Consumer Concerns About Biotechnology:
International Perspectives

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Biotechnology is one of the key developments of the late 20th century with the potential to fundamentally revolutionize the way we produce many of the necessities we rely upon as human beings. Billions of dollars have already been spent on biotechnology in the rush to develop improved foods, fuels, feeds, fibers, and pharmaceuticals. Billions more have been spent on industrial efforts to use biotechnology to manufacture more familiar products with greater efficiency. As the result of this research, some products of biotechnology are already in the marketplace. A few of these, such as recombinant bovine somatotropin (rBST), genetically modified soybeans, potatoes and corn have received worldwide media attention. Yet, most consumers are probably unaware of the true number of biotech products currently used in food, medicine, and manufacturing. These include a growing list of enzymes, hormones, feedstocks and other chemicals produced using genetically engineered organisms.

Science and industry are dramatically poised to bring consumers a wide variety of products that are only made possible through the use of biotechnology. The question is, "What do we know about how the public currently perceives biotechnology, and, does this help to predict how consumers will react to these new products once they reach the marketplace?" The answer to this question has enormous economic, ethical and political ramifications and so, not surprisingly, predicting probable public perceptions has been the sport of pundits, preachers, and politicians. More importantly however, researchers within government, academia, and industry have sought answers using a variety of methods including face-to-face interviews with potential consumers, focus groups, mail surveys, and polling by telephone.

So, how are people likely to react to new biotech products? The results of these studies, collected from around the world, suggest that the ultimate answer, like the response to many other complex questions is: "It depends." While there is considerable safety in giving an answer of this specificity, it's probably the only honest response given the large array of products forthcoming and the diversity of the consumers for whom they are intended. It is possible, however, to provide some specific insights and to illustrate them using published studies of consumer perceptions of biotechnology from around the world.

AWARENESS OF BIOTECHNOLOGY

It is important to begin by pointing out that in nearly every country, surveys of consumer attitudes concerning biotechnology reveal large portions of the population that have neither heard nor read very much about biotechnology. Despite the very substantial media attention stemming from the intense and often conflicting interests of activists, ethicists, and entrepreneurs, much of the public seems remarkably uninformed about biotechnology. For example, a 1998 survey of Japan, found 60% of those surveyed said that they had heard little or nothing about biotechnology (Hoban, 1999). Similarly, in the United States, a 1999 Gallup Poll found that half (50%) of those surveyed said that they had heard or read little or nothing about biotechnology and only 10% reported that they had heard or read "a great deal about" biotechnology (The Gallup Organization, 1999). In 2000, an International Food Information Council Survey found that 55% said that they had heard or read little or nothing about biotechnology, while 14% reported that they had heard or read "a lot" (IFIC, 2000).

It is also important to note that the percentage of people who seem to be aware of biotechnology in the U.S. hasn't grown very much over the last decade. A 1987 survey of public

awareness of biotechnology by the Office of Technology Assessment found that 63% of the respondents had heard or read "relatively little" or "almost nothing" about biotechnology, and only 6% reported that they had heard or read "a lot."

Consumers in the U.S. and in Europe also seem to recognize that they are not well informed about biotechnology. In the 2000 IFIC survey, respondents were asked to rate how well informed they were about biotechnology on a scale of zero to ten, where zero means "you are not at all informed" and ten means "you are very well informed" about biotechnology. In response, more than half (55%) reported a rating of 3 or less, and only 7% reported a rating of 8 or greater. Similarly, a recent Eurobarometer survey of those living within the European Union found that 81% disagree that they are adequately informed on biotechnology, and that only 11% "mostly agree" (INRA Europe, 2000).

Of course, being adequately informed about biotechnology does not typically stand in the way of consumers having an *opinion* about biotechnology, especially when asked for one by someone conducting a survey. As such, in most surveys, the total number of those who report that they approve or disapprove of biotechnology typically exceeds the number of those who report having heard much about the subject. The important point is that these relatively uninformed opinions are "uncrystallized." That is, these opinions are not well thought through nor strongly held and are likely to change once people have some motivation to really think about the subject. These opinions are also highly reflective of how the questions are asked in a particular survey. Seemingly minor differences in the wording of questions can lead to large differences in the responses to those questions. For example, whether one uses biotechnology, genetic engineering, genetic modification, or genetic manipulation to describe the technology can lead to significantly different approval ratings. As such, surveys commissioned by industry often use the more benign and encompassing term 'biotechnology,' while those commissioned by opposition groups often use the more negatively viewed term 'genetic engineering.' Awareness and attitudes concerning biotechnology at any give time may also be influenced by controversy that focuses additional attention on the issues. For example, increases in the awareness of biotechnology were reported in the U.S. and the U.K. after media coverage of the controversies related to the cloning of the sheep named "Dolly" (Charles, 1998; Hoban and Katie, 1998).

Still, for much of the public, biotechnology remains a rather abstract concept, difficult to understand, and, with seemingly little practical relevance for the average consumer. Yet, this situation is likely to change with the introduction of increasingly visible biotech-based consumer goods, especially genetically modified (GM) foods. As a result, a better understanding of biotechnology and its implications may take on greater importance to consumers when they finally become faced with a real choice: To buy or not to buy, that is the question. Once consumers make that choice, their opinions become much more "crystalized," and much less open to change. Having made a choice, whether carefully considered or not, people will often adjust their attitudes to support their decisions.

National and Regional Differences

Not surprisingly, public awareness and acceptance of biotechnology vary in different parts of the world. In general, awareness and acceptance of biotechnology has been higher in the U.S., Australia and Canada than in Europe, Japan, and New Zealand (Einsiedel, 1997; Gamble et al., 2000; Hoban, 1999; Kelley, 1995; Macer et al., 1997). However, such broad comparisons

tend to obscure regional differences, especially in Europe. Several studies over the last decade have shown differences between countries in Northern and Southern Europe in their awareness, knowledte and acceptance of biotechnology (Hamstra, 1991; Zechendorf, 1994). For example, Eurobarometer surveys suggest that, in general, knowledge and awareness has been higher in Northern Europe (especially among respondents in the Netherlands, Denmark, Sweden, the UK and Finland) than in Southern Europe (Greece, Portugal, and Spain) (INRA Europe, 1991, 1993, 1997, 2000). In general however, respondents in Southern Europe have tended to be more accepting of biotechnology (or perhaps more indifferent to it), while those in Northern Countries tend to be much more skeptical (except for respondents in the Netherlands and Finland, who strongly approve of biotechnology) (Zechendorf, 1998).

The Link Between Education and Support for Biotechnology

Within countries, several studies have shown that those who are aware of biotechnology are generally better educated, believe they have a reasonable understanding of science overall, and tend to be active consumers of news reports from television and newspapers. Several studies have also revealed a significant correlation between education and support for biotechnology (Sheehy et al., 1998). A few studies have also shown an association between objective knowledge of basic scientific concepts related to biotechnology and overall support of biotechnology (Hill et al., 1998). It is important to note, however, that this association is not necessarily causal. A recent comparison of the reception of GM foods in the U.S. and Europe shows that, on average, Europeans have greater scientific knowledge concerning biotechnology than their American counterparts. Yet, Americans, on the whole, have more positive attitudes toward biotechnology. In fact, after statistically controlling for level of knowledge, Americans still hold more positive attitudes toward biotechnology than Europeans. In contrast, however, Europeans report more threatening images related to biotechnology than Americans. In fact, the level of threatening images related to biotechnology held by Europeans is at least twice that of Americans (Gaskell et al., 1999).

These differences are also reflected in media coverage of biotechnology. Conrad (1997) observed that in the news reports written after the cloning of the sheep "Dolly," none of the widely circulated British newspapers reported the event as a laudable achievement for British science. Instead, most of the headlines and stories pointed to the perils of human cloning. In contrast, American newspapers typically focused on the scientific achievement represented by Dolly. Many mentioned that the technology had implications for human cloning, but that human cloning was not a present threat.

Barriers to Education

Even if the relationship between knowledge and approval of biotechnology is causal, one should not assume that it is possible to gain consumer acceptance of biotechnology simply through public education. There are significant barriers to educating the public about biotechnology (Hallman, 1997). One reason is that since much of the public is unaware of biotechnology to begin with, it is unclear how education efforts would reach this segment of the population. Moreover, large percentages of those already aware of biotechnology are probably

not actively seeking additional information about it, but are probably more passive consumers of information presented by the media. Unfortunately, unless the science material presented by the media has 'life world' relevance to the audience, it is unlikely to be understood and assimilated by passive observers (Schibeci and Barns, 1988). In most countries, significant portions of the population rate their own basic understanding of science as "poor," and many others clearly overestimate their knowledge of science and technology (Hallman, 1996). Given that these people are unlikely to recognize the gaps in their own knowledge about biotechnology, it is doubtful that they would actively seek information to complete their understanding of the subject. There are also segments of the population of most countries who are suspicious of the scientific community and openly hostile to industry. They would likely reject any public education efforts and perhaps seek to undermine them.

In short, public education efforts designed to influence public acceptance of biotechnology face significant barriers. Currently, biotechnology is an abstract concept for many. Yet, when consumers are confronted with real products that they can touch, feel, smell, and taste, they will be faced with real choices. At that point, they may want information about biotechnology to help them make those choices. Unfortunately, most biotech companies, industry groups, and governmental agencies are relatively unprepared to give consumers, writers, and policy makers the kind of information these very different constituencies will want and need (Hallman, 1995). In part, this is because so little is known about the kinds of information people want, or when and especially where the information will be most useful to people. Moreover, because there has been little widespread consumer interest in the materials already produced, government and industry are unlikely to revise what they have in the face of underwhelming demand.

What Kinds of Information Are Consumers Seeking?

Because the use of biotechnology involves many complex and often abstract ideas, many people are uncertain about the potential risks and benefits posed by this new technology. As such, making good interpretations of complex technical information available to the public is important and welcomed by consumers. Yet, many admit that they have a difficult time using this information to make judgements about the risks or safety of biotechnology (Hall, 1999; Sheehy et al., 1998). Lacking the ability to interpret the science related to biotechnology, many people express less interest in the technical details than in details about the technicians. For most consumers, understanding the mechanics of biotechnology is probably not as important as knowing that the people who use biotechnology share the same values as they do. They want to be confident that the people involved with biotechnology are using common sense, and are taking proper safety precautions to protect the well-being of the planet and its inhabitants (Hallman, 1995).

Lack of Trust in Experts

Because of the complexity of the issues and technologies, many consumers would like to have confidence in experts to make decisions rather than having to rely on their own judgements (Creative Research International, 1996). This is especially true when it comes to judging the safety of biotechnology (Optima Consultants, 1994). Unfortunately, many surveys suggest that people lack exactly this kind of confidence in the scientific and technical community (Gunter et

al., 1999). Data continues to suggest an overall lack of trust in experts and institutions. Some observers also suggest that the merging of science and business required to develop GM products and to bring them to market may have had the effect of making people even more skeptical of the motivations and independence of scientists (Sardar, 1999).

Not surprisingly, people tend to be most mistrusting of the biotech industry itself. A recent Eurobarometer poll found that only 30% of Europeans believe that "the industry developing new products through the use of biotechnology does good work for society" (INRA Europe, 2000). The same survey found that on the subject of biotechnology, Europeans are most trusting of environmental protection organizations, consumer organizations, and the medical profession.

There are, of course, regional differences in public trust of experts and institutions. Zechendorf (1998), suggests that compared to Southern Europeans, Northern Europeans tend to be much more trusting of alternative sources of information about biotechnology such as consumer organizations and environmental groups, and less trusting of established sources such as public authorities and universities. Interestingly, a recent poll shows that Americans are generally more trusting than their British counterparts (Market and Opinion Research International, 1998a). Americans are more likely to trust civil servants (70% v 36% in the U.K.), journalists (43% v 15%), business leaders (43% v 29%), scientists (79% v 63%) and ordinary men and women (71% v 56%). However, the British are more trusting of newscasters (or newsreaders as they are called in Britain). In the U.S. only 44% of the adult respondents said they would trust newscasters to tell the truth, versus 74% in Britain.

Recent national experiences may explain differences in the amount of trust given to "established sources." It has been suggested, for example, that the main difference in acceptance of GM crops between the US and Britain is part of the legacy of Bovine Spongiform Encephalopathy (BSE). As a result of the perceived mishandling of "mad cow disease" the British people may be more skeptical of reassurances given by scientists and government officials regarding the safety of GM foods (Holmes, 1999, Horton, 1999). The differences in trust of experts, government, and other institutions reported by the British and Americans may also help to explain the different strategies and relative success of opposition groups in the two countries. Recently, opposition groups in the U.K. and Europe seem to have gained ground, largely as the result of the introduction of genetically modified (GM) foods. There, a principal strategy of opposition groups seems to have been to persuade influential opinion leaders outside the government to publicly oppose biotechnology. In doing so, the opposition groups have added credibility to their arguments. In the U.K. for example, statements urging caution in the adoption of GM crops have been made by a number of respected institutions, including the Monarchy (HRH the Prince of Wales, 1998, 1999), the British Medical Association (1999), the National Farmers Union (1998), and others. In the U.S., opposition groups have been much less successful in rallying public support for their position, or in getting influential opinion leaders to publically oppose biotechnology. As an alternative, many opposed to biotechnology have grouped together to file lawsuits against agencies of the federal government to halt the approval or implementation of new technologies, patents, and products. Other suits have been filed against individual companies. In the U.S., therefore, the strategy of opposition groups has often been to take their case to court, while in the U.K. and Europe, the strategy has been to take their case to the court of public opinion.

Support for Regulation

Lacking faith in science and industry to properly safeguard human health and the environment, most people, even ardent supporters of biotechnology, favor strict government regulation and oversight of the biotechnology industry. Recent European, American, and Japanese surveys suggest that many do not believe that current regulations are sufficient to protect people from the risks of biotechnology. Moreover, studies suggest that Europeans and Canadians lack faith in their own government to regulate biotechnology would prefer to have an international body regulate biotechnology instead (Einsiedel, 1997; Gaskell et al., 1999; INRA, Europe, 2000). Compared to their own national regulatory agencies, they have greater confidence in international organizations such as the United Nations and the World Health Organization to handle such regulations. Consistent with this are recent calls from the British Medical Association (1999) and the Ministerial Group on Biotechnology (Donaldson and May, 1999) for rigorous regulatory procedures on a worldwide basis.

CONCERNS ABOUT BIOTECHNOLOGY

Health

Among the fears most often cited by consumers in public opinion surveys are health concerns related to genetically modified GM foods. As a result of health, and other concerns, in June of 1998, Britain's Prince Charles wrote, in a widely publicized article for the Daily Telegraph, that he would not eat genetically engineered foods or serve them to his family or guests. Apparently much of the UK agrees with him. A June 1998 poll conducted for GeneWatch by Market and Opinion Research International Ltd., revealed that 61% of the respondents do not want to eat genetically modified foods (an increase of 8% since a similar poll was conducted in 1996). Moreover, 58% said that they oppose the use of genetic engineering in the development of food (up 7% since 1996). In the 2000 Eurobarometer Survey of Europeans, only 22% "mostly agree" that they would be "willing to buy cooking oil containing a little genetically modified soya," and only 19% "mostly agree" that they would be "willing to eat the eggs of hens fed on GM maize" (INRA Europe, 2000).

Food allergies seem to be of particular concern. Without labeling, some people with food allergies are afraid that they will have no way of knowing what foods to avoid. Often cited by consumer groups opposed to GM foods is a study published in the New England Journal of Medicine reporting allergic reactions to genetically altered soybeans. A gene from a brazil nut was introduced into the soybeans. As a result, in scratch tests, people who were allergic to brazil nuts had allergic reactions to the genetically altered soy but had no such reactions to unaltered varieties (Nordlee et al., 1996). However, these soybeans were experimental and never intended for market. More recently, concerns about possible human allergens in genetically modified corn (StarLink) necessitated the recall of taco shells, corn meal, and other products and the buy-back of remaining corn from farmers. The GM corn, which is not approved for human consumption because of its potential to produce Cry9c, a protein that may be allergenic was mistakenly used in a variety of foods (Franz, 2000).

Another health concern is that the use of antibiotic resistance as a marker in GM foods will lead to microbial resistance to antibiotics, with potential human health impacts. In their May 1999 interim statement, the British Medical Association urged a ban on the use of antibiotic resistance marker genes in GM foods, "as the risk to human health from antibiotic resistance

developing in micro-organisms is one of the major public health threats that will be faced in the 21st Century." They conclude that the possibility that antibiotic resistance might be passed onto bacteria that could harm human health cannot be ruled out. Similarly, the Royal Society issued a statement recommending that "any further increase in the number of antibiotic-resistant micro-organisms resulting from transfer of antibiotic-resistance markers from GM food should be avoided" (Royal Society, 1998).

Some consumers also express fears that as the result of genetic engineering "accidental toxins" or other harmful compounds may be introduced into food products. According to the Alliance for Bio-Integrity, the most pressing health concern related to genetic engineering of food products involves the possibility that such alterations might turn a nonionic element in the food into a toxin (Kimbrell and Druker, 1998). Because of the perceived likelihood of unintended consequences resulting from genetic modifications, consumer activists have begun calling for extensive testing of all GM foods to ensure that they are safe. For example, in another widely publicized article published in the Daily Mail entitled "My 10 fears for GM food," Prince Charles asks, "Why are rules for approving GM foods so much less stringent than those for new medicines produced using the same technology? Before drugs are released into the marketplace they have to undergo the most rigourous testing - and quite right too. But GM food is also designed in a laboratory for human consumption, albeit in different circumstances. Surely it is equally important that we are confident that they will do us no harm?"

Unfortunately, providing proof that GM foods are safe using the same techniques used for pharmaceuticals may be more difficult than many believe. In an article in the New Scientist, titled "Unpalatable Truths," Debora MacKenzie (1999a) argues that standard toxicology tests don't work well for food. One reason is that it is often difficult to feed lab animals enough GM food to test for undesirable effects. She argues that this was the case when Arpad Pusztai fed groups of rats normal or GM potatoes to test whether the GM food had different effects (Ewen and Pusztai, 1999). Pusztai concluded that the GM potatoes were harmful to rats because of their genetic modification alone. However, MacKenzie reports that Pusztai could not make the animals eat enough potato, so they suffered from malnourishment no matter which kind they ate. Indeed, a review by the Royal Society (1999) suggests that based on Pusztai's poorly designed experiments alone, it is impossible to determine whether there are adverse effects from GM potatoes. What is possible to conclude from the experiments, according to MacKenzie, is that "rats hate potatoes." Moreover, MacKenzie suggests that even if the rats liked to eat potatoes, animal models are not sensitive enough to reveal small differences between modified and unmodified foods. She argues that typically, the chemical changes resulting from genetic modifications are very small. As a result, researchers would have to feed their lab animals an enormous quantity of food for the animals to receive a dose of toxins large enough to cause a detectable effect. In the process, the researcher may change the diet of the animals so profoundly as to affect even those eating unmodified food.

Food Labeling

In addition to strict government oversight, most opinion polls also suggest that the majority of consumers favor GM food product labeling (Hamstra, 1998). Some consumers support such labeling so that they can exercise personal control over their exposures to genetically modified foods (Ekos Research, 1995). For example, a 1996 poll found that 89% of Austrians would avoid genetically engineered food products if they were recognizable through labels (Schillhab, 1996b). However, many consumers willing to buy biotech food products are also in favor of food labels, not so that they can avoid biotech foods, but so that they can make informed choices. A 1994 Canadian study (Optima Consultants) found that 68% of the respondents felt that choice was an important issue, regardless of their feelings about the products themselves. As such, most consumers support GM food labeling to retain "consumer sovereignty"; the right to make food choices based on their own values (Thompson, 1997).

Of course, whenever you ask people if they would like more information about the foods they buy, they usually respond positively. In principle, most people are in favor of having more information about nearly everything, especially if it doesn't cost them anything. Nevertheless, favoring the provision of such labeling information does not necessarily correlate well with the actual use of this information. Studies of the use of new uniform nutrition labeling information on processed food products in the United States show that consumers are quite happy to have the information on the packages they buy, but most don't use it. Similarly, a 1998 Eurobarometer study on the subject of food safety found that only about six-out-of-ten consumers claim to regularly read food labels. The poll found that young people are much less likely to read food labels than older consumers, mainly due to a lack of interest. Interestingly, the poll found that the most valued piece of information on the label was the sell-by date and that consumers were least interested in information concerning the product's country of origin or information concerning the likely presence of genetically modified organisms (INRA Europe, 1998). A study in the U.K. also suggests that labeling products 'made with genetic engineering' may not increase consumer perceptions of personal control (Frewer et al., 1996). Nonetheless, whether consumers actually use the labeling information or not, the fact that it is publicly available may improve consumer confidence.

From a political and regulatory perspective, the food labeling issue is quite complex. Most consumers are clearly in favor of food labeling, and many feel such information is essential if they are to maintain the right to make informed choices about the foods they feed their families. As such, arguing against food labeling is difficult politically, since doing so risks charges that government and industry are conspiring to deny consumers the right-to-know what they are eating. Yet, agricultural biotechnology companies argue that providing this information would be very costly and it is unclear whether the majority of consumers would use the information they would ultimately be paying for. While labeling whole foods like individual tomatoes grown from genetically modified seeds is technically feasible, as has been shown in the case of the Flavr Savr™ tomato; processed foods present a greater challenge. Given that it is difficult, or impossible to tell if a particular tomato has been genetically modified simply by looking at it, manufacturers of tomato soup would have to make special efforts to keep track of genetically engineered tomatoes and to insure that they are segregated from the other hybrid tomatoes at the packing plant.

Naturally, such tracking and segregation systems required to maintain "identity preservation" (keeping GM and non-GM varieties apart) would add additional costs to the

manufacturing process. These costs and the complexity of the necessary systems would grow with the number of ingredients in the processed food. Manufacturers of vegetable soup for example, would have to have separate tracking and segregation systems for each vegetable that went into the pot. They would then pass on the costs of these systems to consumers. The Food Biotech Communications Initiative, which represents major biotech producers has concluded that such tracking and segregation would increase food costs by as much as 150 percent. However, about 90% of the world trade in GM foods involves just two products, corn and soybeans (Pearce, 1999). As such, some agricultural economists argue that the costs of tracking and segregation would be much lower especially since US and European growers and farmers already separate and label shipments of these crops with different protein and oil contents and are paid a premium by processors for doing so (Mackenzie, 1999b).

Failure to track genetically modified ingredients in processed food has already caused consternation in the organic food community. In the United Kingdom, the Laboratory of the Government Chemist, which operates three food DNA testing centers, discovered that some soya flour labeled as "organic" had come from genetically modified soybeans. International organic growing associations have agreed that genetically modified crops should not be considered "organic." As such, the discovery of "DNA contamination" in soy-based foods marketed as organic has caused concern and outrage among customers and retailers of organic foods. The discovery of genetically modified corn in tortilla chips sold in health food stores in Britain and Europe resulted in the recall and destruction of 87,000 packages of the product. Ultimately, the manufacturer traced the source of the corn to a 7,000-acre farm in Texas (Arthur, 1999). More widespread was the recall of taco shells and other corn-based products mistakenly made with GM corn (StarLink) that had not been approved for human consumption (Pollack, 2000).

When the complexity and costs of providing this labeling information are presented, many consumers who initially support food product labeling become less sure that such a policy is a good idea. Such shifts in position are particularly common among those who say that they would be unlikely to use the labeling information when they shopped for foods. As such, some within the biotech industry are convinced that U.S. consumers would be unwilling to pay more for the segregation non-GM foods (Holmes, 1999). Others suggest that the public assumes that biotechnology should lower food prices, not raise them so passing on costs for tracking and segregating products would be highly unpopular (The Economist, 1999a). Some analysts suggest that forcing such unpopular increases in food costs may be an effective strategy to block the commercialization of biotech products and may, in part, explain activists' insistence that GM food products be labeled (Miller, 1999).

One solution, of course, is to avoid the cost of vegetable segregation altogether and to simply label the can so that consumers are informed that the soup, "may contain one or more vegetables genetically modified through the use of biotechnology." Since this is the least-expensive solution, it is likely that many food processors would adopt this strategy. Yet, consumers would receive little benefit from this kind of labeling, since it furnishes no definitive information, and because it is likely that most food products would have this label, the ability to make informed choices would be limited. Only manufacturers willing to pay the costs to ensure that their processed foods do not contain genetically engineered food products could label their products as "free of genetically engineered organisms." These costs would then be passed on to consumers. While there may be a substantial market for such GM-free products, with profits accruing to processors who provide them, an unintended consequence of such labeling would be a potential increase in the cost of food for those who wish to avoid genetically engineered foods.

Critics argue that this unfairly shifts the costs of the new technology to those who would prefer the status quo while all of the benefits would accrue to those who would seek to impose the technology upon them.

Another strategy, already adopted by many food retailers in the U.K. is to certify that they will sell no products containing "GM ingredients" (The Economist, 1999b). The advantage of such a strategy, popular with consumer groups, is that it does not require individual products to be labeled. On the downside, whether labeled or not, the products must be tracked and segregated, and the retailers are made responsible for ensuring that the promise of "no GM" is kept. In addition, "no GM" policies limit choices and potential benefits for consumers who would like to purchase GM products.

Despite its potential problems, pressure for labeling is mounting. Farm ministers of the European Union (EU) have moved to require manufacturers to label foods containing genetically modified corn and soybeans (European Commission, 1998). This is in addition to existing EU requirements to label novel foods or foods containing ingredients "no longer equivalent to an existing food or food ingredient" (European Commission, 1997).

On May 27, 1988, a coalition of scientists, religious leaders, health professionals, consumers and chefs filed suit in U.S. Federal District Court against the US FDA to require mandatory safety testing and labeling of all genetically engineered foods. The suit alleges that the current FDA policy, which permits GE foods to be marketed without testing or labels violates the agency's statutory mandate to protect public health and provide consumers with relevant information about foods. The suit also maintains that the FDA's policy is a violation of religious freedom. The suit was coordinated by the Alliance for Bio-Integrity in collaboration with the International Center for Technology Assessment (CTA) (Kimbrell and Druker, 1998).

Environmental Concerns

Topping the list of concerns of many environmental activist organizations is the lack of a scientific consensus about the potential environmental impacts of bio-engineered crops. This is especially true in the U.K. and Europe where, Hill (1999) suggests, what is left of the natural environment is inextricably linked with agriculture. As such, changes in agriculture may have significant impacts on wildlife. Many in the expert community are also beginning to publicly express concerns about the potential environmental impacts of GM crops. For example, in their recent interim statement concerning the potential effects of genetic modifications on agriculture, food and health, the British Medical Association (1999) concludes that "Careful consideration needs to be given to the effect of GMOs on farming practices, the countryside and wildlife and we therefore recommend a moratorium on the commercial planting of GM crops in the UK. The moratorium should continue until there is a scientific consensus (or as close agreement as reasonably achievable) about the potential long-term environmental effects."

Some environmental organizations such as Green Alliance recognize that the likelihood of a problem with a particular GM product is small. However, they also argue that there may be reason to be concerned about the possible cumulative effects of a host of subtle changes brought about by the presence of a large number of GM organisms in the environment (Hill, 1999). A recent study showing negative effects of pollen from genetically modified corn on Monarch butterflies has given increased weight to these concerns. The corn was modified to express *Bacillus thuringiensis (Bt)* toxin. In laboratory experiments, pollen from the *Bt* corn was heavily sprinkled onto milkweed leaves (*Asclepias curassavica*) and the leaves were fed to monarch

butterfly caterpillars (*Danus plexippus)*. About half died within four days, while none of a similar group of caterpillars fed unmodified corn died (Losey, 1999). Concerns about the potential vulnerability of Monarch butterflies and other non-target insects to *Bt* plants lead the US Environmental Protection Agency to put additional restrictions on the planting of *Bt* corn and cotton (Anderson, 1999).

Pointing to this event, in his article entitled "My 10 fears for GM food," Prince Charles asks, "How much do we really know about the environmental consequences of GM crops? Laboratory tests showing that pollen from GM maize in the United States caused damage to caterpillars of the monarch butterfly provide the latest cause for concern. If GM plants can do this to butterflies, what damage might they cause to other species? But more alarmingly perhaps, this GM maize is not under test. It is already being grown commercially throughout large areas of the Unites States of America. Surely this effect, which should have been discovered by the company producing the seeds, or the regulatory authorities who approved them for sale, at a much earlier stage? Indeed, how much more are we going to learn the hard way about the impact of GM crops on the environment?" (HRH the Prince of Wales, 1999).

Other environmental concerns are related to fears of the potential consequences of an unintended release of genetically modified organisms into the environment. One feared possibility is the failure to contain genetically modified species such that they begin to spread and displace native species, disrupting the existing ecosystem. Another concern is with the possible unintended crossbreeding between genetically modified organisms and native or traditionally crossbred species. For example, in their report concerning the risks and benefits of biotechnology The Biotechnology Working Group of the National Farmers Union (UK), expressed concern over the possibility that "genetically modified crop plants will spread into the natural environment, or that gene transfer into wild species by cross pollination will occur. This is considered genetic pollution by some environmentalists and could lead to an erosion of genetic diversity if "foreign" genes replace those already present in native plants." They also express concern that "a more complete destruction of weed species at field margins and hedgerow bottoms could reduce the habitat availability for insects,' thereby reducing the number of birds and other predators that rely on the weed and hedgerow environment and the animals that live within them." They also worry that "some GM pesticide-containing crops may affect the longevity and fecundity of predator insects, such as ladybirds, or may affect the behavior of pollinators such as bees" (Biotechnology Working Group of the National Farmers Union).

A related concern deals with the potential irreversibility of the consequences of accidental releases of genetically modified traits into the environment. In an article for the Daily Telegraph, called "Seeds of Disaster," Britain's Prince Charles wrote that, "Once genetic material has been released into the environment it cannot be recalled. The likelihood of a major problem may, as some people suggest, be slight. But if something does go badly wrong, we will be faced with the problem of clearing up a kind of pollution which is self-perpetuating" (HRH the Prince of Wales, 1998). Again, much of the British public seems to agree with the Prince. A June 1999 poll shows that nearly three quarters of those interviewed (73%) do not want GM crops grown in the U.K. because of the potential for genetic contamination of other non-GM crops (Market & Opinion Research International Ltd., 1999, June). Moreover, a 2000 Eurobarometer poll found that on average, Europeans "mostly agree" that "If something went wrong with GM food it would be a global disaster" (INRA Europe, 2000).

Concerns about the incorporation of *Bt* into plants

Another widely expressed concern among activists is the potential for decreased effectiveness of "natural" pest controls such as *Bt* through its widespread incorporation into plants. To fight this, in February 1999, a group of 65 plaintiffs, including Greenpeace, the Sierra Club and other environmental and consumer groups filed suit in a Washington, D.C. District Court against the US Environmental Protection Agency (EPA). They allege that the EPA acted unlawfully when it approved crops genetically engineered to produce their own *Bt* insecticide. *Bt* is a toxin produced by the soil bacterium *Bacillus thuringiensis.* The suit asks the EPA to withdraw their approval of all *Bt* plants and to stop approving any new ones until comprehensive assessments of potential environmental impacts of the plants are completed. The plaintiffs argue that *Bt* plants have the potential to harm beneficial insects and they fear that genes for *Bt* could spread to other species. They also claim that the widespread planting of *Bt* crops could accelerate the evolution of resistance to the *Bt* toxin by insect pests. Such resistance would make useless a natural insecticide now used by organic farmers as a remedy of last resort (Holmes, 1999).

Concern about *Bt* resistance has also been expressed within the scientific community. In their 1998 consensus statement, the FIFRA Scientific Advisory Panel (SAP) subpanel on *bacillus thuringiensis (Bt)* Plant-Pesticides and Resistance Management, concluded that "the widespread use of crops that express *Bt* insecticides is in the public good by providing additional pest control options to producers and by reducing the use of conventional pesticides. The Subpanel also recognizes that the risks of the selection of strains of targeted insects with strong resistance to *Bt* toxins is real, and steps to mitigate these risks are also in the public interest." The panel strongly recommended that resistance management programs "should be based on structured refuges designed to provide sufficient numbers of susceptible adult insects . . . " The subpanel also recommended that "the needs of growers who rely on *Bt* sprays also should be taken into consideration when developing regulatory decisions for resistance management" (FIFRA Scientific Advisory Panel Subpanel on *Bacillus thuringiensis (Bt)* Plant-Pesticides and Resistance Management, 1998).

Moral Objections

One of the most common criticisms of biotechnology is that it is tantamount to "playing God," fundamentally altering the relationship between humans and the rest of nature. In arguing against genetic engineering, Britain's Prince Charles writes, "I happen to believe that this kind of genetic modification takes mankind into realms that belong to God, and to God alone. Apart from certain highly beneficial and specific medical applications, do we have the right to experiment with and commercialize, the building blocks of life? We live in an age of rights. It seems to me that it is time our creator had some rights, too" (HRH the Prince of Wales, 1998).

Another common criticism is that in genetic engineering in general and the transfer of genes across species violates "Natural law." For example, Rabbi Harold White, Director of Jewish Chaplaincy and Lecturer in Theology at Georgetown University, states, "We must resist the irresponsible and irreversible sundering of the natural cross-breeding barriers through which genes from bacteria and animals are being permanently fused into every cell of our grains, fruits and vegetables in ignorance of the full consequences. Since the dawn of life on earth, Divine intelligence has systematically prevented such combinations. Limited human intelligence should not rush to make them commonplace" (Kimbrell and Druker, 1998).

The idea that biotechnology is not natural seems to widespread, at least in Europe. A 2000 Eurobarometer poll found that Europeans "mostly agree" that "GM foods threaten the natural order of things," and that "Even if GM food has advantages, it is basically against nature" (INRA, Europe 2000).

There are also some objections to gene transfers based on religious beliefs. While most Christian and Jewish groups find at least some types of genetic modification acceptable, Muslims, Sikhs, and Hindus typically find biotechnology less acceptable, and particularly object where such modifications violate food purity prescriptions (European Federation of Biotechnology Task Group on Public Perceptions of Biotechnology, 1994).

There are also ethical concerns related to the patenting of genetically modified organisms. In their briefing concerning patenting in biotechnology, the European Federation of Biotechnology Task Group on Public Perceptions of Biotechnology notes that much of the controversy related to the patenting of genes and the resulting organisms has to do with whether the product is the result of a "discovery" or of an "invention." At the heart of moral objections to such patents is the firm belief that because genes are naturally occurring entities, the manipulation of genes results in a discovery, not an invention, and that claims of invention are tantamount to claiming to be God. They also note that some object to granting patents covering living things because doing so changes the relationship between humanity and the rest of nature. People seem to be particularly sensitive about patenting animals, because such patents are seen as conferring "ownership," thereby "undermining the animal's right to independence of being and relegating it to the status of a mere object."(European Federation of Biotechnology Task Group on Public Perceptions of Biotechnology, 1996).

Economic/Social/Political Concerns

Most public opinion surveys concerning biotechnology have focused on consumer concerns, and health and environmental risks. As a result, there is little polling data that examines public opinion concerning the broader impacts of biotechnology on society, so it is unclear how salient these concerns are to the public (Davison et al., 1997). However, there are significant objections to biotechnology advanced by opposition groups, based on economic, social and political concerns. Many of the concerns center on the distribution of benefits and potential costs of biotechnology. In his article, "My 10 fears for GM food," Prince Charles asks, "Do we need GM food in this country?" He argues, "On the basis of what we have seen so far, we don't appear to need it at all. The benefits, such as there are, seem to be limited to the people who own the technology and the people who farm on an industrialised scale" (HRH the Prince of Wales, 1999). In the same article, Prince Charles asks, "What effect will GM crops have on the people of the world's poorest countries? He argues that "Where people are starving, lack of food is rarely the underlying cause. It is more likely to be a lack of money to buy food, distribution problems or political difficulties. The need is to create sustainable livelihoods for everyone. Will GM crops really do anything to help? Or will they make the problems worse, leading to increasingly industrialised forms of agriculture, with larger farms, crops grown for export while indigenous populations starve, and more displaced farm workers heading for a miserable degraded existence in yet more shanty towns?

Other concerns center on the possible impacts of genetic modifications to "cash crops" and other exports. High on this list are the potential impacts of genetic engineering that would allow industrialized countries to grow their own crops or to substitute products they now depend

on Third World countries to supply. Among the feared impacts are economic, social, and political disruptions in Third World/Developing countries. Several studies have examined the potential impacts of biotechnology on employment in developing countries. For example, an analysis by Watanabe (1985) suggested that biotech advances would especially benefit Third World countries, increasing the wealth of individuals and of the nation by improving agricultural self-sufficiency. In contrast, Junne (1991) argues that biotechnology is likely to allow industrialized countries to develop substitutes for commodities currently supplied by developing countries. The reduction in demand will lead to overproduction in the Third World. As such, biotechnology has the potential to "make many importing countries more self-sufficient and increase trade conflicts among overproducing countries." For example, Galhardi (1995) examined the potential trade-related employment impacts in Costa Rica that might result from biotech developments that would allow temperate countries to produce coffee, cocoa, or substitutes for them. Using a set of alternative scenarios making different projections for world demand, and related domestic production, export, and employment, Galhardi's analyses suggest that there is the potential for significant job losses, as much as 48% for coffee and 27% for cocoa.

Other concerns center on the potential dependency of farmers on seeds/ chemicals provided by single corporations. Under some existing licensing agreements, farmers would not be permitted to retain or replant seeds from GM organisms. As such farmers would typically face the choice of becoming completely dependent on a multinational corporation for their 'means of production,' or potentially being put at a competitive disadvantage by raising crops that they can retain their rights to. Another concern is that the widespread use of biotechnology will have unintended consequences for specific sectors of the economy or of society. The introduction of rBST in the United States for example, has led many to wonder what will happen to small-scale family dairy farms that must face increased competitive pressures from much larger production dairies willing and able to effectively boost their per unit output using rBST. Similar questions are sometimes raised about the potential problems of unemployment or dislocation of whole sectors of the world's agricultural economy, resulting from greater efficiencies produced by using biotechnology.

The Role of Ideology and the Hierarchy of Approval

A number of studies also suggest that while some consumers may have ethical or moral concerns about using biotechnology to modify any organisms, most consumers are less ideological in their approach to the issues (Frewer and Shepherd, 1995; Frewer et al., 1997a, Hamstra, 1998). There is, in fact, a "hierarchy of approval" when it comes to the application of modern biotechnology. Universally, studies show that people are much more willing to approve of the use of biotechnology if the organisms involved are plants than if they are animals. People are generally even less approving of the use of biotechnology to transfer genes across species (transgenics) and least approving of the use of biotechnology to introduce non-human genes into humans (except perhaps for specific therapeutic purposes) (Davison et al., 1997; Zechendorf, 1994).

Environmental and consumer activists seem particularly aware of this hierarchy and have made effective use of it, often using "slippery slope" arguments as part of their rhetoric. Thus, it is not unusual for opposing arguments concerning genetic modifications to plants (which are seen by the public as relatively acceptable) to rapidly move to arguments concerning the genetic

engineering of animals, humans, and transgenics (which are generally seen by the public as unacceptable). In doing so, it is possible for opponents to maintain that any advancement in biotechnology is evil since it will ultimately lead to the genetic modification of higher organisms. There is some evidence that this argument may be seen as credible. For example, a 1996 survey among Austrians found that 84% fear the "slippery slope" that begins with the use of genetic engineering of plants and animals and ends with its use with humans (Schillhab, 1996a). The biotech industry is also afraid of the 'slippery slope,' particularly that the current backlash against GM foods in the U.K. and other countries in Europe will escalate into opposition against other aspects of gene research. Already, biotech entrepreneurs are concerned that as a result of public and political reactions to GM crops, investors may be reluctant to put their money into any biotechnology firm, even those conducting medical research.

An important implication of this hierarchy of approval is that consumer acceptance of bio-engineered products at the lowest levels does not necessarily imply acceptance of products at higher levels. More specifically, widespread market penetration of bio-engineered tomatoes, soybeans, potatoes, maize or other produce does not necessarily mean that the battle over GM foods has been won or lost by either side. Studies suggest that it should not be assumed that because consumers have accepted these specific plant-based products that they would be any more willing to accept bio-engineered beef, pork, or any other animal-based products (Hallman, and Metcalfe, 1994). It would also be a mistake to assume that because the public has accepted GM plant-based ingredients in one product that they will accept the same ingredient in another product. For example, in addition to more general concerns about GM ingredients in processed foods, consumer groups have expressed particular concern about soy-based baby formulas (Kimbrell and Druker, 1998). As a result, Gerber, Nestle, Unilever, and other companies have announced that they will not use GM ingredients in their food products (Einhorn, 1999).

Products, Not Process

Several studies suggest that many consumers are more concerned with the characteristics of the products of biotechnology than they are about the use of biotechnology to create those products (Davison et al., 1997; Hamstra, 1998; Zechendorf, 1994). For example, a study of consumers in New Jersey, many respondents said that, in general, they did not approve of the use of biotechnology to genetically modify plants. However, when presented with a list of specific products with tangible benefits, many of these same respondents said that they would very much approve of the use of biotechnology to create more nutritious grain to feed starving people, to create new drugs to cure human illness, and even new kinds of grass that don't need to be mown so often! (Hallman and Metcalfe, 1994). Similarly, in the U.K., Frewer et al. (1997b) found that while people may have reservations about the processes used to create particular products, the particular benefits of the products may outweigh these concerns, provided that the benefits are directed toward the consumer.

Consistent with this, most opinion surveys show that the public is in favor of using biotechnology to create pharmaceuticals and the development of genetic tests. They also show the least public approval for the use of genetic engineering in food production or the insertion of human genes into animals to produce organs for human transplantation (Davison et al., 1997; Hamstra, 1998; Zechendorf, 1994). The results of the most recent Eurobarometer study on the subject also suggest that the applications that are seen as the most useful are also typically

deemed the least dangerous and vice-versa. In addition, the more the applications were judged to be useful for society, the more they were seen as morally acceptable (INRA Europe, 1997).

When is it Appropriate to Use Biotechnology?

For most consumers then, the issue is not whether to use biotechnology at all, but rather what products warrant the use of biotechnology. Many are concerned about the "trivial" use of biotechnology (Frewer et al., 1997a). Many consumers question the need for biotech-based products when conventional alternatives already exist. This is especially true when it comes to GM foods. In Northern Europe studies suggest that there is a strong preference for "natural" food because of its associations with health, quality, and taste (Hamstra, 1991). Moreover, studies suggest that many consumers consider the products of biotechnology as "unnatural" (Frewer, et al., 1996, 1997a; Hallman and Metcalfe, 1994). In general, public opinion surveys show that unless biotech products have perceived benefits for society or for consumers, people disapprove of them. People want those who employ biotechnology are using its extraordinary power to create products that promise real benefits for consumers, not merely big profits for companies.

Cautious Optimism

Despite these concerns and cautions expressed by consumers around the world, most surveys suggest that the majority are relatively optimistic about the potential for biotechnology to improve the lives of average people like themselves (Davison et al., 1997; Hamstra, 1998; Zechendorf, 1994). Many are convinced that biotechnology will create jobs, improve human health and nutrition, and yield measurable improvements to the environment. The question then is how to reconcile this cautious optimism with the public mistrust of science, industry, government, and other institutions, demand for accountability and oversight, the right to make informed choices about the foods we eat, and the avoidance of potential unintended economic and social consequences that might result from biotechnology? Moreover, how does one accomplish this reconciliation in an atmosphere of intense conflict among some, and unawareness and apathy among the great majority?

Conclusion: Who Decides?

The place to start is to recognize that decisions concerning the acceptability of biotechnology have long passed the point of being the sole province of experts or of the scientific community and have entered the realms of public policy and public opinion. Failure to recognize the nature of the differences between experts and consumers in knowledge and perspective regarding biotechnology can lead to faulty conclusions about the public's ability to make decisions about biotechnology and can lead to poor strategies for providing information to consumers (Hallman, 1995, 1997).

People involved with biotechnology (like all other human beings) generally overestimate how representative their knowledge and opinions are. We tend to believe that others share our values, know many of the same things we do, and are naturally interested in the same things we are. We (especially those of us who are scientists) also tend to believe that given the same set of facts, others would come to the same set of conclusions. This belief is also socially reinforced.

We tend to choose friends and colleagues with similar values and interests who do think much the same way we do. In part, this is why we enjoy our associations with them. The result is that we tend to think that everyone does (or should) think the same way we do. When we find out that everyone does not think like we do, the natural tendency is to question the competency or motives of those who do not agree with us. As a result, it is easy for those who work with biotechnology to conclude that when it comes to perceptions of biotechnology, the public is inconsistent and "irrational." But, the public is not irrational. Irrationality implies that the public cannot make decisions about the acceptability of biotechnology. What most surveys suggest is that much of the public has not made decisions about the acceptability of biotechnology - it simply has not been very high on their agenda of things to think about.

It is also important to remember that when people finally do begin to decide about biotechnology, the facts and assumptions they have at hand are likely to be very different from those available to people whose jobs are intimately tied to biotech. For example, eighteen months after she was announced to the world, more than half of the population of Britain (53%) said that they had heard of 'Dolly the Sheep.' Of those who had heard of Dolly, 65% correctly identified her as the first mammal cloned from an adult cell. However, when asked why Dolly was cloned, about half thought (incorrectly) that the research was designed to advance human cloning. Moreover, very few people were able to name the research institute where the work was performed (the Roslin Institute, or the company behind the work (PPL Therapeutics) (Charles, 1998). In contrast, as part of the same research, people within the biotechnology and pharmaceutical industries were also interviewed. Of those interviewed, 96% knew about Dolly, and three quarters correctly responded that the research was particularly valued by the pharmaceutical industry. In addition, 63% correctly named PPL and 54% named Roslin as the organizations involved in the research. Because scientists and regulators have different knowledge and make different assumptions compared to those in the general public, arguments that may seem very persuasive to those with a background in science and biotechnology, may not be very convincing to the public at large (Hallman, 1995, 1996; Rabino, 1998a,b,c). For example, many of the arguments used in communications authored by those in academia and industry tend to focus on the potential benefits and accompanying risks of biotechnology. However, there is little evidence that such arguments are persuasive with the general public, many of whom are arguing against biotechnology on moral and ethical grounds. Thus, many proponents are arguing their case in terms of risks and benefits, while many opponents are arguing in terms of right and wrong (Köcher, 1996). The trap we fall into, of course, is that when it is apparent that the public has not been convinced by what we believe are very persuasive facts and arguments, we again conclude that the public is irrational. (After all, if they were rational, they would come to the same conclusions we have.)

There are several real dangers in believing that the public is irrational when it comes to making decisions about biotechnology. The first is concluding that since the public is irrational, efforts to provide information and education are a waste of time and money. The second is concluding that since the public is irrational they cannot make "good" decisions about biotechnology and, as such, those who are rational (those experts who agree with our positions) should make decisions that are "good for the public." These conclusions are dangerous because the first nearly ensures that the public will not have the tools needed to make informed decisions. The second nearly ensures that the public will become angry that decisions about the acceptability of a perceived risk are being made for them.

Now is the time for extensive public discussions about the merits of biotechnology and the expectations and boundaries society wishes to place upon this powerful new technology. Moreover, efforts must be made to open this discussion to the widest possible audience since the available evidence suggests that despite several decades of heated debate among experts, much of the public continues to be relatively uninformed. Because of the increasingly global nature of the world's economy, and the lifting of protective trade barriers, decisions about the appropriateness of the use of biotechnology to create widely traded commodities take on global importance.

Literature Cited

Anderson, J. L. 1999. Letter to Bt corn registrants. Office of Pesticide Programs, United States Environmental Protection Agency. Monday Dec. 20. Available: htttp://www.epa.gov/oppbppd1/biopesticides/otherdocs/bt_corn_ltr.htm [updated Jan. 28, 2000].

Arthur, C. 1999. DNA tests reveal some 'organic' foods modified. The UK Independent, Friday Feb. 5, p3.

British Medical Association. 1999 May 18. The Impact of Genetic Modification on Agriculture, Food and Health - An Interim Statement. British Medical Association, London.

Charles, S. 1998. Results of a survey commissioned by HCC De Facto. 3rd European Biotechnology Symposium, Glasgow, 14-16 Sept. 1998.

Conrad, P. 1997. Hold the front page. New Sci. 155(2090):47.

Creative Research International. 1996. Environmental applications of biotechnology: Focus groups, final report. Industry Canada, Ottawa.

Davison, A., I. Barns, and R. Schibeci. 1997. Problematic publics: A critical review of surveys of public attitudes to biotechnology. Sci. Tech. Hum. Val. 22(3):317-348.

Donaldson, L., and R. May. 1999. Health Implications of Genetically Modified Foods. Report to the Ministerial Group on Biotechnology and Genetic Modification (MISC 6). London: Office of the Chief Medical Officer, Department of Health Press. Available: http://www.doh.gov.uk/pub/docs/doh/gmfood.pdf. [accessed Dec. 5, 1999].

Einhorn, C. S. 1999. Bitter harvest: Seed firms to press on with research despite public concern about altered foods. Barron's 79(36):13-14.

Einsiedel, E. F. 1997. Biotechnology and the Canadian public: Report on a 1997 national survey and some international comparisons. University of Calgary Graduate program in Communication Studies, Calgary.

Ekos Research Associates Inc. 1995. Biotechnology research design. Final Report prepared for the Office of Consumer Affairs. Industry Canada, Ottawa.

European Commission. 1997. Regulation (EC) No 258/97 of the European Parliament and of the Council of 27 January 1997 concerning novel foods and novel food ingredients. OJ L 43, 14.2.1997, p. 1. Available: http://europa.eu.int/eur_lex/en/lif/dat/1997/en_397R0258.html.

European Commission. 1998. Council Regulation (EC) No 1139/98 of May 26, 1998 concerning the compulsory indication of the labeling of certain foodstuffs produced from genetically modified organisms of particulars other than those provided for in Directive 79/112/EEC, OJ L 159, 3.6.1998, p. 4. Available: http://europa.eu.int/scadplus/leg/en/lvb/l21233.htm [Updated May 31 2000].

European Commission. 2000. Commission Regulation (EC) No 49/2000 of 10 January 2000 amending Council Regulation (EC) No 1139/98 concerning the compulsory indication on the labelling of certain foodstuffs produced from genetically modified organisms of particulars other than those provided for in Directive 79/112/EEC, Official Journal L 006, 11/01/2000 p. 13-14. Available: http://europa.eu.int/eur_lex/en/lif/dat/2000/en_300R0049.html. [Updated Mar.14 2000].

European Federation of Biotechnology Task Group on Public Perceptions of Biotechnology. 1994. EFB-Briefing 2: Biotechnology in food and drinks. EFB Task Group PPB, The Hague.

European Federation of Biotechnology Task Group on Public Perceptions of Biotechnology. 1996. EFB-Briefing 1: Patenting in Biotechnology. EFB Task Group PPB, The Hague.

Ewen, W. B., and A. Pusztai. 1999. Effects of diets containing genetically modified potatoes expressing *Glanthus nivalis* lectin on rat small intestine. Lancet 354:1353-1354.

FIFRA Scientific Advisory Panel Subpanel on *Bacillus thuringiensis (Bt)* Plant-Pesticides and Resistance Management. 1998. Final Report of the FIFRA Scientific Advisory Panel Subpanel on *Bacillus thuringiensis (Bt)* Plant-Pesticides and Resistance Management, Meeting 9- 10, Feb. 1998. Washington: United States Environmental Protection Agency.

Franz, N. 2000. Aventis buys back GM corn. Chem. Week 162(38):35.

Frewer, L. J., C. Howard, D. Hedderley, and R. Shepherd R. 1997b. Consumer attitudes towards different food-processing technologies used in cheese production: The mediating influence of consumer benefit. Food Qual. Pref. 8:271-280.

Frewer, L. J., C. Howard , and R. Shepherd. 1996. The influence of realistic product exposure on attitudes towards genetic engineering in food. Food Qual. Pref. 7:51-67.

Frewer, L. J., C. Howard, and R. Shepherd. 1997a. Public concerns in the United Kingdom about general and specific applications of genetic engineering: Risk, benefit and ethics. Sci. Tech. Hum. Val. 22(1):98-124.

Frewer, L. J., and R. Shepherd. 1995. Ethical concerns and risk perceptions associated with different applications of genetic engineering: Interrelationships with the perceived need for regulation of the technology. Agric. Hum. Val. 12(1):48-57.

Galhardi, R. M. 1995. Employment impacts of agricultural biotechnologies in Latin America: coffee and cocoa in Costa Rica. In B. Herbert-Copley (ed.). Assessing the impacts of agricultural biotechnologies. Proc. Meeting International Development Research Centre, Ottawa, 16-17 May, 1995. International Development Research Centre (IDRC), Ottawa.

Gamble, J., S., Muggleston, D. Hedderly, T. Parminter, N. Richardson-Harman. 2000, February. Genetic engineering: The public's point of view. Report prepared for The Horticulture and Food Research Institute of New Zealand Ltd. (HortResearch). Report No. 2000/249. HortResearch, Auckland.

Gaskell, G., M. W. Bauer, J. Durant, and N.C. Allum. 1999. Worlds apart? The reception of genetically modified foods in Europe and the U.S.. Science 285:384-387.

Gunter, B., J. Kinderlerer, and D. Beyleveld,. 1999. The media and public understanding of biotechnology: A survey of scientists and journalists. Sci. Commun. 20(4):373-394.

Hall, S. 1999. Care for steak TATA? Tech. Rev. 102(4):80.

Hallman, W. K. 1995. Public perceptions of Agri-biotechnology. Gen. Eng. News 15(13):4-5.

Hallman, W. K. 1996. Public perceptions of biotechnology: Another look. Bio/Technology 14(1):35-38.

Hallman, W. K. 1997. Risikoabschätzung in der Biotechnologie. p. 113-125. In G. Kaiser, E. Rosenfeld, and K. Wetzel-Vandai , (eds.). Bio-und Gen-technologie: Anwendungsfelder und wirtschaftliche Perspektiven. Campus Verlag, Frankfurt..

Hallman, W. K., and J. Metcalfe.1994. Public perceptions of agricultural biotechnology: A survey of New Jersey Residents. New Jersey Agricultural Experiment Station, Rutgers, The State University of New Jersey, New Brunswick N. J..

Hamstra, A.M. 1991. Impact of the developments of the new biotechnology on consumers in the field of food products. SWOKA, The Hague.

Hamstra, I. A.1998. Public opinion about biotechnology: A survey of surveys. European Federation of Biotechnology Task Group on Public Perceptions of Biotechnology, The Hague.

Hill, L. 1999. Biotechnology: A public perspective. OECD Obs. 216:26.

Hill, R., M. Stanisstreet, E. Boyes, and H. O'Sullivan. 1998. Reactions to a new technology: student's ideas about genetically engineered foodstuffs. Res. Sci. Tech. Educ. 16(2):203-216.

Hoban, T. 1999. Consumer acceptance of biotechnology in the United States and Japan. Food Tech. 53(5):50-53.
Hoban, T., and L. Katie. 1998. American consumer views on biotechnology. Cereal Foods World 13(1):20-22.
Holmes, B. 1999. The great divide: What do Americans make of the furor engulfing Britain? New Sci. 161(2175):6-7.
Horton, R. 1999. Genetically modified foods: "absurd" concern or welcome dialogue? Lancet, 354:1314-1315.
HRH the Prince of Wales. 1998. Seeds of disaster. The Daily Telegraph, Sat. June 13 1998. p. 1.
HRH the Prince of Wales. 1999. My 10 fears for GM food. The Daily Mail, Tues. June 1 1999 p. A1.
INRA Europe. 1991. Eurobarometer 35.1: Opinions of Europeans on biotechnology in 1991. Report written for the European Commission, Directorate-General "Science, Research and Development," Unit XII/E/1:Biotechnologies. Public Opinion Analysis Unit of DG X of the European Commission, Brussels.
INRA Europe. 1993. Eurobarometer 39.1 Biotechnology and genetic engineering: What Europeans think about it in 1993. Report written for the European Commission, Directorate-General "Science, Research and Development," Unit XII/E/1:"Biotechnologies." Public Opinion Analysis Unit of DG X of the European Commission, Brussels.
INRA Europe. 1997. Eurobarometer 46.1. The Europeans and modern biotechnology. Report written for the European Commission, Directorate-General "Science, Research and Development," Unit XII/E/1:"Biotechnologies."Public Opinion Analysis Unit of DG X of the European Commission, Brussels.
INRA Europe. 1998. Eurobarometer 49. Food safety. Report written for the European Commission, Directorate-General "Health and Consumer Protection." Public Opinion Analysis Unit of DG X of the European Commission, Brussels.
INRA Europe. 2000. Eurobarometer 52.1. The Europeans and Biotechnology Report by INRA (Europe) - ECOSA on behalf of Directorate-General for Research, Directorate B - Quality of Life and Management of Living Resources Programme European Commission, Brussels.
IFIC. 2000. U.S. Consumer Attitudes Toward Food Biotechnology. International Food Information Council. Washington DC. Available: http://ificinfo.health.org/foodbiotech/survey.htm
Junne, G. 1991. The impacts of biotechnology on international trade. p 46-63. In A. Sasson , and V. Costarini (eds), Biotechnologies in perspective: Socio-economic implications for developing countries. United Nations /Educational, Scientific and Cultural Organization (UNESCO), Paris.
Kelley, J. 1995. Public Perceptions of Genetic Engineering: Australia, 1994. Final report to the Department of Industry, Science and Technology. Department of Industry, Science and Resources, Canberra.
Kimbrell, A., and S. Druker. 1998 May 27. Press Release: Landmark lawsuit challenges Food and Drug Administration (FDA) policy on genetically engineered food. International Center for Technology Assessment, Washington D.C.
Köcher, R. 1996, July 17. Emotionen- Einen Standortfaktor. Eine Dokumentation des Beitrags. Frankfurter Allgemeinen Zeitung Nr. 164 .
Losey, J. 1999. Transgenic pollen harms monarch larvae. Nature 399:214.

Macer, D., H. Bezar, N. Harman, H. Kamada, and N. Y. Macer. 1997. Attitudes to Biotechnology in Japan and New Zealand in 1997, with international comparisons. Eubios J. Asian and Int. Bioethics 7:137-143.
MacKenzie, D. 1999a. Unpalatable truths. New Sci. 162(2182):18-19.
MacKenzie, D. 1999b. How to price what we put on our plate. New Sci. 161(2175):6-7.
Market & Opinion Research International Ltd. 1998a. Americans generally more trusting than the British - Except for Newscasters. MORI, London. Available: http://www.mori.com/polls/1998/harris.htm.
Market & Opinion Research International Ltd. 1998b. Public attitudes towards genetic engineering. MORI, London. Available: http://www.mori.com/polls/1998/genewatc.htm.
Market & Opinion Research International Ltd. 1999. GM field trials - Three quarters of the British Public don't want them. MORI, London. Available: http://www.mori.com/polls/1999/grn20699.htm.
Miller, H. I. 1999. A rational approach to labeling biotech-derived foods. Science 284:1471.
National Farmers Union. 1998. Report of the Biotechnology Working Group of the National Farmers Union (NFU). National Farmers Union, London. Available: http://:www.nfu.org.uk/pubs/biote.asp.
Nordlee, J. A., S. L. Taylor, J. A. Townsend, L. A. Thomas, and R. K. Bush. 1996. Identification of a Brazil-nut allergen in transgenic soybeans. New. Eng. J. Med. 334(11):688-692.
Office of Technology Assessment. 1987. New directions in biotechnology - background paper: Public perceptions of biotechnology. Washington DC: U.S. Government Printing Office.
Optima Consultants. 1994. Understanding the consumer interest in the new biotechnology industry. Prepared for the Office of Consumer Affairs. Industry Canada, Ottawa.
Pearce, F. 1999. Living in a GM world: Better luck next time. New Sci. Online. Available: http://www.newscientist.com/nsplus/insight/gmworld/gmfood/gmnews58.html.
Pollack, A. 2000. Kraft recalls taco shells with bioengineered corn. NY Times, Sep 23 2000, p. C1
Rabino, I. 1998a. Ethical debates in genetic engineering: U.S. scientists' attitudes on patenting, germ-line research, food labeling, and agri-biotech issues. Pol. Life. Sci. 17(3): 147-163.
Rabino, I. 1998b. The biotech future. Amer. Sci. 86:111-112.
Rabino, I. 1998c. Societal and commercial issues affecting the future of biotechnology in the United States: A survey of researchers' perceptions. Naturwissenschaften 85:109-116.
Royal Society. 1998 September. Genetically modified plants for food use. Royal Society, London.
Royal Society. 1999 May 18. Public Statement: "Review of data on possible toxicity of GM potatoes." Royal Society, London. Available: www.royalsoc.ac.uk/files/statfiles/document-29.pdf.
Sardar, Z. 1999. Loss of innocence. New Statesman 12(544):47-48.
Schibeci, R, and I. Barns. 1998. Gene technology communication: Facilitating public deliberation of pST gene technology. Sci. Commun. 20(2):204-226.
Schillhab, J. 1996a. Genmahlzeit. Ökonsult-Chef Joschi Schillhab präsentiert die Ergebnisse einer bundesweiten Umfrage unter 1.593 ÖsterreicherInnen, zum Thema Gentechnik in Österreich. Ökonsult Umweltforschung & Management Consulting GmbH, Dornbach, Austria.

Schillhab, J. 1996b. Gensorgen. Ökonsult-Chef Joschi Schillhab präsentiert die Ergebnisse einer bundesweiten Umfrage unter 1.448 ÖsterreicherInnen, zum Thema Gentechnik in Österreich. Ökonsult Umweltforschung & Management Consulting GmbH, Dornbach, Austria.
Sheehy, H., M. Legault, and D. Ireland. 1998. Consumers and Biotechnology: A synopsis of survey and focus group research. J. Cons. Pol. 231:359-386.
The Economist. 1999a. Special - genetically modified food: Food for thought. The Economist 351(8124):19-21.
The Economist. 1999b. Leaders:Who's Afraid?. The Economist, 351(8124):15-16.
The Gallup Organization. 1999, Oct 5. Gallup Poll: What biotech food issue? www.gallup.com/poll/releases/pr991005.asp.
Thompson, P. B. 1997. Food biotechnology's challenge to cultural integrity and individual consent. The Hastings Center Report 27(4):34-39.
Watanabe, S. 1985. Employment and income implications of the "bio-revolution": A speculative note. Int. Labour Rev. 124(3):227-247.
Zechendorf, B. 1994. What the public thinks about biotechnology: A survey of opinion polls Bio/Technology 12(9):870-875.
Zechendorf, B. 1998. Agricultural biotechnology: Why do Europeans have difficulty accepting it? AgBioForum 1(1):8-13.