Chapter One

Ethical Issues Involving the Production, Planting, and Distribution of Genetically Modified Crops

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The discovery of plasmid-mediated gene transfer in 1973 afforded science a revolutionary technique for rearranging and modifying the genetic structure of biological species.[1] Other techniques for transferring genes followed, including the use of viruses, DNA projectiles, and microinjections. Thus far, there appear to be no natural or species barriers limiting the transfer of genetic material across organisms of different phyla and even kingdoms that cannot be overcome by the set of processes known as recombinant DNA or gene transplantation technology.

Agriculture was one of the first industrial sectors to have invested heavily in the new field of biotechnology. By the early 1990s a massive experiment in agricultural biotechnology was underway in which a new generation of crops containing genes from sources outside the plant species was introduced into food production in many parts of the world. The genes transferred include some that express new proteins, some that mark specific parts of the genome (marker genes), some that regulate gene expression (e.g., promoter sequences), and finally some that provide identifying clues that the gene transfer has been accomplished (e.g., antibiotic resistance genes).

We are at the early stages of this global agricultural experiment.

Scores of new food products with altered phenotypes are slowly moving from genetics laboratories into commercial products. By the year 2000, approximately one-fifth of the U.S. corn acreage, one-half of the soybean acreage, and three-quarters of the cotton acreage, comprising nearly 30 million hectares, was planted with crops genetically modified for resistance to insects and tolerance to herbicides.[2]

This global agricultural experiment in biotechnology has been met with controversy in Europe, parts of Asia and South America, Australia, Canada, and New Zealand. This essay explores the ethical and value components of the controversies that have erupted in the wake of the first introductions of genetically modified (GM) crops since the early 1990s. These controversies have affected international trade agreements and have divided environmentalists.

Among the issues that have spurred some of the most highly contested debates are the following: (1) the ecological effects of releasing GM seeds into the environment; (2) the impact of GM crops on global seed markets; (3) farmer and consumer preferences in the adoption of GM products; (4) the role of risk assessment in evaluating the safety of transgenic seeds; and, (5) the impact of the global use of genetically engineered crops on biodiversity.

In recent years science policy analysts considered it possible and desirable to separate the scientific from the ethical issues in science and policy studies; I find this cannot be easily accomplished for the controversies involving biotechnology. The normative and the empirical parts of the biotechnology disputes are tightly interconnected. Sometimes the empirical issues provide false cover for the normative questions. Other times the value conflicts are based on disputed scientific claims. Many of the ethical issues involved in the political debates over GM foods/crops are not sui generis but depend on the resolution of empirical questions.

The one contested issue involving GM crops that comes closest to resting on purely ethical considerations is whether it is morally permissible (irrespective of consequences) to alter plants by genetic engineering technology. Human rights and animal advocacy groups have proclaimed the genomes of humans and animals as inviolate for human genetic manipulation. Their moral justification rests on "natural law" (e.g., species nature or the sacredness of human germ cells) or consequentialist arguments such as the uncertainties that may result from tampering with nature.

Others have appealed to a secular repugnance for bioengineered

plants.[3] Those who claim that applying gene transplantation processes to the germ plasm of crops violates the natural order might be hard pressed to apply the same standards to the other human interventions during the ten thousand years of plant domestication. Are there morally distinguishable issues that make the current techniques of gene modification a transgression against the natural order and the earlier ones not? How are human-selected gene sequences different from those made by hybridization, chemically or radioactively induced mutations, cell fusion, or synthetic foods? An issue that bears directly on whether GM crops/foods should receive special ethical status is the uniqueness or lack thereof of plant germ plasm modified by gene engineering techniques.

Issue 1: Are GM crops/foods unique?

The question of the uniqueness of genetically modified organisms (GMOs) may be divided into two parts. Are compositions of GMOs unique? That is, by applying recombinant DNA processes, can a product be made that would not otherwise be found in nature or that could not otherwise be constructed by other techniques, such as conventional plant breeding? The second part of the uniqueness issue pertains to whether the risks of GMOs to human health or to the environment are unique. Will the introduction of GMOs to the biosphere produce novel hazards?

Three reports of panels convened by the National Academy of Sciences (NAS) concluded that the use of genetic engineering techniques to produce crops do not result in any unique risks in comparison to techniques of conventional plant breeding. The first report issued by the NAS Committee on the Introduction of Genetically Engineered Organisms into the Environment was published in 1987.[4] A second, longer study was released in 1989, also by a committee of the NAS.[5] Finally, a third study, released in 2000, was titled *Genetically Modified Pest-Protected Plants: Science and Regulation.*[6]

The 1989 NAS report stated that "no conceptual distinction exists between genetic modification of plants and microorganisms and classical methods or by molecular methods that modify DNA and transfer genes." It also stated, "crops modified by molecular methods in the foreseeable future pose no risks significantly different from those that have been accepted for decades in conventional breeding."[7] The conclusion was reaffirmed in the third NAS report, which highlighted two points: (1) There is no evidence that unique hazards exist in either the

use of rDNA techniques or in the movement of genes between unrelated species; and, (2) the risks associated with the introduction of rDNA-engineered organisms are "the same in kind as those associated with the introduction of unmodified organisms and organisms modified by other methods."[8]

Although still a contested issue within scientific circles, the claim that there are no unique risks to rDNA techniques has been a key factor in shaping regulatory policy. Genetically engineered crops are regulated by one of three agencies (the Food and Drug Administration, the U.S. Department of Agriculture, and the Environmental Protection Agency) by and large in the same manner that conventional crops are regulated. There is only minimal pre-testing of GM crops. Because there is a presumption the transgenic food products are safe, a strong burden is placed on those who question the safety of the GM food to demonstrate the risks.

What is the basis upon which points 1 and 2 are accepted? Is there scientific evidence or is it based on a trans-scientific argument? The question of unique hazards breaks down into two parts: (1) Are there hazards? and (2) Are they unique? The issue of whether there are hazards in using rDNA techniques has been resolved in the affirmative (e.g., the Brazil nut allergen transferred to a soybean).[9] Are the hazards from the rDNA process unique? A reasonable interpretation of the meaning of *unique* can be framed by asking if a hazard can arise from conventional methods of genetics. Has anyone tried to produce the same results by conventional methods? If it hasn't been tried (successfully or not), how can one know that it is or is not a unique hazard? Besides the use of rDNA techniques, how else would the Brazil nut gene enter the soybean? Is that gene found naturally in soybeans?

In another interpretation, *unique hazards* might refer to a general class of hazards and not any particular one. Under this interpretation it is not inconsistent to state that rDNA technology is the only known way to transfer the Brazil nut allergen to the soybean but it is not the only technique that can transfer allergens from one crop to another, and thus does not introduce unique risks.

Until the term *unique hazards* is clarified and the empirical questions pertaining to non-rDNA methods for transferring allergens are answered, the query "Are GM crops/foods unique from the standpoint of hazards?" remains unresolved. If GM products were unique compositions of matter resulting in unique hazards, there could be ethical reasons to treat those products differently than conventional crops/foods.

This example illustrates the interrelatedness of the normative and empirical dimensions of the problem.

Issue 2: Does society have a right to hold transgenic crops to a higher standard of oversight than conventionally bred crops?

Putting aside whether or not there are unique hazards, it is clear that many public interest groups and the majority of the public in a number of countries believe transgenic crops should be held to a higher standard than conventionally bred crops. To say that rDNA techniques produce unique hazards does not imply that there are no hazards associated with conventional breeding (e.g., hybridization or cross-pollination). The use of rDNA technology in food production may deserve more oversight because it is newer and less rigorously tested than are other methods of crop modification that have been in place for much longer periods. Moreover, even if one were to assert that rDNA techniques do not produce unique hazards, one might still wish to give greater primacy to the hazards of genetic technologies over those of conventional breeding because of the very novelty of the risk potential entailed by the specific gene transfer. Society makes all sorts of risk selection choices based on collective values and perceived risks.

Do regulatory agencies bear a responsibility to respond to public demand for more oversight over GM products? The jurisdiction of regulatory agencies is established through legislative mandate. Within the boundaries of their jurisdiction, agencies make choices. Health agencies decide what goes on food labels. European and U.S. labeling standards are distinctively different, although both respond to health promotion. European labels focus more attention on chemical residues whereas U.S. labeling has a strong emphasis on nutritional content. The priorities agencies set often respond to public perceptions of risk.

Agency personnel and others who comprise the "community of experts" may differ with the public in setting public health priorities. But in democratic societies, even a consensus of elites must defer to the voices of popular opinion. Examples where public concerns influenced agency decisions include the safety standards for nuclear power plants and the risks of toxic waste sites. In both cases the public's concerns about safety exceeded and predated those of regulatory agencies. Eventually, the government's policies became more in step with public concerns.

In the case of GM crops/foods, public risk concerns in the United States and Europe exceeded those of their respective regulatory bodies.

This was clearly illustrated when the USDA withdrew its initial proposal for new federal organic labeling standards that would have included GM products under the organic label. The GM crops/food policies developed by U.S. regulatory bodies were heavily influenced by large biotechnology corporations.[10] When there are sharp differences between agency and public views over risk, governments have resources at their disposal to influence public opinion. However, when public skepticism persists, as it has with respect to genetically modified crops/food, then the representative bodies and their executive branches have an ethical responsibility to recalibrate their priorities in order to meet the democratic mandate.

Issue 3: Do people have a right to exclude themselves from the experiment? Once again, setting aside the question of whether there are hazards or unique hazards associated with GM crops/foods, do people have a right to exclude themselves from this experiment with the global food supply? Suppose that a GM product meets regulatory standards. Are there any ethical grounds for giving consumers a choice over whether they consume the GM product? In many areas where new drugs, new foods, and new technologies are introduced, consumers have had a choice to be first users, last users, or nonusers. This has been the case with the introduction of the synthetic fat (Olestra) used as an oil substitute in chips, as well as sugar substitutes, which have been approved by the FDA. The premise behind the proposal to label GM foods is based on the idea of consumer sovereignty, namely, that people have a fundamental right to know what they are eating, how it was produced, and whether there are any uncertainties about its health effects.

Countries that have adopted labeling include Japan, South Korea, the European Union, Australia, and New Zealand. We label foods for many reasons other than the nutritional content. From public opinion surveys, a majority of Americans seem to support labeling.[11–13] On what ethical grounds is a labeling policy dismissed? Is there a conflict between the FDA's statutory mandate for labeling and the conditions of production for GM foods? Is the FDA forced by its statutes to reject labeling of GM foods, or has the agency interpreted the law in a way that favors industry's interests?

According to the FDA, a label must be materially relevant to the safety or nutritional value of a food product. In its 1992 policy on bioengineered foods, the FDA stated that "[it] has no basis for concluding

that bioengineered foods differ from other foods in any meaningful or uniform way, or that as a class, foods developed by the new techniques present any different or greater safety concern than foods developed by traditional plant breeding."[14] The agency has historically interpreted the term "materially relevant" to mean "information about the attributes of the food itself," and has required labeling where the absence of information poses health risks or misleads the consumer because of other information provided by the manufacturer.

In addition, the law states that the label cannot make or imply false health claims about a food product. On these grounds the FDA opposed mandatory labeling on milk produced with the aid of synthetic bovine somatotropin (rBST), commonly known as synthetic bovine growth hormone, or any other food developed using bioengineering, with some minor exceptions for cases where there have been material changes in nutritional quality or the introduction of an unexpected allergen. The FDA also opposed voluntary labeling unless it contains language stating there is no health or nutritional difference between the bioengineered and the nonbioengineered food product.

The FDA is not opposed to labeling irradiated food on grounds of "materiality." Although it has consistently held that irradiated food is not nutritionally inferior to its natural source, with regard to irradiation the FDA concluded that it "could cause changes in the organoeptic properties of the finished food and that without special labeling, consumers might assume that such foods were unprocessed."[15] As of September 2000, the FDA reported that it had no data or other information that would support a regulatory decision that food or its ingredients produced using bioengineering meets its statutory criteria for mandatory labeling. But considering the strength of public opinion, the FDA acknowledged that "providing more information to consumers about bioengineered foods would be useful."[16] To resolve the conflict between the public's desire and the agency's labeling requirement, the FDA proposed a guidance document to "assist food manufacturers who wish to voluntarily label their foods as being made with or without the use of bioengineered ingredients."[17]

Without mandatory labeling of GM foods, consumers do not have a *right* to extricate themselves from the experiment on the food supply. They can, however, make an effort to purchase organically produced food, which, at least currently, is certified to be 99 percent GM free. From an ethical standpoint, consumers in the United States are not

afforded a *right* to GM-free food. Only those consumers with access to organic foods have an *opportunity* to purchase GM-free products.

Issue 4: What ethical responsibility has society to address genetic pollution? A farmer planting non-GM seeds may find that some of his yield consists of GM crops either from seeds or pollen that was deposited from a neighboring farm. The trespass of unwanted GM germ plasm to a non-GM farm is referred to as genetic pollution.

While the issue of genetic pollution is new to legal systems throughout the world, there is precedent for intraparty compensations from environmental externalities. Pollution by genetically modified pollen may constitute a taking—a legal theory currently being tested in the courts. Thus, a company that contaminates a water supply, which adversely affects another company's production, may be subject to liability even if the polluter is complying with the law.

The National Farmers Union in Canada is supporting action by the federal government to make agricultural biotechnology companies financially responsible for contamination of organic and traditional crops by GM-based agriculture.[18] In 1999 the British Broadcasting Company and Friends of the Earth employed a German laboratory to conduct DNA testing on various farms. The research showed that pollen from a GMO canola field ended up 2.8 miles away in a beehive.[19]

Currently, the only means through which consumers can be reasonably sure that their purchases of primary agricultural products have not been grown from GM seeds is if they buy organic produce. But that doesn't guarantee that transgenes have not contaminated the organic farms. Scientists have reported that at 50 meters from a small plot of genetically modified plants of oilseed rape containing a herbicide resistance gene, about one in ten thousand seeds produced by the surrounding nongenetically modified oilseed rape plants showed resistance to the herbicide.[20] It is uncommon for pollen to be transported more than a few kilometers, but it does occur during unusual weather conditions when the pollen is swept high enough in the air. Writing in the journal *Nature,* a team of scientists from the Scottish Crop Research Institute stated: "Our results show that significant quantities of pollen travel over large distances; this has implications for transgene recruitment by feral populations, provided pollen viability and competitiveness are unaffected by dispersal."[21]

Organically produced food is one of the fastest growing sectors in agriculture. Since public demand for organic produce has increased, the social institutions bear some responsibility to protect organic farmers from controllable externalities like genetic pollution. This type of protection may require the establishment of buffer zones separating farms or the use of sterile seeds for GM crops grown in proximity to non-GM farms. Once the case law develops, it is likely that a new set of agricultural norms will emerge that will provide guidance both for farmers who plant GM crops as well as for those who do not plant them. Liability claims will establish new risk-benefit ratios from transaction costs such as insurance for farmers planting GM crops. However, if farmers who do not plant GM crops are not protected from genetic pollution by the courts or by new legislation, their only option may be a self-initiated sequestration of organic producers to safe regions far enough away from GM farms.

Who bears the responsibility for this type of agro-genetic contamination? Organic farmers in North America can lose their certification if their crops show greater than 1 percent GMOs. In Germany and Japan the standards for certifying crops as organic require that they contain less than 0.1 percent of GMOs.

The USDA has established uniform standards for produce to be labeled organic. At one stage in this standard-setting process, the USDA proposed including GM products under the organic label if they were not grown with synthetic pesticides. However, the USDA retracted that provision in reaction to an overwhelming response from consumers that they wanted organic food to be GM free.[22] Does this imply that the government has an obligation to insure that organic food can be grown without GM pollen contamination? Can farmers seek compensation if their crops have been affected by GM pollen? Is there a "statute of limitations" for farmers who seek indemnity for GM pollution? Who is responsible for testing the food supply to ensure that organic foods are GM free? Organic food organizations are asking for legislative relief against genetic pollution of their crops.

These issues are currently being debated among legislative bodies and contested in the courts but have not yet been resolved. From the standpoint of agricultural ethics, farmers should have a fundamental right to farm natural foods without contamination from industrial or other agricultural sources. If GM pollen and seed dispersal become the norm, then this right will become meaningless.

Issue 5: What ethical principles guide intellectual property ownership of seeds? Seed manufacturers have devised a strategy that protects their intellectual property in germ plasm and can protect organic farmers from GM pollution. They have been able to produce plants whose pollen and seeds are sterile. Once the GM seed is planted, farmers will not be able to save seed for a second planting. At the same time, the sterile pollen of those plants will not be able to outcross with non-GM plants.

Public interest groups have termed the device "terminator technology." It has been argued that sterile seed technology reduces the options for farmers and gives seed companies too much control over what a farmer can plant. Alternatively, the ag-biotechnlogy industry argues that seeds (GM or otherwise) deserve as much intellectual property protection as any other potential product (e.g., software in the computer field).

The only thing holding back biotech companies from producing and distributing "terminator" seeds has been the intense negative publicity, since these seeds do not violate any international or domestic laws and are not inherently more ecologically hazardous than ordinary GM seeds. Paradoxically, terminator seeds may be environmentally safer than their nonsterile counterparts. This likelihood raises an ethical dilemma for some environmentalists who are faced with an issue of containment versus farmer rights to save and replant derivative seeds.

The terminator technology has been of interest to USDA, which announced in August 2000 that it would partner with Delta Pine Land Co. to pursue commercialization of a "technology protection system," their term for terminator technology. In their system three genes are added to a plant, which, if treated with antibiotics, will produce a toxin that renders the subsequent generation of plants sterile.

Do the seed manufacturers have a right to protect their seeds as intellectual property by genetically engineering germ plasm from being repropagated in a second-generation planting? Is there a higher moral duty that gives farmers the right to use the plant germ plasm that they purchased in any way that enhances their agro-ecosystem and maximizes their utility? Can this be done without violating provisions of the patent law, for example, if farmers do not develop and sell commercial varieties based on the original GM seed? On the other hand, do seed companies have a right to market sterile seeds? Farmers who do not want those seeds can buy elsewhere. For American farmers, second-generation high-yield hybrid seeds do not provide the same yield as the first year, largely because of genetic variation introduced in F_2 crosses. As a result, U.S. farmers have become accustomed to purchasing new

seeds each year. This is not true for farmers in developing countries. Thus, the ethics of terminator seeds may depend in part on whether it is applied to Third World or First World agricultural systems.

Another consideration of terminator technology is whether it will eventually be applied to domestic animals (pets and livestock). In such instances, farmers and pet owners will lose breeding rights for animals they own. These applications may be more restrictive to First World farmers than sterile seeds.

Is terminator seed technology in the public interest? Is there an ethical distinction between (1) forcing farmers, through contract, not to use the GM seeds of harvested plants, and (2) the practice of developing sterile seeds (terminator technology) so that farmers are unable to use those seeds?

The autonomy of the farmer to produce safe and nutritious crops must be a high priority of our system of agricultural ethics. Autonomy implies expanding and not narrowing choices. Since so few American farmers save second-generation seeds, there is no loss of choice in introducing sterile seed technology. Many of the U.S. seed manufacturers require farmers to sign contracts that they will not save their GM seeds, sell them for research, or plant them in ways the seed companies do not approve. There is, however, a loss of autonomy to organic farmers if they are faced with uncontrolled genetic pollution of their crops. The ethical arguments look different for Third World farmers for whom seed ownership of any form is culturally unacceptable.

Issue 6: Wherein lies the responsibility to stop the treadmill of resistant organisms?

Scientists have discovered products and techniques that destroy microscopic bacteria, weedy plants, and troublesome insects. But these same products and techniques, if used often, can help nature select resistant strains of organisms that reintroduce the problem. Cases in point are herbicide-tolerant plants. Among the first commercialized products of agricultural biotechnology, herbicide-tolerant crops are attractive both to industry and to some farmers. For the industrial sector, a single broad-spectrum herbicide will centralize chemical inputs and create higher profit margins. Farmers who can use a single herbicide for all their crops will suffer fewer losses from rotational planting of two crops that have tolerances to different herbicides. By applying broad-spectrum herbicides, two ecological effects are likely to occur. First, weeds that are naturally resistant to the herbicides will grow more readily and

proliferate without the competition of the nonresistant strains. Second, the genes that confer herbicide tolerance to the food crop will transfer to weeds, also creating resistant strains.

A second case centers on the proliferation of antibiotic-resistant genes (as markers) in GM crops. The antibiotic-resistant genes may get transferred to the stomach bacterial flora of humans or animals. This will exacerbate the population of bacteria, some pathogenic, with resistance to therapeutic antibiotics. Overuse of a good product such as antibiotics, whether in pharmaceuticals, in antibiotic soaps and cleansers, or in plants can result in a negative outcome. The proliferation of antibiotic-resistant strains of bacteria has become a formidable public problem.[23]

A third case is the introduction of insecticidal genes, such as the gene that synthesizes the toxin for *Bacillus thuringiensis* (Bt). Plants with the Bt gene expose insects to an insecticidal protein at every stage in the plant's development and throughout the entire growth cycle. This will eventually create an evolutionary pressure that favors resistant insects, unless some accommodation is made.

Under whose responsibility is it to minimize the creation of organisms resistant to control agents? The problems of resistance are exacerbated by a number of human activities, including the overuse of antibiotics and antibiotic markers. For example, in 1976 a citizens committee in the city of Cambridge, Massachusetts, drafted the first legislation in the United States regulating rDNA research. One of the provisions of the ordinance was that antibiotic-resistant markers used in the creation of rDNA organisms not compromise the value of clinical antibiotics. Currently, GM crops use antibiotic-resistant genes—some of which may confer resistance to widely used antibiotics.

Do we have an ethical obligation to minimize the proliferation of resistance genes for antibiotics, insecticides, and herbicides? Who bears the responsibility for protecting society against the spread of resistant organisms? If alternatives to antibiotic markers in the development of GM crops are available, should their use in plants be mandatory? Should agriculture be moving in a direction that creates more evolutionary pressure for creating organisms resistant to biocides, for example, by exposing target organisms over a long time span throughout the growing season to these biocides?

The U.S. EPA has linked the registration of varieties of Bt crops with resistance prevention strategies. The agency is aware that the loss

of Bt effectiveness through growing insect resistance could mean the return to higher toxicity pesticides.

Issue 7: When is the introduction of GM foods to the Third World ethically and politically correct?

It is estimated that one-fifth of the world's population is undernourished or living under famine conditions. The author of a recent feature article in *Time* magazine (July 31, 2000) stated that Golden rice (rice modified with the addition of the gene for beta carotene, a building block for vitamin A) is "the first compelling example—of a genetically engineered crop that may benefit not just farmers who grow it, but also the consumers who eat it" (p. 41).[24] *Time* reported that Golden rice could help at least 1 million children who die annually from vitamin A deficiency and an additional 350,000 who succumb to blindness. Some 3 billion people depend on rice as a staple food, while 10 percent, or 300 million, are afflicted with some form of vitamin A deficiency. What are the ethical conditions that define this issue? What are the benefits of introducing Golden rice? Will the necessary conversion of beta carotene to vitamin A occur in malnourished infants? What are the risks? Is Golden rice a ruse product designed to win over the world's approval for GM crops? Is it an authentic humanitarian product? Under what conditions would we accept a vitamin-enhanced rice as humanitarian? New Zealand does not allow any enhancements to its food—no vitamin-enhanced milk or vitamins added to grains in cereals. Would this country be ethically remiss to ban the introduction of genetically engineered, vitamin A–enhanced rice? How would this differ from conventional vitamin enhancement?

One commentator noted that GM-crop risks, if there are any, are relatively insignificant to people who are starving or who have severe nutritional deficits. Should the ethics of GM foods be calibrated to the desperation of people? We use a similar ethical approach in drug development. People with life-threatening diseases take more risks with experimental drugs than healthy people would be permitted to take. How should decisions about exporting new strains of rice to desperate nations be made? Should there be an international ethics board (like our local IRBs that review clinical trials)? If one is not opposed to GM crops/foods in principle, then what are the conditions under which it is ethically acceptable to send GM rice to developing countries to prevent or reduce vitamin deficiencies?

The humanitarian impulse to prevent vitamin A deficiency in children living in impoverished regions of the world is strong and morally defensible. A cynic might question why it has taken bioengineered rice to arouse public awareness about Third World vitamin deficiency. Is genetically modified rice, patented by a transnational seed company, the best way to reduce vitamin A deficiency? Could consumption of a vitamin A-enhanced food source (other than beta carotene) put some people at risk, for example, pregnant women since excessive intake of vitamin A is associated with teratogenicity in humans?[25] Are there natural sources of vitamin A that could be introduced into the agricultural system?

There are ethical concerns regarding the use of Third World peoples as a testing ground for GM products. Political economist Robert Paarlberg has argued that developing countries have much more to gain from the GM crop revolution than do developed countries, and that because of their circumstances they should be willing to bear more of the risk for GM crops than the United States and Europe, where the regulatory thresholds are understandably higher.[26] This polarization among good-intentioned people who assess the risks and benefits of GM crops differently could be sensibly resolved by having an independent international agency such as the World Health Organization or the Food and Agriculture Organization consider the potential benefits and risks of a strain of rice that has been genetically modified with beta carotene.[27] The market system, operating through large and impersonal seed distributors and rice importers, would neither ensure democratic participation in a nation's choice to adopt GM seeds nor see that sufficient attention is paid to the human health, socioeconomic, and ecological effects of the adoption.

An ethical approach that gives primacy to autonomy must adopt as a starting premise that the populations who agree to be the early consumers of GM products are fully informed of the options and give consent to be part of the experiment. The consequentialist approach to GM crops/foods is based on the presupposition that the products are not inherently good or bad but should be assessed on health criteria and the unique sociocultural values of a nation.

Issue 8: Are there religious and/or dietary-ethical concerns about GM foods? We live in a society of many cultural and religious beliefs concerning food. Some Jewish groups do not mix certain food types in the same meal, such as milk and meat products. These observant groups have

taboos against other food types such as pork or shellfish. Hindus and some Adventists do not eat meat. Vegans do not eat meat, fish, or eggs. How can we protect such beliefs within the context of GM foods? Would it matter to individuals who observe dietary rules that the gene from a food product that is a taboo in their culture is transplanted to a food product that is generally accepted? Would a vegetarian be opposed to corn that has been modified by the addition of a gene from an insect? Would an observant Hindu object to eating a plant into which a gene from a cow has been transferred? Would religions that oppose cannibalism object to eating animals with human genes.

Some companies have argued that a recombinant gene from an animal inserted into a plant is not the same as eating the animal. Typically, the animal-derived gene in the plant is expressed; otherwise, what is its function? That means that the person consuming the plant is consuming the protein that is found in the animal. If the person has a taboo against eating the animal protein, would that extend to the plant, which has been transformed with the gene (and its expressed protein) from the animal?

This is a question that must be answered by different religious and dietary-sensitive groups. The answers may not be the same. Suppose that the gene transferred from the animal to the plant is not expressed in the plant. Would that make a difference? Or, perhaps the gene in the animal and the plant codes for a similar (if not identical) enzyme. Does the fact that there is chemical homology between the foreign gene and its expressed protein within animal and plant affect the ethics of the discussion? Let us also suppose that we transfer a gene from an animal to a plant that codes for a nutrient, such as a vitamin or an amino acid. Would there be religious or ethical opposition to groups with special dietary considerations in these cases? John Fagan argues: "Although genes for proteins that are common to both plants and animals are related, there are significant differences in the information contained in those genes. That is, the cow hexakinase gene is different from the tomato hexakinase gene in information content."[28]

Is labeling a sufficient consolation for people who oppose the transfer of genes from a species they do not consume to one they do? Do people have a right to protect certain foods from being transformed by DNA from other species regardless of whether such products are labeled and regardless of whether they are found safe to eat? The issue might be viewed differently by people who follow dietary laws if the food supply was diverse enough to contain both GM and non-GM

products and if they were distinguishable in both primary foods and processed foods.

Food security has taken on a new meaning in the last decade of the twentieth century. The discovery of mad cow disease in England and its spread to France and Germany has severely shaken European societies' confidence in the food supply and caused food-importing countries to be on high alert for contaminated beef and beef products. During the same period, the American public has been warned of the risks to children of pesticide residues on produce and of *E. coli* bacterial contamination in hamburger meat.

Also in the 1990s, a small group of transnational companies helped to define U.S. federal policies on genetically modified crops that circumvented public attitudes.[29] The confluence of mad cow disease, chemical contamination of food, and GM crops proved to be a recipe for heightened public skepticism against any dramatic changes in conventional food production. Concerns about food safety rekindled a deeper debate over the ethical beliefs underlying the production and distribution of food. Among the more audible voices in this debate are those who consider food production part of a vast network of players and stakeholders, including seed manufacturers, growers, distributors, primary and secondary processors, chemical companies, and consumers. They see farms operating within a larger ecosystem and argue that both must be protected for future generations. With issues looming like global warming, agricultural waste contamination of water supplies, and the spread of antibiotic resistance, we can no longer afford to look at the farm as an isolated system.

A primary ethical responsibility for food contamination became a legislative mandate in the United States through the enactment of the first food and drug law nearly a hundred years ago. Currently, food ethics has expanded beyond food toxicity to consider the methods of production, the stewardship of land, the treatment of animals, and the nutritional quality of food developed under modern methods. And now our deepest assumptions about the nature of food are being challenged by the transformative techniques introduced in plant biotechnology. These debates are creating new fault lines within the public interest community, forcing food security groups and environmentalists to reexamine traditional ethical principles regarding food that will cause them to either embrace or oppose bioengineered crops, until the political landscape opens up new areas of compromise.

Notes

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