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Public Acceptance of Genetically Modified Foods

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Abstract

The history of genetically modified foods was discussed. National and international acceptance of g.m. foods was explored. Benefits, economical impact, and risk assessment of g.m. foods were detailed. A consumer poll was conducted to learn the extent of knowledge people had pertaining to g.m. foods. From this information, conclusions were drawn and some solutions were suggested made on how to educate people about g.m. foods.

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Chapter 1: Introduction

Throughout history, new scientific discoveries have challenged conventional thinking. For example, observations made by Galileo Galilei that the Earth revolves around the Sun challenged the authority of the Church in the 17^{th} century. In the history of science, many other new discoveries have been initially greeted with little enthusiasm and harsh criticism. However, over the years society has learned to accept and celebrate these discoveries and the societal benefits they have afforded.

The introduction of new biotechnology methods in agriculture also has met with resistance. Traditionally, genetic enhancements of crop plants have come from breeding programs that capitalize on the natural variation between sexually compatible plants. Selective breeding has been used for centuries to produce new plant varieties. However, hybridization, the most commonly used technique, is subject to severe shortcomings. The plants must be sexually compatible, which limits the diversity of the genetic material available for crossing, and the process results in uncontrolled combinations of thousands of uncharacterized genes.

Biotechnology has made it possible to produce precise genetic changes at the level of single, well-characterized genes selected from one organism and introduced into another (Peters, 1992). The plants own genome also may be modified selectively to control, increase, or turn off specific functions within the plant (Peters, 1992). Applications of biotechnology already have had a profound impact on fields such as biomedical research, medicine, and food processing, and over a thousand biotechnology products have been approved and are in use today (Peters, 1992). In agriculture, biotechnology has been used to develop desirable characteristics in plants with more precision and knowledge than afforded by conventional breeding techniques. Some plants have been genetically modified to tolerate specific broad-spectrum herbicides (Peters, 1992). Others have been altered so that they are biologically protected against insect or viral pests, eliminating the need for some applications of synthetic pesticides (Peters, 1992). Future varieties of plants could be enhanced to produce foods with improved nutritional content or added health benefits, greater tolerance to environmental stresses such as drought, frost, or high salinity, and the ability to provide renewable sources of fuel, industrial oils, and plastics.

Despite an unblemished record of safe use, critics have mounted campaigns against this technology and have raised concerns about its potential impact on human health and the environment. In Europe, these campaigns and other unrelated food scares have seriously undermined public confidence in the safety of foods produced using this new, genetically-based science. In response, many European countries and the European Union have established new rules and procedures designed specifically to address "genetically-modified organisms." These actions have created an international trade conflict that has cost farmers hundreds of millions of dollars and now threatens to drive scientists and agricultural researchers away from a field of research that has tremendous potential for solving food security and environmental problems.

Unlike in Europe, similar campaigns in the United States have not yet resulted in widespread anti-biotechnology sentiment among the public (Smith, 2000). The reaction of U.S. industry, however, has characterized or created the perception among the public that biotechnology foods are inherently different and less safe, without acknowledging that almost all foods sold on market shelves have been genetically modified using traditional techniques.

The basis for the attacks on biotechnology is the idea that transferring genes between unrelated organisms is unnatural and inherently entails greater risks than traditional cross breeding. At the core of this debate is food safety, particularly the possibility that unexpected genetic effects could introduce allergens or toxins into the food supply. The use of antibiotic resistance markers has been criticized as possibly dangerous to human health. These concerns have led to calls both for increased regulation and for mandatory labeling of biotech food products (Smith, 2000). Concerns also have been raised about the impact of pest-resistant and herbicide-tolerant crops on the environment. For example, some biotechnology foes claim that widespread use of bioengineered pest-resistant plants could accelerate the development of pesticide-resistant insects or could have an negative impact on the populations of beneficial, non-target insects, such as the Monarch butterfly. It also has been suggested that the use of herbicide-tolerant plants actually will increase herbicide use and that "superweeds" could be developed through cross-pollination with nearby weedy relatives (Longman, 1999).

Given all of this, there must be a way to bring both sides together. All of the participants' viewpoints must be determined and conflict points identified, whereby solutions can be drawn. Our project focuses on the public's questions and concerns pertaining to g.m. foods and strategies on how they can be answered.

Chapter 2: History

The concept of genetically modifying crop plants, which humans grow and eat, has been in existence for thousands of years. In essence, this is the evolutionary process. Through mutations and natural crossbreeding, various different varieties have been naturally created. The first real attempt to study this phenomenon was in 1856, when Gregor Johann Mendel, who is more commonly referred to as "the father of modern genetics", started his genetic studies on the garden pea. He observed that not all garden peas were the same and that they could vary greatly in color, size, and shape. To see what caused these differences he performed experiments in which he crossbred pea plants with different characteristics. He then examined the offspring and found that the characteristics expressed in the parental plants could be transferred to the offspring. He then postulated a set of rules to explain how these characteristics could be transferred from parent to offspring. This method of crossbreeding plants led to the ability to crossbreed plants to enhance desirable, inherited traits. In 1908, the American botanist George Shull "found that inbreeding tended to purify strains of corn while weakening the plant. By cross-breeding inbred strains, he developed hybrids of maize that produced higher yields than the original varieties from which the crosses were made, and suggested that these hybrids could be used on farms in place of the varieties normally used" (Smith, 2000). Research into crossbreeding continued with the advent of the double cross and the discovery that using double crosses increased the viability of the plant compared to the results of single crosses. Crossbreeding methods were cultured and refined for many years until the 1953 when James Watson and Francis Crick discovered that DNA took the form of a double helix (Watson and Crick, 1953). This discovery led to a breakthrough into understanding the basic makeup of every living organism on the planet. Considerable work then began on the study of DNA and how it could be altered. Modern genetic engineering began in 1973 when Herbert Boyer and Stanley Cohen used enzymes to cut a bacteria plasmid and insert another strand of DNA in the gap (Hurlbert, 1999). Both bits of DNA were from the same type of bacteria, but this milestone, the invention of recombinant DNA technology, offered a window into the previously impossible -- the mixing of traits between totally dissimilar organisms. Since 1973, this technology has been made more controllable by the discovery of new enzymes to cut the DNA differently and by mapping the genetic code of different organisms. Now that we have a better idea of what part of the genetic code does what, we have been able to make bacteria that produce human insulin for diabetics (previously came from livestock) (Peters, 1992). These discoveries set the stage for the modern genetic engineering of plants and foods (Lewin, 2000).

Though crossbreeding plants is an effective way to produce desired characteristics in plants, severe drawbacks accompany this technique. "Traditional cross-breeding relies largely on sexual hybridization and remains a time consuming process that can take 15 years or more before a crop is ready for the market. Traditional breeding is hit-or-miss due to the uncontrolled recombination of tens of thousands of genes producing both desirable and undesirable traits. Also, the constraints imposed by sexual compatibility deny plant breeders access to a diverse range of genetic material, severely limiting the ability to improve crops through traditional means" (Smith, 2000). Modern biotechnology methods have remedied these problems.

Biologists have known for years that genes control most characteristics of living organisms. In the early work that was done with crossbreeding, it was impossible to confer a characteristic from an animal, such as frost resistance, into a plant. "With the development of biotechnology and rDNA techniques, plant breeders now possess the tools to introduce select, useful genes from a wide variety of sources into plants to express specific, desirable traits. Current methods of gene insertion include using a "disarmed" (or benign) plasmid from the plant pathogen *Agrobacterium tumefaciens* as a vector, DNA-coated metal microprojectiles, and direct uptake of DNA by protoplasts of plant cells" (Smith, 2000). This technology of using rDNA techniques offers an enormous advantage in the area of gene selection because it allows a specific gene to be transferred from an unrelated donor organism to a plant. And, unlike hybridization, this transfer can occur between two totally different, unrelated species, e.g., between a fish and a tomato.

Biotechnology and gene transfer has been a part of everyday life since the late 1970s. The transfer of genes from one organism to another was first applied in the medical field. In 1978 bacteria were genetically modified to produce human insulin for diabetics (Rissler, 1996). The insulin used prior to this development came from the pig. The use of biotechnology then spread to the food industry. Bacteria have been modified to produce rennin, for example. "Chymosin (also called rennin) is an enzyme used to clot milk and produce cheese. In the past, processors obtained chymosin from rennet, a preparation scraped from the fourth stomach of milk-fed calves. Today, the enzyme is purified from a bacterium that has been genetically altered to produce it. The chymosin obtained in this process is structurally identical to the naturally occurring form. About 60 percent of the hard cheese produced in the United States is made with chymosin from genetically-modified bacteria" (Smith, 2000).

Up until this point, all the modifications taking place via biotechnology were being done on organisms like bacteria and fungus. Any modifications taking place in the food industry were developed in organisms such as bacteria and then being injected into the foods that people buy. All that changed in 1989 when the Calgene Corporation developed the Flavr Savr tomato (Redenbaugh, 1992). The Flavr Savr tomato was designed to resist the natural softening that occurs over time. This softening results from an enzyme that the tomato creates after a period of time passes. Calgene targeted the gene that produces this enzyme and, essentially, shut it off by introducing into the genome an anti-sense DNA. All double-stranded DNA contains one strand that is complementary to the other strand. One strand that is coded by a G-A-T-C sequence (sense strand) will, in a double-stranded piece of DNA, be found to complementary base paired to a C-T-A-G sequence (anti-sense strand). When anti-sense DNA was introduced into the tomato, it base paired in a complementary fashion to the RNA coding sequence that coded for the softening enzyme. This inhibited the enzyme from being created and released and produced a tomato that had a longer shelf life. This marked the first use of modern gene therapy on a food source consumed by humans, and was the precursor for the production of what has been termed G.M. (genetically modified) or B.T. (biotech) foods.

Chapter 3: Present Day

Since 1989 the amount of research on g.m. food taking place worldwide as well as in the foods that are produced through biotechnology, has increased dramatically. Today, companies like Monsanto, AgrEvo, and Novartis are using biotechnology to modify many types of crops, from cotton to corn. Several g.m. foods are already available on the market, and many more are currently under development for future use. Monsanto's Roundup-Ready soy bean (engineered to produce its own insecticides) and the Flavr Savr tomato are examples of two g.m. foods that have been available for quite some time both in the U.S. and overseas. Modified corn varieties resistant to the European corn borer and the corn earworm have been produced. The NewLeaf brand of potato, engineered by Monsanto, contains a gene that will enable it to produce its own insecticides that will kill potato beetles. Modified sugar beets, canola, and cotton are also available (Carter, 1999). "Two new transgenic tomato varieties—dubbed Vegadura and Vegaspeso—are expected to hit the continental supermarket shelves soon" (Blackledge, 1998).

The use of biotechnology on foods extends far beyond plant crops. The growth rate of salmon has been increased fourfold by genetic modification with growth hormone genes. Cows and sheep are being altered so that human anti-clotting factors can be produced in their milk, while pigs are being altered so that they will produce human hemoglobin in their own blood (Carter, 1999). "At the University of Wisconsin, horticulturists are cultivating onions full of chemicals that inhibit blood clots that bring on strokes. At Boyce Thompson Plant Research Center at Cornell University, researchers have developed bananas that contain their own Hepatitis B vaccine and could be produced for pennies a dose for the 2 billion people affected worldwide – if they can figure out an effective way to measure correct doses" (Carter, 1999). In March of 1999, Kellogg's "introduced psyllium-added pasta, cookies, potato crisps and cereal that come with an FDA-approved promise to help lower cholesterol – only the second product to get approval to make a food-specific health claim" (Carter, 1999). Other companies "are working overtime to produce enough broccoli sprouts, which naturally contain lots of cancer-fighting sulforaphane GS, to meet demands. In studies over the past two decades, sulforaphane was shown to be by far the most potent substance to protect against cancer by activating enzymes that attack carcinogens in the body" (Carter, 1999).

Some of these changes to these foods not only alter the genotype of the organism their appearance as well. For instance, a carrot has been developed that is anything but orange. "Leonard M. Pike and colleagues at the Vegetable and Fruit Improvement Center at Texas A&M in College Station have produced a maroon-colored carrot marketed as BetaSweet that has levels of beta carotene so high that you can get a day's requirement by eating just half a carrot. The conventionally bred carrot also has high levels of anthocyanin, the antioxidant found in blueberries" (Carter, 1999). Beta-carotene has been shown to be very beneficial to the immune system, and it helps improve night vision (Carter, 1999).

The following is a list of modified foods currently available or under development, and was obtained from Sylvia Carter's March 1999 article in the publication Long Island: Our Future. Eggs have been modified to give an added amount of good cholesterol by tripling the level of Omega-3 fatty acids. These eggs are currently sold by Eggland's best and are for sale in Long Island and surrounding areas. Caffeine free coffee beans are being developed at the Center for Plant Biotechnology Research at Tuskegee University in Alabama. This results in beans that will not need to be decaffeinated, which will save coffee manufactures and consumers money. At UCLA's Connelly Lab for Applied Nutritional Science they have developed what is called Met-Rx frozen pizza. The pizza has been made with tomatoes that, as a result of modification, contain more than double the amount of lycopene. Studies have shown that lycopene can help combat many forms of cancer.

All of these foods claim to be beneficial in some way to man, whether they be health benefits or simply cost saving benefits for farmers. Yet they have sparked debate among people throughout the entire world. Not all people support modifying our foods with these new biotech methods, and there is dissent among consumers, farmers, and even scientists as to whether g.m. foods are needed, or even wanted.

Chapter 4: Acceptance Here And Abroad

Until recently, g.m. foods have been accepted by the American public. But opinions are slowly starting to change as more people become aware of the existence of these foods and exactly how far reaching the impact is into their everyday life. This was most clearly witnessed at the protests that were held in Seattle during the World Trade Organization meeting in early December of 1999. These protests received a high degree of coverage by the media, especially since they seemingly appeared out of nowhere. What many people actually witnessed was the beginning of a battle that has been ongoing in countries like Japan and Europe for the past few years, one that has now been declared here in the United States. It is something many of the food companies had hoped to avoid, and now it is something they have been scrambling to get under control.

Prior to their exposure during the year 2000, many Americans were unfamiliar with genetically modified foods. Many had no idea that foods were modified in such a way, or that many of the foods that they were eating had been altered by such means. In contrast g.m. foods have been a topic of considerable controversy for several years in England and Japan. American companies such as Monsanto began to slowly introduce products such as g.m. soya into the U.K. market place, and this was mostly done without the consumers' knowledge. After several news stories and investigations, U.K. consumers' became alerted to the fact that their food was being genetically modified without any public announcement, labeling, or any other means (Lambrecht, 1999).

A poll taken in the United Kingdom during 1998 showed that 61% of the population did not want to eat modified foods, and that 77% had wanted these foods banned completely. Prince Charles spoke out against modified foods, asking people to boycott any modified foods imported into Britain. In a speech during October 1998, the Prince stated " 'we have to recognize that genetically modified food is already coming into this country in large quantities from elsewhere. The only effective restraint will be strong and sustained pressure from consumers demanding choice in the matter'" (McCarthy, 1998). In Japan, "more than 80% of those questioned in a 1997 government survey said they have 'reservations' about such foods, and 92.5% favored mandatory labeling" (Efron, 1999). But polls are not the only indication that people in these countries are not accepting modified foods. In Britain many fields full of genetically modified crops have been completely destroyed, having been ripped up out of the ground or burned by protesters (Lambrecht, 1999). In June of 1999, British protesters destroyed a plot containing sugar beets that had been genetically modified. Later, in August of the same year, protesters then attacked and destroyed a plot of land containing modified canola (Lambrecht, 1999). As of February, 1999, Britain had "a voluntary, one-year embargo on commercial planting of GM crops: green groups want it to last five years, the biotech companies are keen to go into full-scale growth" (Matthews, 1999). Britain is not the only country to be taking action in response to importation and growth of these modified foods. France has implemented temporary bans on modified foods. In other parts of Europe, "grain shipments from America have been blocked at the border of Switzerland and other countries because they contained 'suspicious DNA'" (Carter, 1999). In Japan, several cities have completely banned the foods from being used in their school lunches (Lambrecht, 1999). In India, during November of 1998, several of

Monsanto's plots of genetically modified cotton were burned during what was called "Operation Cremation Monsanto" (Lambrecht, 1998).

In contrast to these extremes, many protesters are advocating that consumers should have a choice as to whether they will eat g.m. foods versus foods that have been grown naturally and with modern, non-biotech methods. Though modified and unmodified foods may be grown completely separately from one another in many cases, eventually they are mixed and stored in the same storage facility or silo (Longman, 1999). They are then exported to Europe or Japan and used for consumption. The problem perceived is that these people did not have a choice. But it is difficult to tell consumers which foods do and do not contain modified foods because "food manufactures themselves don't know which GMO's may lurk in their products. Pillsbury, for example, avers that its Green Giant brand sweet corn varieties are not genetically modified. But in a written statement, the company allows that 'many of our products contain food ingredients derived from soy (soy oil, soy protein, soy sauce) and corn (corn starch, corn oil, high fructose corn syrup), all of which could have been produced using genetic modification. Since soy and corn are managed as commodity ingredients in the United States, it is possible that traditional and genetically modified products could become commingled during harvest, storage, and processing'" (Longman, 1999). Because of this, there have been many calls for segregation of these crops from one another. "One technology American farmers lack is the mechanism to separate genetically altered grain before exporting. Those bins on the edges of Midwestern towns hold the harvest from farmers nearby. In Illinois, about 40 percent of soybeans and 25 percent of corn in those repositories – modified and unmodified mixed together – will head by truck or rail to the Mississippi River to begin their voyage to foreign lands. The U.S farm establishment doesn't want the complications of a separate system" (Lambrecht, 1998).

Opponents would like to be able to choose between modified or completely organic foods for a variety of reasons. For some, choice is simply a matter of principle. They feel that biotech companies are tying "to hide information [about product origin] and force-feed people what they don't want to eat" (Efron, 1999). In several European surveys, it's been found that "Europeans instinctively ask for choice and the option to say no to GM food. They continue to demand stringent labeling for any produce to reach the supermarket shelves" (Blackledge, 1998). In the United States, by contrast, since there are few laws requiring differentiation between modified and unmodified foods, many Americans simply discovered on their own that they were not eating completely organically grown foods. They were not asked. They were not given any sort of choice in the matter. As geneticist Don Grierson put it, " 'people were outraged because they wanted to be treated—rightly—as individuals with minds of their own'" (Williams, 1998a).

Choice, or lack thereof, is not the only reason that modified foods have been opposed. Religious and moral factors also play a role. " 'Jews and Muslims have rigid dietary laws against eating certain animals, yet their tomatoes or lettuce may one day contain pig genes'" (Feduschak, 1999). As stated previously, new anti-freeze genes from fish are being placed in fruits and vegetables to keep them from being damaged by frost. For many vegetarians, this may pose a serious moral problem because they have taken a vow to eliminate all meats from their diets. By eating these newly modified fruits that resist freezing, they may inadvertently break their vow without even knowing it.

1998 was a difficult time for farmers in India due to insecticides that no longer worked and increasing debt. Monsanto's modified soybean could have helped these farmers. "But even amid such despair, Monsanto is viewed with hostility. In India, opposition to those seeds is fueled not by concerns about the environment, as in Europe, but by a strain of dedicated nationalism. Farmers and intellectuals preaching the mantra of self-sufficiency inveigh that foreign companies must not gain a foothold on India's farming and food" (Lambrecht, 1999). Thus g.m. foods are an unacceptable substitute for completely natural and organic foods for religious, moral, and rational reasons.

Other groups simply do not accept modified foods because they consider modification a form of food tampering. It must be remembered that here in the United States, aside from occasional droughts, there have been no real famines or contamination of food supplies. In contrast, Europeans are very distrustful of having their foods experimented with or altered due to a history full of famines and catastrophes. Many Irish people remember the Great Potato Famine of the 1840's. Awareness of the recent experimental work done to modify the potato has made many people worry "that genetic tinkering might threaten a food supply that has grown bountiful" (Lambrecht, 1998). In recent years Europeans have had to deal with contaminated beef, which led to an outbreak of bovine spongiform encephalopathy (Mad Cow Disease). It was a total disaster, which resulted in "human deaths, the slaughter of 11 million cattle and a scar on the European psyche. In hearings this month [December of 1998] in Britain, people continue to ask what went wrong in science and government regulation. Europe's skepticism also is connected to attitudes toward food – even though no dangers from eating modified foods have been proved" (Lambrecht, 1999). It is believed that this outbreak was "triggered by new cattle food processing techniques [and] has made the public much less inclined to trust the assurances of scientists, politicians and the food industry" (Matthews, 1999). To this day many remember this outbreak, and even American's were affected by the fear. Fast food restaurants halted shipments of meat that were imported from England, grocery stores pulled beef off the shelves, and schools stopped having beef as part of school lunches one the initial story broke about contaminated beef. The US even stopped importing beef from England (Nando, 1996). As outraged and fearful the Europeans were, that sentiment was quickly adopted by Americans as well, and the scare opened many eyes to the dangers of working with foods. Europeans have also had to face problems of poultry contaminated with *Salmonella* and outbreaks of *E. coli*. "In some other countries, there is a general abhorrence of any genetic manipulation because of Nazi abuses of genetics in the name of science" (Williams, 1998a). Similar problems have arisen in the Japanese market. "In Japan, the credibility of the Ministry of Health and Welfare was severely damaged by the 1996 revelation that its bureaucrats had knowingly allowed the sale of HIV-tainted blood products—a scandal that broke the same year that the ministry approved the first of 22 GMO crops for human consumption here [in Japan]" (Efron, 1999). With all of these events still fresh in the minds of many European and Japanese people, the arrival of these modified foods has not gone over as well as expected, and for obvious reasons.

Chapter 5: Benefits

Genetically modifying foods is a field ripe with controversy. In Canada and the United States, more than 20 different companies are involved in genetically modifying crops. Different reasons have been cited for the commercial growth of these technologies. Supporters claim that biotech companies such as Monsanto are creating products that are extremely helpful for both people and the environment. It is now possible to create tomatoes that will not freeze, fish that grow at three times the normal rate, and potatoes that create their own insecticides. The ability to control the growth of food "could help feed the growing world population by lowering production costs and increasing productivity" (DeRinaldis, 1999). Farmers are also able to save money by reducing spraying of crops with insecticides and herbicides. In Britain, for example, "bioengineered soybeans saved farmers an average $30 a hectare because they used 40 percent less herbicide. Pest-resistant corn saved $42 per hectare" (Belsie, 1999). And because pests can be controlled, bigger harvests can result. Larger crop yields per hectare also benefit the environment. Farmers can grow one and a half times the amount grown from non-g.m. crops in the area. In a fact sheet titled Healthy Harvests: Growth Through Biotechnology, prepared by the U.S. Secretary of State Madeleine Albright, she states the following:

> "Biotechnology helps the environment. By allowing farmers to reduce the use of herbicides and pesticides, the first generation of biotechnology products is helping to reduce herbicide and pesticide use, and future products are expect to yield more environmental benefits. Reduced herbicide and pesticide use means a smaller risk of toxic contamination of both surface and groundwater. In addition, herbicides used in

conjunction with genetically engineered plants are often safer for the environment than the herbicides they replace. Bioengineered crops also may reduce the need for farming practices, such as tillage, that can result in soil loss" (Albright, 2000).

She also goes on to state in the document that

"Biotechnology has tremendous potential to help fight hunger. Biotechnology developments offer significant potential benefit for developing countries where almost a billion people live in poverty and suffer from chronic hunger. By increasing crop yields and making crop disease- and drought-resistant, biotechnology could reduce food shortages for a world population expected to exceed 8 billion by 2025 – and increase of more than 30 percent from our current population. Researchers are developing varieties of staple crops to enable them to survive harsh conditions such as droughts and floods" (Albright, 2000).

Opponents, on the other hand, believe that companies like Monsanto, AgrEvo, and Novartis are motivated by either "scientific challenge or the chance of making a lot of money" (Matthews, 1999). They believe that these companies would like to establish a monopoly over organic foods by flooding the market with their g.m. seeds while the benefits "go into the pockets of (often U.S.-owned) biotech companies" (Williams, 1998a). Several other companies in and around the United States have already started investing money into developing their own g.m. seeds, and opponents believe that if g.m. foods are allowed to permeate the market, the farmers that wish to stay with organically grown foods will get squeezed out of the large-scale food market and instead have to use their crops to fill a specialty niche market. It is also feared that such a monopoly would allow a few large companies to control the world's seed supply, which in turn would dictate which foods are grown. One farmer in France, for instance, believes that "the consolidation of seed companies by Monsanto and rivals around the world ultimately will diminish farmer choices and even force them to use modified seeds against their will" (Lambrecht, 1999).

Chapter 6: Industrial Worth

The entire food industry is affected by the acceptance or rejection of genetically modified foods, from the scientific company that developed the seeds to the farmer that grows them, to the grocery store or small market in which these foods are sold. In 1999 the total worth of Monsanto was estimated at $35 billion. In the U.S. the food and drink industry is worth almost $600 billion. In 1998 "25% of corn, 38% of soybeans, and 45% of cotton grown in the United states were genetically altered...[while] U.S. agricultural exports reached about $50 billion, or more than 7 percent of all American goods bought abroad" (Longman, 1999). In 1999 those numbers have risen. Nearly one-third of the corn grown in 1999 as well as half the soybeans grown were modified. Almost 20% of those goods exported were shipped to Japan, making Japan number one in U.S. agricultural exports and bringing in almost $11 billion in sales. In China in 1998, "some 650,000 farmers in China planted genetically modified cotton. And this year Monsanto, which produces the cotton seed, expects to double that number" (Belsie, 1999). More than 60 million acres of modified crops are currently grown in the United States and almost 23 million acres grown around the rest of the world. In 1994, there were none. Merrill Lynch has predicted that "the global market for genetically engineered seeds will reach $6.6 billion by 2005" (Blackledge, 1998).

These figures show that biotech companies and the food industry as a whole have much to gain and everything to lose if modified foods are not accepted by consumers around the world. Farmers also stand to lose because so many of them have switched over to using modified seeds. In December of 1999, a class action lawsuit was filed against Monsanto and their Roundup-Ready soybean. Six farmers, 5 from the Midwestern United States and one from France, are accusing Monsanto and other biotech companies of " 'corporate abuse of power' in giving farmers and farm groups 'false and fraudulent guarantees' about the safety of seeds engineered to resist pests, withstand herbicides, and even produce their own insect toxins. The companies also misled farmers regarding the marketability of the seeds, the lawsuit charges, by glossing over objections from European Union nations, which import a large percentage of U.S. corn and soybeans" (Lazaroff, 1999). These farmers feel that not enough testing was performed on these seeds and the foods they produce, and that they were rushed out to market at the farmers' expense. Due to the outrage overseas over newly engineered crops, many farmers last year found that the market dried up. Because many countries were boycotting these modified foods, the farmers could not do anything with these crops because very few countries wanted to import them.

The biotech companies wish to avoid events like this. If farmers start to lose confidence in these modified seeds, then the future of g.m. foods will be in jeopardy. Already for this year, predictions are that less modified foods will be grown due to last year's events and poor results. Biotech companies like Monsanto argue that confidence in their modified seeds is still high, and have countered with figures that show that roughly the same number of farmers this year will use modified seeds as they did last year. Monsanto and several other companies have invested heavily in the production of these genetically modified foods, and the export of food to other nations is an extremely important source of revenue to the United States. With such a large percentage of crops being genetically modified in the U.S., the continued boycotting of such foods such in the

U.K. and Japan could have severe repercussions throughout the entire food industry. There is a substantial profit to be made in this industry as a whole, but financial ruin is also possible, and the outcome is dependent on how consumers respond to the rapidly increasing production market of g.m. foods.

Chapter 7: Risk Assessment

With every new technology comes some associated risk. Questions are raised and answers are expected. The genetic modification of foods impacts everyone, and has thus sparked far-reaching debates.

Unfortunately, some potential effects of genetic manipulation are difficult to predict. Opponents fear the creation of dangerous new species of plants resulting from crosspollination by genetically modified crops. Some biologists worry about emergence "of super-resistant weeds that pick up biological pesticide genes through cross-pollination, or super-bugs that develop genetic resistance to the pesticides in altered plants" (Carter, 1999). England's own conservation agency—English Nature—fears that "breeding new plants to be resistant to pesticides and herbicides will mean more of the chemicals are used, endangering birds, insects and other wildlife" (Matthews, 1999). In May of 1999, a study conducted at Cornell found that pollen from genetically modified corn, when fed to monarch caterpillars, caused them to either die or have serious developmental problems (Losey, 1999). But as George Johnson puts it in an article in the St. Louis Post-Dispatch:

> The genetically modified corn was engineered to contain an insect-killing toxin (harmless to people) to combat corn borer pests. Of course it will kill any butterflies or other insect in the immediate vicinity of the field. What we should focus on is the fact that the genetically modified cornfields do not need to be sprayed with pesticide to control the corn borer. An estimated $9 billion in damage is caused annually by the application of pesticides in the United States,

and billions of insect and other animals – including an estimated 67 million birds– are killed each year. This pesticide-induced murder of wildlife is far more damaging ecologically than any possible effects of genetically modified crops on butterflies (Johnson, 1999).

Another possible environmental problem was found when Nick Birch at the Scottish Crop Research Institute conducted a study on genetically modified potatoes. His results concluded "potatoes containing a novel lectin, which reduces aphid attack without killing them [causes] ladybugs that feed on these aphids [to suffer] significant loss of viability of their eggs compared to ladybugs feeding on control aphids" (Williams, 1998b). Other fears, such as a loss of crop diversity due to the fewer varieties of seeds being available by the biotech companies, as well as the effects of the environmental equilibrium on birds and other wildlife populations that depend on various weeds and insects found solely on farms, are also valid. But most of these fears are merely speculation with no hard science available to neither support nor deny these concerns. Some scientists, though, agree that in the end "too little research has been done on the long-term environmental effects" (Schmickle, 1999).

Fears also arise over what effects these modified foods will have on human beings. Genetically modified soybeans, for instance, have come under fire for causing certain allergies in people. It was found that "addition of a methionine-enhancing gene from the Brazil nut into soybeans (which are deficient in this amino acid) was discontinued when six of eight individuals allergic to Brazil nuts produced antibodies to the GM soybeans" (Johnson, 1999). Other reports state that "the use of chemical weed-killers on transgenic soybeans stimulates production of a soybean estrogen, a harmful substance similar to the female sex hormone.....[which] might have the harmful effect of making a male fetus become feminine or prevent the full formation of male genitals in babies" (Kakuchi, 1998). In February of 1999, an article in New Scientist magazine suggested "food containing antibiotic-resistant DNA – such as grain used to feed livestock – could introduce bacteria-resistant genes to bacteria in the cattle's digestive system. Some scientists say eating an animal fed this altered food could cause someone to contract a disease immune to strong antibiotics. Others argue there is no risk since DNA breaks down too quickly once inside the consumer" (Anonymous, 1999).

G.M. foods could also affect the work force. Because growing these crops is more efficient, and because less spraying and maintenance are needed, a smaller workforce is needed to maintain the farm. Prince Charles made this point clear in his speech in June of 1998 where he pointed out that "organic farming helped to sustain rural communities, increasing full-time employment by 80 per cent after conversion. In the US, one farmer growing genetically-modified crops now needs less than a dozen staff to farm 8,000 acres" (McCarthy, 1998).

Supporters of this technology have rebuked many of these claims and accusations. In a report submitted to the U.S. House of Representatives Committee on Science it was stated that "There is no evidence that transferring genes from unrelated organisms to plants poses unique risks. The risks associated with plant varieties developed using agricultural biotechnology are the same as those for similar varieties developed using classical breeding methods. As the new methods are more precise and allow for better characterization of the changes being made, plant developers and food producers are in better position assess safety than when using classical breeding methods" (Smith, 2000). The National Academy of Sciences reported in 1987 that 'There is no evidence that unique hazards exist either in the use of r-DNA techniques or in the transfer of genes between unrelated organisms," and that "The risks associated with the introduction of r-DNA organisms are the same in kind as those associated with the introduction in the environment of unmodified organisms and organisms modified by other genetic techniques" (Smith, 2000). In fact, the risk involved using modern biotechnology methods has been shown to be about equal to the risk involved in using modern hybridization techniques.

Supporters have also rebuked the argument that the use of this technology will result in super weeds through cross-pollination. "Extensive field trials overseen by USDA and scientific assessments by major scientific organizations demonstrate that the environmental risk of biotech crops is no different from the environmental risk associated with similar crops bred using conventional means. Because the genetic manipulations being performed today are on crop varieties that already are being grown commercially, we have a broad base of knowledge from which to assess these risks. Standard practices in crop development, field-testing, and management will ensure the environmental safety of these crops" (Smith, 2000). While it is possible that a gene for pesticide resistance could be transferred to a weed through cross-pollination, this is highly unlikely. Crossbreeding does not usually occur between two unrelated species of plant, meaning that corn engineered to produce its own insecticide does not readily cross-pollinate with a nearby weed. If cross-pollination did occur more than likely it would result in either sterile progeny or a new type of fertile hybrid weed. "In the improbable event that a resistance gene from a crop plant became established in a weed population, the fact that a number of other genes from the crop plant also would be part of the weed's genome means that it will behave more like the crop plant, and its impact will be confined primarily to agricultural fields where it can be controlled through standard management practices" (NRC, 1989; IFT *et* al., 1996). "Of course, where the potential for environmental damage is significant, both USDA and EPA have the authority to discontinue field trials and suspend further development of the plant" (Smith, 2000).

Questions have also been raised as to whether these new pest-resistant crops could result in crops that become weedy themselves, multiplying and choking off other plants that grow in the area. And with their ability to be pesticide resistant, a situation could develop where these crops could not be readily removed. But supporters have countered with the fact that "The risk of a domesticated crop plant accidentally reverting to a weedy condition was described by National Academy of Sciences as "negligible" (Smith 2000). This is particularly true for crops that have undergone long-term breeding, during which the weedy characters of the wild plant have been removed deliberately from the hybrid. (Smith 2000) The traits normally associated with domestication make crop plants reliant on a managed agricultural environment, and thus less capable of competing and surviving in the wild and becoming an invasive weed (Smith 2000). The addition of herbicide tolerance, pest resistance, and other traits important to improve cultivation have not been shown to confer weediness to domesticated crop plants (NRC, 1989; IFT *et* al., 1996). Dr. R. James Cook, a Professor of Plant Pathology at Washington State University, stated that " 'I am not aware of a crop plant having become an invasive weed because of plant breeding," he said. "In fact, just the opposite occurs: through plant breeding and selection, wild plants with their tendency to be weeds are made into high-yielding crop plants increasingly more dependent for their survival on human nurturing. There is no evidence after some 20 years of experience with gene splicing to suggest that these trends will somehow reverse towards more wild as we move toward greater use of this new technology'" (Smith, 2000).

Many concerns have developed over the use of genetically modified foods after a letter was published in the journal *Nature* in which genetically modified corn was shown to kill monarch butterflies after their larvae were exposed to toxin produced by the corn (Losey, 1999). This was the ammunition many activists against genetically modified foods needed. Various media outlets also picked up this story and this only helped to further the backlash. Since the publishing of that article though, it has been reviewed by many and questions have been raised as to its validity. "[T]he Bt/Monarch study has been heavily criticized in the scientific community because every entomologist knows that...if you feed Monarch butterfly larvae Bt toxin, whether it be in corn or whether it be on a spray, that insect will die" (Shelton, 1999). This opinion was echoed by many respected entomologists, such as University of Nebraska professor John Foster, who wrote in a recent article, "there probably was not an entomologist in the world who was not aware that corn pollen containing the Bt gene could harm butterflies—if butterflies ate corn pollen, which they don't" (Smith, 2000). Most scientists are well aware that the gene inserted into the modified corn is harmful to the monarch butterfly as well as their larvae but, as the corn is not a food source for the butterfly, it is not a concern. The letter's lead author even stated in an article published in *The Wall Street Journal* that using the letter "would be inappropriate to draw any conclusions about the risk to Monarch populations in the field" (Fumento, 1999).

Since the publishing of the letter in *Nature*, further studies have been conducted to determine the potential risk to the Monarch butterfly, or to find if a risk even exists. "Preliminary data from other researchers performing field studies show that the concentration of pollen on the milkweed leaves in the Losey *et al.* laboratory study was greater than could be expected in the field (Hansen and Obrycki, 1999). The Monarch's migratory pattern does not bring it in contact with corn during the short time it sheds pollen. Monarchs also prefer to lay their eggs on milkweed plants in open meadows, prairies, and roadsides, not in or around cornfields, as even the *Nature* letter's authors recognized. And as EDF's own literature states, it is widely recognized that 'most corn pollen settles out within a few dozen feet of the corn plant' (EDF, 1999), a finding supported by the Hansen and Obrycki field study. Results similar to those recounted above were reported in a conference of scientists held to discuss the issue last November in Chicago (Kendall, 1999)" (Smith, 2000).

The stir created by the letter published in *Nature* had far reaching repercussions on the acceptance of genetically modified foods. Though the published efforts of scientists have exonerated the genetically modified corn, the damage was done and it only helped to strengthen the resistance to accepting genetically modified foods into the mainstream market.

Another risk that must be taken into count is the threat to human health that these genetically modified foods may offer, if any. One of these threats comes in the form of food allergies. Most allergies are caused by the body's immune response against a protein. When foods are genetically modified, new genes are placed into the plant, and these new genes code for new proteins that weren't present before in the plant. These

new proteins could very well trigger an immune response in a person that is allergic to that protein. "A first and important line of defense in protecting susceptible persons from exposure to food-borne allergens involves proper testing when known allergenic foods are used in the creation of a new food type. Thus, when a food crop that is known to be allergenic is used as the donor of genetic material in the creation of a new plant-based food, a high standard of proof of non-allergenicity in the resulting food is used.
This is a key component of the approach taken by the FDA in determining the safety of new plant-based foods. As outlined in FDA's Statement of Policy, if a company developing a new plant-based food uses genes from a known allergenic source of genetic material for transfer, the company should assume that this genetic material encodes an allergen unless they can conclusively prove otherwise" (Smith, 2000).

As previously stated, an incident was reported in which an allergic reaction was caused in six of eight individuals after they were exposed to soybean that had been genetically modified with genes from Brazil nuts. "Testing discovered that the gene taken from the Brazil nut encoded for an allergen (Nordlee, 1996), and the product was never commercialized. "This [was] a perfect example of how the system works," Dr. Cook testified, 'It is always cited as how things can go wrong, but it is exactly how good testing in the laboratory can provide for safety'"(Smith, 2000). The six individuals that suffered from the allergic reaction were, more or less, test subjects to test whether the Brazil nut gene would cause an allergic reaction in people that were allergic to the actual Brazil nut. The tests proved positive that a food allergy could be transferred from one food to another, and the modified food product never made it to market.

All the testing in the world, though, cannot mollify all the concerns that stem from genetically modified foods. While foods can be screened rigorously for allergenic causing proteins, "it cannot be determined absolutely that a gene that sits benignly in one organism will not cause an allergic response when put in another organism, [and] it is important to remember that the introduction of new allergens to the food supply can come from any new food—not just those created through biotechnology. For example, when the kiwi fruit was introduced to this country, a small number of individuals experienced allergic reactions to it. As even Dr. Goldburg, who made clear in her testimony that she is critical of FDA's policies regarding testing for allergenicity, had to admit, 'there is no clear-cut mechanism' for determining the allergenicity of any new food product, whether imported or produced using classical breeding or biotechnology methods. Clearly, this is an area where more research is needed. Finally, if a company were to insist upon going ahead with bringing the new food containing a known allergenic compound to market, current FDA policy would *require* labeling of the product" (Smith, 2000).

Though it has been shown that genetically modified foods can causes allergies in individuals, it has also been shown that the foods are thoroughly screened and must pass rigorous standards in order to actually reach the market and make it out of the testing stage. One important benefit of these foods actually stems from the fact that they must be so rigorously screened. It is possible to actually stop a harmful product from going to market, e.g., one that would induce severe allergic reactions. In all organically grown, unmodified food, no specific allergy is tested for. People consume it and usually discover for themselves if they are allergic to it. The screening of genetically modified foods as well as FDA regulations should make it unlikely that no food that will cause an allergy in humans will make it to grocery store shelves.

Beside food allergies, another concern is with the toxins that may be present in g.m. foods. If plants are engineered to produce more of a specific chemical, could any food products that come from that plant possibly be toxic to humans who eat it (after all, too much of anything, even vitamins, can be toxic)? An example of this is the study conducted by Dr. Pusztai, a Scottish scientist that performed studies on genetically modified potatoes. He used potatoes, which had been altered to produce lectin, and fed these potatoes to rats. Lectin is a toxic substance, and it was reported that the rats suffered physiological damage that hadn't been seen in the control groups. Shortly after this article was published, it was revealed that in the experiment, the rats were forced essentially onto a starvation diet, as rats neither like potatoes nor can get enough of certain essential nutrients from them. Thus, many of the results the researchers saw were quite possibly artifacts of the dietary conditions imposed on the rats. Many scientific observers see this paper as seriously flawed, as even the editor of the journal in which the article was published—the *Lance*t—recognized. He wrote in an editorial accompanying the research paper that it had been rejected by half of its peer reviewers and that a sizable number of the author's initial claims were left out of the published version because they were unsupported by the evidence. Deflecting criticism of the decision to publish the article, he said, 'This is absolutely not a vindication of Dr. Pusztai's claims' (Smith, 2000).

There is no real evidence that genetically modified foods are more toxic than any other food produced the "traditional" way. In fact, regular organically grown food can be just as toxic, yet many people either ignore this fact or simply don't realize it. "Potatoes can have high levels of solanine, for example, which can make people ill. Many legumes, such as kidney beans, contain high levels of lectins, which if not destroyed by cooking or removed by soaking, can cause severe gastro-intestinal distress. Another component of legumes, cyanogenic glycosides, can produce cyanide if the food is not prepared properly. The levels of these cyanogenic glycosides are so high in some foods, such as cassava, that death can result from improper preparation. Cruciferous vegetables *(e.g.*, broccoli and cauliflower), squash, cucumbers, chickpeas, spinach, celery, and many other fruits and vegetables also contain chemicals that are toxic to humans. Yet, each of these foods is consumed widely" (Smith, 2000). Again, FDA policy requires that "A company using a food with a known capacity to harbor toxins as either the donor or the recipient of genetic material is required to verify that any resulting plants do not have unacceptable levels of the toxins" (Smith, 2000). Such policies work in favor of genetically modified foods because each product is tested thoroughly in specific areas to ensure safety to the public. Most conventional crops are subjected to few analytical studies, yet there is no controversy at all with regards to eating these foods, serving them in schools, or buying them at the local grocery store.

Thus far, no real proof has been unearthed to prove that genetically modified foods are any less safe then conventionally grown foods. Instead, critics have used hypothetical risks as well as poorly conducted studies to fuel the resentment of this new technology. There have been no reported deaths or injuries caused from consumption of genetically modified foods, but these facts are simply ignored when a story, based on a poorly constructed study, is reported in the media.

Another concern that many have with genetically modified foods is the possibility of creating antibiotic resistant bacteria, which could pose a serious health risk to humans. This concern stems from the fact that much of the work done with genes deals with the use of selectable markers to determine weather the gene of interest was indeed transferred or not. The easiest way to do this is to incorporate into the gene that will be inserted a gene that also codes for antibiotic resistance, such as resistance to ampicillian. The cells are then grown on a plate that contains ampicillian. If the gene of interest was not incorporated into the cell, then neither was the cell conferring the ampicillian resistance, and the cells lacking the gene of interest die on the plate. In this way scientists are able to "mark" which genes are recombinant and which are not. Foods that are genetically modified contain recombinant genes, so often the genes that have been inserted also carry a gene for antibiotic resistance. This, coupled with the fact that more and more disease-causing bacteria are becoming resistant to the antibiotics that are currently available, has caused quite a scare among people, causing many to believe that foods that have been genetically modified will only help to create more strains of bacteria that are resistant to antibiotics.

The concern that g.m. foods will somehow cause an increase in antibiotic-resistant bacteria, while not misplaced, is certainly greater than is justified. "Theoretically, the possibility that an antibiotic resistance gene could be transferred from the DNA of an ingested plant or plant product to pathogenic bacteria exists, but it is exceedingly unlikely because it demands numerous steps, each of which also is highly unlikely: the antibiotic-resistance DNA would first have to be liberated from the plant cell and remain intact long enough to be absorbed by a bacterium; it would have to be taken up by a bacterium after evading it defenses; it would have to become part of the bacteria's own chromosome through a rarely-occurring 'illegitimate recombination' event; it would have to become integrated into the bacterial chromosome in just the right way and in the correct position; and finally, it would have to be transferred from the harmless bacterium into which it has been incorporated to a pathogenic one" (Smith, 2000).

There is also some concern as to what the repercussions could be to the bacteria that are found in the human digestive tract. But, many of these "good" bacteria found in the human gut are already antibiotic resistant, and many scientists feel that " 'an occasional introduction of these genes into bacteria would have no medical significance'" (Smith, 2000). It is of little concern to scientists that the bacteria in the human gut may become antibiotic resistant because, for the most part, the bacteria are beneficial to humans. The fact that some of the bacteria in our digestive system are resistant to antibiotics is evident when one considers the use of penicillin in humans. Though it is used to kill of a variety of bacteria, when used by humans the bacteria in the human gut stay mostly intact (Van de Graaff, 1997). The fact that the bacteria in the gut have built up a resistance is very important because, without it, our system could be seriously compromised and possibly damaged due to the loss of all the healthy bacteria.

It is very evident that there are many risk-associated concerns attached to g.m. foods. But these concerns have quickly become fears due to misleading reports and studies. While safety is an issue, bad science cannot and should not be used to prove a point, nor should rousing fears be used to prevent a new and potentially better product from reaching the market. Because of these fears, though, the focus has shifted from protecting individuals from potentially harmful products, genetically modified or not, to trying to create such a stir that genetically modified foods are all but banned from the human diet. For instance, "The focus on unfounded concerns over antibiotic resistance transfer from biotech foods has led public health officials in Europe to make poor decisions with potentially grave consequences. As Dr. Salyers, a Professor of Microbiology at the University of Illinois, explained, 'The EU [European Union], distracted by the debate over marker genes in transgenic corn, approved with virtually no debate the use of avoparcin as a growth promoter in animals. As a result, a very serious form of bacteria resistant to vancomycin (an analog of avoparcin) has been introduced into their food supply. Since colonization of the intestines of humans by these bacteria could possibly lead to their death due to subsequent untreatable post-surgical infection, this is a serious health concern.' Thus we are provided with another instance in which a more immediate risk has been ignored while the insignificant risks posed by agricultural biotechnology have been blown out of proportion" (Smith, 2000).

Though the debates about the safety of genetically modified foods will continue, these debates should not be allowed to distract attention from other, more potentially dangerous products. Nor should they be allowed to prohibit the development of new ideas or the applications of these ideas without proof that these applications are dangerous. And fear cannot be allowed to be substituted as substantial and adequate proof.

Chapter 8: Risk Management

Both biotech companies as well as the scientists involved with genetically modified foods have tried to show that these new foods are just as safe and healthy as more traditional organically grown foods. But the one question that has not been answered to consumer satisfaction is "what will these foods do to me and my family in the long-run?" The answer is simple – no one knows for sure.

As yet, there have been no long-term studies conducted that can support either the opponent's or proponent's positions. Even the reasons for the lack of testing have been a source of controversy. The biotech companies themselves perform many tests. But most of these are short-term studies conducted on laboratory animals like mice and small trial groups consisting of a few individuals. "These reports are passed to various Government approval committees, who make a judgment on whether the safety is convincing. In contrast to the pharmaceutical industry, however, biotech companies face no demand for evidence from human trials. Nor are any independent checks made of the company's claims" (Matthews, 1999). In other words, there have been no long-term studies conducted on the affects of genetically modified foods on humans. No laws in the United States require such studies. And because we export much of our foods to England and Japan, this has many people overseas concerned. J. Craig Venter, the President of Celera Genomics Corporation, has stated that "some of the major agriculture companies haven't done exactly a stellar job at testing risks and helping to convince those who are skeptical in the public that the science in really solid. The solution is very simple. It can be based on solid science" (Schmickle, 1999). Finally, in July of 1999, U.S. Agriculture Secretary

Dan Glickman, responding to the requests of the consumer, politicians, and scientists, stated that the United States would begin conducting long-term studies on the effects of genetically modified foods and food products containing genetically modified elements (Smith, 2000).

But why would the government, food companies, and biotech companies wait so long to make a decision like this? One popular belief in the biotech and food industry is that by conducting studies on the affects of these foods on humans, it would "startle Americans who have been, often unwittingly, eating the stuff for years. Though Americans place more faith than do Europeans in food regulators, there is widespread fear within the food industry that Americans, too, may become phobic about GMOs, especially now that the administration seems to be validating at least some concerns raised by critics of bioengineered food" (Longman, 1999). Many of the companies involved in genetically modified foods, whether it be producers or sellers, simply didn't invest the time into doing long-term studies, or ask for them to be conducted, because they feared the backlash this would cause among American consumers. When tests are conducted the public usually becomes aware of them very quickly through media coverage, stories, and published reports. If long-terms studies and tests were done, consumers could interpret this as implying doubt about g.m. food safety.

Another important factor that must be considered is the length of time that current genetically modified foods have been available on the market. Long-term studies usually surpass the ten-year mark. Genetically modified foods and products have been commercially available for less than ten years. Therefore the long-term affects are unknown because these foods simply haven't been on the market, or even existed, long enough to study their effects. Many studies are being conducted currently but they can still only effectively report the short-term affects, even though these studies have been ongoing since the first foreign gene was inserted into the target food source. Genetically modified foods simply have not been in existence long enough for any comprehensive or conclusive facts to be drawn about long-term risks. The most that can be done is to monitor the foods that are on the market now while conducting as many studies as possible and then reporting the findings to the consumers, and these are precisely the steps that scientists are taking to ensure that these foods are safe risk-free (Smith, 2000).

Chapter 9: Public Opinion

Opinions from scientists, food companies, and protesters within this debate concerning g.m. foods are readily accessible except from American consumers. It is their opinions that really matter; their purchasing power will affect what is produce and eventually what guidelines will be set, because they elect the officials that make policy. It is for this reason that many polls are taken of the American public to determine where they are positioned on certain issues.

There will always be certain sectors of the population who will hold extreme opinions on any topic. In this case you have the anti-biotech activists stating that the science behind genetically engineering foods is imprecise and the long-term effects of their manipulations are unknown. The human genetic code is about 3 billions base pairs long (Peters, 1992) and up until now the entire human strand has just been decoded, but that was the easiest part. It makes possible the long-term analysis of how this information is used to produce an organism such as a human being. So when scientists tinker with specific genes they know what the immediate results are but not the long-term effects nor the repercussions the gene will have on the rest of the organism. To state their argument by using an analogy the genetic code is like a computer program. It is made of up millions and millions lines of code. Each line of code by itself is relatively easy to comprehend its purpose and function; assuming one has the pre-requisite knowledge. The problem is when you have a plethora of these lines assembled and interdependent upon one another, the complex interactions are very difficult, if not impossible to understand; much like the genetic code. Now when a large computer software program has a problem, or in other words a bug, debugging it is very tricky to do because by changing a line or a few lines of code the whole program is affected. Such is the case when a bug is found in your Microsoft Windows software program, which is comprised of millions upon millions of lines of code. As a fix, the program itself is not debugged, but rather a supportive software package, or a patch, is written and must be installed as an addition to the program to counteract the bug. This parallel is drawn by many in the anti-biotech side to support their claim that the modification of foods through genetic alterations must be stopped.

On the other end of the spectrum, are the scientists who are the pioneers and true believers in this technology. Much of their beliefs have already been stated throughout the previous pages of this paper. Their contentions are that this process of genetic modification has been carried out by humans for thousands of years, but now genetic engineering technology has allowed the scientific community to perform these very same actions more accurately and precisely. Consequently, the need for anything but the usual regulations is unwarranted and unnecessary.

This tug-of-war between these two groups and among the other major players in this battle can continue indefinitely but the ultimate decision will rely on what the public wants, both here and abroad. So if the money or research funds are unavailable due to lack of interest then very little advancement will be made. The marketers and stores are in it for profit and will follow whatever the consumers are will to buy and to forgo what they will not purchase. The farmers want to plant whatever will make them the most money, and if that means there is no market for g.m. crops they will not plant them.

Lastly there is the government which, in principle, should respond to what its people want.

The only way to find out what the public wants or knows about a specific subject is to ask them. The information cannot be found in a journal, newspaper, or a television program but must be collected directly from the source. In our project one hundred people outside a supermarket were asked six yes or no questions. The questions and their answers follow:

Question #1: Do you feel you understand the science behind g.m. foods?

Question #2: Do you feel you trust the scientists that are engineering g.m. foods?

Question #3: Do you feel you are knowledgeable about the amount of g.m. foods already on the market?

Question #4: Do you feel if foods are labeled genetically modified that this label will affect your shopping habits?

Question #5: Do you feel you are knowledgeable about the concerns surrounding g.m. foods?

Question #6: Do you feel that the media coverage (i.e. newspapers, television news programs, ect.) of g.m. products have influenced your view on this topic?

	#1		#2		#3		#4		#5		#6	
	number	%	number	%	number	%	number	%	number	%	number	%
Yes	18	18%	33	33%	27	27%	75	75%	38	38%	47	47%
No	82	82%	67	67%	73	73%	25	25%	62	62%	53	53%

Table 1

- 100 people interviewed
- Approximate age of individuals polled ranged from 21-40 years old.

The first question might seem like an obvious one, but it is very important. An overwhelming majority of the people polled felt that they do not understand the science behind genetically modified foods. So these people are making judgments, whether pro or con, about g.m. foods, without understanding how they are created and manipulated to achieve a desired trait. On question number six, which asks about whether the media influences their view, opinion was divided equally. Dealing with the half who claimed influence by the media, their opinions are based upon information that can be sensationalized at times and skewed dramatically from the truth. Terms such as "gene gun" (Carter, 1999) and misleading reports such as the ones dealing with the monarch butterfly can be used to influence public opinion. A story about genetically modified corn killing butterflies is more likely to attract attention than is a story about how genetically modified corn decreases pesticide usage. In researching this project, we found that many articles that were not from scientific journals were written negatively towards genetically modified foods. We speculate that corporate control of the media leads to an overridden concern with market share compared to the competition. In an effort to sell the news to the public, sometimes the truth can become distorted because all the facts are never truly reported or even known. One excellent example of this is the Monarch butterfly story, which has previously been mentioned. As for those who are not influenced by the media, there is still the remaining fact that an overwhelming majority of those polled claimed to not understand the science behind these foods so, therefore, whatever the influence of media, it has not provided them with a feeling of being informed.

Looking at the results from question two, a majority of the people surveyed has very little trust in the scientists who are the pioneers and implementers of this technology. This creates an interesting dilemma for the consumer; a product might not find market acceptance simple because the source is questionable. Interestingly enough, when one examines question three, a majority of the people polled feel they do not know the amount of g.m. foods already are on the market. This potentially creates an atmosphere of distrust between the public and the food producers.

People are very thixometic in that they remember past events and future occurrences are predicated upon them. When troubles arise with the food supply, even those not related to genetic modifications, people store this information and their opinions are based on these facts when new information is revealed indicating scientists are "playing around" with their food. So not all events, which influence public perception, are under control of the scientific community. This adds to the fact that even though people do not know much about the science, what matters is the previous associations made about the relationship between science and food.

The public's perception is not an abstract ideal that has no meaning; its effects are very concrete and have immense value. This can be seen by the results of question four. An overwhelming majority of those surveyed stated that labeling of g.m. foods would change their shopping habits. So how people feel about science, scientists, and the scientific community may have direct effects on how consumers choose products. This point highlights just how important it is to understand what the public thinks. A product cannot be manufactured and marketed in hopes that consumers will recognize its usefulness and begin to purchase it. This is why focus groups have been developed to understand what the public wants and is willing to buy (Smith, 2000). In the case of genetically modified foods, the scientists focused solely on what beneficial affects genetic engineering could provide to our foods and never considered the fact that the public would react poorly to these new foods. An example of this is the development of the Flavr-Savr tomato. Calgene spent millions creating this tomato and getting it past FDA approval, only to find that once it was placed in the market no one was buying this product. Since then Calgene has gone bankrupt and been absorbed by Mansanto (Peters, 1992). Today scientists and the products they have helped to develop are experiencing unanticipated backlash.

Lastly, the result for question five shows that there is about a fifty-fifty split in the number of people who believe they are knowledgeable about the concerns of biotech foods. This is in contrast to the first question in which the majority claimed to have very little knowledge about the science itself. Consequently, there seems to be an inherent contradiction; how are these people learning about g.m. foods if not from the science that it is based upon? The answer to this crucial question is beyond the scope of our questionnaire. A possible way to educate consumers is to conduct forums in which people have easy access to, are willing to participate in, and proliferate factual, scientific knowledge in an understandable format.

The answers to these six questions reveal that the public surveyed felt they had little knowledge of the science of g.m. foods, yet they expressed a lack of trust in the foods that result from this technology. The divides that separate the producers and consumers of g.m. foods need to be addressed in such a way that an effective or productive discussion can occur.

Chapter 10: Bridging Gaps

The public has a right to choose what they want and do not want to buy. This is an important decision with respect to g.m. foods. Biotechnology is now a big business. Many foods have already been modified and are on grocer's shelves, including corn, cotton, potatoes, oilseed, soybeans, squash, and sugar beets, so if people are adamant in rejecting these products, a major economic swing has to be undertaken to change what farmers are growing and what the food companies are producing. This should occur only if the public's decision is an informed one.

One of the findings in a report entitled, "SEEDS OF OPPORTUNITY: AN ASSESSMENT OF THE BENEFITS, SAFETY, AND OVERSIGHT OF PLANT GENOMICS AND AGRICULTURAL BIOTECHNOLOGY" which was submitted to Congress on April 13, 2000, stated that most of the opposition to genetic modification of foods is not scientifically based. Consumers hear this opposition but are unaware of its lack of scientific merit. How can the public be educated about g.m. foods?

People need to know that research of this kind has been developed and widely used for over twenty-five years. There also exists a mountain of evidence that shows that the risks associated with traditional crossbreeding methods and the rDNA techniques are similar. Until now the information has been available in readily inaccessible places to the public, such as professional journals, and often contains terminology or is written to a specific audience, mostly other specialists within the field, that it leaves the public dumbfounded. As this information has become commercialized, much of it has become 'trade secrets'. Governmental institutions like the USDA, EPA, and the FDA need to establish Web-sites, as they have done for countless other topics, at which the public can readily access information about plant genetics and agricultural biotechnology in terms that can be understood by the general public. They need to have available forums and discussions in which differing points of view on the issue are public expressed.

Aside from what the government can do, the biotech industry as a whole needs to step up to the plate. They cannot sit idly on the sidelines and hope the public will eventually come around. They have to take a proactive stance and actively participate in defense of their science. Arguments that have arisen on the basis of science need to be argued with science. One major point that the public needs to be aware of is the amount of time and money that is involved in developing this science. Many years and hundreds of millions of dollars have been spent on research and development of these products (Peters, 1992). The regulations that already have been set forth by the major governing bodies of the United States, such as the FDA, USDA, and the EPA, have to be followed by all of the corporations and universities who have contributed to this field. The biotech revolution has been conducted by these rules throughout its history and consumers must know this. These rules were instituted by these government agencies to make absolutely sure any science that is done is safe to the public, and any time these rules are broken serious repercussions result. Getting any sort of food or drug approved by these agencies takes a fair amount of time because they are rigorously tested, and it is possible for a company to lose millions of dollars when the product is rejected. These companies follow these rules to the letter because it is known that any mistake on their parts can result in not only the rejection of their product but also in the destruction of their company.

The scientific community also needs to express the benefits of this technology. The potential solutions to domestic and global problems must be made known not just to the consumer but to everyone else who has a stake in this field, including CEO's of companies or the farmers who grow the crops and depend on the availability of a market to sell their goods. These benefits are plentiful and far reaching and consumers must realize this.

Independent scientists and researchers have to come forth and help the cause. They understand the most intimate details of the science that is used in the biotechnological industry and they have to make it a point to reveal to the public what are reasonable concerns and what are not. They have to express the great benefits this technology can bring in the immediate future, twenty years from now and hundreds of years down the road. An appreciation for the necessity of continued research should be engendered. There are many problems that loom over our heads as a planet. These scientists know what they are: an ever-expanding world population, decreased fertility of farmland, decreased farmland availability and an increase in difficulty to properly nourish everyone to avoid common and treatable illnesses. Biotechnology has the opportunity to not only address these concerns but eradicate them. The people need to realize that if by their actions they impede the progress of biotechnology that the after effects could be disastrous. Getting involved in public forums and debates are just some of the way scientists can expose the truth to the public along with interactions in government both on the local, state, and national level. Any degree to which the scientists can get involved would be tremendously valuable. Realizing this means an extra commitment on the part of scientists, they in turn must realize how valuable their efforts can be and what they mean to the scientific community as a whole. This extra burden must be taken on for the good of not only the science but for the good of the people this science will undoubtedly help.

Basically it comes down to informing the consumer; an informed consumer is a smart consumer. Any forum that allows an intelligent exchange of information is desperately needed and encouraged, and all of those who can productively contribute should participate.

Many protractors of biotechnology believe an effective method to inform the consumers of genetically modified foods is to have them labeled, such that they can determine whether or not to buy a certain product right at the supermarket self. This solution is misguided at best because labeling of product would not inform the consumer but only make them more confused and mislead them into thinking the product is unsafe because it has a specialty label on it.

First and foremost, the FDA has had years and years of knowledge about biotechnology in both the medical and food industry. From this exposure, the FDA has gained experience in dealing with g.m. foods and its policy of not labeling them is just because it is consistent with the law, governmental policy and most importantly, "consumers have a lifetime of direct personnel experience with foods genetically modified through hybridization that are indistinguishable from those produced using biotechnology." (Smith, 2000)

These genetically modified foods are basically the same as their traditional counterparts. There are no material differences between the two foods. If there happened to be substantial enough changes between the two then a name change would be warranted and then a label would have to be utilized. In these cases the burden of proof rests on the company to prove the safety and the effectiveness of the plant as not to harm or react negatively with the consumers system, but these are not the cases we are dealing with. And since there are no safety issues that exist, then the FDA is following its own guidelines and any criticism is unwarranted. In the cases in which characteristics are introduced into an organism that would not normally have occurred, or from an entirely different species, then there are possible allergen and toxin safety issues. In these cases there are already guidelines that are established to label these foods so the consumer is aware of any possible allergic reactions or carcinogens. But the fact still remains genetically modified foods are indistinguishable from their traditional crossbreeding counterparts.

Consumers like all kinds of information contained on labels of the food products they buy, but the fact is that labeling is usually restricted to nutritional facts. These facts prove beneficial and are able to be understood by the consumer. If foods were to be labeled genetically modified this conveys no pertinent information to the consumer about the product and would lead the consumers to draw false conclusions. Conventionally crossbred plants are not labeled for the pesticides and herbicides that are used on them and organically grown foods are not labeled for their possible contamination by *E. coli* and other bacteria. There are no mandates by the federal government to label the manufacturing process by which any food is processed.

In the United Kingdom a mandatory labeling policy has forced all of the supermarkets to remove all foods developed with the rDNA process. This has caused a decrease in consumer choice at the stores and also fueled the opinion that these foods are dangerous. The American public deserves to know the facts about this new technology, through the proper educational formats, and left alone to judge for themselves whether the risks outweigh the benefits. History has countless examples in which ignorance of society about new emerging technologies and concepts have resulted in an unwarranted backlash and stifled progress, only to eventually discover these new technologies have their place within society and can reap tremendous rewards for everyone. Outer-space study and exploration, for example, stems from the simple discovery that the earth revolves around the sun. Yet this concept for the longest time resulted in people being ostracized from society for believing this. Modern medicine is another example, where in the late 1700's the simple solution was to "bleed" the individual and to removed the bad blood that was causing the sickness. The idea of using assorted chemicals and actually injecting them into an individual was unheard of. Today it is taken for granted that the Sun is the center of our universe and that if we happen to suffer from a bacterial infection, a little penicillin and some rest is all that's needed.

Chapter 11: Conclusions

There is a lot of misinformation floating around about genetically modified foods. People who are not scientists perpetuate it and have no factual proof to substantiate their claims.

What should not and cannot be allowed to happened is for government regulations and the uninformed public to dictate the course of action for this new technology. This is exactly what has occurred in the United Kingdom. People have hindered the progress of genetically modified foods and will not receive all of the benefits they have to offer. The only way to circumvent this is, aside from the governmental aspects, to educate the public about what biotechnology of foods is all about. They need to understand that crossbreed plants and g.m. plants are virtually indistinguishable and there are no new safety concerns that have arisen with these new plants. They must also realize that g.m. foods have been on supermarket shelves for over fifteen years and there have been no adverse affects seen within the public and therefore they should realize their benign nature. They need to know what the tremendous benefits there are from using this technology, from increased nutritional foods, to increased yields with the same amount of acreage, and the destruction of common diseases in Third World nations where malnutrition is of the utmost concern. Research and development must continue and this can only occur through the public's acceptance and approval.

Only through education of the public will biotechnology flourish. Many forums need to be accessible to the consumer; Web sites, frequent informational secessions, commercials, TV programs, brochures, and truthful media coverage. Only then will the public be able to intelligently engage in debates and make a sound and informed decision about genetically modified foods. This, above all else, must occur in order for biotechnology to thrive and for society worldwide to reap its rewards.

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