

Review Article

Factors determining the public understanding of GM technologies

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Abstract

GM technologies challenge our understanding of what it means to be human, and of what role we play in the natural world. These technologies arise out of particular contexts. Our experiences and understanding of events in our own lives and of events observed and reported in other places around the world, inform our understanding, giving rise to fears about the risk of genetic modification. What could their impact be in the long-term? What are the possible problems? What information about them can be trusted? What choice do I have? Who benefits and who would bear the brunt of any problems? This article presents some of the findings of social scientists about the many interrelated factors that underlie the public's response to GM technologies. The challenges these technologies present can contribute to increased feelings of uncertainty because the world as we know it is changing, alienation because of our lack of control over the development and use of many GM technologies, and ambivalence as we appreciate their benefits but worry about their possible negative impacts. Overall our attitudes to GM technologies reflect the issues associated with living in the contemporary world.

Keywords

risk
biosafety
public opinion
New Zealand
United States
GM food
transgenics
plants

1. Introduction

Where do I fit in the natural world? Am I part of nature or apart from nature? What power do I actually have over what I eat and what happens to the environment? How can we really tell whether something will have good consequences or bad? Who knows? How can we choose when we know that some technology has enormous potential to help human kind but also could put us at great risk? All these questions and more are raised when we consider the place of GM technologies in our lives and in the world.

This review is divided into two parts. The first considers the context of this research: what events and stories are likely to have informed our attitudes to GM technology. The second part summarizes the factors that social science researchers have found to influence the public understanding of GM technologies.

2. Historical and contemporary issues framing the debate about GM technology

Our understandings of GM technology have arisen from many different social contexts. Certain issues

and controversies featured in the public media and our own experiences may explain our attitudes or provide a background to our understanding of the use of GM technology and research. The way in which issues are presented as stories in the media impacts on our perceptions and influences what we go on to learn or understand about GM.

In the country that I come from, New Zealand, attitudes to GM technology have been filtered through some key events in both New Zealand and internationally, and I suggest that this will be so in your country. I will briefly refer to some of these New Zealand stories to encourage you to think of parallels in your own situation.

In New Zealand after World War II, DDT was used extensively to control an endemic pasture pest, grass grub. This use of DDT on pastoral land was banned in 1970, but because DDT residues persist in soil, it has restricted the conversion of certain land for dairy production. A chemical that was welcomed in the 1950s has been seen to produce problems that the following generation have had to deal with [1].

New Zealanders are often linked to sheep, probably since a famous visitor, George Bernard Shaw said

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after a visit in 1934, "Altogether too many sheep ...". Hence, they have taken great interest in Dolly, the sheep cloned by PPL Therapeutics. This story took on a New Zealand slant when the same company gained permission in 1999 to breed sheep genetically modified by the addition of human genetic material in order to produce milk with human protein to be used for therapeutic purposes. After breeding up to 3,000 sheep, PPL Therapeutics became financially troubled and discontinued this research in 2003. The sheep had to be destroyed [2]. This event brought to life questions about where do animals with human genetic material fit in the natural order, how should they be treated, and the use of GM by corporate business.

Another issue related to the development and use of GM technology is that of informed consent. In New Zealand this came to the fore in what has become known as 'The Unfortunate Experiment'. This medical experiment on the treatment of cervical cancer, involved women unknowingly being used as experimental subjects. They were not given treatment so that the researchers could observe the course of the disease. Many died as a result [3]. From this event New Zealanders have developed a healthy suspicion of being 'experimented on'.

New Zealanders have been sold the image of New Zealand as a clean and green country and this image has become a strong part of our national identity. Anything that threatens this identity, such as the use of GM technology in agriculture, is suspect.

A final related problem is that of global warming. New Zealand is a signatory to the Kyoto Protocol, which binds countries to lower their production of greenhouse gases. In New Zealand farmers were told that as their livestock were the main producers of methane, a greenhouse gas, they would be levied for research on the problem. This became known as the Farmers Against Ridiculous Taxes or FART tax. As farmers revolted against its imposition, it was much publicized. This raised questions about who pays for what, who benefits, and the nature of that benefit or payment.

It is apparent from this brief introduction to context that many other factors outside of the technology itself influence our understanding of that technology. I go on to summarize what factors researchers have found to influence public attitudes to GM technology.

3. Factors influencing attitudes to GM technology

Perceptions the general public have about biotechnology, particularly genetic modification, have been widely researched. More recently this research has been carried out using focus groups in which a cross-section of members of the public are chosen to participate in discussions about biotechnology, usually by the presentation of particular scenarios (e.g. the PABE study - *Public perceptions of agricultural bio-*

technologies in Europe [4], *The fate of biotechnology: why do some of the public reject novel scientific technologies?* in New Zealand [5]). Members of the public have also been subjected to many surveys on this topic. Surveys have the limitation that the chosen topics are ones that the researchers believe to be important or that they have found from the literature, but these topics may not represent public concerns unless some explorative qualitative research, such as focus group research, has been carried out initially. In survey questionnaires there is also a limited array of responses to each question or statement.

Many of the public perceptions found in research studies relate to the perceived risks associated with biotechnology. The growth of the awareness of risk was coined by Ulrich Beck [6] with his notion of the 'risk society' and this preoccupation with risk has continued to emphasize the uncertainty of contemporary life.

The factors that have become apparent across the literature will be covered under the headings perceptions of risk, sense of place, end use, and ambivalence, alienation and uncertainty. These factors are often interrelated and difficult to separate. Most often they have emerged from studies that have shown that the public's perceptions of GM technology have to be considered on a case-by-case basis. There is no 'one rule fits all'.

3.1. Perceptions of risk

People are very concerned about the consequences of biotechnology [4,5]. In a study of the linguistics of the 'Eurobarometer',¹ it was found that the word 'risk' did not arise spontaneously. Participants were more likely to use the word 'danger' especially with respect to food, eugenics and 'artificiality'. Another key word was 'fear'. Risks were not material phenomenon but drawn from social, political and ethical issues [7]. This section will cover different factors involved in risk perception: the need for choice, the risk/benefit distribution, fear and dread, distrust, perceptions of the public by dominant institutions, information wanted by the public and, judging risk by the size of the problem.

The public pays more attention to the consequences of risk (impact on the environment and public health) than do the 'experts' and decision-makers, while the 'experts' focus on the low probability of risk (e.g. [8,9]). The public do not expect life to be risk free [10]. It has been suggested that it is the decision makers who demand "certainty, unconditional explanations and precise estimates of risk" [11].

There are many different dimensions of risk. Is the exposure to risk voluntary or involuntary? Are risks balanced by benefits? What is most feared? Does familiarity with biotechnology affect perceptions?

¹ The 'Eurobarometer' is a survey regularly undertaken throughout Europe to measure attitudes to different technologies.

3.1.1. The need for choice: voluntariness

A perceived lack of choice and control over GM food because of the lack of information on labels and regulations about labelling challenges the idea that such consumption can be voluntary [5,12–14]. Other literature documents concerns the public has about the degree of individual and collective control over risk. There are issues of consent. Is the way that collective consent is obtained acceptable to those who bear its consequences? [10].

3.1.2. Risk/benefit distribution, equity issues, social fairness

The public want information about risks and benefits of GM technologies [16]. Who would receive the benefits? Would they only be for the rich? [15]. Would such technologies just “reinforce the existing patterns of capital ownership”? For example, the poorer members of the community could carry a potential negative impact, because they would have no choice but to buy cheaper GM food [14]. Biotechnology companies and food manufacturers are seen as the recipients of the benefits of GM while the consumers and the environment would end up paying for it [4].

Many people express a strong desire to not cause any problems that future generations will have to ‘clean up’. They would like to leave the world the same as it is now or preferably, better [5].

3.1.3. Fear/dread/safety/catastrophic potential

There is generally considered to be two main sources of anxiety about genetic modification – the potential impact on human health and on the environment. Respondents in many studies are concerned about potentially irreversible side effects and unknowns [5,14,17]. Many worry that GM will cause a problem ten or twenty years on which would then have to be fixed as well [5,18]. There is also concern about the potential for abuse in biotechnology, for example, in cloning, eugenics, experiments deliberately releasing genetically modified organisms (GMOs), or stealing a biotechnology and using it for something that is not good [5,19].

Medical therapies are seen as more targeted, while environmental interventions could impact on a whole population [4,5]. Living organisms are part of complex chains and this interdependence has enormous implications when one part of a chain is changed through genetic modification. There are concerns about the lack of containment of such organisms, their impact on humans through consumption and on farming practice. Laboratory experiments are not seen as replicating ‘real’ life and therefore could not predict what would happen outside the laboratory [4].

For some people research and the preliminary use and testing of GM technologies was acceptable as long as it was carried out somewhere else: on an offshore island or another country from their own. This has been expressed as ‘not in my back yard’ syndrome or NIMBY. For many people the products of GM technologies are acceptable as long as they do not have to eat or use them or they are not tested on them. This aspect of NIMBY could also be referred to

as ‘Not In My Body’ or NIMB syndrome, to coin a new acronym [5].

The level of familiarity with technology plays a part in people’s perceptions, as does its visibility [20]. If a product is already on the market then often it is assumed that it must have been tested and found to be safe [5].

3.1.4. Distrust: challenging the motivations and knowledge of stakeholders

A UK study on public attitudes to GMOs, gathered from focus groups conducted in 1996, showed that:

- Respondents’ knowledge was grounded in experience they viewed as relevant.
- Such knowledge included observations of the behaviour of regulators and stakeholders such as scientific and industrial institutions [4].

Out of such public awareness has risen the question: are institutions worthy of trust? [10]. As early as 1980, Brian Wynne said “... at the heart of risk perceptions and risk conflicts was not the issue of technical risk magnitudes but rather trust in institutions” [21]. Slovic confirms this: “If trust is lacking, no form or process of communication will be satisfactory” [22].

Many studies have found the public have concerns about corporate control, and research being driven by industry to produce a profit rather than a public good. This attitude could lead to more targeted, short-term, profit-driven research. The public feel that companies and researchers have not been willing to recognize mistakes and have not been good at predicting negative impacts. One of the major risks is seen to be centralisation of power with large corporations with their limited focus and their perceived lack of accountability and integrity. Generally there is a lack of trust in big corporations and the scientific community [4,13,14].

People are aware of their ignorance about GM technology but feel that somehow the promoters of GM are responsible for this because they have not been providing consumers with appropriate or comprehensible information. Concerns about GM are not related to incorrect technical knowledge but to people’s experiences of plants, animals and humans outside the lab. Events such as the way the BSE outbreak was managed in the UK, coca-cola contamination, and the use of pesticides, are linked to how institutions behave in “fallible” ways and have not learnt from these experiences so could not be expected to behave any better as far as GM technologies are concerned. In other words people do not expect honesty and openness from regulatory or commercial bodies [4].

What participants in the PABE study drew from these observations of institutions was:

- It is impossible to anticipate harmful or beneficial impacts.
- This is not admitted.

- Preventative action is always delayed. Decision makers only act when they have no choice.
- Regulations are not adhered to. (They are often unrealistic for those who have to implement them).
- Decision makers only tell what decisions have been made, not how or why, or possible consequences.
- Important decisions are made by those 'above' us and we have no control over them. Decision makers are not accountable.
- They suspect that economic interests dominate: particularly the interests of 'big' companies.
- Innovations in the primary sector encourage intensification and industrialisation [4].
- What is this biotechnology? What is it made of? How is it produced?
- What is the impact of this biotechnology on humans, animals, plants, society, the economy and the environment?
- What other problems could it lead to? What are the side effects? Can it be contained?
- Who is paying for the research? What are their ethics? Who will benefit? Who makes the profit?
- Is the research underpinning this objective and trustworthy?
- What would be the cost to the end-user?
- What are the alternatives?
- How do you know whether to trust the information you do have?

It has been observed that there are two sides to the public perception of scientists. In the first, science is "neutral and autonomous from society" and in the second, science is "part of society and influenced by contingent factors". The first perception implies that scientists and their knowledge is neutral and the responsibility for misuse lies with others. The second perception acknowledges that scientists are 'normal' human beings, dependent on funding and institutions for their work [4,5].

3.1.5. Perceptions of the public by dominant institutions

From interviews with stakeholders, and focus groups selected from members of the public, on access to information about new technologies, it was found that public concern about new technologies arose out of a perception by stakeholders of the public's inadequate knowledge, and the denial by industry and Government of uncertainty and ignorance [17]. The PABE report writers developed ten dominant so-called 'myths' of the public held by stakeholders and proceeded to show them to be incorrect [4]. Industry viewed human beings as consumers (of products and services) in a one-way market model of something that is a complex human interaction [17].

3.1.6. Information wanted by the public

Marris *et al.* [4] would title this section "definitions of the issue made by dominant institutions" because it describes what information the public want and therefore it must be assumed that this is not the information the public are getting.

The general feeling people have of not being informed was found to be a dissatisfaction with the quality of information provided. They want better labelling of products as this is related to personal choice and control, and want information from neutral sources or a variety of sources [4,5,23]. Lack of information is seen as intentional [4], for example, it has been described as "technical opaqueness" [17].

Participants in one study wanted answers to these questions:

- What is the problem? What is its extent? Whose problem is it? Who ends up paying?

- What is this biotechnology? What is it made of? How is it produced?
- What is the impact of this biotechnology on humans, animals, plants, society, the economy and the environment?
- What other problems could it lead to? What are the side effects? Can it be contained?
- Who is paying for the research? What are their ethics? Who will benefit? Who makes the profit?
- Is the research underpinning this objective and trustworthy?
- What would be the cost to the end-user?
- What are the alternatives?
- How do you know whether to trust the information you do have?
- Priorities. Is this the way to spend our money? Isn't something else more important?
- Should something be fixed that is 'natural'? [5]

Key questions the focus group participants in the PABE study wanted answers to were:

- Why do we need GMOs? What are their benefits?
- Who will benefit from their use?
- Who decided they should be developed and how?
- Why were we not better informed about their use in our food, before their arrival on the market?
- Why were we not given an effective choice about whether or not to buy and consume these products?
- Do regulatory authorities have sufficient powers and resources to effectively counter-balance large companies who wish to develop these products?
- Can controls imposed by regulatory authorities be applied effectively?
- Have the risks been seriously assessed? By whom? How?
- Have potential long-term consequences been assessed? How?
- How have irreducible uncertainties and unavoidable domains of ignorance been taken into account in decision-making?
- What plans exist for remedial action if and when unforeseen harmful impacts occur?
- Who will be responsible in the case of unforeseen harm? How will they be held to account? [4]

As is apparent from this section, the information the public wants relates to the concerns about risk discussed earlier. There is also an overarching concern for consumers to have a choice based on reliable knowledge.

3.1.7. Judging by the 'size' of the problem: the micro versus macro arguments

Some people have a favourable attitude to a biotechnology if it solves a big problem: something that affects a lot of people, usually something in the environment. However, in this situation it is unlikely an

individual would have any choice over its use, as in the bioremediation of DDT using a GM microorganism, for example. Countering those with this perspective are those who feel biotechnologies over which they could have individual control would pose less risk, and be more likely to be containable and reversible [5].

3.2. Sense of place: perceptions of nature and natural

There is a sense in which people have a model of how they think the world is and where everything fits or belongs in it. For some this model is hierarchical. At the top are humans, then animals, and then plants. Everything has its place. This perception places boundaries between the hierarchies or the different 'kingdoms' meaning that some think such boundaries should not be crossed. Parallel to this there is a perceived feeling or emotional hierarchy in which it is thought that animals are more likely to feel to a certain extent the way we humans do and this makes animals more like us than plants. The place of microorganisms such as bacteria and viruses in this hierarchy is not often articulated though they are strongly associated with humans and antibiotics. Participants in studies were aware of the "complexity and interdependency of ecological systems" which contrasted with the perceptions held by scientists and GM promoters, of the public as ignorant when they express concern about transferring genes across human, animal and plant boundaries [4].

What is natural? How much should we humans be able to change 'nature', to change what is 'natural'? Something that occurs in 'nature' is often considered 'natural'. Using something natural is regarded as unlikely to interfere with other things such as our natural bodily processes. Some people warn that if humans do interfere with natural processes then we will have problems such as an increased risk of cancer or the likelihood that we could accidentally create something bizarre. Natural selection is "nature's way" and is perceived to be the way balance in nature is maintained [4].

If humans do 'interfere' then what is interfered with is no longer 'natural'. What did people mean when they used this word 'interfere'? This is not simple. For example, there might be something in a genetic structure of a human, animal or plant that is just not 'turned on' or expressed, and we can learn how to turn it on. Some want to draw a distinction between the suppression of a natural process and dealing with the result of that natural process, for example in the production of methane by animals. If any product had anything to do with a laboratory it some regarded it with suspicion as not being natural [5].

3.2.1. The ethics and morality of GM technologies

Some people are totally opposed to genetic modification on cultural, ethical or spiritual grounds [14]. Such perspectives often relate to those on nature and, as the above section has outlined, there are many such perspectives. Nature can be seen as bad or threatening, or nature can be seen as pure and good apart from humans who keep spoiling it [24].

Humans keep intervening in nature. If we are 'part of nature' then this is 'normal' behaviour, but if we are not part of nature this is 'unnatural' behaviour because everything has its place and it should be left like that [25–27]. It is 'playing God', trespassing, going into forbidden territory or interfering with nature [5,28]. The unknown or unpredictable aspect of biotechnology is related to the perception that people are "tinkering" or "upsetting the natural balance of nature" [13]. The implication is that 'natural' is good, unnatural is bad [29]. GMOs are viewed as 'unnatural' and genetic modification is regarded as "qualitatively different from any previously used technique" as it is producing things that would not have existed otherwise though for some they are seen as the next logical "step in the human history of manipulating Nature" [4]. People are conscious of their ambivalent feelings. They feel good about how we seek to prevent and treat disease and benefit human kind and the earth. They are very aware that vaccines, blood transfusions, and plant and animal breeding provide examples of biotechnology that have become accepted practice.

One of the sources for humans' sense of difference from the rest of 'nature' is embodied in this quote:

Our religious tradition teaches us that we are much more than mere chemicals ... Humans, cannot then, in the Christian view, be reduced to their genes, in a genetic reductionism. Humans are not merely the reaction of their genes with the material environment (Richard Davis in [14]).

One survey established that those who believed in God found genetic engineering of plants and animals less acceptable than those who did not believe in God [18]. The hierarchical model of nature produces different attitudes to research focused on humans and animals compared to plants and microorganisms [18,23]. The former is viewed as unnatural, harmful and dangerous whereas the latter is "beneficial, progressive and necessary" [30].

3.2.2. Words and their connotations

The choice of words used to convey information about different biotechnologies can have powerful consequences. Words can quickly convey bias. Words are rarely neutral. Words conjure up different meanings for different people. A number of meanings may be held in common, others are unique to the individual. For example, the word 'bacteria' has links with infection, antibiotics, inoculations and invisibility for some people [5]. The response to some words is often difficult for people to articulate. The automatic reaction to certain biotechnologies has been labelled the "yuck" factor [15].

3.3. End use of GM technologies

3.3.1. Medical and food applications of GMOs

End use of a GM technology is an important part of the public's acceptance of it. If something helps human health or cleans up pollution then it is more acceptable than increasing the shelf life of a product

or making a fish grow faster. Medical uses are seen as the most acceptable as long as there are no side effects, the benefits are 'real', there is a "good reason" for it, and there are controls. There is a general concern about what goes into our bodies, and the question of who was reaping the benefit [15].

There were more positive perceptions of medical than food applications of GMOs in Europe. These were attributed to much more than personal benefit, and the contrast was made between buying a food and taking medication. The latter is to do with curing or managing disease, saving life. Often there are no alternatives, whereas the former involves choice, and a surplus that could be used in poorer countries. Need was to do with societal need rather than personal benefit [4].

Certain assumptions are made about medical therapies. It is felt that information was provided on these as compared with no information for food. Such information was usually from a trusted source. Medicines are presumed to be well tested and to have passed through various regulatory procedures, but it is felt that GM food has come on to the market too quickly for thorough testing to have taken place. It is thought that medicines are monitored after their commercialisation, whereas food is not. The use of medicines is linked to traceability, the provision of information and labelling [4]. In New Zealand, for example, it has been noted that "confusion exists over difference in the regulation of dietary supplements, food and medicine" [5,14].

3.3.2. Motivations

The use of GM technology in agriculture is perceived to be aimed at producing commodities of low price and low quality and demand for them was created by the manipulation of consumers. GM medicine on the other hand was of high price and quality, and though produced in a competitive and profit-driven environment, was regarded as acceptable because its development was responding to human need [4].

However, this did not mean that all medical GMOs are regarded as 'ideal'. People discriminate on the basis of:

- The reason for the genetic modification.
- The type of organism to be modified. (There was no concern for microorganisms but increasingly for plants, animals and humans.)
- The source of the different gene.
- The history of use – it is more acceptable if already in use.
- Containment.

It was felt that GM should only be used if there is no alternative [4].

In a Spanish study it was found that there was a reluctance to have genetic engineering applied to food production even though it was assumed to be beneficial to humanity [31]. In contrast, in New Zealand the genetic modification of food was seen as

unlikely to relieve hunger in the world because there was already enough food but the distribution was inequitable [13]. In the PABE study participants were sceptical about statements that said GM crops would lessen world hunger and poverty. They could not see any need for GM food unless there was a threat of extinction [4].

The influence of gender is still under debate with some studies finding men more supportive of GM than women [e.g. 18,32] and women were more concerned about food safety [33]. Others have not found any differences [e.g. 34].

3.4. Ambivalence, alienation and uncertainty

Generally people express ambivalence about GM technologies seeing both the positive and negative possibilities, and considering their use as a balancing act, discriminating between them on a case-by-case basis, but not having hard-line opinions [4,5]. Sometimes one person can express opposing opinions within the same utterance. Health and the environment are seen as linked and so there is an ambivalence about food as it is necessary but is both a source of pleasure and risk [4] as "humans have an ongoing ambiguous and paradoxical relationship" with food [14].

Many people feel *ambivalence* [35] about the way society is changing because they are aware of both the good and bad elements of change [4]. Some think that those who viewed GM technologies as "upsetting the balance of nature" are limiting progress [13]. Members of society are also experiencing *ontological insecurity* [36] because of the instability of social identity in a time of rapid social change and this is "giving rise to diffuse ... anxiety" [4]. This response to biotechnology can be seen as part of a greater issue of living in contemporary society.

There is a perception that social and technological change is speeding up [4] and people feel powerless to affect this change. The driving force for this change is the seeking of economic gain over environmental and social concerns. This leads to a "sense of alienation", a "lack of agency", and a "lack of control in the life-world". Decisions affecting everyday life are perceived to be taken by distant institutions that are not open to influence by and not accountable to ordinary people. Political elections are not an adequate way of dealing with this (*ibid.*). In the UK, risks were related to a perceived lack of control over new technologies [16]. In America, there was a "degree of technological fatalism; the belief that ordinary people can't have much influence over the spread of new technologies ..." [37]. Lyn Frewer has suggested that one of the causes for the lack of public confidence in GM had been the exclusion of the public from the debate about it [14].

The attitude to institutional behaviour could be better described as sceptical rather than a lack of trust. People related to the food system as consumers not citizens and saw the only way they could exercise power was by 'not buying' a product (though this

power was dependent on labelling.) This has been linked to how much a market ideology has pervaded all levels of society. Such an ideology is regarded as unsatisfactory but people see no alternative [4].

Uncertainty was a dominant theme.

... there is an inherent unknowability, as well as unpredictability, concerning ecosystems and the societies with which they are linked. There is therefore, an inherent unknowability and unpredictability to sustaining the foundations for functioning systems of people and nature ... [38].

It might be more accurate to talk about 'public perceptions of uncertainty' rather than 'public perceptions of risk', focusing on a concern for the long-term or possible chronic impacts of biotechnology. Uncertainty is seen as a "fact of life" supported by past experience. Hence, the denial of uncertainties by officials and stakeholders is unconvincing. The perception by stakeholders that the public demanded zero risk was demonstrated to be incorrect. People want to see long-term monitoring and contingency plans in place should things go wrong [4].

This acknowledgement of uncertainty led to the question of need for GM technology (see the questions raised earlier). Did the need justify the uncertainty? Hence the divide between ethical issues and risk becomes fuzzy [4].

4. Summary and conclusion

This paper has described some historical and contemporary issues that may have influenced the debate about biotechnology. It has then gone on to identify the factors found to influence people's perceptions of GM technology from a broad sample of the literature, with particular emphasis on recent research in Europe (the PABE Report), in Australia, and New Zealand. People's perceptions of risk were found mainly to centre around certain perceived qualities of risk such as how much choice was able to be exercised over the use of a biotechnology, what was the benefit compared to the risk, and the anxiety about potential negative impacts on health and the environment. Many of these perceptions are related to issues to do with the level of trust in, or rather a scepticism about, both commercial and public institutions involved in decision-making about biotechnology, and the information that the public is given compared with the information they would like to have. The quality of information is often related to the perceptions that such decision-makers had of the public. In addition there are factors of an ethical, cultural and moral character associated with attitudes to living organisms and nature. The end use of GM technology played an important part in its acceptability, with a greater acceptance of genetic modification in medical applications than in food. Some writers have commented on the ambivalent

feelings that are prevalent about biotechnology, the lack of power that people are experiencing over its use and how these factors relate to living in a world filled with uncertainty. As has been emphasized in a discussion paper released by New Zealand's Parliamentary Commissioner for the Environment, policy and decision-making takes place in an environment complicated by:

- *uncertainty* (for example, uncertainty about cause and effect relationships, and outcomes)
- *dispute* (for example, conflicting opinions, beliefs, interests, values, and paradigms)
- *distrust* (for example, lack of trust in science, decision-making processes, and decision makers)
- *poor communication* (for example, leading to a lack of awareness of the issues) [11].

It is suggested that there is a need to find ways of helping people to participate in this contemporary society as more than consumers. As Gerrard said of the BSE crisis in Britain, the debate needs to be re-democratized "so that values other than purely scientific and technological ones can be injected into the deliberating process" [39].

Many, perhaps most, significant disputes about the use of science and technology in society centre on issues of ethics, equity, and justice, and how to choose the most prudent collective course of action ... not necessarily on the science itself [40].

Acknowledgements

This review has been assembled by the author from a report [5] written for the Agribusiness and Economics Research Unit at Lincoln University in New Zealand as part of the research programme, *The fate of biotechnology: why do some of the public reject novel scientific technologies?* led by Dr John Fairweather and funded by the New Zealand Government through the Foundation for Research, Science and Technology. Later this year, the results of a national survey on public attitudes to biotechnology will be released as part of this ongoing programme.

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