be a biotechnologist], just about <*laughs*>…

One stated, rather ironically, that s/he was ‘pretending to be a biotechnologist’, and another relatively young participant said: ‘I still don’t see myself as a proper scientist because I’ve only [just finished] my degree...I think it’s my age as well’. This tentativeness can be linked with McClam’s (2004) discussion about how scientists’ perceptions of their own identities as scientists might have an influence on their communication practice. It is difficult to see how someone with a weak sense of professional identity could do well in communicating about their work.

Many laughed because they seemed to feel that answering the question would be a difficult task — there were too many variables involved and it was a challenge to sort them out into a coherent answer. There were more than the usual number of long pauses to think about the answer and the expression ‘oh god’ was used in an exasperated way by several participants:

> Oh god <laughs>, I’ve always liked science I suppose, but I also, when I started doing biotechnology, it was a new area of science. The whole genome was starting up…

> Oh god <laughs> ehm, I think I was always very interested in science…

> Oh god, um <long pause> actually it was more [that] I liked the project, I didn’t plan to become a biotechnologist, per se…

The participants also laughed about who inspired them to become a researcher in a biotechnology institute, including parents and other family members. I suspect that this was because they thought it was a bit (what an Australian would call) ‘daggy’ to be inspired in this way — uncool, unfashionable, but comfortably so — a father who bought and made his children read a set of encyclopedias, relatives who were scientists (in one case a participant had five siblings who were either practicing scientists, or had science degrees), the science teacher who had a scary manner, but was nevertheless inspiring, an article about a local scientist in the media and then a later realization that the same scientist had been at the NICB. As mentioned in the previous chapter, scientists know that this form of communication works in the recruitment of students to science. This is perhaps why this non-formal communication is tolerated or even encouraged in junior researchers, while other forms of informal communication are ignored or frowned upon.

Secondary schools were often credited by the participants with the role of creating obstacles that needed to be overcome before someone could do science. However, perhaps the nature of self-reporting means that the positive influences of the secondary school system were assumed and not mentioned — only the negative influences had remained fresh in the minds of participants. Participants laughed somewhat wryly when secondary schooling was put forward as a possible influence on their decision to become a scientist. Several participants thought that they had needed to make career or life choices too early in the final few years of secondary school (at around 18 years). This was, for many of the participants, only a few years prior to the interviews.

Wry laughter was also expressed because some participants pursued science, despite having being streamed into other subjects in secondary school — one had not been able to take chemistry as a subject, for example, yet ended up doing chemistry as an undergraduate and doing well. One school was mentioned as placing a heavy emphasis on becoming a 'nurse or teacher'; another on other possible careers that lacked something for the participant:

> I didn't like a lot of the other careers that we'd been presented with and I wasn't really that interested in accountancy and was never really intrigued by being a policeman or a fireman, didn't really fancy being a stockbroker or any other kind of parasite...

Some had originally wanted to do something else as a career, such as art or architecture, but ending up as a researcher somehow: 'one thing led to another' or 'I changed my mind'.

Four participants laughed self-deprecatingly when explaining that they had ended up doing science (or biotechnology) because they did not get enough entry points to study medicine. To add a layer of complexity to their motivations, one had not wanted to 'waste' his/her relatively high university entry level points, and another had ended up deciding that s/he wanted to work in an area of human health without the 'gore' associated with clinical practice.

Some participants laughed to express their enjoyment with being a biotechnology researcher — in finding a specialism to pursue in their first year of study, ending up doing exactly what they wanted and had said they would do when they were 16, perusing an early liking for nature and biology and being able to follow it through to a research career, and 'sounding like a nerd' by expressing this enjoyment. The enjoyment did not seem to be associated necessarily with financial gain — one participant laughed as s/he said that s/he was 'unlikely to make a few million along the way, at least not in Ireland' — although at least one participant thought science to be a relatively safe career option.

This enjoyment would surely be apparent in the communication of their research. The suggestion by Small *et al*. (2007) that scientists describe the implications of their work within an intrinsic theme of 'the advancement of science' as an important social outcome on its own might be expanded here. Science, for these participants, is personally satisfying.

7.1.3 Motivated by the media

Media of various sorts appeared to have had a role in motivating some of the participants to take up their chosen career. Laughter in these cases was less wry and more mildly embarrassed that something seemingly trivial could have such a long-lasting effect. In the following quote, the participant credits Carl Sagan's television program *Cosmos*, which was broadcast in the 1980s in Ireland, with sparking an interest in science:

> Carl Sagan's *Cosmos* absolutely blew me away, like it was so, that was the, you know, it was left-of-field altogether, [it] absolutely enthralled me and I knew that science was…you know, so I've always [given] the science vote, but I must admit, it did tilt towards the astronomy side of things, but then I went over to the dark side of biotechnology...

Another participant tells the story about his/her avid reading of the *Irish Times* supplement 'Education and Living', which led more specifically to a career in biotechnology research:

> I used to read the 'Education and Living'supplements in the *Irish Times* on a Tuesday. My uncle used to collect them for me and cut them out for me. There was

> a guy called [name withheld] (he actually did his PhD under Martin in the NCTCC), and the *Irish Times* used to interview somebody working in a certain profession...he had done biotechnology and he was talking about his cancer research here and I just, you know when you just go ‘that’s what I want to do’? And I did. He was very inspiring...I’d be too embarrassed to say that to him. You know the name meant nothing to me at the time and I didn’t even actually realize, you know I kind of forgot about that after I did biotechnology and when I was in college...then it was only when I was working in the Centre and I saw his thesis and I said, ‘god, that’s the guy from, from the *Irish Times*’ and I’m doing exactly what I said I would do when I was 16.

One participant admitted to a fascination with dead bodies, but was also one of the participants who has also lacked the university entry points to study medicine, and discussed the glamorization of pathology with programs such as *CSI: Crime Scene Investigation*, a hugely successful television program that is part of a ‘franchise’ series of programs about forensic scientists in the United States. Another admitted to an early interest in genetics sparked by the 1993 film *Jurassic Park*, based on the Michael Crichton novel of the same name, about an amusement park containing dinosaur species recreated from DNA.

These media influences are fictional and non-fictional, dramatized and documentary. What they have in common is the communication of the fascination of science, and the enthusiasm of the presenter or author, which was communicated and taken up by the participant as a significant element in their own science communication environment. Presumably, and this was obvious to me at least as the audience for the communication in the interviews, these participants were in turn able to communicate this fascination and enthusiasm to others.

7.2 Communication practices: case studies

This section presents everything that was explored in the interviews with three individuals. The direct quotes presented throughout the rest of this thesis were chosen to provide some insight into being a biotechnology researcher in a participant’s own words. Those quotes were chosen to highlight specific points that are more generally applicable to many of the participants. This section, in contrast, presents three researchers from the NICB as case studies. Therefore, most of the three individuals' responses are quoted.

The case studies track each of the chosen participants through the entire interview and thereby provide a deeper understanding of what it means to be a researcher in a biotechnology institute in Ireland. The three participants were chosen according to criteria identified in Chapter 4, in which the NICB population was described in terms of, among other characteristics, age, sex, seniority, qualifications, and whether participants did research and teaching or research only, in order to represent the range of researchers working at the NICB (see Section 3.5).

Based on their overall characteristics, it made sense to describe the three participant case studies as 'the student', 'the senior researcher' and 'the research assistant'. The idea explored here is that these inherent characteristics are associated with both participants' identities as researchers and their communication practices.

7.2.1 The student

The student — a young woman under 25 years of age — had a Bachelor of Science and had been working towards getting a PhD for about one-and-a-half years. She was a member of one Irish professional organisation. She had spent approximately three-quarters of her working life in the university sector and one-quarter in the industry sector, but at the time of the interview considered herself to be in the university sector.

Overall, the student worked approximately 40 hours a week. During her last normal working week, she had spent 30 hours in the laboratory doing research, 5 hours reading or writing about research, 2 hours in meetings, 3 hours teaching and half an hour doing administrative tasks.

Communicating about science in general

The student stated that she was PRTLI-funded and that the funding body required her to communicate formally in written progress reports and abstracts, and by producing a postgraduate thesis/dissertation. In the past year she had attended two conferences, but had not made an oral or poster presentation at either event, and she had not submitted a manuscript to a peer reviewed journal. She had never participated in communication activities related to public policy.

Communication with colleagues within the same laboratory or research group or within the adjoining laboratory occurred several times a week for the student. She communicated with outside researchers once a week, but with researchers from groups affiliated with her own research group, presumably within the NICB but located at a different campus, only once a month. The student had spoken at non-scientific academic conferences, talked at schools or colleges, and participated in open days for the general public in the previous year, taking 3 hours, 3 hours and 2 days for both preparation and the activity, respectively.

The most important group to communicate with, if she had to, was doctors, as her work was on a human health/medical issue. The student said that she ‘wouldn’t mind either way’ if she was asked to talk to groups of non-specialists in the future, such as schools, interest groups and public meetings; however, she would not actively seek out such opportunities.

The student could see that there were personal benefits for her in communicating her research and its implications with the public, such as gaining experience in communicating and advancing the role of science. The personal disadvantages that she recognized were that communication can take too much time and that she might feel forced to take a particular stance.

In response to the statements about communication, the student felt neutral about whether scientists have a duty or responsibility to communicate, whether she herself felt that she had too little time to communicate due to job constraints, and whether she wanted to spend more time communicating to non-specialists. She tended to agree with the statement that scientists should report on social and ethical implications of their work when publishing. She also tended to agree that scientists should get help from funders and professional communicators for communication, and she strongly agreed that scientists should only publish findings when they are peer reviewed.

Out of the four articles that the student had been co-author on, which had been published in peer-reviewed journals, none had been mentioned in non-specialist media (i.e. non-peer-reviewed media — popular science media or general news media). The student's own work had never been the source or subject of a media story.

The student thought that the non-specialist public obtains information about scientific research and its social and ethical implications from the following sources:

- general interest magazines (e.g. women's or men's magazines)
- information published by campaigning groups (e.g. on environment and health)
- information published by charities (e.g Cancer Research Ireland, Irish Heart Foundation)
- local newspapers
- radio documentaries and current affairs programs
- radio news
- the 'popular' science press (e.g. *New Scientist*)
- the internet/websites
- television documentaries and current affairs programs.

Communicating specifically about research

The student operated as if she worked under a confidentiality agreement:

> I don't think there's any strict [agreement] I just talk as if I was [under an agreement]...in certain places you wouldn't talk about it, you know, that kind of way
>
> I wouldn't really have an issue [talking about my work with other biotechnology researchers], as long as I wasn't at a conference, and somebody was working on something that might be closely related to [my work]…

When asked if the agreement had an effect on how she talked about her research with non-specialists, she replied 'no'.

When she was asked to relate what happened the last time she communicated with a specialist audience about her work, she chose to relate a situation where she was obliged to give a talk to lecturers also located at the same site. As she was only

6 months into her PhD at the time, she gave what she described as an introductory talk on the topic. She thought that the lecturers had found her talk interesting and they had asked questions that were useful to her. Reflecting on her performance, the student thought that she could have communicated better in that situation — she had given the talk nearly a year prior to the interview and ‘at this stage now I’d be more confident...I know more about what I’m doing...you can always talk better [when you know what you are doing]’.

The student chose as her non-specialist communication situation a time when she had talked to and with secondary school students visiting the institution for a kind of open day. This had taken place a week prior to the interview. She talked to the students about what she was working on and its importance for human health. She thought that the students had been interested in what she had to say and that they would not have known beforehand what it means for someone to do postgraduate research. As one of the visiting students had expressed an interest in doing research in the laboratory over the coming summer, the student considered that she had received positive feedback. She felt that she had communicated well in that situation.

Recent media coverage of biotechnology-related topics had changed the likelihood that she would discuss her research with non-specialists. She considered that it was less likely for her to talk to non-specialists due to the coverage of cloning (animal or human) and stem cell research, and more likely due to the coverage about genetically modified foods and funding for biotechnology. Coverage of assisted reproductive technology made no difference to the likelihood of her talking to non-specialists.

> [For cloning and stem cell research] I don’t know, some people have very strong views on [those topics] and if you have the opposite view, it can be the cause of more hassles...

> [For the topic of genetically modified foods] I tend to speak to people that aren’t [knowledgeable]. If they hear one story off the news they don’t know what the other side of the story is...[in] some cases people hear a lot of the bad things about GM crops, but they don’t get to hear the good things...

> [For funding for biotechnology] ...because we need, there’s very little R&D in Ireland and we need people to, maybe, go towards that…

> [For assisted reproductive technology] I don't see anything really bad about that anyway, so I wouldn't have any issue with [talking].

Being a biotechnologist

(Note: This part of the interview, about career commitment and aspirations, is explored in more detail across the whole population in Section 7.3.)

The student did not necessarily consider herself to be a biotechnologist, even though she had a BSc that was specifically about biotechnology:

> ...I don't know really...I do a lot of things but I wouldn't categorize them under a particular area. I do genetics, I do immunology and I do a lot of molecular work as well. So the time when I did my BSc, I was in science originally in first year, [then] I transferred into biotech and basically it was a more specialized course, and as well, at the time, it led to better career opportunities.
>
> [She did not base this decision to transfer solely on improved career prospects] ...the biotechnology course seemed to be a lot more varied and to [apply to human health and 'real life'] as opposed to plant applications, which are the kind of thing that [I] would have been doing in biology.
>
> I always liked science [even in secondary school], but I think I was 17 or 18 years old, too young, when I filled in my CEO form; I had everything on it, business, maths, physics, and then I had a complete turnaround. [I had listed] business and marketing first of all, I think because that was trendy at the time, and then after my Leaving Cert[ificate] I realized that I didn't really [want to do that], I liked science, I'd been good at science and maths and stuff like that, so I changed the form. I think people are too young at 17 or 18 to decide what they want to do.

She had worked abroad for a 4-month period in the United States, and had taken part in cooperative research with people working in other life sciences-related fields, but not with researchers from other scientific disciplines or from non-scientific disciplines.

Despite nominally not calling herself a biotechnologist and being indefinite initially about wanting to work in research in the future, the student stated that ideally she would want to go on to do postdoctoral research after finishing her PhD:

> The research, I don't know, I'd like to. I love doing research. If you could, say, do a postdoc and do research in what you love and as well got health insurance and a

> pension and all that kind of thing, I'd love to do that. But, at the end of the day, it's a shame really because [I have] a lot of [interest in doing a] postdoc. And then the problem is that there isn't much R&D in Ireland, so you're talking 'going into manufacturing' really. It's a shame that. I'll probably stay with the science thing really, but, if I could get an R&D position here in industry, that would be perfect. I think I might do a postdoc after my PhD, I think after that, like, in terms of what I want out of life ... <laughs>...

The student was obviously tentative about communicating in areas of perceived controversy and in calling herself a biotechnologist. However, her youth and her experience of becoming a researcher at the NICB, served her well in communicating with younger people about her research and she had seen her own advances in her ability to do well in communicating more formally to peers. In some ways the student is clearly affected by the research she is doing in terms of it being biotechnology (otherwise, controversial topics in the media would not discourage her communication), but she also denies being a biotechnologist.

7.2.2 The senior researcher

The senior researcher was a man aged between 35 and 44 years of age, who had held a PhD for a period of time somewhere between 11 and 20 years. He belonged to two professional organisations. He considered his current position as placed within the university sector and had spent all of his previous working life within the university sector.

Overall, the senior researcher worked approximately 40 hours a week. During his last normal working week, he had spent 4 hours reading or writing about his or related research, 32 hours teaching or lecturing and 4 hours doing administrative tasks.

Communicating about science in general

The senior researcher stated that he was funded by the NICB and that the NICB required him to communicate about his research in the following ways: written progress reports and abstracts, oral presentations and written articles for specialists, and by facilitating students in completing their thesis or dissertation. He had not taken part in communication activities relating to public policy.

In the past year he had not attended any scientific conferences, but he had submitted three manuscripts to peer-reviewed journals as first author, all of which were still in press at the time of the interview. The journals he submitted to had much higher impact factors than the median impact factors for the subject area (Section 4.5.3).

Communication with colleagues within the same laboratory or research group occurred once a week for the senior researcher; with colleagues within the School of Biotechnology once a month; with an individual from a research group affiliated with the School of Biotechnology once a year or less often; and with a researcher from outside the organisation, several times a year.

In both preparation time and doing the actual activity, the senior researcher had spent 200 hours in submitting manuscripts to peer-reviewed journals, 50 hours writing and presenting research grant proposals, 2 hours talking at schools or colleges, and half an hour participating in open days for the general public.

The senior researcher nominated colleagues as the most important group to communicate with because he did not consider that what he does has large implications for society. He stated that he would be willing to talk to schools, interest groups and public meetings in the future, and added that due to his being on a scholarship when he was at university, he had been expected to give regular talks:

> ...[they] usually had one humanities speaker and one science speaker. Students came from a mixed background, so we always tried to make it interesting. Everyone wants to know about the human body.

Personal benefits in communicating his research and its implications with the public that were recognized by the senior researcher included the attraction of possible funding, the advancement of the role of science and of his career, and the opportunity for others to contact him for collaborative or other purposes. He did not think that any of the possible disadvantages of this kind of communication that were provided in a list (see Appendix 3, Card C5) applied to him, and he did not come up with any of his own disadvantages for this activity.

In response to the statements about communication, the senior researcher strongly agreed with the following statements:

- Scientists have a duty to communicate their research and its implications to the non-specialist public.
- Scientists should obtain assistance from professional communicators when communicating their findings to the non-specialist public.
- Scientists should publish findings only when they are peer-reviewed.

He also tended to agree that he would like to spend more time than he does communicating the implications of his research to non-specialist audiences.

The senior researcher tended to disagree with the following statements:

- Scientists should report on any social and ethical implications of their work when they publish their research findings.
- Scientists have a responsibility to communicate the social and ethical implications of their research to policy-makers.
- The day-to-day requirements of my job leave me with too little time to carry out my research.
- Funders of scientific research should help scientists to communicate research findings and their social and ethical implications to the non-specialist public.
- The day-to-day requirements of my job leave me with too little time to communicate the implications of my research to others.

However, the senior researcher paused to think about the statement ‘scientists should report on any social and ethical implications of their work when they publish their research findings’ because he thought that it might not be the scientists’ place to make these comments: ‘society should know enough to see the ethics involved’.

One of the two articles that the senior researcher had published in peer-reviewed journals had been mentioned in non-specialist media (i.e. non-peer-reviewed media — popular science media or general news media). His own unpublished work had never been the source or subject of a media story.

The senior researcher thought that the non-specialist public obtains information about scientific research and its social and ethical implications from the following sources:

- general interest magazines (e.g. women's or men's magazines)
- information published by campaigning groups (e.g. on environment and health)
- national newspapers
- computer magazines (e.g. *Computer Weekly*)
- the internet or websites
- television documentaries and current affairs programmes
- television dramas and films (e.g. soaps, fiction films)
- television news.

Communicating specifically about research

The senior researcher did not think that he operated under a confidentiality agreement associated with his current or recent research.

When he was asked to relate what happened the last time he took part in communication about his research to specialists, the senior researcher chose to talk about the last paper he had written — one of two that he had submitted within the same week, recently, within the last year. This, he said, meant that when it was published, he would be communicating to any colleague, anywhere.[27] The topic of the paper came about:

> ...from left-over research from a PhD student of mine who's gone a good few years now, but I had been reading his thesis again and I remember we used to argue about this particular aspect of his thesis as well, I thought there'd be something in it, but he didn't think so. I've over-ruled him now that he's gone [the proof will be] whether it gets accepted or not.

This particular aspect of the student's work had occurred towards the end of his PhD.

[27] In fact, the research paper was published in the journal he submitted it to in 2005.

Imagining that the paper had been published, the senior researcher discussed what he thought colleagues' reactions would be:

> I think it will, I hope it'll be well received because I think it is something new that hasn't been seen before and a lot of the things that go on in science is incremental, you know, bits and pieces, and I think this is a new phenomenon, which no one has [previously] observed. I'd be really disappointed if it wasn't <laughs> I'd start to really doubt myself. I'd be seeing things.

The senior researcher talked about the sort of feedback he would expect once any paper was published, and compared this to what would have happened in the fairly recent past (and also from my own experience, in the mid-1990s):

> I suppose the way most people do it and the way I would do it would be to just look at my citations. [We don't get people contacting us directly any more], we used to, I think now with electronic sources of papers, a lot more people have access to the original paper. In the past, you'd often get requests [for reprints]. That doesn't seem to happen now.

Commenting on whether he thought he communicated well writing for peer-reviewed journals, the senior researcher thought that he was 'reasonable at it'.

For the discussion about communicating with a non-specialist audience, the senior researcher chose to talk about a recent open day held at his institution for Science Week. He had volunteered to take mostly young people and their teachers around on tours of the facilities. He also spoke to them about:

> ...the DCU philosophy of what biotechnology is, because it's a word that can mean anything, and particularly the fact that we have a unique combination of biology and engineering...what they'd be letting themselves in for [if they enrolled in an undergraduate course].

During the open day, he had not really talked about his own research, except as a part of research at the larger institution. He had not received any formal feedback about the day, at least none specific to his own communication, but he 'had the general feeling that people were happy with it'. He thought that he had communicated well in that situation: 'I think so, I've been doing it for long enough <laughs>'.

Recent media coverage of the biotechnology-related topics of animal and/or human cloning, assisted reproductive technology, genetically modified foods and stem cell research had made no difference to the propensity of the senior researcher to discuss his research with non-specialists. This was because he considered that his research had only ‘a tenuous link’ to each of the topics. He also thought that it made no difference, even if non-specialists knew that he worked at the NICB, an institution with the word ‘biotechnology’ in the title.

However, recent media coverage of funding for biotechnology had made the senior researcher more likely to discuss his research with non-specialists, because:

> Well, if the whole issue of biotechnology comes up, being an engineer, I always try to explain to people what biotechnology is, and it’s more than sort of tinkering with cells and their genes and whatever. I’d certainly argue that it has to do with large-scale production of things...my connection with biotechnology is through large-scale production and the engineering aspect of it. So funding for biotech is funding for engineering in some ways.

Being a biotechnologist

(Note: This part of the interview, about career commitment and aspirations, is explored in more detail across the whole population in Section 7.3.)

The senior researcher did not consider himself a biotechnologist, but an engineer. When asked why he became a scientist, he replied:

> I just always wanted to, I suppose a lot of these things go back to your early childhood...I never really considered doing anything else other than simply science or engineering. And the reason I didn’t become a pure scientist I suppose was because when I left school it was in the early 80s, which was a terrible time in Ireland, you know, and it helped that engineering was a better option. But I always wanted to be a physicist really. [I’m glad I didn’t] because I would have been a very mediocre physicist, they’re too clever.

The senior researcher had worked abroad in the 1980s to do a 2-year Masters degree in the United States. He had taken part in cooperative research with groups doing research in life-science fields, but not with groups doing research in other scientific disciplines or with non-scientific disciplines.

When asked whether he would be doing research in the future, the senior researcher replied ‘I hope so’, but expressed concerns about the funding environment:

> ...the funding environment is difficult for everybody. There’s a lot of money, but there’s a lot more people doing full-time research. In a lecturing job, you’re really, you’re only kind of half treated, half-heartedly doing research in many ways...I like, I like what I’m doing because there is a lot of variety in a lecturing job and it’s a luxury.

The senior researcher, in contrast to the student, was confident and committed to the kind of formal communication expected of senior researchers at the NICB. He was a bit lukewarm in terms of communicating to non-specialist audiences, although he described himself as competent in doing so. Controversial topics in the media did not put him off talking about his research but only because he thought that his research was not related to any of the topics suggested. On the other hand, funding for biotechnology, a very pertinent subject given his grant writing activities, prompted him to communicate about biotechnology, albeit from an engineering perspective.

7.2.3 The research assistant

The research assistant was a woman aged between 25 and 34 years, with a Master of Science. She did not belong to a professional organisation. She considered her current position as within the Irish government sector and had spent all of her previous working life in the same sector. The research assistant was from a non-DCU campus of the NICB, which may explain her not considering herself to be in the ‘university’ sector.[28]

Overall, the research assistant worked approximately 40 hours a week and explained any overtime she might do from time to time as depending on ‘experiments [that] may take longer, so I stay until they are finished’. During her last normal working week, she had spent 28 hours in the laboratory doing research, 4 hours reading or writing about research, 4 hours in meetings, no time teaching, despite being involved in both teaching and research, and 4 hours doing administrative tasks.

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[28] The Institutes of Technology are third-level institutions, but not strictly ‘universities’.

Communicating about science in general

The research assistant stated that she was HEA/PRTLI-funded and that the funding body did not require her to do any communicating personally, but that they audited and communicated about their own projects. In the past year, she had not attended any conference or submitted manuscript(s) to peer reviewed journals. She had never participated in communication activities related to public policy.

Communication with colleagues within the same laboratory or research group occurred several times a week for the research assistant. On average, she communicated with a colleague within the NICB once a week, and with an individual from a research group affiliated with the NICB or a researcher from outside the NICB only once a year or less often. The research assistant had participated in open days for the general public in the previous year, which had taken her a total of 2 weeks of preparation and participation time.

When asked to nominate the most important group to communicate with, the research assistant chose schools because she thought that ‘secondary school students need to understand research careers in science’. She stated that she would be willing to talk to groups of non-specialists in the future about her research, such as schools and interest groups, but not public meetings or other groups.

The research assistant could see that there would be personal benefits for her in communicating her research and its implications with the public, such as gaining experience in communicating, attracting possible funding, advancing the role of science and her career, and as an opportunity for others to contact her for collaborative or other purposes. The personal disadvantages that she recognized were that she felt nervous about talking to the public and that she might feel forced to take a particular stance.

In response to the statements about communication, the research assistant strongly disagreed that the day-to-day requirements of her job left her with too little time to communicate the implications of her research to others. She tended to disagree that scientists have a duty to communicate their research and its implications to the non-specialist public and said that she would not like to spend more time communicating the implications of her research to non-specialist audiences.

The research assistant tended to agree that funders of scientific research should help scientists to communicate research findings and their social and ethical implications to the non-specialist public. She strongly agreed that:

- scientists should report on any social and ethical implications of their work when they publish their research findings and should only publish peer-reviewed findings
- scientists have a responsibility to communicate the social and ethical implications of their research to policy-makers
- scientists should obtain assistance from professional communicators when communicating their findings to the non-specialist public
- scientists should publish findings only when they are peer-reviewed
- the day-to-day requirements of her job left her with too little time to carry out her research.

Out of the two peer-reviewed articles published by the research assistant, one had been mentioned in non-specialist media (i.e. non-peer-reviewed media — popular science media or general news media). The research assistant's own unpublished work had never been the source or subject of a media story.

The research assistant thought that the non-specialist public obtains information about scientific research and its social and ethical implications from the following sources:

- local newspapers
- computer magazines (e.g. *Computer Weekly*)
- the Internet/websites
- television documentaries and current affairs programs
- television dramas and films (e.g. soaps, fiction films)
- television news.

Communicating specifically about research

The research assistant stated that she operated as if she was under a confidentiality agreement when talking to other biotechnology researchers: '...you wouldn't be able to go into the specifics, like mentioning specific drugs or [cell lines]'. However, when talking about her research with non-specialists, or, as rephrased by her, 'people in general':

> ...generally they wouldn't be interested. They're just like, 'oh, fine, don't want to hear it'. I suppose you do get some people that would be interested, [but] you wouldn't go into specifics anyway.

When she was asked to relate what happened the last time she communicated with a specialist audience about her work, she chose a presentation she gave to the laboratory on an aspect of her own work. This presentation had taken place 'a couple of weeks ago' and was part of a series where each person in the laboratory would get a chance to present their work. The aim of the series was to enable others to have input and to help the presenter with problem solving.

She thought that she had received a positive reaction to her presentation and some 'ideas and support', which she had found useful. However, when asked to reflect on whether she had been able to communicate well in that situation, she responded:

> I don't like presenting work. I don't, I mean, most people don't. I'm not comfortable with that kind of public speaking and stuff...I suppose because [I] don't do it often enough.

The research assistant responded sarcastically 'ah, there are so many' when asked to describe a non-specialist communication situation that she had been involved in, but chose a group of friends as the audience when pressed. Someone in the group of friends had asked her 'what are you doing now?' and 'the usual question, "what do you actually do all day?"'. It was, she said, a challenge to 'try to explain that to a group of people with four or five drinks on them' as the situation she was describing occurred at the pub.

The subject of the conversation was 'just general stuff, nothing specific, there's no point [talking about specifics]' and people in the group reacted differently to what she said. Some, she said, were probably 'sorry they'd asked in the first place', 'only a couple of people would be sort of interested in it', 'a lot of people would tune out, because they know I don't like talking about it' and 'I don't think people like talking about work when you're out for the night anyway'.

She did not get any feedback from that particular instance, although she did think that there were other times when she had been talking to non-specialists about her work and people had reacted by being enthusiastic ('wow') and interested ('that's really interesting'). Some non-specialists, in the research assistant's opinion, 'have a real interest in science, they would genuinely be interested in it, but there aren't many people like that'. In the situation at the pub, she thought that she communicated well because 'if people ask me questions, I would explain'.

Recent media coverage of the biotechnology-related topics of cloning (animal or human), assisted reproductive technology, genetically modified foods and stem cell research had made the research assistant more likely to discuss her research with non-specialists:

> I suppose it makes it more likely when, like, hot issues like that come up. People would tend to ask you questions, but then, I'd kind of like to avoid those people, but you can't...<laughing>

She thought that the topic of funding for biotechnology was unlikely to get coverage in the media. If it did, then she would probably be more likely to discuss her research, particularly if it was coverage related to NICB funding.

She described possible scenarios where she might be discussing her research with non-specialists, as a result of media coverage, as only occurring if someone asked her about it. She would never initiate such a discussion with a non-specialist because 'it just gets so complicated, you could be talking about it for hours'. As for non-specialists initiating the research-related conversations, she said: 'people would ask you questions; they'd just assume that because of your work you'd know everything about it'.

Being a biotechnologist

(Note: This part of the interview, about career commitment and aspirations, is explored in more detail across the whole population in Section 7.3.)

The research assistant did not consider herself to be a biotechnologist, despite the word 'biotechnology' being part of the name of the NICB, because she considered biotechnology to be related to industry; instead, she self-described as a biologist. She had been interested in biology from childhood 'since I was a kid I always interested in science' and thought she was good at it.

She had never worked abroad, but had taken part in cooperative research with people working in other life sciences-related fields, with chemists (people from other scientific disciplines) and with information and communication technology groups (people from non-scientific disciplines). She hoped that she would be doing research in 5 years time because she hoped to stay in research: 'I like doing it'.

The research assistant was most obviously involved in the types of communication activities that are associated with recruitment of students, and not involved at all in the formal communication activities that are a part of doing science. She did not appear to enjoy more informal communication about her work because of her perceptions of negative audience reactions. Although she would be more likely to talk about her work when 'hot topics' associated with biotechnology came up in the media, she was in two minds about whether to avoid such situations where she was asked questions about the science.

7.2.4 Comparing the case studies

There were striking differences between the senior researcher and the two more junior researchers in terms of type and level of communication undertaken. These differences between men and women and between senior and junior, often one and the same difference, have been apparent throughout the present thesis. For example, in Chapter 4 in terms of formal communication activities and confidentiality agreements, in Chapter 5 in the groups identified as important to communicate with, in Chapter 6 in willingness to communicate and recognition of the benefits of communicating.

The student, the senior researcher and the research assistant all spent similar amounts of time at work, yet they divided their time differently and gave communication different priorities. The junior researchers did bench work and communicated with non-scientists who were somewhat engaged with science (e.g. science students). The senior researcher wrote formally and communicated with colleagues and funding bodies.

Although all three of the case studies did approximately 40 hours in any normal working week, the student and the research assistant spent the bulk (approx. 75%) of their time (in the specific working week they were asked to describe) in the laboratory doing research, while the senior researcher spent his teaching, with no time at all spent in the laboratory in that week. All three spent approximately 10% of their time reading or writing about their research.

None of the three case studies gave presentations at conferences in the previous year or had been involved in communication about public policy ever, and only the senior researcher had submitted manuscripts to peer review in the previous year. The senior researcher had also spent a large number of hours in the previous year (250) in the more formal communication activities of writing manuscripts and grants, compared with a mere 2 hours talking to student groups. In contrast, the student and research assistant had spent 20 and 80, respectively, in the previous year in the less formal activities of talking to secondary school students and at open days, and no time in more formal communication activities.

The senior researcher chose ‘colleagues’ as the most important group to communicate with, although he claimed that he would be prepared to talk to anyone, and did just that during the specialist communication event he described — publishing a manuscript in a peer reviewed journal. The student chose ‘medical doctors’ as the important group to communicate with, but did not, and said she would not, seek out this kind of communication. The research assistant chose secondary school students as an important group to communicate with, was willing to do more of this in the future and to communicate with interest groups, but was definitely not willing to speak to public interest groups.

The senior researcher saw no disadvantages in communicating his work to non-specialists, whereas both the student and the research assistant were concerned that they might be forced to take a particular stance. An additional concern for the student was that it would take too much time, and the research assistant felt nervous about talking to the public.

All of the case study individuals strongly agreed with the statement that scientists should only publish their findings when they are peer reviewed. They were also all for getting assistance in communicating their research to the non-specialist public. None of the case studies actually worked under an explicit confidentiality agreement, although the student and the research assistant claimed that they acted as if they did. Either way, neither the student nor the research assistant thought that the (implied) CA had any effect on how they communicated with non-specialists, due to a lack of desire to talk to non-specialists in any detail and a perception that non-specialists would not be interested anyway.

The question that associated certain media topics with (un)willingness to talk about research was based on the assumption that a perception of greater topic controversy would be associated with reduced willingness to talk research with non-specialists. Actually, only the student felt this way. In contrast, the senior researcher thought that the topics were unrelated to his research (and therefore coverage would make no difference to his talking about it), or, in the case of the funding for biotechnology topic, were pertinent and would mean that he was more likely to talk about his research. The research assistant thought that coverage of any of the topics would make her more likely to communicate with non-specialists about her research; however, she said that she would try to avoid people who were likely to initiate such conversations and she would never initiate such conversations herself.

None of the case studies considered him or herself a biotechnologist — the student because she did not like to limit to a single category such a broad array of work (immunology, molecular work etc), the senior researcher because he considered himself to be an engineer and the research assistant because she thought that 'biotechnology' as a term was associated with industry and that she considered herself to be a biologist. Despite this, all of them hoped to be doing this kind of research in the future — the student as a postdoctoral researcher after her postgraduate degree — although the senior researcher expressed his concerns about future funding.

The case studies have shown in greater detail (than previous chapters which were about trends across the NICB population, rather than an examination of individuals) that a researcher's seniority and gender is associated with different types and levels of communication. It is impossible to tease out cause and effect from these data; however, McClam (2004) also found links between (she would say historically influenced and locally produced) gender and academic science and communication. It is difficult to say whether biotechnology per se has meant that communication has been particularly fraught for these three case study participants, particularly as none of then seemed to be particularly keen on identifying themselves as biotechnologists.

Glasner and Rothman (1999, 2004) suggest that the greater the distance from bench work in big science, the more likely an individual scientist is to express certainty about the robustness of the results and that '…attitudes near the laboratory bench are more complex and diverse than many commentators have assumed' (1999; p. 236). This could explain some of the variation in communication found at the NICB that is associated with seniority — more senior scientists are less likely to be doing benchwork, but are more likely to be communicating. In contrast, most of the hours spent by the student and the research assistant were in doing benchwork and they were less certain in their ability to communicate.

7.3 Career commitment and aspirations

This question explores whether the participants thought that they would be involved in biotechnology or other related research 5 years from the date of the interview. The idea was to explore the participants' sense of commitment to research, their enthusiasm and, in the negative cases, the reasons why some thought that they would not continue in research. My contention is that these future aspirations are linked with McClam's (2004) idea that participants' identities have an effect on their willingness to continue being researchers (how they feel about their work, how they fit with the culture of science), and how issues with the workplace can influence self-doubts about career progression (Hermanowicz 2003), but also how these things can influence willingness to communicate.

7.3.1 I *will* be doing biotechnology 5 years from now

Fifty-six out of 73 participants said that they would definitely be doing biotechnology or other related research five years from the date of the interview, and another two said that they would definitely *like* to do so, which is approximately four-fifths of the participants in total.

The following lengthy quote shows that this attitude can be part of a well-thought-out career strategy:

> I took 2 years out of research and while I was in that position I decided that research was where I wanted to be and now that I'm back in it I think I'm here to stay.
>
> ...probably the main reason I moved out of research was the lack of career structure for scientists. I was really disillusioned with it, I was on these rolling over 1-year contracts and I was just getting really fed up with it at the time and we were trying to buy our first apartment and it is difficult to get a mortgage when you've only got a 1-year contract. So those things kind of made me think: 'oh, do I really want to be doing this for the rest of my life?'
>
> So then I left and I got a job in the Health Research Board, which was a fully permanent, pensionable job and I stayed there for 2 years and for the first year or so it was interesting because it was a new position within the HRB and so it was kind of challenging in setting up new systems, but I got bored with it and I realized there was a part of my brain that I had been using before that had gone to sleep while I was doing that job. I missed that kind of stimulation.
>
> I am doing a lot of bench research now [and] the bench research isn't that stimulating in terms of sitting there pipetting things and, you know, the routine of it. [What's stimulating is] actually sitting down and coming up with the ideas...piecing together the results, piecing together the puzzle if you like, that's the part that I really enjoy, that and the coming up with the ideas in the first place, you know, seeing what other people have done...

Nearly all of the 'yes' participants talked about the enjoyment they got out of doing research, their continuing interest, their love of it, and the passion they feel for it: 'it's my kick', 'I love the job, seriously' and 'I love the research; if I didn't have to get my PhD I'd love it even more'.

Aspects of research that led to this enjoyment — ‘almost a compulsion’ according to one participant — included the:

- challenges and opportunities
- continuous learning (‘there’s so much we don’t know’)
- solving of problems and the hands-on practicalities
- variability (‘there is no end to it, which is good’)
- relative autonomy (‘no one is on your back’).

For many, the enjoyment came from doing something that they’d always wanted to do. For others, it was the feeling that they were doing something that has implications for human health and clinical benefits:

> I don’t think any one of us is going to make a major breakthrough, so it’s not from that point of view, but collectively, hopefully we can do something to come up with better treatments for people with diseases like cancer and diabetes.

Some participants commented that they had a lot invested in getting to this point in their career and that they would be very unlikely to change their area of research at this point, especially the chemists. These researchers did not want to start their training again. Some researchers considered themselves to be at the beginning of their training (e.g. post-undergraduate degree, but pre-postgraduate research assistants) and were looking forward to continuing. Others were hoping to do postdoctoral research, for example, ‘...because I’ve been doing it for the last 9 years [and I] can’t see myself moving out of Dublin now’.

Many were optimistic that the projects that they were currently working on would continue to develop and evolve to cover the 5-year period. One participant mentioned that s/he usually planned 5 years into the future anyway. The NICB itself was referred to positively in responses to this question, because it was a relatively new institution with a lot of potential, for example: ‘get good quality postgraduates and you’re made’ and ‘I can see the collaborative research really building up’.

However, some participants responded that, although they thought that they would be doing biotechnology 5 years in the future, they would not necessarily be doing it at the NICB. One participant thought that staying in the same place was not a wise career choice; but, in contrast, another participant thought that the new research and techniques s/he was using were new enough that they would still be exploring them in 5 years:

> I quite like the research and we're at an important time at the moment. I'm heading up a new [X] unit which is going to generate thousands of results that we're going to be analyzing for the next couple of years. We're also getting into [X] and we're really at quite a junior stage in all of that, so it's going to take a couple of years to get that up and running, and maybe a year or two extra to see the benefits…

Others thought that they might be working abroad (e.g. in Canada, in order to sidestep potential language barriers in Europe) or that they might get out of academia, start a small biotechnology company, and still be doing research 5 years from now, but with a commercial, rather than academic focus.

Alternatives to remaining in biotechnology research were not seen as attractive, consisting of quality-control production-line microbiology in industry, doing a Masters in Business Administration, or ending up in some kind of administrative non-research position. Even though the responses mentioned in this section are based on a 'yes' answer to the question of whether they thought they would be doing biotechnology research 5 years form now, participants mentioned negative aspects of doing so:

- the work is relatively secure, but dependant on funding and short-term contracts ('if it wasn't for the funding I would stay on for a lot longer')
- the work is time consuming and is not always rewarded with results
- very long hours are required, particularly for early-stage researchers — too long for some.

One participant summed up nearly all of the aspects of the 'yes' answer:

> I enjoy it most of the time, it's frustrating for a large part of the time, but there are those moments when it comes together and it's worth it. Secondly, I've invested a lot of my own time in training to reach this level, so it's not something that I would lightly walk away from. It's a relatively secure job at the moment. It could be better, but it's relatively secure, so there's an element of security.

7.3.2 I *might* be doing biotechnology 5 years from now

Eight participants responded with variations on ‘I don’t know’ and ‘I’m not sure’. The uncertainty for these participants was associated with the uncertainty of research and the relative stability of a job in industry. Some were currently in the throes of finishing their postgraduate degrees and could not think or answer beyond their graduation. Two were interested in related work — one in an administrative and pedagogical position at the university and the other in the field of medical and scientific writing (see below).

Interestingly, three of the ‘maybe’ participants mentioned Wyeth, a large pharmaceutical company dealing in drug discovery and development, including biotechnology products. It appears that Wyeth, and similar biotechnology companies, is seen as a positive career option for people with this kind of training who are more ambivalent about their current positions. This is in contrast with participants who were more positive (See 7.3.1) and who considered industry as ‘quality-control production-line microbiology’. All three responded that they were not sure if they wanted to work in research or in industry in the future. One stated that s/he liked doing research because ‘you find out one thing and something else changes, so it does keep your interest’.

One participant was concerned that Wyeth, or other large industrial groups, would not necessarily be looking for a senior research scientist like her/him and stated that, therefore, s/he might end up leaving Ireland if necessary if s/he went down the path of pursuing biotechnology as a career.

The perceived insecurity of working as a researcher, particularly at the level of postdoctoral research was a concern for one participant:

> ...the thing is, in a perfect world, one would like to be doing pure research [which is] very well funded and very well guaranteed, but [in terms of] career development, it’s just that sometimes there are other opportunities that people feel would give them a better career, or more stable environment...in a perfect world, you should be able to do pure research, but it depends on funding, on an awful lot of things...

The pressure of doing a postgraduate degree was taking its toll on two of the participants, which they expressed in responses that showed that they were unsure about their future in research. Both used the term ‘tough going’ and talked about the uncertainty associated with future work or postdoctoral positions.

Only two of the ‘maybe’ answers were associated with a desire to do a different kind of work. One participant’s initial plan was to take up a postdoctoral position and then consider doing research, but s/he was now leaning towards doing scientific and medical writing. Another already had a high-level administrative position at the university. S/he talked about her/his general interest in science and in things scientific, and that research and development currently informed a lot of her/his decision making in terms of program development in education. Being in research 5 years from now was a less likely prospect for these two.

7.3.3 I *will not* be doing biotechnology 5 years from now

Seven participants responded with ‘no’ or ‘probably not’. One had just taken an administrative post with the university, although s/he was still supervising research students, presumably until their graduation, and had been an academic and doing research for 17 years:

> I’m just better at [the administrative work] and I’m better at communicating to policy makers and writing stuff…I’ve always had a much greater interest in higher education in general and in the university, rather than my individual research. I’ve a far better understanding of it and I’m better at communicating it. I think it’s just where my talents lie… It’s really about including people, getting them interested in [the topic]. It takes a long time to get to [this point], I mean to do what I’m doing, you have to have credibility, [people need to know that you know] when you’re talking about the difficulties of research or things like that, you’re talking about it as someone who knows what writing papers is like, because I’ve done it and that makes a big difference. I think credibility is very important in the particular job that I [now] have.

The administrative role, for this participant, was largely about communication, but at a specific level, in policy areas. Interestingly, previous research work served him/her as a marker of credibility in new interactions with the research community.

One participant wanted to use his/her PhD as a 'gateway' to other sorts of work — middle or higher management — and was unhappy about the long hours required in research:

> ...it's the hard work and the long hours and the [lost] weekends and holidays and things like that and it's also the sacrifice that goes along with it, working those hours, it's what you're not there for. I would see a PhD as a gateway, so that I'm getting my lab work done now, out of the way, I will hopefully go into middle management, or even higher, I wouldn't see myself working in this in the future. I'm not too sure I have the kind of, the continued inquisitive spirit that's required for it...I'm not sure I constantly want to strive and search for the outcome...I just realize that there's more to life...

This participant recognized a kind of commitment, a 'continued inquisitive spirit' that s/he did not feel.

One participant was going though a particularly bad patch in his/her laboratory-based work, another could see that doing a post-doctoral research 'forever' meant a lack of job security ('no health insurance' and 'I want to have kids down the line') and thought that Ireland did not have enough in the way of biotechnology manufacturing companies for her/him to move to, although another of these 'no' participants thought that there were *more* manufacturing jobs than research jobs. Another participant wanted to work in the pharmaceutical industry.

The theme of insecurity with post-doctoral research came up again in another participant's talk:

> If you stay on in a post-doc for too long, in something like this, then it's kind of frowned upon, and you always get contract work, so you don't have any benefits really, so people tend to drift into industry. In fact I'm going to be leaving in the end of March and I'm trying to get another post-doc for a year [in X]...I was thinking like I might try it for a year and then when I came back the building would be ready...it'd make a difference with everyone in the same building.

This concern about post-doctoral research as insecure and the allure of working instead in industry, manufacturing or for pharmaceutical companies, was a reasonably common theme.

7.4 Summary

Being a research scientist in a biotechnology institute means different things to different people, although there are elements common to all, besides training and career structure. It is clear from the data presented in this chapter that communication is a significant part of being a research scientist, and that one's identity as a research scientist has an effect on communication practices, perceptions and attitudes. Some of the participants identified people (communicators) or communication events as early motivators for becoming a biotechnologist, but this association was rarely straightforward, and many described being drawn to science through inherent interest and aptitude. McClam's (2004) and Hermanowicz's (2003) claims that a scientist's perception of his/her identity will influence communication practice, perceptions and attitudes are borne out by the data presented throughout this chapter, but most specifically in the case studies.

The participants who stated that they would be doing biotechnology research 5 years from now had career plans, felt enjoyment, even a compulsion, about their work and could provide a long list of its positive aspects. They had 'always wanted to' be a scientist, they felt heavily invested in their training and career and, although they could also list problems with research as a career (e.g. funding-dependent, occasionally frustrating, long hours) they did not consider the alternatives to be attractive. None of them mentioned communication as a part of their career, but it is axiomatic that they would only progress in their careers if they participated in the 'doing science' type of communication at the least. They would also be more motivated to communicate, given their positive professional identities.

Beckwith (2002), a well-known bacterial geneticist and science activist with a particular interest in the social implications of science, describes his epiphany 15 years before [writing *Making Genes, Making Waves: A Social Activist in Science* in 2002] when considering his activism versus his science; the though: '"I really love this stuff, I love science". I had never explicitly expressed that thought before' (pp. 216–217):

> Today my excitement about my lab research is stronger than ever; I no longer dream of other lives. I feel more committed than ever to communicating the joy of doing science and to explaining its method…' (p. 217)

For Beckwith, the communication of the joy of doing science is both the means and the end. In the present chapter, participants express their love of science — why they became scientists in the first place (Section 7.1) and why they believed that they would be doing science 5 years hence (Section 7.3.1). Perhaps it is only due to a great deal of self reflection and experience in his activism that Beckwith explicitly linked his love of science with communication (after all, it took him nearly 30 years from receiving his PhD in 1961 to have his epiphany), but I hope that the NICB participants and other individual scientists might also consider the communication of the joy of doing science as the means and the end. Certainly, many felt delight in doing science.

The participants who were ambivalent about continuing mainly seemed to feel that way because of the downsides of doing research (e.g. funding-dependence) and that seemed to be why some of them were interested in Wyeth as a career option. Others mentioned communication-related jobs that they might be interested in pursuing — medical writing and education.

The only participant who thought that s/he was better at communicating science than doing research was going to leave research to do just that. However, s/he felt that a background in research was a good basis for this type of work — lending credibility to the communication of science and providing the opportunity to work at a high level in policy making. Both McClam's (2004) and Hermanowicz's (2003) proposals are pertinent in terms of the way the researchers told their 'future aspirations' stories.

Most participants wanted to continue doing research in the future. Any hesitation or ambivalence they felt appeared to be due to career issues, rather than the work itself. The complexities of influence of the institution on communication practice described in Chapter 4 seem to be borne out in this finding.

The clearest findings in the present chapter are from the case study material — that gender and seniority have a bearing on the types and levels of communication that researchers engage in. The senior researchers engaged in more formal activities, while less senior researchers engaged in less formal communication activities, or did not engage at all.

Chapter 8 Conclusions

In the present study, I set out to investigate the communication of science in the science communication environment (Van Dijk 1998) against the background of Jasanoff's idiom of the co-production of science (Jasanoff 2004a). My objectives were to show that individual research scientists engage in communication of their work and that this communication — its practice, their perceptions and their attitudes — is affected by institutional setting and audiences, that research scientists are influenced by communication, and, ultimately, that the communication environment is a dynamic space.

I was able to do this by exploring the communication of biotechnology by individual research scientists located at the National Institute for Cellular Biotechnology (NICB) in Ireland — how they understand communication, and engage with and communicate science. Using face-to-face semi-structured interviews, I gathered participants' responses to queries about their research area and professional practice, communication activities and attitudes, perceptions of media sources, coverage and effects, and recent and future communication events. The ensuing discourse was used to gain an understanding of participants' self-positioning in the landscape of the science communication environment. This chapter completes the study by discussing the findings, proposing future research and reiterating the importance of this kind of inquiry into the communication of science.

For all biotechnology researchers at the NICB, the audience is a significant component of the science communication environment. I found that women at the NICB tended to be younger, more junior and less qualified than men. Gender and seniority mattered in terms of identity and career issues, and for communication practices. Even if modern biotechnology provides greater opportunities to accept and exploit a communication framework of economic exchange and the maximizing of personal advantage, there was little evidence that these researchers do so. Some of the participants used the deficit model as a resource in their discourse, but nevertheless engaged in a wider range of communication practices that this suggests. This provides support for my contention that the science communication environment is an appropriate umbrella under which science is done via communication and other means.

8.1 Discussion

Chapter 4 provided evidence that the institutional part of the participants' communication environment had an effect on their communication. The busy working weeks described by the participants proscribed the time available for communication and even the formal communication that is a part of the doing of science had a relatively low priority for many of the participants. Teaching, however, satisfied the two personal drivers for the communication of science described by PSP (2003) — the recruitment and career answers.

It was clear that one's seniority and gender mattered in terms of communication as senior scientists did the bulk of the formal 'doing science' type of communication, were the highest ranked teachers, were more likely to belong to professional science organisations, hold patents, and access and communicate in the public sphere.

In the exploration of confidentiality agreements (CA) as part of the institutional setting, it was apparent that participants' communication was affected, even if they were not formally bound by a CA. The existence of CAs supports the assertion of Blumenthal *et al*. (1997) that modern science involves the withholding and restricted dissemination of research results, and also Lievrouw's (2004) suggestion that constraints on informal interpersonal interaction among researchers is growing. The analysis of CAs in the NICB supports the existence and partial application of the 'secrecy' counter norm (counter to Merton's [1973] norm of free and open exchange) proposed by Mulkay (1976).

However, Sunder Rajan's (2006) *frictioned* terrain where the corporatization of the life sciences is both 'rapid and hegemonic' and 'contingent and contested', mirrors Glasner and Rothman's (2006) claim that the commodification of science is reconstructing Mertonian norms and threatening 'science as public knowledge', but also has a progressive aspects because it 'opens the way to new solutions to human problems through the innovation process' (p. 90). These effects are not straightforward, nor are they mutually exclusive.

Chapter 5 provided evidence that the audience(s) part of the participants' communication environment had an effect on their communication. Again seniority and gender mattered to the NICB participants, with women tending to describe the social and political implications of their work within the extrinsic theme (Small *et al*. 2007) of health and men within the extrinsic theme of economics. All of the sociopolitical and personal drivers (Stocklmayer *et al*. 2001, PSP 2003) for the communication of science were represented in the participants' responses to queries about audiences.

In this chapter, both the relatively new framing proposed by Lievrouw (1998) — that science communication is viewed within a framework of economic exchange and the maximizing of personal advantage — and the older framework she suggested was being replaced — a framework of sharing meanings and reinforcing social ties — were applicable to participants' responses. This finding formed the beginning of the conjecture that there are differences when referring to (framing) 'big' science as a homogenous, corporate and government-controlled mass, and a smaller science of the individual scientist or research institute. Framings are obviously not as clear-cut as 'either/or', but would be better conceived of in terms of 'and depending on the circumstances'.

Waterton *et al*. (2001) and Waterton's (2005) suggestion that scientists are indeed able to communicate the contingent nature of science under certain circumstances came out strongly in this chapter on audiences. This is particularly clear when the formal, less formal and informal modes of communication in which a researcher may engage with specialists, non-specialists or both, were considered and compared.

Seniority and gender mattered in the findings described in Chapter 6 on consequences for individual scientist-communicators, their communication practices, perceived advantages and constraints. Senior participants, a larger proportion of whom were men, did more communicating, did more formal 'doing science' communicating, and were less preoccupied with self-confidence, fears about potential audience reactions and public speaking nerves. Junior researchers, a larger proportion of whom were women, made greater use of the deficit model of science communication as a resource in their discourse about communication (Hilgartner 1990).

Stocklmayer *et al*. (2001) and PSP's (2003) sociopolitical and personal drivers to communicate were explored again in this chapter as these drivers have implications for the individual scientist communicating. It emerged that a reasonably high proportion of researchers had some link with research mentioned in the non-specialist media

Again, in Chapter 7, one's seniority and gender were shown to matter in terms of communication. This was most apparent in the case studies, where it was even more obvious than it was in Chapter 6 that the senior researcher (male) was influenced by aspects of the communication environment that were strikingly different from those influencing the (female) research assistant and postgraduate student. Identity also mattered in other ways, providing support for McClam (2004) and Hermanowicz's (2003) conjectures linking scientists' perceptions of identity and their communication practice, perceptions and attitudes.

The notion that I have used here of the science communication environment, in which scientists and others communicate in doing science, can be described by a multitude of science communication models ranging from deficit to dialogue. As such, the science communication environment concept is rich for descriptive purposes, but relatively poor for predictive purposes. Nevertheless, several interesting findings have emerged from the descriptive process, which have implications for the variety of communication that may occur in institutional settings, with different audiences and with reciprocal consequences for individual scientists and their identities as researchers.

Constraints on communication occur, that is evident in participants' responses and expected, given normal social and personal expectations involved in doing biotechnology. There is something about biotechnology that makes it a fraught area for communication, and not just due to the prominence of the gene in the general media and the scientific press (Keller 2000), although I would agree with Keller that the Human Genome Project (for example) transformed expectations and challenged biological thought. In terms of communication, the Human Genome Project looked to the interested observer to be both tightly controlled and a bun fight between proponents and opponents, with communication dependent on ascendancy in the press.

Glasner (2004) in his conclusion (pp. 311–315), suggests two reasons why biotechnology is a fraught topic: that the commercialisation of biotechnology has meant that its promise has often exceeded its delivery, and that that large variety of stakeholders in biotechnology (politicians, scientists, non-government organisations, socioeconomically disadvantaged people and big business etc) commonly coupled with misconceptions about its implications, has created an environment of heightened sensitivity. I think it is clear from the discourse of the NICB scientists that these two issues are combined in their horror of the potential for the communication of false hope.

It was not as obvious to me, prior to the present study, that the researchers at the NICB might communicate about their work, related science and science in general, and do so from a variety of perspectives, and not just about the 'facts' of their research. In addition, the different types of communication that was described and the participants' attitudes towards it might be fit into science communication models across the spectrum. Crucially, the deficit model style of communication was present, but did not dominate — the younger participants in particular used it as a resource in their discourse, but not to the exclusion of other modes of communication.

Sturgis and Allum (2004) challenged 'the de facto orthodoxy that has connected the deficit model and contextualist perspectives with quantitative and qualitative research methods respectively'. In their argument, they brought together four points to be covered in the communication of science, which were based on Wynne's (1992) elements of the public understanding of science and Miller's (1998) concept of what constitutes scientific literacy:

- scientific knowledge and constructs
- how science happens (process)
- where science comes from (how it is organised, funded, controlled)
- what kinds of impacts science has on individuals and society.

My contention is that when these four points are communicated in the science communication environment, scientists and non-scientists can engage fully with the doing of science. There is robust evidence from the present study that individual biotechnology researchers do indeed cover the four points when they communicate about their work.

If the science communication environment is considered from the perspective of the institution (explored in Chapter 4), then the associated formal requirements and organizational constraints mean that the 'doing science' type of communication (formal, legitimate, required) is given a premium. 'Doing science' communication is about scientific knowledge and constructs and, to a degree, process, but is not about where science comes from or its impacts on the social and natural world. However, if the science communication environment is considered more broadly, then it is clear that scientists as individuals do communicate and across the range of communication modes.

The biotechnology researchers at the NICB communicate across the range with each other in less formal and informal situations, and with non-scientists in a variety of contexts (Chapter 5). This occurs despite the sometimes pessimistic attitudes of the participants in the present study about their non-scientific audiences — the repetitiveness of the communication required, how non-scientists latch on to issues of human health so that other aspects of science are downplayed, and the superficial understanding of science and its constructs that non-scientists can have, and on which they base their opinions about the other three points. There was evidence that the participants regarded non-scientific audiences as *different* to scientific ones (to be handled differently), but little evidence for their *disregard* (which Bauer *et al*. (2007) suggest can explain misguided communication efforts that alienate the public). However, this attitude did occasionally surface, particularly if a participant was discussing 'the public' as (mis)informed by 'the media'. Overall, the participants had a respect for the non-scientist audiences (Chapter 6) It should be acknowledged that the participants in the present study may well be experts in the first two points in regard to biotechnology and related science, but they are likely to know just as much about where science comes from as an interested non-science enquirer and have equal footing in regard to speculation on the impacts 'their' science may have on individuals and society. The NICB Director's communication in the public sphere urging the Irish Government to reject research involving the destruction of human embryos is a case in point.

There is clear evidence in the analysis of the NICB population as a whole, and in the more detailed analysis of the case study material, of differences between senior and junior, and between men and women, in the types and levels of communication that takes place. Men do more of all types of communication, but this phenomenon is most striking in the premium communication associated with 'doing science'. Junior participants did not want to initiate communication and this insecurity was associated in their discourse with a deficit model-style of outlook, in which participants communicated only when they felt obliged to do so, and in situations where they felt they were rectifying an information deficit (*I will communicate if I have to and when I do it will be because 'they' have an information deficit*). The outlook of senior participants, in contrast, was associated in their discourse with the other end of the science communication model spectrum (*I actively seek out opportunities to communicate, listen to and engage with others, assist them to have more control over science and the knowledge etc*).

McClam (2004) compared the conversations she had with female academic scientists with those she had with male academic scientists and found that 'women felt far more constrained or limited…there was a greater gap for the women between their images of themselves and their images of academic scientists' (p. 239). So too, it seems, are junior scientists constrained and limited. McClam's proposed solution was to 'denaturalize these historically narrow definitions [of academic science]…create broader, more flexible, and more inclusive spaces for being an academic scientist' (p. 241). Analysis of the discourse used by participants in the present study, when they told their different stories of future aspirations, showed that their identities as research scientists, women or men, young or not so young, were bound up with their communication practice.

The sociopolitical drivers for the communication of science proposed by Stocklmayer *et al*. (2001) — economic, utilitarian, democratic, cultural and social — and the personal drivers ('answers') proposed by PSP (2003) — sharing, recruitment, science and society, pragmatic, career and personal satisfaction — were all represented in the discourse of the participants. In addition to these, for the participants in the present study, there was something else going on. Particularly when the participants were talking about human health issues, it became apparent that another driver/answer could be added to the lists — the humanist driver, which is not covered by the social driver or the science and society answer.

The humanist driver — 'humanist' defined as seeking rational ways of solving human problems and behaving as a responsible and progressive intellectual being — for the communication of science is, in regard to the participants in the present study, a response to the human health focus of much of the research that is done at the NICB. However, it could also be associated with a humanist drive to communicate about environmental issues, such as shown by Rier's (2003) toxicologists communicating about potential exposure to toxins in the environment. This could also include McClam's (2004) ecological scientist who is constrained in communicating about the negative ecological effects of logging, and the environmental scientists interviewed by Waterton *et al*. (2001) and Waterton (2005).

Human health and the environment are examples of key issues for someone behaving as a 'responsible and progressive intellectual being', within the context of their work 'seeking rational ways of solving human problems', to communicate. This humanist outlook is apparent in the nearly universal agreement (in the present study and the two UK-based surveys of scientists) with statements about the duty and responsibility of scientists to communicate. This is not something new in the context of scientific research, but perhaps it is an outlook that is seldom recognized and poorly developed in areas where skills in science communication might be cultivated. Many models of science communication neglect this important aspect of individual researchers communicating science.

In the context of biotechnology, there is a kind of 'duty of care' flavor to the humanist driver that I am proposing. This manifested most strongly, in the discourse of many of the NICB researchers, in the nearly painful desire to avoid the giving of false hope to people with cancer or diabetes and their carers. It might be speculated that the humanist driver is predicated on a dialogue model of science communication — the motivation behind the driver requires that scientist–communicator engages with the other.

It is difficult to reconcile the humanist driver with Lievrouw's (1998) view that the communication of modern science should be viewed within a framework of economic exchange and maximizing of personal advantage, although there is some evidence for this framing within the findings, particularly as they relate to the institution (Chapter 4). Perhaps this framework applies in circumstances where, for example, communication is bound up with commercial transaction within science or between science and industry. Lievrouw's model takes a broad-brush approach, which does not take into account that individuals might be motivated to do science because they wish to behave as 'responsible and progressive intellectual beings', where being responsible and progressive is a stronger driver than economic and personal advantage. Perhaps this aspect of doing science could be incorporated into Lievrouw's model to add a subtlety that is lacking --- as I suggested in Chapter 1:

> The exploration of alternative science communication models led me to reject them as insufficient to account for science communication as a whole, but to accept them as sufficient to account for aspects of the science communication environment.

The sharing of meanings and the reinforcing of social ties is obviously important to the NICB researchers communicating more widely in the community. Also, many participants expressed their ambivalence about the style of communication associated with economic exchange and the maximizing of personal advantage. Many mentioned that they were originally motivated to take up research for humanistic reasons.

8.2 Reflections on the methodology

The mixed methods approach was rewarding because it provided information about macro trends, such as the differences found between junior and senior, woman and men, and also about the individuals within the categories identified. In retrospect, it would have been useful to link an individual's responses more strongly with their categorical groups, so that, for example, more complex cross tabulation of the data could be possible. Ultimately, though, the data of the most interest to me was the narrow and deep qualitative data that came from the participants' dialogue.

It was fitting to have the entire population of the NICB as the study population, to minimise biases that might have been introduced due to sampling error. It was a large enough group to provide robust evidence of macro trends. The study could be usefully extended to similar-sized institutions in the future for comparative purposes, or as stand-alone research.

Using scientists' own discourse was a fruitful methodology because it allowed participants to tell the stories that have had an effect on *their* science. For example, someone (discussed in Chapter 5) thought that communicating their 'lovely results' led to a cascade of beneficial consequences, and (in Chapter 4) someone else had felt keenly the outcome of talking openly about their research to another biotechnology researcher, with similar work being published by the other researcher. In addition, scrutiny of laughter in participants' responses provided insights about their communication in relation to their identities (in Chapter 7).

8.3 Conclusions and future research

This study presents some issues that merit future investigation. It would be useful to make explicit the links between third-level education of scientists and communication practices. For example, only one participant — the senior researcher case study — talked explicitly about the incentive for him to give semi-public lectures as a student to other students from different backgrounds. He had to 'make it interesting'. I am not suggesting that communication should be compulsory, just that any links between early training and communication during one's career might be teased out. This information could then be used to provide scientists with the resources to draw on if they have the will and the opportunity to communicate.

As has been shown in the present study, many scientists do communicate in informal contexts across the range of the four points to cover in the communication of science (see above). It may be that, in such contexts, the first two points — scientific knowledge and constructs and the processes of science — are relatively minor components of scientists' discourse and the origins and impacts of science are paramount. This could be pursued in more detail, possibly using direct observation or immediate recording methodologies, to capture the moment.

One participant made the observation that, as someone who had worked at a high level in science, he was well-placed to move into science policy work because he had gained the credibility to have his communication taken seriously. He knew ‘what writing papers is like’. People who had made a similar move from high-level science into the boundary work of science policy could be identified, and this communication credibility explored from both sides of the boundary.

This research explores the communication of science within an Irish context, which has potential cultural significance. Further research could consider these findings in other situations and cultures. In Ireland, and particularly Dublin, the opportunities for science communication are presented within a science communication environment that includes locally produced and consumed media, and a generally homogenous cultural setting. Culturally dominant modes of communication and gender roles may have had a bearing on the findings in the present study, so further research that compares the NICB with similar institutes elsewhere would be relevant.

Personally, I would be interested in investigating the differences between men and women in their claims about operating under confidentiality agreements. It would be interesting to explore Huckin’s (2002) manipulative silences in this context, that is, the deliberate concealment of relevant information. Do women do this, but not acknowledge it? Do men do this to a greater degree, even when they are not obliged to do so? If so, why?

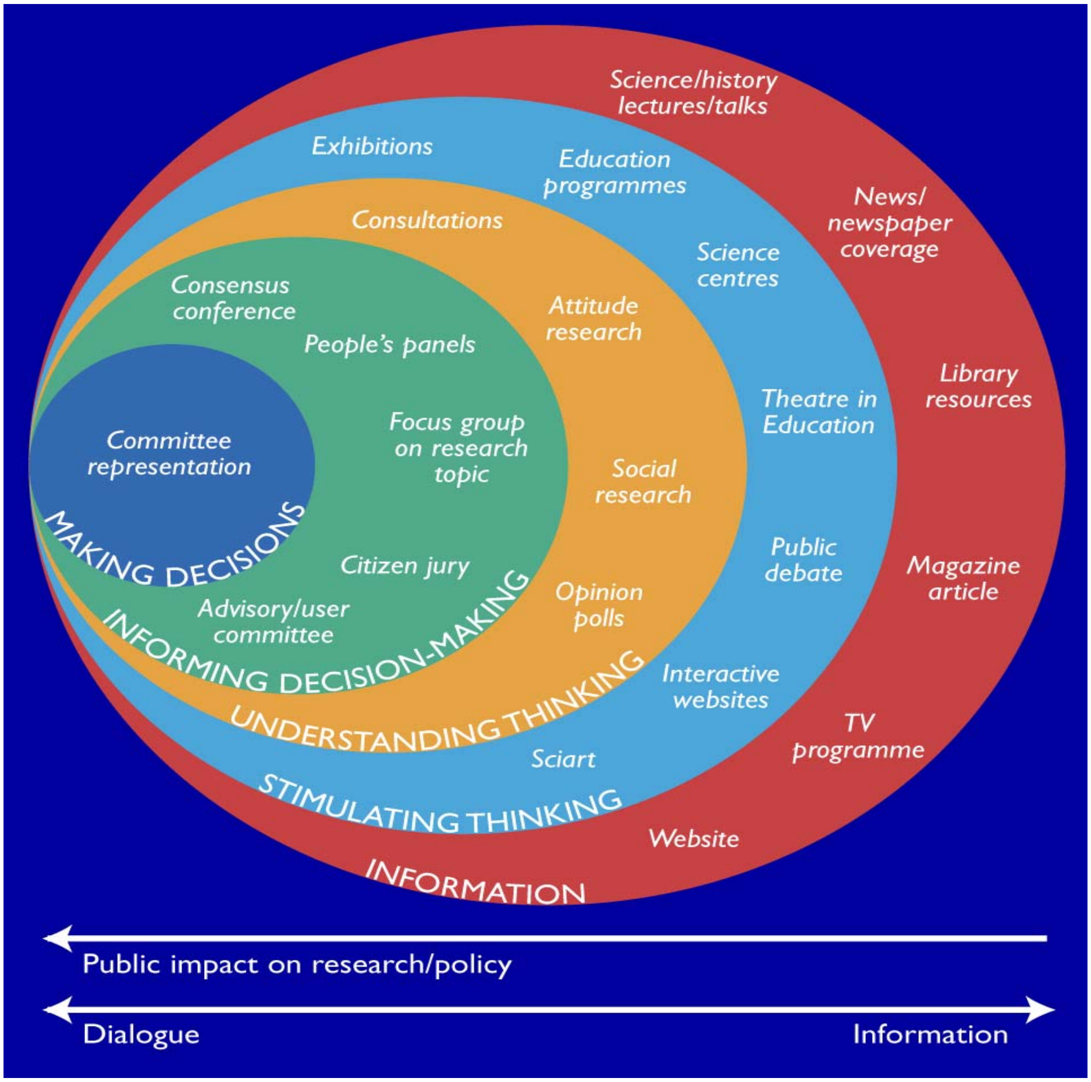
8.4 Aspirations for the research

The communication of science becomes more important as science seeks to tackle climate change in the policy arena. This is keenly felt in countries such as Australia, where the effects of drought, peak oil and rising sea levels have already begun to be addressed at all levels of government and in broader public discourse. As a cautionary tale, Wynne in 2007 discussed an earlier finding that relevant research actually existed to assist Cumbrian sheep farmers in reducing the radiation load in their sheep following fallout from the Chernobyl nuclear reactor accident, but the research had been overlooked.[29] Communication across the deficit–dialogue spectrum is the key to avoiding similar mistakes in the future, and ensuring that social and policy decisions can be made under the best possible conditions. Unfortunately, as Bauer *et al*. (2007) note: '...in all but a few countries, little is done to prepare scientific researchers for communication activity with lay audiences, despite the commitment expressed in official documents' (p. 88).

The present study has not been an exercise in comparing biotechnologists making discourse with purportedly superior or inferior conceptions of making discourse. Neither should these findings simply add to the stockpile of descriptions about the social in biotechnology. I believe that the findings may be generalised or transferred to other arenas, but I hope that they will also enable us to reflect on the constraints on discourse in science and seek to overcome them.

[29] Canadian Broadcasting Corporation (2007) *How to Think About Science, Episode 10, Brian Wynne*. (Available from: http://www.cbc.ca/ideas/features/science/index.html#episode10)

Appendix 1 The onion



Source: Clare Matterson, Director of Medicine, Society and History, Wellcome Trust, personal communication, 2005.

Appendix 2 Interview schedule and question revisions

This appendix contains the final interview schedule and documentation of the changes made to some of the schedule in response to the pilot interviews.

A2.1 Interview schedule

Code:

____

Day of interview:

Mon Tue Wed Thur Fri Sat Sun

Date of interview:

(day)	(month)	(year)

Length of interview (min):

____

Thank-you for taking the time to do this interview today.

I'll be asking you 3 types of questions:

1. yes/no questions;

2. multiple choice questions; and

3. a few where I would like you to answer in your own words.

For the yes/no questions, you will always have the option of answering “I don’t know”, and in all cases, if you do not have an answer for any of the questions I ask, please say so.

For the multiple choice questions, some will require **only one answer**, while for others you will be able to **choose more than one option**. This will be clear to you when the question is asked.

Many of the questions that you’ll answer in your own words are near the end. I will be keeping an eye on the time, so if we go over time, I may stop you. Please don’t think that I am not interested in your answers. In fact, if it suits you, we can continue after this point.

I should mention that I will also be taking notes, just because I don’t like to rely totally on the recording equipment.

A1. Sex

Male	1
Female	2

A2. What age group do you belong to? Stop me when I get to the group. READ OUT

Under 25	1
25–34	2
35–44	3
45–54	4
55–59	5
60–64	6
65+	7

A3a. Approximately how many hours a week do you work, in an average week? WRITE IN

[   ] hours

ASK IF **>40 HOURS** IN A3a

A3b. That is more than a 40-hour week, why do you work longer than this? WRITE IN

A4. What is your official position? WRITE IN

A5a. Which is the highest educational or professional qualification you have obtained?

Bachelor Degree or equivalent	1
Masters	2
PhD or higher	3
Other (WRITE IN)	4

ASK IF THEY **DO** HOLD A PhD OR HIGHER QUALIFICATION IN A5a

A5b What year did you get your PhD?

1 year ago or less	1
>1–2 years ago	2
>2–3 years ago	3
>3–5 years	4
>5–10 years ago	5
>10–20 years ago	6
More than 20 years ago	7

A6a. Employment function

Teaching and research	1
Research only	2
Other (WRITE IN)	3

ASK IF **TEACHING** CHECKED IN A6a.

A6b. What type of teaching do you do?

Lecturing full-time	1
Lecturing part-time	2
Lecturing occasional	3
Tutoring/demonstrating	4
Other (WRITE IN)	5

A7a. What is the <u>principal</u> source of funding for your research? ONE CODE ONLY

European Union	1
Irish Government	2
University	3
Industry/Private	4
Charity	5
Other (WRITE IN)	6
Not funded	7

A7b. Please list any other sources of funding. WRITE IN

A8. In what ways do these organisations require you to disseminate information about your research? Please look at **Card A8.** MULTI ANSWERS OK PROVIDE **CARD A8** WRITE IN?

B1. What is your main research area or areas? Please look at **Card B1**…these definitions are intended to be indicative rather than exclusive. If you feel that they exclude relevant areas of research in which you are active, please indicate this in your answer MULTI ANSWERS OK PROVIDE **CARD B1** WRITE IN

____

____

____

B2. Are you a member of any professional science organizations? Please specify. WRITE IN

____

____

____

B3a. Which of the sectors (on **Card B3**) would you describe yourself working in in your <u>current</u> research? Just read out the code letter. MULTI ANSWERS OK, PROVIDE CARD **B3**

____

____

IF **D** 'OTHER' PROBE FOR LOCATION IN DEFINED CATEGORIES

B3b. Still looking at **Card B3**, what <u>percentage</u> of your entire working life have you done research in any of these sectors? Please give your best estimate. PROVIDE CARD **B3**

Irish Government	%

University	%
Industry/Private	%
Other (specify) ……………..	%

IF **D** 'OTHER' PROBE FOR LOCATION IN DEFINED CATEGORIES

B4a. Have you ever worked in research abroad? CIRCLE

Yes No

B4b. If so, in which countrie(s) and for approximately how long (in months)? WRITE IN

B5a. Have you ever taken part in cooperative research with groups doing research in fields other than your own (on **Card B1)**? PROVIDE **CARD B1** WRITE IN

B5b. What about with other scientific discipline(s)? WRITE IN

B5c. What about with other non-scientific discipline(s)? WRITE IN

____

____

____

B6. Think back to your last normal working week. How many hours did you spend…(up to approx. 40 h WRITE IN)

In the laboratory doing research	
Reading or writing about your (or related) research	
In meetings with colleagues	
Teaching/lecturing	
Administrative tasks	
Other (specify)…………………	

B7a. Have you or your group applied for any patents? CIRCLE

Yes	No

B7b. Were you successful in your application(s)? CIRCLE

Yes	No

B8. Thinking back over the past year (I mean to THIS MONTH LAST YEAR), over the year, did you…

B8a. Attend any scientific conferences? CIRCLE

Yes	No

B8b. If so, which one(s)? WRITE IN

B8c. Did you present a paper or a poster? TICK

Name of conference/meeting	Paper	Poster	No

B9. Again, thinking back over the past year (TO THIS MONTH LAST YEAR), over the year, did you…

B9a. Submit one or more manuscripts to peer-reviewed journals as first author? CIRCLE

Yes	No

B9b. If so, which journal(s)? WRITE IN

B9c. Was it (WERE THEY) accepted and published? TICK

Name of journal	Yes	No	Inpress

B10. Again, thinking back over the past year (TO THIS MONTH LAST YEAR), over the year, did you…

(a) Submit one or more manuscripts to peer-reviewed journals as a co-author? CIRCLE

Yes	No

B10b. If so, which journal(s)? WRITE IN

B10c. Was it (WERE THEY) accepted and published? TICK

Name of journal	Yes	No	Inpress

WOULD IT BE POSSIBLE FOR ME TO HAVE A LIST OF YOUR LAST 5 PUBLICATIONS (AS AUTHOR OR CO-AUTHOR)

None	4

B11a. How many articles have you ever published in peer-reviewed journals as first or co-author (please give your best estimate)?

1 to 10	1
11 to 30	2
More than 30	3

B11b. ASK IF MORE THAN NONE IN (a)

How many of these articles have been mentioned in non-specialist media (non-peer-reviewed; e.g. popular science media or general news media)?

None	1

1 to 2	2
3 to 5	3
More than 5	4

C1. I am going to read out a list of individuals. Please look at the scale on **Card C1** and tell me how often you talk about your research with them. PROVIDE CARD **C1**

A colleague within your laboratory or research group	
A colleague within YOUR ORGANISATION (please define this)	
An individual from a research group affiliated with YOUR ORGANISATION	
Other researcher	

C2a. This is a question about time spent on communication activities… Which, if any, of the activities on **Card C2** have you participated in in the last year? PROVIDE CARD **C2**; MULTI ANSWERS OK; IF M 'OTHER' WRITE IN

C2b. IF ANY ANSWER EXCEPT N OR O, Still looking at **Card C2**, about how much time MEASURED IN HOURS and including preparation time did you spend on these activities? Please give your best estimate

C3. Looking at **Card C3**, which, if any, of these communication activities relating to public policy have you ever participated in? PROVIDE CARD **C3**, MULTI ANSWERS OK; IF **C 'OTHER' WRITE IN**

C4. Looking at **Card C4**, what PERSONAL benefits, if any, do you see in communicating your research and its implications to the public? PROVIDE CARD **C4**; MULTI ANSWERS OK; IF G 'OTHER' WRITE IN

C5. Looking at **Card C5**, what PERSONAL disadvantages, if any, do you see in communicating your research and its impactions to the public? PROVIDE CARD **C5**; MULTI ANSWERS OK; IF F 'OTHER' WRITE IN

C6a. Do you operate under a confidentiality agreement associated with your current or recent research?

Yes	1
No	2
Don't know	3

ASK IF 'YES' IN c6A.

C6b. In your own words, how does this affect how you talk about your research with other biotechnology researchers?

C6c. In your own words, how does this affect how you talk about your research with non-specialists?

C7. Please look at the scale on **Card C7**…how strongly do you agree or disagree with the following statements? PROVIDE CARD **C7**; READ OUT A – I ROTATE ORDER AND TICK START

A	Scientists have a duty to communicate their research and its implications to the non-specialist public	
B	I would like to spend more time than I do communicating the implications of my research to non-specialist audiences	
C	Scientists should report on any social and ethical implications of their work when they publish their research findings	
D	Scientists have a responsibility to communicate the social and ethical implications of their research to policy-makers	
E	The day-to-day requirements of my job leave me with too little time to carry out my research	
F	Funders of scientific research should help scientists to communicate research findings and their social and ethical implications to the non-specialist public	
G	Scientists should obtain assistance from professional communicators when communicating their findings to the non-specialist public	
H	Scientists should publish findings only when they are peer - reviewed	
I	The day-to-day requirements of my job leave me with too little time to communicate the implications of my research to others	

D1. Card **D1** has a list of sources of information.

Which, if any, would you say the non-specialist public uses to obtain information about scientific research and its social and ethical implications? (By non-specialist public, I mean people with no specialist knowledge of, or training in, science). PROVIDE CARD **D1**; MULTI ANSWERS OK; IF Q ‘OTHER’ WRITE IN

D2a. I am going to read out some topics of recent media coverage. Please look at the scale on **Card D2** and tell me if the coverage has made you more or less likely to discuss your research with non-specialists, or has it made no difference?

PROVIDE CARD **D2**; READ OUT THESE TOPICS AND WRITE IN ANSWER CODE

(i)	Cloning (animal or human)	
(ii)	Assisted reproductive technology	
(iii)	Genetically modified foods	
(iv)	Stem cell research	
(v)	Funding for biotechnology	

D2b. You said that media coverage of **INSERT TOPIC** has made you (***more likely to/less likely to/made no difference)*** discuss your research with non-specialists.

Why do you say that?

PROBE FULLY FOR WHY COVERAGE DOES OR DOES NOT AFFECT COMMUNICATION

(i)

(ii)

(iii)

(iv)

(v)

D3a. Have you or your work ever been the source or subject of a media story? CIRCLE

Yes	No	IF **YES**, CAN I HAVE THE DATE/OUTLET ETC SO I CAN RETRIVE THE ARTICLE/BROADCAST?

D3b. If yes, and looking at **Card D3**, in general, how satisfied have you been with the coverage? PROVIDE CARD **D3**; WRITE IN ANSWER CODE

E1a. If you had to communicate your present research and its social and ethical implications, who do you think would be the most important group to communicate with? PROBE FOR NATURE OF GROUP. WRITE IN

E1b. Why do you say that? PROBE FULLY FOR **WHY RESEARCH IS RELEVANT TO THE GROUP** LISTED

E2. Would you be willing to talk about your research with groups of non-specialists in the future, such as: TICK

(i) Schools	
(ii) Interest groups	
(iii) Public meetings	
(iv) Other (specify)	

PROMPT FOR WHY IF THEY SAY **NO**

OPEN QUESTIONS

O1. Why did you become a biotechnologist?

PROMPT FOR PERSONAL MOTIVATIONS, RATHER THAN PRAGMATIC LIFE-HISTORY ACCOUNTS

O2a. I would like you to think back to the last time you communicated with a specialist audience about your research. That is, formal communication, such as published written material or a conference presentation or poster.

O2b. I would like you to think back to the last time you communicated with a non-specialist individual or audience about your research. That is, informal communication, such as to relatives at Christmas, at the pub, to a school or college audience.

PROMPT FOR:

- WHO WAS THE AUDIENCE?
- WHAT DID YOU TALK/WRITE ABOUT?
- WHEN AND WHERE DID IT TAKE PLACE?
- HOW DID IT COME ABOUT?
- AT WHAT STAGE WERE YOU IN YOUR RESEARCH?
- HOW DO YOU THINK THEY REACTED TO WHAT YOU SAID?
- WHAT SORT OF FEEDBACK DID YOU GET AND DID YOU FIND IT USEFUL?
- DO YOU THINK YOU WERE ABLE TO COMMUNICATE WELL IN THAT SITUATION?

O3a. Do you think you will be doing biotechnological research 5 years from now? CIRCLE

Yes	No

O3b. Why do you say that? PROBE FULLY FOR WHY

REMEMBER TO ASK FOR LIST OF LAST 5 PUBLICATIONS AND INFORMATION ABOUT THE MEDIA STORY (STORIES)

A2.1 Question revisions in response to pilot interviews

Front page

Set out preamble differently: easier to read (numbered list and larger paragraph spacing) and more ‘conversational’.

Changed ‘if you do not know the answer to…’ to ‘if you do not have an answer for…’ and used contractions.

A questions

The A questions are mostly demographic/factual, except A8, which is positioned here because it needs to be asked after A7.

A1 and A2

These questions are straightforward, with categories taken for the MORI–WT survey for comparative purposes. Added the following to A2 because I found that I was saying it anyway: ‘Stop me when I get to the group. READ OUT’

A3a

The majority of respondents reported that overtime was normal and there were no part-time workers, so this question will be changed to ‘approximately how many hours a week do you work, in an average week? WRITE IN’

A3b

In response to the changes in A3a, A3b was changed to ‘ASK IF >40 HOURS IN A3a: that is more than a 40-hour week, why do you work longer than this? WRITE IN'

A4

Although there are no *Research Officers* or *Research Assistants* in the pilot sample, they are expected in the NICB sample. In addition, academic positions (which were absent from the questions for the pilot sample) should be included in this question (e.g. *Senior Lecturer, Lecturer, Assistant Lecturer, Professor*). This question was changed to 'what is your official position? WRITE IN'.

A5a

Categories taken from the MORI–WT survey for comparative purposes.

A5b

Categories taken from the MORI–WT survey for comparative purposes, although question wording was changed to 'what year did you get your PhD' because the smaller sample means that a calculation can be made and the code entered at the time of interview or later. In addition, people are more likely to remember the year they graduated and more information is retained if the question is asked in this way.

A6

This question must be changed to discriminate between full-time lecturing, one-off lecturing and tutoring/demonstrating.

Changed to:

A6a. Employment function

Teaching and research

Research only

Other (WRITE IN)

ASK IF TEACHING CHECKED IN A6a.

A6b. What type of teaching do you do?

Lecturing full-time

Lecturing part-time

Lecturing occasional

Tutoring/demonstrating

Other (WRITE IN)

A7a

Should emphasize that it is the *principle* source of funding that is of interest here.

A7b

New question. ‘Please list any other sources of funding’.

A8a and A8b

All respondents, even the two who answered ‘no’ to this question, would be required to provide periodic progress reports to the funding body (or to the university if they are postgraduate students).

This question will be changed to a closed format ‘In which ways does this source require you to disseminate information about your research? MULTI ANSWERS OK PROVIDE CARD **A8** WRITE IN’ and collapsed into a single question (**A8**), with the following categories on a response card:

A	Written progress reports;
B	Written end-of-grant reports;
C	Written abstracts;
D	Oral presentations for specialists;
E	Oral presentations for non-specialists;
F	Written articles for specialists;
G	Written articles for non-specialists;
H	Thesis/dissertation;
I	Web publication;
J	Other (please specify)

B questions

The B questions are about research areas and formal communication behaviours.

B1

These categories were taken from the Forfás publication: *Baseline Assessment of the Public Research System in Ireland in the areas of Biotechnology and Information and Communication Technologies* (August 2002), with an ‘Other (please specify)’ category added.

B2

No change.

B3a

It is difficult to know where to classify ‘research institute’ (proposed under the ‘other’ category, although I have assumed that the person meant ‘university’ and would not change the card to include a separate category. The prompt to the questioner should be ‘IF ‘OTHER’ PROBE FOR LOCATION IN DEFINED CATEGORIES’.

B3b

The prompt to the questioner should be 'IF 'OTHER' PROBE FOR LOCATION IN DEFINED CATEGORIES'.

B4a

Change 'overseas' to 'abroad'.

B4b

Add '(in months)'.

B5a, b and c

When asking this question in the pilot, it was difficult to discriminate between 'other biotechnology', 'other scientific' and 'other non-scientific fields'. Changed to:

B5a. Have you ever taken part in cooperative research with groups doing research in fields other than your own on Card B1? PROVIDE **CARD B1** WRITE IN

B5b. What about with other scientific discipline(s)? WRITE IN

B5c. What about with other non-scientific discipline(s)? WRITE IN

B6

Add the category 'Administrative tasks' and change the hours to 40. This question is problematic because there will be different answers during the teaching and non-teaching periods. However, as I'll be interviewing most respondents during the non-teaching period, this potential source of error should be minimised.

B7a

Change to 'Do you or your group hold any patents?'

B7b

Change to 'Have you or your group ever applied for any patents?'

B7a and b

Swap these around so that the question about applying for patents comes before the one about holding them.

B8

Change to:

(b) If so, which one(s)? WRITE IN	**(c)** Did you present a paper or a poster? (TICK)		
Name of conference/meeting	Paper	Poster	Didn't present

B9

Change to:

(b) If so, which journal(s)? WRITE IN	**(c)** Was it (WERE THEY) accepted and published? (TICK)		
Name of journal	Yes	No	In press

B10

Change to:

(b) If so, which journal(s)? WRITE IN	**(c)** Was it (WERE THEY) accepted and published? (TICK)		
Name of journal	Yes	No	In press

Also added the following to gather data for bibliometric analyses: WOULD IT BE POSSIBLE FOR ME TO HAVE A LIST OF YOUR LAST 5 PUBLICATIONS (AS AUTHOR OR CO-AUTHOR). I will insert a reminder at the end of the schedule.

B11a

No change.

B11b

Add ‘non-peer-reviewed (e.g. popular science media or general news media)’

C questions

The C questions were about general communication activities and attitudes.

C1, C2a, C2b

No change.

C3

The public policy question in this survey is exactly the same as the WT-MORI survey. In that survey, 24% said yes to ‘contributed’ and only 3% said yes to ‘gave oral evidence’. No one suggested (unprompted) any ways of contributing to public policy, so the prompt card will be changed from ‘Other’ to ‘Other (e.g. personal contribution in an open forum or position on committee/board)’. I think this change is justified because of the lack of unprompted responses and the change should not affect responses to the first two categories.

C4–C5

No change.

C6a

Current work must be emphasized here, so this will be changed to ‘Do you operate under a confidentiality agreement associated with your current or recent research?’

C6b

Change to C6b only ‘with other biotechnology researchers’

C6c

Add this question ‘with non-specialists’.

C7

No change.

D questions

The D questions are about sources of information and media coverage.

D1

No change.

D2a

This question was too complicated to ask in the form it was in. Respondents were required to remember that I was asking about *media coverage* of *five topics* and to simultaneously think about their *likelihood of talking about their research with non-specialists* (i.e. they had to come up with an assumption about how they would feel/react in a situation, which would include an assumption about how non-specialists might think about the five topics). However, it is still a worthwhile question to ask as the pilot respondents provided rich answers, despite the complexity of the question.

The question has been re-worked so that the likelihood part is asked first about each topic, then each of their answers is fed back to them:

D2b

‘You said that media coverage of (TOPIC) has made you (MORE LIKELY TO/LESS LIKELY TO/MADE NO DIFFERENCE) discuss your research with non-specialists.

Why do you say that?’

D3a

No change, except emphasis on ‘<u>you or your work</u>’

D3b

No change.

E questions

The E questions are about communication groups.

E1a

No change.

E1b

No change, except to emphasize the probe about why the research is relevant to that group.

E2

Many of the respondents wanted to split this question, meaning that they might, for example, be willing to speak with schools, but they would not be willing to speak at public meetings. The question has been changed to ‘would you be willing to talk about your research <u>with groups of non-specialists</u> in the future, such as:’

(i) Schools

(ii) Interest groups

(iii) Public meetings

(iv) Other? (specify)

E3a and b

These questions (Do you think you will be doing biotechnological research 5 years from now? Why do you think that?) led to the most emotional and relaxed responses of all the open questions, so they will be moved to the end of the questionnaire as the wrap-up question.

New E3

This question was not piloted because it did not occur to me to ask it until I thought about the possible association between motivations to take up science (or biotechnology) and the likelihood of communicating about research. For example, a study of medical students reported that altruism (defined as a desire to help others) was the most important motivation to take up a medical career, followed by the scientific nature and intellectual challenge of the profession (Todisco *et al*. 1995). There may indeed be a link between altruistic motivations to become a scientist (e.g. especially in research related to human health) and positive attitudes to communication about the research; it could be hypothesized that less altruistic motivations (e.g. the scientific/intellectual challenge) are less strongly associated with the desire to communicate.

The question will be: 'Why did you become a biotechnologist? PROMPT FOR PERSONAL MOTIVATIONS, RATHER THAN PRAGMATIC LIFE-HISTORY ACCOUNTS'.

Appendix 3 Prompt cards

Card B1

A	**Molecular and Cellular Biology** – e.g. virology; microbiology; biochemistry.
	(i) Biomolecular structure and function
	(ii) Biomolecular processes – biochemistry of gene expression, metabolic biochemistry (and engineering)
	Cellular biology – cellular organization, signal transduction
B	**Genetics –** e.g. genome mapping; evolution; biodiversity.
C	**Plant and Animal Sciences** – e.g. plant and animal reproduction; pathogenesis; improved nutritive value in crops.
D	**Environment/Marine –** e.g. bioremediation; pollution; risk assessment.
E	**Medicine/Diagnostics/Therapeutics –** e.g. vaccines; neurobiology; immunology.
F	**Food/Industry** – e.g. industrial microbiology; neutraceuticals; food/beverage processes.
G	**Instrumentation/Technology –** e.g. bioinformatics; biosensors; nanotechnologies.
H	**Pharmacology/Pharmacognosy**.
I	**Other** (please specify)

Card A8

A	Written progress reports
B	Written end-of-grant reports
C	Written abstracts
D	Oral presentations for specialists
E	Oral presentations for non-specialists
F	Written articles for specialists
G	Written articles for non-specialists
H	Thesis/dissertation
I	Web publication
J	Other (please specify)

Card B3

A	Irish Government
B	University
C	Industry/Private
D	Other (please specify)
E	Don’t know

Card C1

A	Several times a week
B	Once a week
C	Once a month
D	Several times a year
E	Once a year or less often
F	Never
G	Don’t know

Card D1

A	General interest magazines e.g. women's or men's magazines
B	Information published by campaigning groups (e.g. on environment and health)
C	Information published by charities (e.g Cancer Research Ireland, Irish Heart Foundation)
D	Local newspapers
E	Museums
F	National newspapers
G	Radio documentaries and current affairs programmes
H	Radio dramas
I	Radio news
J	Scientific journals
K	The 'popular' science press (e.g. New Scientist)
L	Computer magazines (e.g. Computer Weekly)
M	The Internet/websites
N	TV documentaries and current affairs programmes
O	TV dramas and films (e.g. soaps, fiction films)
P	TV news
Q	Other (Please specify)

R	None of these
S	Don't know

Card D2

A	More likely
B	Less likely
C	Made no difference
D	Don't know

Card D3

A	Very satisfied
B	Somewhat satisfied
C	Neither satisfied nor dissatisfied
D	Somewhat dissatisfied
E	Very dissatisfied

Card C2

A	Presenting at scientific conferences for scientific professionals
B	Presenting at public conferences, other than scientific conferences for scientific professionals
C	Speaking at non-scientific academic conferences
D	Speaking at public meetings
E	Submitting manuscripts to peer-reviewed journals
F	Writing and presenting research grant proposals
G	Talking to or writing for the popular science press (e.g New Scientist)
H	Talking to or writing for national newspapers
I	Talking to or writing for local newspapers
J	Talking to TV or radio journalists or speaking on TV or radio
K	Talking at schools or colleges
L	Participating in open days for the general public
M	Other (Please specify)
N	None of these
O	Don't know

Card C3

A	Contributed to a response by my institution to a government advisory body or a parliamentary committee
B	Given oral evidence to a parliamentary committee
C	Other (e.g. personal contribution in an open forum or position on advisory/steering group; please specify)
D	None of these
E	Don't know

Card C4

A	Gives me experience in communicating
B	Gets my name known
C	Attracts possible funding
D	Advancing the role of science
E	It advances my career
F	Opportunity for others to contact me for collaborative/other purposes
G	Other (Please specify)
H	None of these
I	Don't know

Card C5

A	Takes time/Takes too much time
B	Don’t feel adequately trained/equipped
C	Feel nervous about talking to the public
D	I might feel forced to take a particular stance
E	Could be bad for my career
F	Other (Please specify)
G	None of these
H	Don't know

Card C7

A	Strongly agree
B	Tend to agree
C	Neither agree nor disagree
D	Tend to disagree

E	Strongly disagree
F	Don’t know/no opinion

Appendix 4 Introduction and follow-up letters

Introduction letter

Dear ____,

My name is Eve Merton and I am a postgraduate researcher with the NICB Biosciences and Society (BSS) Research Programme, which is associated with the School of Communications at DCU.

My project explores how scientists involved in biotechnology communicate with each other and with non-experts. I hope to obtain a better understanding of biotechnology, which is widely recognized to present new opportunities in research and development, and to raise new social and ethical issues. Concurrently, I am examining biotechnology coverage in Irish media. The results from my study will provide both a broad overview and a detailed picture of the way biotechnology is communicated in Ireland, augmenting recent European research in this field.

For part of my research, I will be surveying and interviewing scientists at the NICB. I will be asking you to take part in an interview lasting for approximately 30 minutes, at a time and place convenient to you.

I will be asking questions about your education and employment history, your communication activities and social issues arising from your research. My intention is to gain an understanding of the overall topic of your research and how you communicate with your colleagues and with non-experts. Sensitive information endangering scientific publication, patenting or confidentiality of sponsored work will not be discussed.

The interviews will be recorded for later transcription, subject to the permission of the interviewee. All materials will be stored securely and treated in the strictest confidence, and codes will be used so that I will be the only person able to identify interviewees. This phase of my study has the approval of Martin Clynes and Brian

Trench. If you have any queries about this project, please email or telephone me, or contact Brian (700 5668).

Please reply by return email so that we can arrange a time and place to meet.

Thank-you,

Eve Merton

Follow-up letter for NUI Maynooth

Dear ____,

Over the last two weeks, I've been coming to NUI Maynooth to interview everyone involved with the NICB. This is part of the data collection phase for my PhD thesis on biotechnology researchers communicating their work.

The interviews last approximately 30 minutes at a time and place convenient to the interviewee. I've already interviewed Kevin Kavanagh, Sean Doyle, Julie Renwick and Joseph O'Keeffe. I'm sure they won't mind if you ask them about the interviews if you have any concerns.

I would appreciate it if you would agree to being interviewed and reply by return email so that we can arrange a time and place to meet.

Thank-you,

Eve Merton

Appendix 5 Transcription code

Normal text	interviewee speaking
[Text in square brackets]	interviewer speaking
{Text in curly brackets}	interviewer comment, e.g. ‘did not ask’
<Text in less than and greater than symbols>	non-verbal information, e.g. interviewee laughs

Punctuation was used as consistently as possible, but was of minor importance compared to the text.

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