Foods

from Genetically Modified Crops

From the Editor:

The agricultural scientists and farmers all over the world who improve our crops are the true heroes of our time. They have kept food production ahead of massive population increases. These advances were made possible by the continued genetic modification of our crops. In addition, our food is safer now than it has ever been in human history.

Most of us know very little about the way our food plants are grown and are far removed from the factories where they are processed. All we care about is that our food be wholesome, nutritious, and tasty. Critics of crop biotechnology are of the opinion that potential ecological and food safety disasters are looming on the horizon because genetically modified (GM) crops have entered the food chain. Alarmists have introduced emotionally charged terms into the debate and speak of "frankenfoods" and "genetic pollution." The debate that rages in Europe has reached the shores of the United States; it is a high-stakes game with powerful economic and political forces on both sides.

As plant scientists associated with public research institutions, we believe that the issues of food safety and food sufficiency are extremely important. The debate cannot be left entirely to the well-funded efforts of either the big multinational agricultural biotech companies or to the opponents of GM foods funded by the organic food industry and radical "consumer" groups. We take our responsibilities seriously and this brochure is our own small contribution to this debate.

As scientists, we always demand and rely on evidence. It has been claimed that the risks of genetic engineering of crops will be "superweeds" and "superbacteria," the appearance of unknown toxins and allergens in our food, paralyzing crop losses, and extensive ecological damage. We have not seen any evidence for these scenarios. We believe that agriculture could be less ecologically damaging and be made more sustainable, and that GM crops can play a positive role in this development. We also believe that GM crops will make food cheaper to produce and more nutritious.

We hope that you will read this brochure and we hope that its contents will help you think through the issues raised by the GM food debate. Scientists and professional scientific societies support the introduction of GM crops in the human food chain. As consumers you have the last word. If the food is good, whether GM or not, you will buy it; if it's not, you won't.

Maarten J. Chrispeels
Director
San Diego Center for Molecular Agriculture
mchrispeels@ucsd.edu

TABLE OF CONTENTS

This brochure has been produced by the San Diego Center for Molecular Agriculture (SDCMA), an alliance of scientists who work at public research institutions in San Diego. The SDCMA accepts small donations ($1,000 to $5,000) from public agencies, individuals, and industry for its activities, which include scientific symposia and outreach. These basic scientists are not directly involved in producing GM crops, but the discoveries they make are sometimes used by companies for crop improvement. For more information, see <www.sdcma.org>. For additional copies of this brochure, email <mchrispeels@ucsd.edu>.

Produced and printed with funds provided by the University of California Systemwide Biotechnology Research and Education Program and a grant from the Samuel R. Noble Foundation.

0001-178

Genetically Engineered Crops Will Help Feed The World

By the year 2050 there are likely to be 9 billion people on this Earth, an increase of 50 percent over the present day. Most of this increase will occur in the cities of developing countries, primarily in Asia. If present economic development continues, this population increase will require a doubling in food production. Only a fraction of the food that all these people will need can be produced in the breadbaskets of the world. Most of this food has to be grown locally. The problem of feeding all the people is worsened by the uneven distribution of cropland. For example, China has a quarter of the human population but only 7 percent of the world's farmland.

During the last doubling of the human population from 3 billion in 1960 to 6 billion in 2000, food production increases kept up with population growth because we created and adopted multiple new technologies. Better techniques to cultivate the soil, new irrigation technologies, more advanced pesticides that are biodegradable, better genetic strains, machinery that harvests more of the crop, synthetic fertilizers, and green manures that restore the nutrients to the soil all have helped raise food production.

GM Crops Are Only Part of the Answer

GM crops are not the magic bullet that will feed the world. But they can certainly help because they are an integral part of our continuing quest for the genetic improvement of crops. We can't afford to reject this technology as some are advocating. Progress must be made in other technologies as well. We need more durable, longer-lasting disease and insect resistance, irrigation systems that waste less water, agronomic systems with multiple crops that limit erosion on sloping land. We need to find out which types of soil tilling, fertilizer application, and crop rotation produce the healthiest soils with the most beneficial microbial activity. We need to learn so many things, and yet financial support for agricultural research has been slowly eroding for twenty years.

GM crops cannot eliminate poverty and hunger because these problems are rooted in the socio-political realm. People need jobs to purchase food and with economic demand food production usually picks up. Although the world does indeed produce enough food to eliminate hunger, we have not yet devised an economic system that permits the distribution of that food in an equitable way.

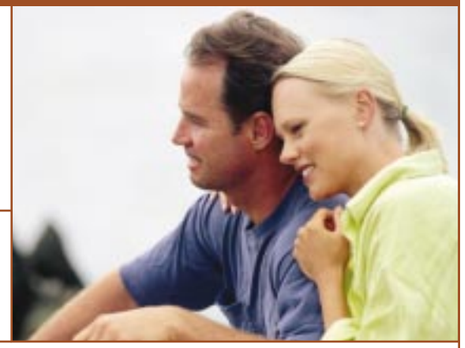
Technologies are not an unmitigated blessing, especially when they are first introduced. Cars pollute the air and people are killed in accidents, but few people want to be without an automobile. Agricultural technologies also have negative effects. To make them better requires our human ingenuity. President Jimmy Carter said it so well: "Responsible biotechnology is not the enemy; starvation is."

GLOSSARY

Genetic engineering: changing the genetic make-up of an organism using molecular techniques. This includes introducing one or more genes from unrelated organisms.

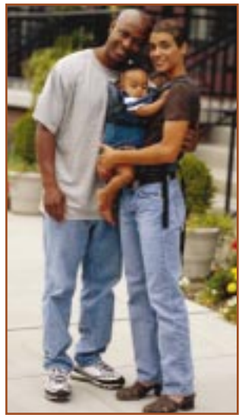
Genetic modification (GM): often used interchangeably with genetic engineering although there are many types of genetic modification that do not involve genetic engineering.

GM foods: foods derived entirely or in part from GM crops.



GM Foods Affect Your Life

Here are some things you should know...



If you worry about food safety *you should know that GM foods are as safe as other foods and that GM crops are grown with fewer pesticide applications than traditional crops.*

If you treasure butterflies *you need to know that pesticides used in conventional farming are far worse than GM crops for butterflies.*

If you have allergies *you need to know that GM technology can eliminate food allergens and that all GM crops are extensively tested to make sure that no new allergens are introduced. In addition, GM crops are being created in which the major allergens have been eliminated.*

If you are worried about cancer *you should take note of the fact that 99.99 percent of the carcinogens in your food supply are natural chemicals that humans have been eating for thousands of years. However, GM technology provides the means of increasing levels of phytoestrogens, isoflavones, carotenoids, and other antioxidants known to prevent cancer.*

If you are a woman and worried about getting sufficient iron *you should know that genetic modification can increase the iron content of cereals and has eliminated chemicals (phytic acid) that prevent iron absorption.*

If you have doubts about the government's approval of GM crops *you need to know that extensive testing and a long approval process accompany every GM crop introduction. In the United States, three agencies regulate these crops.*

If you care about the environment *you may want to know that GM foods can make a significant contribution to alleviating the negative impact that agriculture has on our environment.*

If you are worried about eating genes *you should know that a GM-free meal that has ten ingredients (wheat, potato, broccoli, meat, etc.) has billions of copies of 250,000 different genes. If five of those ingredients are GM crops you will eat an additional ten to fifteen genes. All those genes are quite readily digested by your stomach juices.*

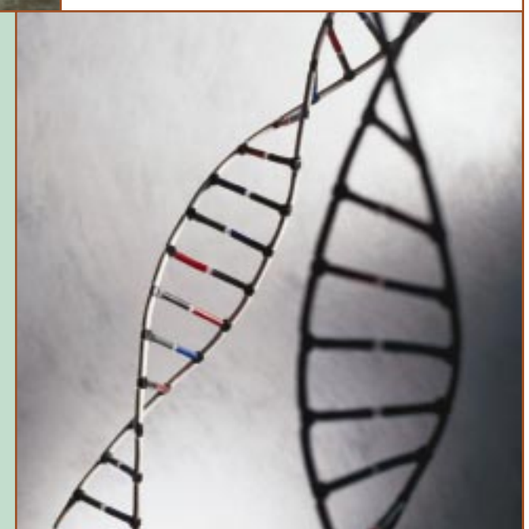
If you have religious beliefs *you should be aware that ethicists and religious leaders do not object to genetic engineering of crops on ethical or religious grounds.*

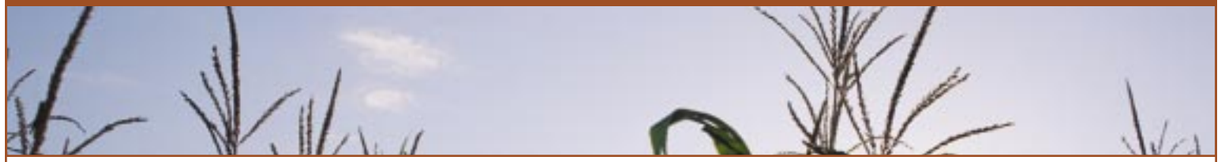
If you care about developing countries *you should take note of the fact that the most eminent plant breeders in those countries want to have access to GM technology to breed more productive and more nutritious crops.*

If you don't trust industry spokespersons *then listen to independent university scientists. The overwhelming majority agree that GM technology is safe for the consumer and the environment and that it is needed to raise crop productivity. They also support scientific testing and regulation of such crops.*

GENETICS 101

What is a gene? Genes are the units of inheritance first discovered in the middle of the nineteenth century by Gregor Mendel. He examined thousands of pea plants and discovered that some pea flowers had a purple color that was inherited when peas were crossed. Now we know that genes are made of DNA and are arranged in long strings on the cell's chromosomes. Bacterial cells have about 2,000 different genes, a flowering plant has some 25,000 genes, and humans may have as many as 50,000. Every cell has two copies of every gene. Each gene has the information to make a specific protein. Thus, in peas the gene for "purple" specifies a protein that converts a colorless chemical into a purple pigment in the pea flower. When the gene is passed from one generation to the next, so is the capacity to make the purple pigment.





10,000 Years of Manipulating Crops

We are all familiar with the glorious sight of a full ear of ripe sweet corn, but what does the ear of the ancestor of the corn plant look like? Some 6,000 to 8,000 years ago Native Americans in Mexico began the slow process of domesticating teosinte, the ancestor of corn. Teosinte still grows wild in Mexico. It produces tiny "ears" with very small seeds, each contained in a tough thick husk, that fall on the ground when they are dry. The plant itself also does not look like a modern corn plant with its single tall stalk, because the species was genetically modified through the intervention of humans. Corn probably has as many as 25,000 different genes and we have no idea how many have been mutated, deleted, rearranged, or duplicated in the past 5,000 years of human manipulation. All these genetic modifications are to our advantage because an acre of corn yields 1,000 times more food than an acre of teosinte.

As you travel through the countryside, whether in Mexico, Iowa, Kenya, or Italy, all corn-growing regions, you never see corn growing outside of a field or garden. That's because corn cannot survive without our assistance. It is a natural plant, but it can't survive in nature!

What is true of corn is also true of our other food crops: wheat, rice, beans, and soybeans were all genetically modified and can't survive on their own. Crop domestication, the process of changing wild plants to crop plants, started in south China and the Middle East about 10,000 years ago and in west Africa and central Mexico 8,000 years ago.

Plant Breeding is Systematic Genetic Manipulation

At the start of the twentieth century, farmers and breeders started improving crops more systematically. First they simply worked in the field, making crosses and producing hybrids from plants of the same species. Starting about 1950, breeders began experimenting with wide hybridization: crossing different species and rescuing the tiny embryos through laboratory culture (otherwise, the embryos die because the plants are of unrelated species). To produce a crop from such a cross does require many generations of plant breeding. A major new cereal called triticale was produced in this way by crossing wheat and rye.

Then came radiation breeding. Seeds were irradiated with gamma rays—which knock the DNA for a loop—and the plants with their damaged DNA were crossed back to healthy plants. The idea was—and this proved to be correct—that some changes in the DNA would prove to be beneficial to the farmer. In this, as in all plant breeding, extensive crossing (six to ten generations) eliminates all the "bad" DNA and keeps only the "good" DNA. Chemicals have also been used to induce mutations. Hundreds of crop varieties are now in use that were produced by these methods. Organic farmers and opponents of genetic engineering accept such varieties as "natural." However, they consider the next innovation in breeding, which uses molecular techniques, to be "unnatural."

"We cannot turn back the clock on agriculture and only use methods that were developed to feed a much smaller population. It took some 10,000 years to expand food production to the current level of about 5 billion tons per year. By 2025, we will have to nearly double current production again. This increase cannot be accomplished unless farmers across the world have access to current high-yielding crop production methods as well as new biotechnological breakthroughs that can increase the yields, dependability, and nutritional quality of our basic food crops. We need to bring common sense into the debate on agricultural science and technology and the sooner the better!"

Norman E. Borlaug
Winner of the Nobel Peace Prize, 1970

Twenty Years of Crop Modification Through Genetic Engineering

All DNA has the same basic structure, and gene analysis has revealed that, in the course of evolution, some organisms have exchanged DNA with each other; one organism passing a few genes to another organism when no one is watching! This process doesn't occur frequently in nature, but plant molecular biologists now use this natural gene exchange mechanism to insert new genes that carry valuable agronomic traits into the genome (the entire set of genes) of our crop plants. This is referred to as "genetic engineering" and is presently still done one gene at a time; in the future, researchers will transfer segments of DNA carrying multiple genes. Crops created in this way are referred to as genetically modified (GM) even though genetic modification has really been going on for millennia. Scientists don't know exactly where in the genome a gene lands, but this is usually not important because the genome seems to be constantly rearranging itself anyway. Furthermore, all the crop breeding that normally follows such a gene insertion will "separate the grain from the chaff." If the DNA lands in an unsuitable place that makes the plant less useful or edible, then those plants will be eliminated in the breeding process.

Genes that have the potential to greatly improve the human condition by allowing more food and more nutritious food to be produced on the same amount of arable land are being discovered at an ever-increasing rate. Will we be allowed to use these genes for the benefit of humanity or will the green groups prevent us from realizing the benefits of this unique technology?

GM Crops: Present and Future

These techniques have been used to create insect resistant crops, reducing the need for pesticides, and "golden rice," a variety that is rich in vitamin A and will help prevent blindness in millions of poor children. In the future, scientists will be able to replace an existing copy of a gene with another copy that may be slightly better. New molecular and genetic techniques will make genetic engineering of crops ever more precise. Such precision may well make unnecessary the many generations of crop breeding that currently follow the laboratory procedures.

Genetic engineering is not the only way that crops will be genetically improved in the future. The study of the genome of plants will allow more rational, and more clever, approaches to traditional plant breeding. Furthermore, as genome analysis becomes easier and cheaper, we will be able to tackle the orphan crops of the developing world, such as cassava and millet, that have been neglected so far.

Is Organic Farming the Answer?

Certified organic farming is defined as much by what it does not accept as by what it does accept. For most of its farming practices it turns the clock back to 1950 and disavows the use of all but a few pesticides (such as rotenone, which is actually quite poisonous), and rejects all herbicides and most inorganic (chemical) fertilizers. It prefers organic fertilizers (manure), mechanical removal of weeds (with tractors), and biological pest control. It accepts all methods of producing improved crop plants (including radiation breeding) but rejects GM crops that use gene transfer. Organic farming can feed about 3 billion people, not the 6 billion that we now have, or the 9 billion that we will have.

Why is this so? There are several reasons, according to Professor Tony Trewavas, an eminent British plant biologist and fellow of the Royal Society of Great Britain. First of all, to produce the manure necessary to raise the organic crops, a considerable amount of land must be set aside to raise food for the animals. Secondly, crop harvesting and food consumption result in a net transfer of plant nutrients from the soil to the toilets of city dwellers! Replacement of these nutrients through crop rotations with legumes and by utilizing rock phosphate is imperfect at best. Also, biological control of insects and diseases is not as efficient as chemical control or control by genetic modification in many crops. These factors all conspire to make organic farming less efficient and certified organic produce more expensive than traditional farming.

Farming Must Be Made More Sustainable

However, there are many positive aspects to organic farming that are practiced by many farmers. Crop rotations with legumes, the use of crop residues to improve the soil, integrated or biological pest control when appropriate, and use of lime to change the acidity of the soil are just a few examples of practices that are part of "sustainable" agriculture. The problem is that certified organic farming is driven by ideology, not by sound science or even a "love of the land." Organic farmers reject technologies that other farmers incorporate in their cropland management schemes to achieve a sustainable form of agriculture. Scientists who support GM crops agree that farming must be made more sustainable, but reject the ideology-driven approach of organic farmers.

Organic Farming: Who wins and who loses?

In spite of what everyone believes, there is absolutely no scientific evidence that organic produce is more wholesome or more nutritious than conventional produce. Organic produce may be tastier, but that is usually because it was harvested more recently. On the upside, there may be less pesticide residue, but on the downside there may be more bacterial contamination. So, if there is no real benefit to consumers, then who benefits? Mainly the mid-size corporations and grocery store chains that push organic products and claim to be in the health food business. They also help fund the colorful anti-GM food demonstrations when children dress up as monarch butterflies. The objective of these demonstrations is always to instill fear of the unknown. Simple economics is behind this support for anti-GM foods groups. GM Foods, just like organic foods, have low pesticide residues and in addition are cheaper. So, if people can be scared out of buying GM food, the market for organic produce will be better. The bottom line, as always in America, is market share and profit!

So, we know who gains, but who loses when fruits and vegetables are more expensive? You have heard the medical advice: "Five or more servings of fruits and vegetables a day help to fight cancer." It's the people at the bottom of the economic ladder who lose out when fresh produce is more expensive than it needs to be.

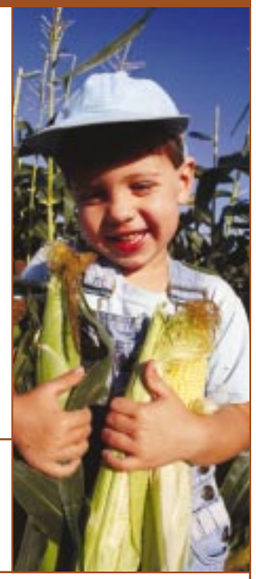
Most importantly, unlike organic farming, genetic engineering has the potential to really improve the nutritional value of crops. Just around the corner are crops with more vitamins, more anti-oxidants and minerals, and with fewer allergens. Unlike the organic foods, these future GM foods will have real health benefits.

New antibiotic-resistant bacteria because of GM foods?

The emergence of strains of bacterial pathogens that are resistant to antibiotics has become a major health and food safety problem. Antibiotic-resistant bacteria develop when people misuse antibiotics to fight viral infections (like colds) and when they do not use antibiotics long enough to kill all the infecting bacteria. In addition, large doses of antibiotics are fed to animals because, for unknown reasons, it stimulates their growth. The emergence of antibiotic-resistant strains as a result of these practices was widely predicted by microbiologists many years ago. Antibiotics are also used to create GM crops in the laboratory, and opponents of GM crops maintain that this will lead to the appearance of new antibiotic-resistant bacteria. Although further studies are needed, microbiologists think it extremely unlikely that this will occur, and experiments bear out their belief.

Where does that organic produce come from?

Does that organic produce in your local grocery store come from a small farmer who lives up the road in a picture-book farm with ten cows, a pig, and twenty-five chickens? In Western Europe, 70 percent of all organic produce available in the stores is flown in on big jets coming from developing countries. With lax laws about preserving biodiversity in fragile ecosystems, they are all too happy to satisfy their rich customers' demand for organic produce. It is yet another reason why organic produce is more expensive.



Foods from genetically modified crops are just as safe as those made from other crops...

Newspapers frequently carry stories about safety problems with our food. For example, in 1999, animal feed contaminated with dioxins was fed to chickens in Belgium; as a result the chickens and their eggs contained high levels of this noxious chemical. Several months went by before the problem was corrected. This food scandal was caused by unscrupulous dealers in animal feed out to make a quick buck. In addition to such episodes, each year some 300,000 people are hospitalized for food-related illnesses in the United States. The large majority of these cases are caused by the presence of bacteria in our food: *Salmonella, Campylobacter, Staphylococcus and E. coli* have all become household words. According to the Centers for Disease Control and Prevention, 7,000 people die annually from food-related illnesses. In the overwhelming number of cases, poor household food preparation or storage is to blame. However, in many cases microbial contamination occurs earlier and results from the way our food is produced and handled before it reaches the store. Although our food supply is now safer than ever before, there are still problems. Microbial contamination is the major food safety issue in the United States. We could do a much better job.

So what about GM crops whose safety has been questioned? No evidence has surfaced that foods made from GM crops are any less safe (or more safe) than traditional foods. That is because GM foods are much more extensively tested than traditional foods. Indeed, in the United States, GM crops and foods are regulated by the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), and the United States Department of Agriculture (USDA). The process to approve a GM crop can take up to six years. Crops produced by traditional breeding techniques (including radiation breeding) do not need to be tested in this way.

GM Crops Are Exhaustively Tested

Tests are run to make sure that the GM crop contains exactly the same components as traditional varieties. That includes the nutrients as well as other chemicals found in our food plants. Indeed, our crops contain a variety of chemicals that are part of the plant's arsenal to fend off insects, bacteria, and fungi. When eaten in small quantities they don't present a problem for people; however, several new lines of crops bred by traditional methods had to be recalled because they contained unacceptably high levels of such chemicals. The crops were approved because testing is not required for crops produced by traditional methods. Genetically modified crops are tested in a more rigorous way.

The additional components present in a GM crop but absent from the traditional crop, usually a few extra genes and a few proteins, are tested for their potential to cause an allergic reaction, and to make sure that they are rapidly broken down by the stomach's digestive enzymes. The rules are the same as those for pesticides and other food additives introduced by the food industry: there must be reasonable certainty that no harm will result from cumulative dietary exposure.

Bad Science/Good Science!

Phytoestrogens are newly-discovered biologically active chemicals that are particularly abundant in soybeans and soy products. They lower the risks of certain cancers in women that are linked to high serum estrogen levels. A group opposed to GM crops measured the levels of phytoestrogens in traditional and genetically engineered soybeans and came to the conclusion that the phytoestrogens were substantially lower in the GM seeds. However, they did not measure phytoestrogens in the seeds of the GM crop line and its parent crop line, harvested from plants grown side by side. Phytoestrogen levels vary considerably in different soybean varieties, and vary depending on the conditions of growth (weather, soil, fertilizer, etc.). Thus, no definitive conclusion could be drawn from this poorly controlled experiment. Nevertheless, the group prepared an extensive press release condemning GM crops.

Recommendations of the American Medical Association Regarding GM Foods

At its meeting in December 2000, the American Medical Association (AMA) adopted a number of recommendations regarding GM crops and GM foods. The AMA believes that "there is no scientific justification for special labeling of GM foods, as a class, and that voluntary labeling is without value unless it is accompanied by focused consumer education." The AMA believes that "federal oversight of agricultural biotechnology should continue to be science based and guided by the characteristics of the plant, its intended use, and the environment into which it is introduced, not by the method used to produce it." The AMA "supports efforts for the systematic safety assessment of GM foods" and "continued research into the potential consequences to the environment of GM crops."

You can't taste those aflatoxins!

Aflatoxins are potent carcinogens produced by fungi that infect peanuts and corn seeds. These fungi grow when the seeds are in storage. Although we can minimize the problem, there will always be some aflatoxins in your peanut butter. GM offers the prospect of eliminating aflatoxins by equipping the seeds with an enzyme that will break down the aflatoxins.

Is your baby allergic to soybeans?

Many babies are allergic to soybeans. One way to get around this problem is to eliminate the allergenic proteins the soybeans contain. USDA scientists recently identified the main allergen in soybean and eliminated it using GM technology. It will take at least five years, probably longer, before these soybean products are on the market. However, many baby food manufacturers have rejected GM soybeans. Consumers will have to choose between "natural" allergenic soybeans and GM non-allergenic soybeans!

What About the Environment?

For some 5000 years, crop production has been reshaping our landscape. Forests have been cleared and prairies plowed under. The landscape may still be pleasing to the eye—vineyards in California, olive groves in Spain, rice paddies in Malaysia—but the diversity of plants and animals that characterized earlier times has been lost. Not because of GM crops, but because of our need to feed an ever-growing human population coupled with our inability to increase productivity (yield per acre) fast enough. This means that ever-increasing amounts of land have had to be put to the plow.

The results are plenty of food for 90 percent of the human population—100 percent if we could distribute it equitably—and a litany of problems: loss of species diversity, soil erosion, and salt build-up. The spread of weeds and pathogens from one continent to another and the emergence of new insect pests also result from the intensification of agriculture. But none of these problems exist because of GM crops.

We need to do much better! We need to make agriculture more sustainable so that at least some of these problems can be partially alleviated. Increasing sustainability and raising productivity will tax our human ingenuity to the limit.

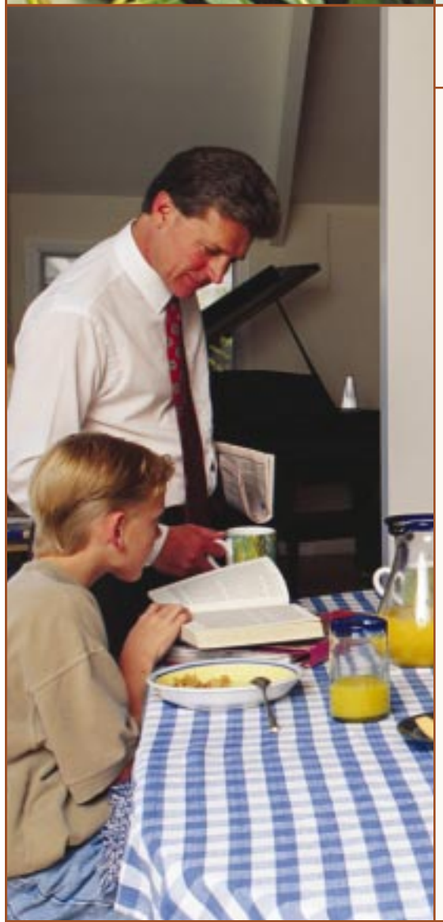
Preserving Wilderness Will Require Increasing Crop Productivity

It is odd that environmentalists who rightfully lament the loss of biodiversity are not taking a strong position in favor of technologies that can raise agricultural productivity. Indeed, there is a clear link between crop productivity and the maintenance of biodiversity.

All the good land and much marginal land is already being cultivated. What is left is even more marginal: poorer soils or drier climates, fields higher on the slopes of mountains. If we push production into those areas the damage to the environment will be greater. So, if we want to preserve wilderness lands and the biodiversity they offer, we have to increase crop productivity on agricultural lands. GM technologies can make a real contribution to this goal. The GM crops already in the fields require fewer pesticide applications and less tilling of the soil—thereby causing less erosion. Most importantly, we need to increase productivity. If doubling food production will require us to double the cultivated area, there would be no wilderness left. Let's bring all our knowledge and all our technologies—simple and sophisticated—to bear on the important issue of making agriculture more productive and environmentally friendly.

There Are More Insects and Greater Insect Diversity in Fields of Bt Crops

Bacillus thuringensis, Bt for short, is a bacterium that produces a protein called Bt toxin; this protein pokes holes in the guts of insects and insect larvae that ingest these bacteria. Organic farmers use this natural pesticide to keep the population of some insects under control. Scientists have taken the Bt gene and transferred it into cotton, corn, and potatoes, so that every cell of these plants now makes the Bt protein. The lepidopteran (butterfly) larvae that dine on the roots, leaves, or seeds of such crops are doomed. Farmers are happy because they do not have to pay for pesticides. The farm workers are safer because they do not come in contact with pesticides. The consumers are happy, because they don't have to worry about pesticide residues. But most of all, the insects that don't care to eat the crop because they have other food sources and are not killed by insecticide sprays are very happy to live out their lives in a Bt crop field. Recent research shows that fields of Bt crops have more insects and a greater diversity of insect species.



"Dad, are there genes on my plate?"

"Dad, are there any genes on my plate?" my 14-year-old daughter asked. What if your child asked you this? An opinion survey showed that 70 percent of the people have the mistaken idea that ordinary food does not contain genes, whereas GM food does. Rather than explain to my daughter that every bite of food on her plate has billions of genes, I told her a story.

"In the mountains high above Cristobal de las Casas in Chiapas, Luis and Jimena Rodriguez tend their small field of corn and beans. They are 'organic' farmers because they don't have enough money to buy fertilizers or pesticides. After they bring in the corn harvest, they store the ears in a large corn crib that covers the entire back wall of their one-room house. It's the safest place to store the corn. This room also has their bed and the four kids sleep on the floor. After the harvest is in, Luis goes to town to buy some pesticide to fumigate the corn inside his house. In the house his corn is safe from rain, rodents, and thieves, but not from insects. If he does not fumigate, the weevils will eat the stored corn. If he does not fumigate, he will have more weevils than corn kernels in six months' time. Indeed, each female weevil lays about 100 eggs, and after the larvae hatch, they burrow into the seeds. After thirty-five days mature insects emerge and the cycle begins again. Half of those insects are females, so just multiply 50 by 50 by 50 by 50 by 50 and figure out how many that is," I said to my daughter.

"More than 5 million," she answered, "all coming from two weevils."

"Now suppose that the corn was genetically modified with a Bt gene to kill those weevils, the parents and children wouldn't have to sleep in those pesticide fumes," I said. "Don't you think those children would benefit from having some genes on their plates?"

Should genetically engineered food products be labeled?

This question is one of the most difficult ones in the entire GM food debate. The FDA policy guidelines state clearly that foods produced through biotechnology will be subject to the same labeling laws as all other foods: the focus is on the safety of the product, not on the process that created it. Labeling will definitely be required of certain foods that have been created by biotechnology, but not because they were created using such procedures. According to present regulations, no special label is required if any new food is essentially equivalent in safety, composition, and nutrition to an existing food. For example, foods that have been engineered to be enriched with certain vitamins will have to be labeled, because this is important nutritional information. Other labeling will be voluntary. Companies may also label their food as being GM crop-free. This would allow interested companies to develop a niche market, much like organic produce or kosher foods.

Does Labeling Result in More Choice?

What about the argument that people have a right to know and should be given a choice? Labeling is required in Europe, but it has not resulted in more choices. Rather, supermarkets, worried about losing any customers because of protests, are simply not carrying GM foods. Most people see such labels as "warning" labels rather than neutral information. What would have happened if all the foods derived from crops produced by laboratory procedures had been labeled as such? People would probably have shunned them. As a result of such labeling we might have lost the benefit of this important technology.

People often say that they want to know if their food contains "natural" or "artificial" ingredients. Fungi that produce carcinogenic mycotoxins grow naturally on peanuts. The deadly Ebola virus is natural. "Natural" cannot be equated with "good," unfortunately. Many processes, not occurring in nature, led to the improvement of crops during the past fifty years. Are foods made from those crops all to be labeled as not natural?

Labeling Also Has An Economic Dimension

If all food made through biotechnology is to be labeled, then we have to keep it separate from conventionally produced food. Developing these two separate and parallel production streams, "from plow to plate," will add to the cost of food. So far the European Union (EU) is requiring labeling of GM foods and has essentially banned the growing of GM crops. This gives EU farmers an advantage over the US farmers, who may need to separate their GM and traditional crops if labeling is imposed.

Many products derived from GM crops (corn oil, for example) contain neither the genes nor the proteins that were responsible for the GM nature of the crop. Are they GM foods? Labeling "yes" or "no" is not as straightforward as it sounds.

The recent production of "golden rice" is a brilliant application of GM technology. This rice is rich in the precursor of vitamin A, which the body readily converts into the vitamin itself. Genes that cause the yellow color of daffodils were re-engineered so that they would be expressed in rice seeds and the resulting GM rice looks faintly yellow. Vitamin A deficiency is extremely common in Southeast Asia, Africa, and Latin America among poor people for whom rice is the major staple and often just about the only food available. The FAO estimates that 124 million children suffer from vitamin A deficiency and that 250,000 go blind every year because they lack this essential vitamin in their diet. When this rice comes on the market, it will have to be clearly labeled as "Vitamin A-enriched."

Are GM crops and GM foods properly regulated in the USA?

Who Regulates GM Crops in the U.S.?

The U.S. Department of Agriculture (USDA) regulates the transport, growth, and propagation of plants. Special regulations deal with GM crops. Companies that develop such crops need to apply for a permit to conduct field-tests of new GM crops or new varieties of already approved crops (e.g., introduction of a different gene). Regulators try to predict the environmental impact of the new GM crop. Especially important is the presence or absence of wild relatives of the crop and the possibility that genes could spread to those wild relatives. This is not necessarily bad, but it needs to be considered. The USDA also oversees the nutritional content labeling of foods.

The Environmental Protection Agency (EPA) regulates new chemical substances, especially hazardous ones. The EPA decided some years ago that genetically engineered pest control "agents" such as Bt genes should be considered as chemical substances and that the EPA should regulate GM crops engineered to be pest-resistant. This does not make much sense to most scientists because these agents are usually proteins or other natural substances that are already present in plants. Alternatively, they may be proteins that are toxic to insects but easily digested by people. There is no evidence that these agents pose an environmental threat. The involvement of the EPA does not rest on sound scientific principles because both conventional and GM crops contain natural pesticides. Despite this, the EPA regulates only the GM crops, not traditional crops.

The Role of the FDA

The Food and Drug Administration (FDA) regulates both new foods (and drugs) that are introduced and foods derived from conventional or GM crops. Its primary concern is with food safety. The FDA is not particularly interested in how the food is produced (GM or non-GM) and treats all foods equally. Because some people maintain that GM foods are unsafe, the FDA has become involved in the issue of labeling them. However, so far there are no indications that GM foods are either more safe or less safe than other foods. Scientists generally support the idea that regulation is important and they agree that it should be based on sound scientific principles and free of political considerations. Having GM crops regulated by three different federal agencies is cumbersome and the United States government is moving towards creating a single food safety agency to ensure the safety of all foods, including GM foods.

WHAT'S THE RISK AND WHAT'S THE BENEFIT?

When trains were first invented few people took them because they perceived great risk and little benefit from this mode of travel. The same happened with airplanes. Very few people who now want to go from San Diego to New York think that the risk of air travel outweighs the benefit, even though plane crashes occur regularly and planes pollute the air. The British shunned pasteurized milk for decades because the unknown risks from this "unnatural" process of pasteurization were seen to be greater than the benefits. Ultimately, the consumer decides. Do I pay more for foods clearly labeled as non-GM foods because I perceive a risk with GM food? If I believe the risk from GM foods to be no greater than the risks from other foods, and the benefits (perhaps lower price, better nutrition, or fewer pesticide residues) to be tangible, then I go ahead and buy GM Foods.

What's the Bottom Line on GM Crops and GM Foods?

1. **SAFETY**: To the best of our knowledge, GM foods and crops are as safe as conventional ones. Nutritionists and other scientists do not know of any unresolved safety issues.

2. **REGULATION**: GM crops and foods are highly regulated by the United States and other governments. The approval process requires many tests and takes many years. Scientists and agricultural biotech companies support such regulations.

3. **ENVIRONMENT**: There is no evidence that GM crops harm the environment or have the potential to harm the environment any more than traditional agriculture.

4. **ENVIRONMENTAL BENEFITS**: Certain GM crops have environmental benefits because they require less pesticide to be used and less tilling of the land (and therefore less danger of erosion). GM crops can play an important role in making agriculture more sustainable and more productive.

5. **BETTER NUTRITION**: In the near future, GM crops and foods derived from them will have higher levels of vitamins, minerals, biologically active phytochemicals, and other nutrients. Many allergens will be eliminated.

6. **FARMERS**: Most farmers want GM crops because they make crop production cheaper. For their own safety, they especially like crops that require less pesticide.

7. **OPPONENTS OF GM CROPS**: Groups that oppose GM crops on ideological, philosophical, or economic grounds (such as Greenpeace and the Sierra Club) have not brought forth scientific evidence to back up their claims of negative health consequences or environmental impact.

8. **DEVELOPING COUNTRIES**: Plant breeders and farmers want access to GM technology to improve their crops. Everyone knows that this will not solve world hunger. It is simply another tool to increase productivity and reach that goal.