A Model for Communication about Biotechnology
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INTRODUCTION

In general terms, biotechnology can be defined as:

Any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use (Eichelbaum et al., 2001, p. 420).

Biotechnology has been practised, perhaps since before historical records were kept, to make products such as wine, beer, bread, and cheese. Any controversies surrounding its introduction have long since been forgotten. This is not the case in respect of modern biotechnologies, those that have become possible in the last decade or so with the advent of genetic engineering. Whilst companies that employ biotechnologists are keen to exploit the commercial potential of such products, the populations of many countries remain deeply divided over the economic, ecological, ethical, and safety issues involved. This is particularly true of New Zealand, where the 2002 General Election campaign substantially revolved around these issues.

Across the world, biotechnologists are trying to persuade ‘the public’ of the rightness of their case, whilst ‘the public’ is trying to argue a sceptical, or even contrary, case. All to no avail, for the divide in ‘public opinion’ has shifted little. The problem, in our analysis, is that no useful model for the processes of communication between the parties exists, and hence effective means of communication cannot readily be developed. We set out to attempt to remedy this situation, to produce a model that might be of use in any field where technological controversy takes place.

This monograph is the product of some three years’ intermittent work. It was tempting to structure it so as to present the model first, followed by a deductive exposition of its possible consequences. However, conscious of Peter Medawar’s remarks on such a ‘scientific paper as a fraud’ (1967), we have presented it as it evolved: inductively, with forays into scholarship and empirical enquiry. Nevertheless, it may be helpful for the busy and impatient reader to have a summary of the model itself at the outset.

We have used two major ideas in the model. The first is that of communicating community, which we define as a relatively coherent social group engaging in communication within itself. As biotechnologists do not constitute a unitary group, we talk about biotechnology communities. Similarly, we find the broad notion of ‘the public’ to be inadequate and instead talk in terms of distinct public communities. The members of any community, we argue, have a ‘view’ on biotechnology that is made up of their: understandings of the nature of science and of biotechnology; understandings of the key concepts and models used in biotechnology; perceptions of the nature of risk; and beliefs and attitudes about biotechnology. We can represent these within an arbitrary geometric convention as in Figure 1.

![Figure 1: Elements affecting a person’s ‘view’ of biotechnology.](image-url)
Our second major idea is that of search space. This is the intersection, in a virtual arena, of the components of the ‘views’ of two communities. Where there are elements of the views that are in common to the two, communication in terms of them is possible. Where there is no commonality, the degrees of understanding reached must be used to construct a mutual understanding that may evolve into an agreement (see Figure 2).

Figure 2: A model of communication about biotechnology

Many ‘holes’ were found in the factual base on which the elements of the model are based. Future work has two directions. First, to ‘fill in’ (or encourage others to ‘fill in’) the ‘holes’ identified. Second, to test the model by designing, running, and evaluating the outcomes of approaches to the promotion of communication based on the model. The model will only have been shown to be worthwhile if this second group of tasks can be satisfactorily accomplished.
CHAPTER 1
The need for improved communication about ‘modern’ biotechnology

Introduction

It has been suggested that public discussion about any new technology passes through three stages. First, the ‘eureka’ stage, in which there is interest in and excitement over the new process or product. Second, the ‘spaghetti’ stage, in which the technology and its applications are modified by producers and consumers to make it generally more capable of adoption by the public at large. Third, the ‘black box’ stage, in which the technology is adopted, culturally accepted, and has become socially invisible (Gradwell, 1999, pp. 256-256).

Traditional biotechnologies, for example bread-making, yoghurt-making and waste disposal, have long since passed into the ‘black box’ stage. However, most of the biotechnologies based on genetic engineering that represent some sectors of the ‘modern biotechnology’ industry are currently at the ‘spaghetti’ stage and are experiencing a situation where there is intense debate. Anecdotal evidence from BF’s editorship of the ‘New Zealand Biotechnology Association Journal’ would indicate that the biotechnology community (involved directly or indirectly with genetic engineering) is concerned that this discussion leads to an appropriate level of public approval for, and use of, their science and craft.

Such a discussion about modern biotechnology, and in particular genetic engineering, is worldwide but the issues have saliency within New Zealand. The Royal Commission on Genetic Modification (Eichelbaum et al., 2001a) showed that New Zealand has led the way with its focus on the interaction of the different interested communities.

This chapter will:

• define the terms relevant to this discussion;
• describe changing attitudes to the applications of science and technology, with particular reference to modern biotechnology;
• describe the sequence of events that led to the production of the Report of the Royal Commission on Genetic Modification (Eichelbaum et al., 2001a) and to subsequent actions by New Zealand government agencies; and
• establish the need for communication between biotechnologists and interested groups.

Clarification of terms

Biotechnology can be defined in the broadest sense as:

Any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use (Eichelbaum et al., 2001a, p. 420).

This definition allows for the broad spectrum of activities to be accommodated. However, if this definition is made more specific by separating it into activities that can be considered ‘traditional’ i.e. bread-making, cheese-making, brewing wine and beer, and waste disposal; and those involving genetic engineering that can be considered ‘modern’, the outcome is fraught with anomalies.

There are many biotechnologies that have their origins in the ‘traditional’ biotechnology camp that use genetically modified microbes. For example, cheese production which uses chymosin
(an enzyme that separating curds from whey) that has been obtained from a genetically altered microbe. The fermentation industry may similarly have its origin in the ‘traditional’ camp, but the methods of selection of the organisms employed in the bioprocess as well as the design of the process, product processing, and downstream processing of the effluent, demonstrate that this classification is shaky (France, 1997).

Other ‘modern’ biotechnologies may use the techniques and knowledge from genetic engineering (GE) but have no direct relationship with genetically modified organisms. Examples are: DNA testing for diagnosis and forensic purposes, xenotransplantation research, tissue culture (both plant and animal), as well as the assisted-reproductive technologies that help preserve endangered species.

Then there are the processes that are directly linked with genetic engineering where established types of foods, crops and medicines are the outcomes.

We believe that it is very difficult for the non-specialist to distinguish between biotechnologies that involve GE and those that don’t. For example, the Dunedin-based biotech company Ovita uses sheep genome research to improve stock productivity that does not involve genetic manipulation. Likewise, the BLIS (Bacteriocin-Like Inhibitory Substances) Technologies’ commercialisation of ‘BLIS K12 Throat Guard’ contains naturally occurring probiotics that are not enhanced by genetic modification (Ministry of Research, Science and Technology, 2003).

There is further confusion between the terms genetic engineering (GE) and genetic modification. This publication will use the term genetic modification (GM) while recognising genetic engineering and genetic manipulation as terms used by other writers.

Although we recognise that ‘modern’ biotechnologies may involve products and processes from genetic modification, there are ‘traditional’ biotechnologies that also use genetically modified organisms or products. At present, biotechnology tends to be tarred with a common ‘genetic engineering’ brush. For this reason we have chosen to focus on genetic engineering/genetic modification and acknowledge that the development of our communication model relates in particular to this subset of the biotechnology industry. However, as discussed previously, this narrow definition is tenuous and in many instances in the monograph the writers use the term biotechnologists rather than genetic engineers/genetic modifiers to acknowledge the diversity of members and interests within the broad church of biotechnology.

The Royal Commission publication (Eichelbaum et al., 2001a, p. 5) defines genetic engineering as:

- the deletion, change or moving of genes within an organism; or
- the transfer of genes from one organism to another; or
- the modification of existing genes or the construction of new genes and their incorporation into any organism.

**Changing attitudes to the applications of science and technology**

The need for dialogue about the effects of scientific and technological innovations between scientists and the public became apparent with the publication of the book ‘Silent Spring’ (Carson, 1962) and its subsequent focus as a voice for public dissent. The perception by the public of the indiscriminate use of DDT in agricultural practices led to the formation of a ‘problem-centred community’. This opened up the discussion to those not within the scientific community who were concerned about the unexpected side effects of DDT in the food chain. These groups of concerned citizens questioned unexpected effects that may arise from ‘the evolution of technology and systems’ (Böschen, 2002, p. 3). This situation may have contributed to a change in the public perception of science and technological adaptations from an unquestioning acceptance to the
situation today where they are viewed, at best, with qualified optimism and, at worst, with scepticism or blanket opposition.

In the USA, surveys by the National Opinion Research Centre (NORC) and the Office of Technology Assessment (OTA) have documented the changing views of the public towards science and technology (Albrecht, 2002). In 1957, over 90% of the US public believed that the benefits of scientific research compensated for any harmful results, but by 1979 this percentage had declined significantly (NORC). By 1986, 62% of Americans in a survey of 1,273 adults believed that benefits outweighed risks (OTC). Albrecht (2002) attempts to explain this erosion in confidence as a recognition by the public that major technological breakthroughs have resulted in negative social consequences. Thus, changes in agricultural practices have resulted in the decline of agriculturally-dependent rural communities. Other pollution problems, as well as knowledge of technologically-linked disasters such as Three Mile Island, Chernobyl and Bhopal, have achieved high social saliency.

Albrecht's (2002) survey of the public perception of biotechnology in the USA noted that up until 1986 there was limited social science research in this area because of a lack of funding from industry and government. He comments that only recently have scientists and industry recognised the public perception problems that biotechnology faces. The failure of the biotechnology industry to develop educational programmes to deal with the concerns of the public is 'a major blunder that will not be easily overcome' (p. 4).

Recently there have been surveys that look at world trends in the public perception of biotechnological applications. The Angus Reid (1999) world poll provides recent data and its citing in the Blaine et al. (2002) review of world trends in public perceptions of biotechnology provide accessible data for analysis that is not so readily available from commercial websites. Blaine et al. (2002) note that approval for biotechnology had continued to drop to 59% in 2000 but that American consumers have indicated acceptance of foods when they see a tangible benefit.

The paper by Blaine et al. (2002) confirms that Americans (including Canadians) ranked first in the world for positive responses to the benefits of agricultural biotechnology with Australia, Germany and France having a lower but similar response (Blaine et al., 2002, pp. 320-323). The products of agricultural genetic modification have had a mixed reception in other parts of the world. The Eurobarometer Surveys of 1991 and 1993 (Marlier, 1992, 1993) provide more data to illustrate this complexity of response. In 1991, optimism about biotechnology and genetic engineering was identified in 50% of the sample, with 11% being pessimistic about such innovations (Marlier, 1992). By 1993, the percentage of optimistic interviewees had dropped to 48% with 15% having a negative view (Marlier, 1993). In Europe there appears to be a qualified acceptance of research into GM for agriculture and food research with a demand for governmental control of the applications. These surveys have identified a range of factors that appear to influence attitudes to biotechnology, for example ethical concerns, a lack of information, and distrust of those promoting the application. The reports also concede that there is a diversity of responses that reflect socio-demographic factors (Marlier, 1993).

Disquiet about GM crops has led to a number of EU Member States blocking approval of GM food until new rules have been established to provide consumers with more information. This, in effect, has resulted in a moratorium on GM approvals in the EU since 1998 (Select-Committee, 2002). The EU is preparing to lift the moratorium and replace it with tougher labelling requirements for genetically altered products including the labelling of all GM food and feed products derived from GMOs regardless of the presence or absence of GM material in the final food or feed product. This will mean that highly processed products, as well as those cooked in oil derived from GM crops, would require labelling. The threshold for this labelling will be at levels of 0.9% (The GM Science Review Panel, 2003).
This EU policy is in response to the negative perception of GM foods in Europe and it is interesting to note that recent polls of US citizens now favour mandatory labelling (92% of an ABC News Poll of 1,024 randomly selected adults in July, 2003) even though the food industry opposes such a move (News-Summary July 17, 2003). As the editorial in ‘New Scientist’ observes, the imposition of such strict labelling may provide a way out for the EU to make a decision on the de-facto ban on GM and the looming trade battle with the US (Editor, 2003).

The products of GM have also had a mixed reception in other parts of the world. Macer and Ng (2000) found that support for many GM applications had declined in Japan between 1995 and 2000, from 45% of the sample accepting GM food in 1995 to 31% in 2000. Similar changes in attitude have occurred in Australia. A telephone survey of 1000 Australians in 2002 by Market Attitude Research Services found that 53% of the respondents felt the benefits of GM foods were greater than the risks (Cormick, 2002). This ambivalence is demonstrated with the approval of the commercial cultivation of GM canola by the Federal Government in July 2003, but all states still have moratoria on the growing of such crops (Cauchi, 2003).

Blaine et al. (2002) conclude that worldwide acceptance of biotechnology applications is limited in all countries although it is most marked in Europe. They note that acceptance tends to be conditional and dependent on the perception of benefits and moral acceptability.

New Zealand’s pathway to the Royal Commission Report

The debate about GM has also been occurring in New Zealand. Couchman & Fink-Jensen (1990) provided data that reflected New Zealander’s unease about genetic engineering, with 56% of those professing to know something about the process voicing their concern about such applications.

In 1999 concern about genetic modification started to hit the headlines. ‘Leaders focus on a deadly diet’ (NZ Herald, 23/6/99) was followed by an article that reported that world leaders have “labelled genetically modified food, alongside AIDS and the Millennium bug, as one of the greatest threats facing the planet” (p. A13).

Whether subsequent governmental activity was galvanised by media interest or not is a matter of supposition. However, a range of initiatives was undertaken by the New Zealand government to promote an awareness of biotechnology-based industries including setting up the Independent Biotechnology Advisory Council (IBAC) in May 1999 to explore and consider issues associated with biotechnology. In September 1999, IBAC published an educational/consultative booklet inviting New Zealanders to communicate their views about biotechnology (IBAC, 1999).

As this consultative process was beginning, the ‘New Zealand Green Party’ (a New Zealand political party) presented a petition of 92,000 signatures to Parliament calling for a Royal Commission on genetic modification and for a moratorium on field trials. After the general election in November 1999, the new Labour led government announced that a Royal Commission would be established. From July 2000 the consultation programme of the Royal Commission commenced with formal hearings between 16 October 2000 and 15 March 2001. In addition to these formal hearings, regional and national hui (meetings within the Maori community), a youth forum, public meetings, and a national telephone survey were held to gather public opinion.

Another major survey of New Zealand opinion provided a context for the ‘problem-centred’ public (Böschen, 2002) to contribute to the discussion. This was an examination into the environmental consequences of possum control and the desirability of GM options in exerting that control (Parliamentary Commissioner for the Environment, 2000).
Possums are the number one animal pest in New Zealand, posing a huge threat to biodiversity. Possum damage is estimated to cost $NZ60 million/year (Parliamentary Commissioner for the Environment, 2000). Possum management, being of vital interest to New Zealand and its economy, led the government to appreciate that New Zealanders needed and expected to be involved in the debate on the subject. Because most of the biocontrol methods being researched involve GM, it was important that the public be consulted about acceptability of such methods (Parliamentary Commissioner for the Environment, 2000, p. i).

This discussion took place against the backdrop of a general, passionate debate about GM that was occurring at this time. Morgan Williams (Parliamentary Commissioner for the Environment) noted in the preface to the report:

In terms of public acceptability, the application of GE to possum control appears to be somewhat in between medical application and applications to food (Parliamentary Commissioner for the Environment, 2000, p. i).

This statement was based on a continuum of risk perception (low to high) against a health profile (poor/illness to fit and healthy/wellness) (Parliamentary Commissioner for the Environment, 2000, p. 55) that had been constructed from the responses gained from a series of focus group meetings.

Trust, or more specifically the lack of it, was an issue that spanned most of the focus group discussions. The report concluded that a loss of trust could be attributed to a range of factors, for example the perceived arrogance of the stakeholders and the impression that commercial imperatives were driving GM applications rather than scientific, environmental or social goals (ibid., p. 64). A distrust of science was also justified as being a legacy of well-known scientific mistakes, for example thalidomide, Agent Orange, breast implants, BSE (Bovine Spongiform Encephalopathy) and RCD (Rabbit Calicivirus Disease). Biotechnology companies were perceived to be driven by mercenary interests and to be part of the globalisation thrust for corporate world domination.

Parallel to this research project the Independent Biotechnology Advisory Council (IBAC) was carrying out its function to “facilitate societal dialogue on biotechnology” (IBAC, 2000, p. 5). Research organisations (including universities) generally saw IBAC’s role as “leading the discussion between scientists, ethicists, people involved in business, and concerned members of the public” (IBAC, 2000, p. 5).

The report (ibid) described their role in this debate and summarised the views of 51 organisations and some individuals about biotechnology. Participating organisations ranged from: those that would be expected to have positive views (BIOTENZ, Genesis Research); those groups who may be concerned but are neutral (Maori Women’s Welfare League, National Council of Women, Grocery Marketers Association); to those with a stated policy against biotechnology (Revolt Against Genetic Engineering, New Zealand Green Party, Organic Product Exporters Group). IBAC’s educational role continued and further publications have provided balanced factual information (IBAC, 2001, 2002).

However, IBAC realised that there were difficulties in communication between the biotechnology community and the general public. There was confusion over the terminology being used by the latter: ‘GM’ and ‘biotechnology’ were being used synonymously; as were ‘organic food’ and ‘non-GM food.’ There was a lack of distinction being made between ‘cloning’ as a laboratory methodology (making copies of DNA) and ‘reproductive cloning’ (making copies of individual animals or plants). Because of an apparent loss of confidence in scientists’ independence, the general public was found to be unwilling to take part in public debates.
The report also noted that the media was seen as exacerbating the negative image of scientists and encouraging the polarisation of opinion between the scientific community and other New Zealanders. This polarisation of attitudes was reflected in newspaper headlines, for example, ‘Distrust and polarisation in GE debate’ (NZ Herald, 3-4/3/2001), where Dr Morgan Williams (Parliamentary Commissioner for the Environment) was reported as saying: “There was a perception that ‘expert arrogance’ on one side and ‘interest group pressure’ on the other had hardened attitudes in the debate” (p. A18).

Other headlines did little to promote communication between these different groups:

- Dr Frankenstein will see you now (Listener, 24/3/2001)
- Tensions rise as GE battle looms (NZ Herald, 13/5/2001).

In July 2001, as a result of very wide consultation1 within New Zealand, the Report of the Royal Commission on Genetic Modification (New Zealand) was published (Eichelbaum et al., 2001). The report rejected a blanket moratorium on all field trials and instead called for stricter controls and a case-by-case examination of each application. The three major proposals outlined below all provided avenues for dialogue and reflect the Commissioners’ emphasis on continuing this extraordinary communications exercise.

The major proposals made by the Royal Commission on Genetic Modification were:

- the establishment of a Bioethics Council
- the establishment of an Office of the Parliamentary Commissioner on Biotechnology; and
- the adoption of a national biotechnology strategy.2

The Commissioners emphasised the importance of the values that New Zealanders shared: the uniqueness of New Zealand’s natural environment, the uniqueness of its cultural heritage, the vital importance of sustainable technologies, being part of the global family, the well-being of all, freedom of choice and participation (Eichelbaum et al., 2001a, pp. 11-12). However, these findings provoked a public challenge in Auckland when more than 10,000 demonstrators gave expression to their disappointment at the Commission’s findings. Their responses were reflected in newspaper headlines:

- Clean Green & Angry (NZ Herald, 19/8/2001)
- Beast is unleashed – but what now? (NZ Herald, 2/9/01)
- Rage against the Machine (Listener, 22/9/01).

Stances were taken up, rather than dialogue promoted, during the six-week election campaign (June/July 2002) that was fought largely on GM issues. The following headline reflects the election focus:

- Genetically modified electioneering - will the GM issue really change people’s votes this election the way nuclear ship visits did in the 1980s? (NZ Herald, 5/7/2002).

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1 The report and recommendations with appendices runs to over 1200 pages and contains 49 specific recommendations. Evidence was heard from over 350 witnesses during the 14 weeks of the hearing, and considered thousands of written submissions from all over the world (Christensen et al., 2001).

2 Two of these proposals have been adopted by the Labour Government of New Zealand with the publication of a consultative paper asking for comments on a New Zealand Biotechnology Strategy (MoRST, 2002) and the establishment of a Bioethics Council (Christensen et al., 2002).
Even though there was a focus on GM there was little opportunity for reasoned discussion as all the protagonists took up a position and argued from that perspective. The Green Party held the position that the exploitation of GM must be stopped in New Zealand; they wished to continue the moratorium indefinitely. The following headlines provide a flavour of the debate:

Greens go for broke over GM (NZ Herald, 25/5/2002)
Too late once you open Pandora’s Box (NZ Herald, 8/7/2002).

The ‘debate’ raged with disclosures of cover-ups, political intrigues and accusations of dirty politics. In the event, the Labour Party gained enough seats to form a minority rule soon after Election Day (27 July 2002). Throughout this period the Green Party had taken a principled stance about GM and vowed to continue their opposition to this technology. Since July 2002, the NZ government has adopted a cautious approach and announced that the moratorium on the commercial release of genetically modified crops would be lifted in October 2003.

A report in the NZ Herald (23-24/8/2003), ‘GM: Is it too soon?’ comments via headlines that ‘Arguments rage on’ and, as the date for the lifting of the moratorium approached on 29 October that there were ‘Signs of creeping panic’ (p. B7). The Minister for the Environment, Marion Hobbs, expressed confidence that the Royal Commission process had worked with the government adopting two of the three proposals (establishment of a Bioethics Council and the adoption of a national biotechnology strategy). The government was confident that the Environmental Risk Management Authority (ERMA) would set stringent conditions for experimental GM crops (p. B6).

In October 2003, in a last-ditch effort to exert pressure on the government to continue the moratorium, protest marches were held throughout New Zealand. Auckland’s protest turnout of 25,000 signalled that significant numbers did not consider the Government’s “proceed with caution” stance to be adequate (Putting their Foot Down, NZ Herald, 13/10/2003, p. A18).

A similar exercise unfolded in the United Kingdom with a national dialogue on GM issues being set up by the government (GM Steering Committee, 2002). The report obtained information from three areas: the science community was requested to submit academic papers; the public via workshops and open meetings; and a commissioned study of the economics of GM.

‘GM Nation: The findings of the public debate’ (Department of Trade and Industry, 2003) was published in September and the public responses had an uncanny parallel to the New Zealand findings. To the question ‘Under what circumstances, if any, would you find it acceptable for GM crops to be grown in this country?’ over half the respondents (54%) never want to see GM crops grown in the UK. The key messages from the debate were that people were generally uneasy about GM and there was little support for early commercialisation, with widespread mistrust of government and multi-national companies.

The contribution from the science community has been released for comment and, together with the report from the GM public debate ‘GM Nation?’ provided the basis of a second report that was published in late 2003. This, in turn, provided the basis for government decision-making and policy on GM (The GM Science Review Panel, 2003). The scientists’ report indicates that although this group ‘conducted an issue-led, evidence-based review of the issues of concern to the science community and the general public’ (p. 22), their findings demonstrated that the issues are complex and cannot be answered in the affirmative or negative. Instead, they observe that:

Genetic modification is not a homogeneous technology and … each specific application of genetic modification must be considered on a case-by-case basis (p. 25).
The study that the government commissioned on the overall costs and benefits of GM crops is equally equivocal. It notes that the “overall balance of future costs and benefits will depend on public attitudes and on the ability of regulatory systems to manage uncertainties” (The Strategy Unit, 2003).

The proceedings leading to the Report of the Royal Commission on Genetic Modification in New Zealand (Eichelbaum et al., 2001a) demonstrated that scientists were not able to talk to non-scientists about issues of concern, and instead were cast in the role of defending their practices and profession. A gulf of misunderstanding between them and sections of the general public resulted. It will be interesting to see if such a situation arises in the UK.

**Bridging the divide between biotechnologists and the community**

The New Zealand Royal Commission report (Eichelbaum et al., 2001a) documented issues of public confidence in science and scientists. Throughout this period of intense ‘debate’, issues of trust were a corroding undercurrent. This lack of trust of scientists was explicitly linked to the relationship between commercial interests and the funding of science.

Dr Morgan Williams (Parliamentary Commissioner for the Environment) reported to the Royal Commission about this viewpoint. These opinions were identified during the forum discussions about possum control:

> What we’ve found, and it came out through this possum GE study, was that [the] New Zealand community is asking, how independent is our science voice today? Who actually owns that voice? … and there’s a widespread perception that the soul of science is, or has been, bought, and … the objectivity, rightly or wrongly that was bestowed upon science in previous decades, is not seeking to be as strong as it was (Eichelbaum et al., 2001a, p. 64).

This viewpoint was echoed in the comments by Dr Roger Wilkinson, who appeared as witness for Landcare Research and was responsible for the research into possum control:

> People don’t trust genetic engineering … They also don’t trust genetic engineers. Some groups described how scientists have let us down too many times … Biotechnology companies were described as being interested only in profits … Motives of scientists were regarded as important, along with the source of their research funds … and who their employers were (Eichelbaum et al., 2001a, p. 64).

A research project was commissioned by the Ministry of Research, Science and Technology (MoRST) from the New Zealand Council for Educational Research (in association with A.C. Neilsen) (Hipkins, et al., 2002). This research suggested that distrust of science amongst ‘the public’ might result from a lack of broad understanding of how science ideas are investigated, debated, and resolved within the science community. It suggested that an understanding of the nature of science is as important to science communication as are knowledge of the relevant science concepts.

This lack of trust in scientists is not confined to New Zealand society. The PABE project 3 in Europe (Marris, Wynne, Simmons, & Weldon, 2001) identified the lack of trust as being a key issue to

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3 Public Perceptions of Agricultural Biotechnologies in Europe (PABE research project) (Marris et al., 2001) was funded by the Commission of European Communities and explored and described the factors shaping the diversity of viewpoints about agricultural biotechnologies and related food-products in the UK, France, Italy, Germany and Spain.
be addressed by policy makers. They assert that restoring trust requires not just the use of better public relations strategies but also a demonstration that the ‘views of the public are understood, valued, respected and taken into account by decision-makers—even if they cannot all be satisfied’ (p. 8).

This lack of communication between scientists and the public provided a focus of a MORI research study for the Wellcome Trust (MORI, 2001). This looked at The Role of Scientists in the Public Debate by interviewing over 1600 scientists in Great Britain. Rather than recognising the communication barrier as an explanation for their perceived untrustworthiness, three out of four of the scientists interviewed identified the major obstacle to good communication as being a lack of knowledge and/or interest by the public. Although the vast majority of them believed it was their duty to communicate their research and its social and ethical implications to policy makers and the non-specialist public, many felt constrained by the day-to-day requirements of their job (MORI, 2001, p. 4). Although these scientists felt that scientists in general should have the main responsibility for communicating the social and ethical implications of scientific research to the non-specialist public, fewer (62%) felt that scientists are best equipped to do this (p. 25). The report noted that a culture of communication was not widespread. It was disturbing to read anecdotal evidence from scientists who had raised their public profile that they may be considered by their peers and their managers to be neglecting serious scientific research in favour of seeking public recognition (p. 46).

One project, attempting to bridge this communication gap about GM applications, asked an international group of eminent scientists with expertise in global health issues to identify the top ten biotechnologies for improving health in developing countries (Daar et al., 2002). The top ten biotechnologies were ranked and predictably, because of the health focus, there was strong medical focus: technologies for diagnosis of infectious diseases (1st); recombinant technologies to develop vaccines and technologies for more efficient drug (2nd) and vaccine delivery systems (3rd). ‘Technologies for environmental improvement’ were ranked 4th and ‘genetically modified crops providing increased nutrients to counter deficiencies’ were ranked 8th. This ranking has parallels with that of the public’s preference for GM applications when perceived to have health benefits rather than just providing commercial advantages to biotechnology companies.

Whether it is based on a lack of knowledge or a lack of trust, the chasm between scientists and interested public is wide.

**The need for a model of communication**

This introductory chapter has, we hope, established the need for improved communication between biotechnologists and other interested groups. As observed at the beginning of the chapter, the general public is sceptically alert to the potential and implications of any new technology, not least biotechnology (Gradwell, 1999). The two broad groupings that are involved in the dialogue (biotechnologists and the interested public) both have strong vested interests in ensuring that their mutual communication is effective.

In New Zealand, this dialogue is of significant importance. Both the commercial stakeholders and the government have identified biotechnology as an underdeveloped industry of great potential. Statistics New Zealand conducted a benchmark survey of modern biotechnology activity that estimated the income of this sector in the year to June 1999 to be $NZ475 m, in the same league as the furniture manufacturing industry ($NZ398 m) (MoRST, 2003, p. 15). This document identifies strengths and weaknesses in the biotechnology industry and presents an argument for improved dialogue that parallel those outlined in this chapter. The report concludes (p. 17) to the effect that New Zealand has:
• an excellent, robustly regulated and ethically guided science community which is world class and relatively inexpensive;
• the world’s best understanding of sheep breeding and dairy husbandry;
• a livestock free of many of the world’s most serious diseases;
• primary industries that are well connected to global markets and responsive to consumer demand;
• recently completed a community conversation about genetic modification with extensive consideration having been given to the pros and cons;
• a culture that tends to be critical of both entrepreneurial success and failure;
• a regulatory system that is perceived by some to be complex, with uncertain timeframes for approvals, thus adding compliance costs; and
• a general population that does not understand biotechnology or scientific processes.

Whether the last generalisation about the New Zealand population stands up to scrutiny is debatable. The level of command of technical detail shown by the general population, who submitted over 10,000 public submissions to the Royal Commission, demonstrated that there is sufficient interest in and, in many cases confidence in, an understanding of genetic modification (Eichelbaum et al., 2001).

Even though this list tends to identify the commercial opportunities for New Zealand biotechnology we believe that the depth of public interest makes it imperative to develop a model to facilitate dialogue between groups:

[The] high degree of public interest in biotechnology and GM matters provides a basis for strengthening links between the sector and the broader community, and developing community understanding of potential economic, environmental and social benefits and risks (MoRST, 2002, p. 18).

This will not be easy, for as Bazerman (1999) has pointed out:

For any technology to succeed (that is, to establish an enduring place within the world of human activities), it must not only succeed materially (that is, produce specified and reliably repeatable transformations of matter and energy), it must also succeed symbolically (that is, adopt significant and stable meanings within germane discourse systems in which the technology is identified, given value, and made the object of human attention and action) (p. 33).

There is a tendency to suggest simplistic solutions to the problem of overcoming barriers to communication. Scientists perceive the problem to be lack of understanding by ‘the public’; ‘the public’ suggests that scientists have too close an allegiance to industry. However, as Fischhoff and Fischhoff (2001) suggest, the solutions found must recognise the complexity of the problem.

As we later found, and here recount, the search for a model of communication was a long and difficult one that is as yet far from complete.
CHAPTER 2
Biotechnologists and communication: An enquiry

Communication: The notion of ‘search space’

At an early stage of our research we were aware that representing the determinants of effective communication between biotechnologists and ‘the public’ would not be a simple matter. It would not be just a case of questions from ‘the public’ being answered by biotechnologists in a form that the former would understand. Nor would it just be a matter of biotechnologists telling ‘the public’ what they thought the latter should understand. Rather, it would be a case of the two parties being able to understand, evaluate, and respond to the concerns and ideas of the other.

In our search for a model of communication, we started by proposing that dialogue between biotechnologists and ‘the public’ can only occur under specific circumstances. This is when there is a ‘space’ between them that both allows the participants to ask questions of each other and which allows them the scope to develop a common understanding of matters of mutual concern. We called this a ‘search space.’ At this stage of the evolution of our model we had little idea of its composition.

The term ‘search space’ was developed from a concept of ‘problem space’ or ‘design space’ that has been used by Stankiewicz (2000):

[The] ‘space’ that occurs when participants are solving technical problems or inventing. During this process the ‘space’ is defined by the participants’ familiarity and access to sets of ‘operants’ (heterogeneous information packages) that may be used. Access to this ‘problem space’ increases the potential for participants to generate a variety of possible solutions (p. 236).

We postulated that communication would be enhanced if there was opportunity for participants to access some sets of ‘operants’. These would provide the space for discussion and problem-solving about issues which caused them concern. It was hoped that the users of this space would be able to acquire a generic knowledge of its ‘grammar and syntax’ and be able to use these to produce understandings that could be shared. In short, this knowledge would enhance their capability to communicate effectively.

A small-scale enquiry

In order to explore some of the issues that had to be represented in such a model for communication, we decided to conduct a small-scale enquiry. Ideally, we would have liked to have asked both ‘the public’ about biotechnologists and biotechnology and biotechnologists about ‘the public’ and biotechnology. In the event, a lack of resources meant that we could only do the latter.

In spite of this limitation we believed that we should provide biotechnologists with: a chance to talk about their specialism in a public forum; the opportunity to answer questions that had arisen from the public domain; and a public forum to voice their concerns and to suggest the directions which research and debate might take. We hoped that their responses might provide us with some of the components/dimensions of the search space as perceived by biotechnologists.

Specifically, the enquiry focused on genetic engineering and sought to:

• encourage an interest in communication issues amongst biotechnologists;
• identify themes within genetic engineering about which the public may have concerns;
Design and procedure

The work had four phases:

1. Setting the research agenda

In order to provide a forum for communication about biotechnological issues, we published a research agenda in the *New Zealand Biotechnology Association Journal* (of which BF was the editor). We had identified themes on which questions were likely to be asked of biotechnologists by members of ‘the public.’ This was done by an analysis of relevant articles that had appeared in non-specialist magazines. The publications analysed were the *New Zealand Herald, New Scientist* and *New Zealand Listener* from January 1999 to January 2001. Five themes were identified: the conduct of agriculture; the production of food; food safety and labelling; the environment; and patenting. We set the scene for the later phases of the enquiry by publishing the outcomes of this analysis in the *New Zealand Biotechnology Association Journal* and inviting the interest of biotechnologists in the enquiry (France *et al*., 2001).

2. Response elicitation

In the light of the interest shown by members of the New Zealand Biotechnology Association, we then invited each of five practising New Zealand biotechnologists to write an article, intended for a non-specialist audience, which would be published in the *New Zealand Biotechnology Association Journal*.

The following general questions were posed to each of them:

- What public concerns about biotechnology in your field of special interest need attention by the biotechnology community?
- Are these issues being researched?
- If so, what is the latest information about this research?
- Are there alternative procedures and projects that need to be brought to the attention of those outside the biotechnological community?

In addition, each biotechnologist/scientist was asked specific questions that had been posed in the generalist literature. It was hoped that these specific questions would provide a context for a discussion of the general questions that had been posed in the research agenda paper.

These articles, republished with permission in the appendices, had the following titles:

- Public concerns about ...Transgenic animals (Blair, 2001).
- Embryonic stem cells and human therapeutic and reproductive cloning (Gilmour, 2001).
- Environmental impacts of genetically modified organisms (Glare, & O’Callaghan, 2001).
- The safety of genetically modified foods (McIntyre, 2002).

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4 Scientist and biotechnologist are used interchangeably in this chapter and correspond with the way in which the contributors have described their community. There were six contributors as one paper was co-written by two biotechnologists.
3. Analysis of the articles

The published papers were analysed to identify:

- the biotechnologists’ responses to the questions, both specific and general;
- issues of concern and avenues for research and development from the biotechnologists’ perspectives;
- issues that the biotechnology community may need to consider;
- ‘operants’ that may provide clues to the composition of the ‘search space’ as perceived by biotechnologists.

4. Presentation of this analysis

The analysis, presented in the section below, will in turn:

- summarise each of the biotechnologist’s answers; and
- identify issues of concern, as well as areas for further research and development, that were raised.

Finally in this chapter there is a secondary analysis that:

- discusses issues for the biotechnology community that biotechnologists have identified;
- discusses the assumptions that may indicate a range of ‘operants’ that these biotechnologists utilised in their explanations. These may provide clues to the composition of their ‘search space’; and
- indicates the direction of our theoretical analysis towards a model of communication.

An analysis of the biotechnologists’ responses


France et al. (2001) posed three questions about transgenic animals to Hugh Blair: What are the animal rights’ issues? Can there be an entire line of transgenic descendants? What are the ethical issues involved in such an activity?

Blair answered the question ‘What are the animals’ rights?’ by describing scientists’ acknowledgement of a ‘duty of care’ (p. 65). Even though these freedoms are spelt out, i.e. freedom from pain and disease, hunger and thirst, fear and distress and discomfort, and freedom to exhibit normal behaviour, he acknowledges the tensions that are apparent when Animal Ethics committees take a utilitarian approach to animal welfare as they balance “welfare costs to the animal(s) to be used against the benefit(s) gained through improved health and/or well-being for animals or humans” (p. 65). He noted that it is this utilitarian approach that causes disagreement between vivisectionists and anti-vivisectionists.

It was apparent that our questions about transgenic animals were not significant to this scientist even though it is the stuff of science-fiction entertainment and hence a source of potential public misinformation. Instead, he noted that there is a significant difference between science’s definition of a transgenic animal and that used in the public domain. The public definition: “… one that has had genes found in other species transferred into some or all of its cells” (p. 61) is not congruent with that used by scientists who are working in this field. Instead, their definition includes those animals with artificial DNA sequences added, as well as ‘knock-out’ animals, where DNA sequences have been removed or silenced. He commented that the scientist’s definition is a significant factor in this debate because transgenic animals are treasured objects that are tracked and quarantined. He asserted that the environmental impact of such animals is low because of this containment.
Blair acknowledged that sections of society object to the production of GM animals on cultural or spiritual grounds. However he thought it may be pertinent to consider the purpose to which such an animal would be used; for example, the use of ‘knock-out’ animals in medical testing. He commented that moral issues are not the prerogative of the antagonists to this research: scientists may feel a moral obligation to contribute to the solution of some of the problems of humanity and may choose to work in these areas for this reason.

Even though the scientist made an economic and humanitarian case for research on transgenic animals, he also provided the reader with arguments for and against such techniques. For example, xenotransplantation (pp. 64-65) could provide scarce organs for transplantation and reduce the potential for organ trading between under-developed and developed countries, but there was also the spectre of the transmission of disease via retroviruses between animals and humans.

It was significant that Blair was aware of the need for open dialogue but was pessimistic that such a situation could occur:

> Scientists must be encouraged to exchange their experiences (both good and bad) with other scientists AND with the public. The current social environment is not encouraging this dialogue (p. 68).

**Gilmour, R.S. (2001). Embryonic stem cells and human therapeutic and reproductive cloning.**

Gilmour’s (2001) paper demonstrated the difficulties faced when scientists are asked questions by (or on behalf of) the public. For example, he stated that the question ‘Is stem cell research ethical?’ cannot be answered by a simple ‘yes’ or ‘no.’ His response suggested that such a question needs contextualisation, i.e. different processes pose different ethical problems. Even though there is a close operational link between therapeutic and reproductive cloning, there is, for him, a sharp divide in the acceptability of the two: "The intent of cloning has a profound influence on both the ethical justification and public acceptability of the science" (p. 52). He proposed that the role of legislation is to define boundaries of acceptability.

Although this scientist acknowledged the importance of ethical safeguards, he reasoned that scientific oversight is more problematic and commented that the huge therapeutic potential of stem cell therapy could be jeopardised by the spectre of eugenics, racist selection and human organ farming. He argued that the well-publicised failures of reproductive cloning deflect attention from the enormous potential of nuclear transfer as a research tool that will enable scientists to understand the differentiation process in early-stage embryos.

The following quote illustrates the dilemma that scientists face in seeking a dialogue with the public. He called for a response that is not blinded to reasoned debate by the horrors of eugenics and other potential affronts to a commonly-held view of the sanctity of life:

> Given that ethics derives in a large part from our fear of scientific advances it is important that future legislation evolves in parallel with new knowledge through reasoned debate at all levels of society (Gilmour, 2001, p. 53).


The questions asked of Glare and O’Callaghan (2001) were more specific and reflected the detailed questions then currently being posed in the generalist literature. These scientists answered the following questions: ‘What are the environmental issues associated with Horizontal Gene Transfer (HGT), the invasiveness of Genetically Modified Organisms (GMOs), and the impact of GMO’s on non-target organisms?’ by providing a comprehensive review of the literature relevant to each answer. They explained the scientific processes involved before providing the reader with their assessment of the potential impact of each on the environment.
This careful case-by-case analysis concluded that the term GMO covers a wide range of organisms and modifications and it is difficult to make generalised predictions about such a diverse assemblage. More significantly, Glare & O’Callaghan observed that very few GM systems have been studied for impacts that may afford the modified system a selective advantage.

The authors acknowledged that the literature demonstrates that HGT, non-target impacts, and invasiveness have been shown to be potential hazards, at least under artificial experimental conditions. They called for field experiments to quantify the probability of adverse impacts occurring. If there is one message from this detailed analysis it is that:

The next challenge is to assess the risk to ecosystems and evaluate those risks against what could be significant potential benefits (p. 46).


The questions posed to McIntyre (2002) similarly reflected the anxiety of ‘the public’ to the likelihood of GM food being an unknown component of their diet. McIntyre’s response to the questions ‘Is ‘substantial equivalence’ an appropriate way to test for food safety? Are there alternative marker genes capable of replacing antibiotic-resistant genes? Are new tests available that don’t involve animal models? Is it possible to guarantee foods to be GM free?’ demonstrated that the generalist literature had failed to ask the most significant question, i.e. ‘How are GM foods detected?’

She commented that the focus of current research is to find more efficient techniques and systems to differentiate between non-GM and GM foods. She explained the two most common methods of detection, i.e. the Polymerase Chain Reaction (PCR) and the use of immunoassays. She identified the problems in the development of an international agreement on methodology, validation and availability of suitable standards and noted that there is little laboratory analysis of GMOs in New Zealand, presumably because of limited demand for the service and the current reliance on suppliers to supply documentation on the GM status of their foods and/or ingredients (p. 52).

Once this question was answered there was the issue of public acceptance, with two potential areas for concern: the risk of allergic reactions; and the transfer of antibiotic resistance genes into the food chain.

Food safety and the likelihood of an allergic reaction involve a ‘substantial equivalency’ test, which has been adopted by the ANZFSC (Australia New Zealand Food Standards Council). McIntyre (2002) commented that alternative methods are being researched because of the criticisms of the usefulness of this test, even though she notes that these criticisms have, as yet, been unsubstantiated. She evaluated a range of alternative techniques identified from the literature, for example animal models, NMR spectra, metabolite and protein profiling, as well as messenger RNA profiling. McIntyre noted that all of these procedures are in the research development phase.

Normally marker genes encoding resistance to antibiotics and herbicides are used to identify successfully engineered GMOs. Although there is no evidence of transfer of antibiotic resistance genes from GM foods in vivo, there is some cause for concern with in vitro demonstrations that there may be a potential hazard. McIntyre (2002) also identified the use of antibiotics as growth promoters in animal production (which select for increased resistance in opportunistic bacteria) as another source of concern. However, she pointed out that HGT is happening in the community in general, not just in clinical settings, so that unprocessed foods such as yoghurt containing live bacteria may also be potentially problematic commodities.
There is a movement towards a prudent use of antibiotics because of the compelling evidence of increased antibiotic resistance, as well as their widespread use in animal husbandry. McIntyre (2002) reported:

The UK Advisory Committee on Novel Foods and Processes suggest that antibiotic resistance genes should be banned from use particularly in unprocessed projects make using GM bacteria (p. 55).

She identified alternative strategies that range from a more prudent use of antibiotic resistant genes, an improved functionality of dairy starters that would provide naturally occurring bacteriocin immunity, and bacteriophage resistance markers (using carbohydrate markers, or alternative markers) for Baker’s yeast. She commented that the future of alternative markers looks bright.

The significant issue that McIntyre (2002) raised was the presentation of genetically modified foods to the public, for “general acceptance will only come about through adequate labelling, GM-free options and greater perceived benefits to the consumer rather than the food producer” (p. 56).


The processes of research and development were discussed by Maddox (2001) when he explored intellectual property protection. He noted that an issue is the public perception that multi-national companies are making large amounts of money at the expense of consumers. The commonly-asked questions ‘Can the intellectual property law work to benefit us all?’ and ‘Will underdeveloped countries benefit from the farming of GM crops?’ reflect this concern. However, they fail to address the major issue that confronts farmers when they are faced with patenting laws that prevent them from using ‘collected’ seeds. He comments that this issue is an example of intellectual property laws failing to cope with a new technology. Rather than critiquing biotechnological innovations, he notes that more attention needs to be given to a review of and, if necessary, modification of the relevant laws.

However, this argument does not answer some of the other issues that opponents of GM crops raise. For example, how will developing countries benefit from farming GM crops? At present the benefits are fewer than expected. Maddox (2001) makes the point that the patenting laws mean that the information is available to all, even though a process cannot be used by all without specific permission, for the duration of the patent.

Maddox (2001) explained the significance of patents as a mechanism for the recovery of the costs of research and development. He noted that the most successful research and development is carried out in countries that have strong patenting systems. In the case of pharmaceuticals, the major expense is the cost of the safety testing that the public insists upon before the product can be used in medicine. As he noted:

Unfortunately, by insisting on absolute safety, we raise the costs so high that often only the rich, developed countries can afford the products! (p. 44).

He concludes that intellectual property laws need to be reviewed so that benefits can be shared as widely as possible.
Issues for the biotechnology enterprise to consider

In all of the articles, the biotechnologists identified issues to be discussed with 'the public.' In some cases they identified the challenges that faced the biotechnology community, while in others they commented on the roles they or their community could assume.

Both Gilmour (2001) and Maddox (2001) discussed the need for legislation to keep pace with scientific developments. Gilmour signalled that such legislation could only be developed as a result of dialogue between scientists, for example those engaged in stem cell research, and the public. He reflected that there needed to be "the continual cycle of evaluation and debate (both learned and lay) which contribute to the evolution of public perception and eventually the legislation itself" (p. 60).

Likewise, Maddox (2001) comments that, instead of critiquing biotechnological innovations, there needs to be more attention given to the review and modification of relevant intellectual patent laws.

McIntyre (2002) saw her role as an informer about safety. Even though she provided sufficient evidence for a discussion about the regulations governing the sale of such food, she saw her role as a scientist and communicator to "eliminate the emotional responses of consumers to the perceptions of risk associated with genetically modified foods" (p. 56).

Glare & O’Callaghan (2001) did not identify themselves with either side of the argument, but instead challenged the scientific community to develop field trial procedures that addressed the key issues of the environmental impacts of GMOs.

There was an underlying message from all the biotechnologists that the benefits of genetic engineering had not been identified to 'the public.' They suggested that there are few applications for approval to sell or use foods produced by GM technology which propose a potential health benefit associated with the application. McIntyre (2002), for example, comments that "the question of "who benefits" from GM foods plays an important role in overall acceptance" (p. 50).

She predicted an enormous future for GM foods but warned that such a potential will be lost without adequate research to address public concerns. Customer preference must be acknowledged with clear labelling and the provision of GM free options. It is significant that this biotechnologist also acknowledged that without the identification of perceived benefits for the consumer, there is little chance for acceptance by the public at large in many countries.

Similarly Blair (2001) made an economic and humanitarian case for research on transgenic animals and provided a list of benefits, for example improved animal health, more efficient animal production, and healthier animal products. He also provided altruistic examples of benefits, for example human disease models and novel proteins for human health. He suggested that a more open dialogue may provide an opportunity for participants to reflect on the tension between the acceptance of vaccines that had been generated using GM methodologies, and a rejection of research based on transgenic animals.

Although all of these issues are laudable and indicate that biotechnologists are willing to discuss issues about the biotechnological enterprise with 'the public,' this preliminary research project indicated that there are ‘operants,’ employed by these scientists, which could provide a barrier to communication.
Clues to the composition of a search space

At this point we need to identify the characteristics of the explanations needing attention when we explore the dimensions of the ‘search space.’ These explanations may indicate the knowledge areas that these scientists take for granted when they attempt to communicate with ‘the public.’

The following characteristics were identified:

1. **The need for biotechnologists to define the precise context when answering a question**

   Even though we had gathered questions from three established popular media outlets, it was apparent that in many situations we had asked the ‘wrong’ questions of the scientists. In many instances they analysed the questions asked of them and either provided a range of questions that only could be answered within a particular context, or alternatively posed their own question which provided a more significant answer. For example, the answers when the ethics of therapeutic cloning are considered cannot be lumped with a consideration of reproductive cloning (Gilmour, 2001).

2. **Answers involve an assemblage of evidence**

   The impact of many of the answers provided by the scientists were obscured because of their concurrent need to develop the argument by presenting a range of evidence to substantiate their claims. An example is Glare & O’Callaghan’s (2001) case-by-case analysis of the evidence on the environmental impacts of genetically modified organisms. Similarly, Blair’s (2001) presentation of the benefits and drawbacks of research with transgenic animals was carefully and thoroughly presented. In these accounts there was careful attention to the substantiating evidence before any conclusions are drawn.

3. **The employment of specialist language needed to understand the concepts and biotechnological processes that take place**

   The need to define terms and explain processes was very evident in many of the explanations. Because Glare and O’Callaghan (2001) chose to provide a range of scientific evidence in their case-by-case exploration of the problem, they assumed that the reader had an extensive scientific vocabulary, i.e. secondary and multi-trophic impacts, organic pollutants, aphid vectored, metabolic burden, as well as knowledge of a range of biological processes and inter-relationships, for example conjugation, virus gene recombination, relationships between predators and parasitoids. The assumptions may seem reasonable, given the forum and assumed readership for the publication, but would not be reasonable if carried over into other media or with other audiences in mind. Blair (2001) recognised that a lack of space limited any technical explanations in his discussion of the merits of research on transgenic animals. It was inevitable that technical terms (defined rather than explained) needed to be included in the discussion, for example transgenic animal chimera and ‘knock-out’ animals. Even the general discussion of patents still required Maddox (2001) to define the terms patent, inventive step, novel invention, plant variety rights, as well as explain the practices of patent laws. Although he provided a careful explanation for the layperson, he assumed that the reader would be familiar with the process of risk-benefit analysis (p. 44).

4. **Concern about the impact of adverse beliefs about GM on public behaviour**

   These concerns were somewhat muted in the biotechnologists’ writing, perhaps because of their intangibility. Blair (2001) drew attention to the tension that might exist between an idealised and utilitarian approach to animal welfare. Gilmour’s (2001) identification (as we put it) of the ‘spectre
of eugenics’ leads him to suggest the necessity of keeping the development of legislation in step with the development of knowledge. Clare and O’Callaghan (2001) hint at the significance of public beliefs about the impact of GM on the environment that are held without scientific justification. McIntyre (2001) identifies the unease that the public may feel when unsure of the presence, or not, of GM in the food that they eat. Lastly, Maddox (2001) points out that the recipients of the benefits of the introduction of GM need to be identified. All these sub-texts suggest that these scientists are aware of the impact of beliefs about GM - especially scientifically unjustified or hitherto uninvestigated beliefs - on public response to GM at an individual, social, and societal level.

**Indications for the development of our model**

It is apparent from this preliminary foray into the responses of biotechnologists to questions posed by the media that there are many issues to consider in the development of our model.

In particular, the enquiry suggested that we pay close attention to:

- language, focusing on the specialist language of science in general and of biotechnology in particular;
- context, focusing on the relationship between the context in which a biotechnological phenomenon is identified and the importance attached to it;
- explanation and argument, focusing on how explanations are presented, contended, and evaluated;
- beliefs, considering how they are formed and how they impact on behaviour;
- the level of knowledge of science and technology, and in particular the conceptual understanding of genetic modification.

These conclusions, drawn from the enquiry described above, set the scene for the subsequent period of scholarship, extending for over a year, in which we arrived at the model for communication set out in Chapters 3 and 4.