Genetic Engineering: Overview and Worldview

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Definition and Overview

Genetic engineering describes the artificial manipulation and transfer of recombined genetic material across species lines with the goal of producing fundamentally-changed patentable organisms that are sold for profit. By its very nature (no pun intended), genetic engineering or genetically engineered (both hereafter referred to as GE) organisms entail considerable controversy. GE organisms are sometimes referred to as genetically-modified organisms (GMOs). GE represents perhaps the most enormous experiment in history, one whose outcome is inherently unpredictable. No generational plant or animal studies have been performed to monitor how GE crops or animal feeds may affect future plant or animal generations or the people who eat them. The human studies are you and me.

Left to their own devices, plants and animals reproduce themselves "after their own kind". GE seeks to develop plants and/or other organisms with traits never found in nature – a concept radically different from traditional plant and animal breeding. While selective breeding and other time-proven biotech methods operate on whole organisms with their completed sets of coordinated genes, GE is restricted to 3 or 4 isolated gene transfers per organism, with little control over where the altered genes are inserted.

In GE, fundamental genetic barriers between species – and even between humans and animals – must be disrupted so that genes of non-related species can be randomly inserted. This requires a whole complement of new biotechnologies. In order to successfully manipulate targeted genetic material to receive the artificially-added biological agents, transfer agents that disregard natural barriers must be used. To achieve this goal, GE scientists use viruses, antibiotic-resistant genes, and bacteria as vectors, markers, and promoters, permanently altering the genetic codes of the new organisms. The genes, parts of genes, and vectors are all patented by their promoters.

Admittedly, not all GE foods will be proven toxic, and not all released GE organisms will proliferate to cause damage to the environment. On the other hand, the short-term survival of a GE plant – or the animal or person that eats it – does not mean that the plant is safe. These new organisms will be released into the environment to reproduce, migrate, and (possibly) mutate, transferring their characteristics to other organisms with changes that – because they are genetically encoded – can never be undone or contained. Therefore, the specifics of harm from GE should be assessed on a case-by-case basis using long-term studies; levels of harm can vary greatly depending upon a number of factors.

Common Traits of GE Crops, and How GE is Achieved

The most common GE crops were developed for 6 purposes: 1.) to increase plant tolerance to insects (corn, popcorn, sweet corn, cotton, potatoes); 2.) to increase plant tolerance to herbicides (canola, corn, cotton, soybeans); 3.) to increase plant tolerance to viruses (papaya, squash, sugar beets); 4.) to alter plant oil content, reducing polyunsaturated oils and/or increasing shelf-life (canola, soybeans); 5.) to create sterile male plants using terminator genes, in effect containing the spread of transgenes (canola, radicchio); and 6.) to alter ripening and/or plant pectin, and/or to promote thicker skin of the plant product (tomatoes).[1.]

GE crops that probably will appear in world markets in 2005 include herbicide-tolerant wheat and herbicide-tolerant rice. Also on the horizon: altered bollworms that will attack other, more pesky bollworms; honeybees that will resist pesticides; cloned cattle for human consumption; male insects engineered so that their offspring will die; fast-growing salmon; and silkworms that will produce pharmaceutical drugs.

Recognizing the future dwindling of world-wide petroleum supplies, the bio-tech pharmaceutical industries may be looking to plants to help fill the void, with plans of pharmed plants that will contain: birth control promoters; cytokines and alpha interferon; human lactoferrin and human insulin-like growth factor (IGF); interleuken-10; lysozymes; proteins for treating anemia, cirrhosis of the liver, and cystic fibrosis; vaccines for cholera, foot and mouth disease, hepatitis B, and rabies; and viral sequences like the pig-corona-virus protein gene, which is related to SARS. The industry also hopes to harvest plants for raw materials for plastics, hardening agents, and other chemicals, and to produce GE trees. Within the decade, 10 percent of the US corn crop could be GE bio-pharmaceutical, with plants essentially functioning as biological factories. By definition, GE bio-pharmaceuticals will not be circumscribed by the same containment measures controlling current pharmaceutical laboratories.

Insect-Resistant Crops

Bt (Bacillus thuringiensis) is a soil bacterium that produces a toxin highly valued by organic farmers. Insect-resistant GE crops are produced by using the Bt toxin gene, in effect giving the transgenic plant a built-in insecticide. GE Bt plants are classified by the EPA as pesticides; about one-fourth of all GE crops contain Bt proteins.

Bt bacteria store multiple toxic proteins in spores. The main Bt crystal toxins are designated Cry, with individual alterations and subsets. In every case involving GE Bt, submitters' evaluations have been based on natural Bt toxins, not their transgenic alterations. [2.]

Unlike the occasional use of Bt in organic farming, transgenic Bt is continually expressed in most of the crafted plant genes, which then constantly expose the toxin to insects, presumably building up resistance in those that survive. The British newspaper The Independent reported as much in announcing a discovery about GE Bt made by British and Venezuelan researchers: diamondback moth larvae eating GE Bt-treated cabbage leaves grew bigger 56 percent faster than moths eating normal cabbage leaves. Rather than controlling the pests, the GE Bt seemed to help them thrive! [3.] By contrast, Bt appears to heighten mammal sensitivity to allergens and immunogens.

Bt used in this broadsided manner does not distinguish between beneficial and detrimental insects. For example, Cornell University researchers found that GE Bt pollen is poisonous to Monarch butterflies, important crop and wild plant pollenators. Ladybugs that eat aphids poisoned by GE Bt potatoes become poisoned themselves. Green lacewings that eat insects fed GE Bt have higher mortality rates than green lacewings eating insects fed natural Bt; surviving lacewings have more developmental problems than lacewings eating insects fed natural Bt. [4.] The future viability of some of organic farming's most valuable tools may be at risk from GE Bt.

Herbicide-Tolerant Crops

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Herbicide-tolerant GE crops are doubly interesting: seed producers engineering herbicide-tolerant seeds also manufacture the herbicides to which the plants are resistant, and farmers must sometimes agree to use only those herbicides.

While conventional crops have traditionally been sprayed by pre-emergent chemical applications, GE plants require post-emergent applications, leaving plants and food crops with much higher herbicide residues. After herbicide-tolerant soy was approved, the industry persuaded the government to raise herbicide residue standards by over three hundred percent!

About 75 percent of all GE plants worldwide are now resistant to one of two major broad-spectrum herbicides used in GE farming: glyphosphate and glufosinate ammonium. Since the debut of GE herbicide-resistant crops, approximately 50 million additional pounds of glyphosphate have been applied each year in the United States alone. [5.]

Virus-Resistant Crops

Almost all GE crops contain genetic material from viruses. While infectious viruses simply kill their infected cell (and sometimes, eventually, the whole host organism), dormant viruses insert their DNA or RNA into the targeted cell's chromosone and then lie dormant. Dormant viruses, such as the promoter of the Cauliflower Mosaic Virus (CaMV), are used in GE. CaMV is used in GE canola, cotton, maize, and soy.

The CaMV promoter overpowers the targeted cells' self-regulatory mechanisms, allowing the foreign gene to be permanently turned on, producing large amounts of transgene proteins. CaMV's aggressiveness is a plus for GE scientists, as is its ability to transfer to all types of plants. One possible minus: CaMV is a rapidly-multiplying pararetrovirus that multiplies by making DNA from RNA messages! According to genetics Professor Emeritus Dr. Joseph Cummins, this quality makes CaMV very similar to Hepatitis B.

Unfortunately, CaMV has a recombination hotspot that makes it prone to destabilizing and breaking up other DNA chains, joining them at the rupture. It can reactivate dormant viruses and create recombinant viruses in new species. Some scientists believe that it may even create a growth factor. [6.]

CaMV may be harmless, but mutations of normally harmless viruses can occur when a host animal is malnourished. At that point, the virus can become deadly even to well-fed animals [7.]

The widespread use of viruses in GE should raise serious questions from concerned farmers, food handlers, and consumers. Experiences have shown that the artificial insertion of dormant virus genes makes the dormant virus more prone to future combining with genes from infection viruses, thereby creating recombinant viruses with new properties. Recombinant viruses may be more dangerous than those found in nature, and have a greater tendency to cross species lines. The Director of Regulatory Science from one of the world's largest biotech companies admitted that GE "viruses can recombine."

How Bacteria, Viruses and Antibiotic-Resistant Genes are Used as Vectors, Markers, and Promoters

Bacteria

Glyphosphate resistance is engineered into the new seeds' DNA using E. coli as a vector: E. coli contains a mutant form of an enzyme found in plants, called EPSPS. [8.] The EPSPS enzyme promotes amino-acid synthesis essential to plant growth in cell chloroplast. Glyphosphate inhibits the natural, or plant form, of EPSPS, but E. coli's mutant EPSPS is less sensitive to glyphosphate. Scientists basically isolate the mutant E. coli gene and splice it into a Ti plasmid, which transfers resistance to the new plant genome by means of bacterial infection. Ti plasmids would normally result in plant tumor growth, but scientists remove the tumor-inducing genes. [9.]

Contamination during transfer is an inherent risk when using bacterial vectors. In the 1980's, Japan's third-largest chemical company produced GE tryptophan, which became contaminated during the recombinant DNA process. The supplement killed over 30 Americans and afflicted at least 1,500 others with a painful and potentially fatal blood disorder, eosinophilia myalgia syndrome, causing the company to pay out over $2 billion in damages. [10.]

Viruses

The protein coating that encapsulates viruses not only comprises hereditary DNA or RNA material but has special properties that enable it to adhere to targeted cell walls. Once attached, the viral DNA or RNA transfers through the cell wall in question, forcing it to alter its normal function and produce large numbers of virus copies.

GE also involves using capside, or hybrid, virus genes to make plants more resistant to infecting viruses. Capside genes are combined with the CaMV promoter to ensure their activity in the new host cell. Scientists debate whether they also have a propensity to recombine with other viruses, creating new pathogens that are more aggressive than the original virus.

Still a third GE transfer technique involves inserting viral satellite RNAs, genes known to reduce the damage from a viral infection. According to Physicians and Scientists For Responsible Application Of Science And Technology, these genes often mutated into harmful variants when inserted into cucumbers. [11.] On average, RNA polymerases are one thousand to ten thousand times more prone to error than are DNA polymerases, greatly increasing the likelihood of mutation. [12.] GE plants resulting from viral transfer often contain the CaMV virus gene in each of their hundreds of millions – or billions – of cells, any one of which could potentially result in a recombinant-associated viral epidemic. Even though only 3 or 4 are transferred per plant, this translates to about 50,000 billion recombinant virus-prone promoters per average corn field. Because of the birds and the bees – and the wasps and the wind – GE genes are also transferred by pollenation to nearby – and distant – weeds and crops, and possibly from there to animals and humans.

Antibiotic-Resistance

The foreign genes spliced to GE seeds are often linked to other genes called antibiotic resistance marker (ARM) genes. ARM genes help determine if the first gene was successfully spliced. Scientists have warned that ARM genes could recombine with disease-causing bacteria or microbes in the environment or in the guts of animals or people who eat them, particularly if they are carrying other pathogens or taking antibiotics. Experimental evidence from the Netherlands suggests that GE DNA can be taken up by soil bacteria as well as bacteria in the human gut. [13.]

Theory Upon Which GE is Based

GE is based on the 40-year old theory of co-DNA discoverers Francis Crick and James Watson that a single gene controls a single characteristic. This theory presumes that DNA strictly controls the production of RNA, which in turn strictly controls the creation of proteins, which in turn give rise to specific inherent characteristics. This theory was proven wrong by the Human Genome Project: there are about 100,000 different proteins in humans, who have only 30,000 genes.

At least 3 factors present in genetic replication show that GE can be an uncontrollable and inherently unreliable experiment. First, RNA can split into several parts, giving rise to different proteins and several different characteristics. This phenomenon, called alternative splicing, influences genetic behavior. A second factor is repair proteins. These proteins become operative when cell division entails DNA errors, and special proteins are required to repair them. A third factor influencing genetic behavior is the presence of chaparone proteins, additional proteins whose presence influences the folding patterns of regular proteins. Crick assumed not only that a single gene gave rise to a single protein, but that the proteins would be chemically identical and identically folded. The Mad Cow research suggests that some proteins can reproduce without any DNA whatsoever – an impossibility under Crick's theory! All three of these variables suggest that removing single genes from their natural surroundings and transposing them onto an unrelated species could at some point disrupt that species in inherently unpredictable ways. [14.]

This element of uncontrolled unpredictability was acknowledged when GE soybeans were found to contain extra fragments of a transferred gene. The following year, Belgian researchers discovered that the soybeans' own DNA had been scrambled as a result of new gene insertion, and that the resulting abnormal DNA was large enough to produce a new, potentially dangerous, protein. [15.] By definition, GE foods contain unidentified transferred foreign proteins that have not been eaten previously by humans or tested for safety. Proteins are what trigger most allergic reactions to food.

Available at a Store Near You

GE foods are no longer theoretical – they are in a grocery store near you, and probably in your pantry and refrigerator!

The US has been producing GE animal products since 1994, when recombinant Bovine Growth Hormone (rBGH or rBST) was first injected into dairy cows to force them to produce more milk. Today about 4 to 5 percent of America's cows, over one-half million, are injected with rBGH.

The track record for rBGH dairy products does not bode well for GE food crops. In 1998, Canada released previously undisclosed documents suggesting damage to laboratory rats fed rBGH. The rBGH infiltrated the rats' prostates and was implicated in thyroid cysts. Canada banned rBGH the following year. [16.] The European Union has banned rBGH since 1994, and the United Nations food safety body (Codex Alimentarius Commission) currently refuses to certify its safety. [17.] Cows forced to produce more milk also produce higher levels of pus and bacteria, requiring higher antibiotic use, and the milk seems to contain higher antibiotic residues as a result. [18.] It also contains more fat, producing significantly higher levels of Insulin-Like Growth Factor (IGF-1). Humans with elevated IGF-1 levels are more likely to develop cancer. [19.]

America has been raising GE food crops since 1995, and they are in various stages of development. There are about 40 GE plant varieties, not all of which are currently marketed: canola (4), corn (14), sugar beets (2), chicory/raddichio (1), cotton (4), flax (1), potatoes (3), soybeans (3), squash (2), tomatoes (5), and papaya (1).

Up to 100 million acres of America's 943 million arable acres are currently planted with GE crops. About 90 percent of our soy and 50 percent of our corn are GE, about a 5 percent increase over last year. In a few years, GE foods will intersect with most of the more common food allergens. In 10 years, almost all commercially available food in the US could be GE.

Canola, also known as rapeseed, has never been used as a food crop in traditional cultures. Non-GE canola contains a fatty acid called erucic acid, thought to be toxic to cardiac muscle. [20.]. GE canola was introduced in part to lower the levels of this substance. For this and other reasons, caution is advised with respect to all forms of canola. [21.]

Cotton, one of the world's most heavily-pesticided and herbicided crops, is normally not considered as a food crop. However, 80 percent of US cotton seed is fed to dairy cows, and cotton seed oil is heavily utilized in the manufacture of processed foods. If you eat non-organic dairy or packaged foods, the chances are high that you are consuming GE Bt cotton seed oil either directly or indirectly.

As for soy, a 1999 study by Dr. Max Lappe found GE soy to be lower than conventional soy in phytoestrogens. Tests suggest that GE soy has less choline, more trypsin inhibitor, lower phenylalanine levels, and more lectins than non-GE soy. [22.] Dr. Gabriel Cousens suggests a linkage between these facts and considerable increases in soy allergies. [23.] Though I advise against eating any non-fermented soy product for a number of reasons, here is an additional one: about 40 percent of organic soy products are now contaminated with trace amounts of GE soy. By 2005, the degree of contamination could increase substantially. [24.] Even organically-raised animals could be dining on contaminated organic soybeans, one more reason to be sure that your organic meat supply is grass-fed.

Escaping GE foods is almost an impossibility. Two independent labs have reported that in the US, half of all non-GE corn and soybean seed batches and 83 percent of all non-GE canola seed batches contain GE material. [25.] The US Biotechnology Industry Association said it is "not surprised by" the reports. These results may adversely affect the agricultural export industry, which markets to countries that do not allow the importation of GE products. Should contamination levels continue to rise, organic food could become more expensive both to grow and to test for GE contamination, and US organic labels may lose their legitimacy. Unfortunately, consumers can not test food for GE because the equipment necessary to do so is not publically available, and the GE DNA sequences are trade secrets.

GE products are present in about 70 percent of all processed foods and, with the exception of occasional produce, GE foods are not labeled. Labeled organic produce has a PLU number that begins with 9, while labeled GE produce has a PLU number that begins with 8. If you wish to avoid GE produce, just remember: don't get stuck behind the eight-ball – get dressed to the nines! And avoid hybrid plants and foods, seedless fruits, and all processed foods. Abundant sources of consumer-friendly information about GE are readily available to the seeker, as can b e seen in the references below. [26.].

There may be a philosophical reason to keep alert as well. In October 1998 a biotech official told The New York Times that his corporation should not have to "vouchsafe the safety of biotech food" products, adding that "our interest is in selling as much of it as possible. Assuring its safety is the FDA's job."

Federal Regulation of GE Organisms

Comprehensive or up-to-date federal safety or liability regulations specifically governing GE foods or requiring their labeling as such are generally lacking. Even FDA-required labels for GE soy and canola products need not disclose the GE origin of their significantly-altered oils. A paradox has thus emerged: despite the existence of 8 different regulatory agencies and 12 different sets of potentially- applicable 40-to 50-year-old laws, there are no constraints or guidelines for scientific protocols, and no laws requiring or regulating pre-market or post-market testing or labeling.

Requests by scientists seeking guidance, and by American consumer and environmental groups wanting labeling laws, have fallen on deaf ears. The government's position that GE foods pose "no inherent safety risk" is based on its underlying assumption: that GE foods are "substantially equivalent" to their undoctored counterparts. Other countries have adopted an entirely different approach called precautionary principle. Under their doctrine, if there is no certainty of the absence of risk, necessary care should be taken to prevent harm. Perhaps because of the enormous controversy that GE foods have inspired, many nations have requested that GE foods be labeled.

The dynamic between competing GE philosophies plays out at international levels. In 2000, the Conference of the Parties to the Convention on Biological Diversity adopted a supplementary agreement known as the Cartagena Protocol on Biosafety: The Protocol, signed by 89 nations, is concerned about the lack of transparency and safety in GE trade and usage. In February 2004, representatives from 87 nations met in Malaysia to discuss its enforcement. Europe has the world's toughest standards for GE approval processes and labeling; its regulations are to take effect in April 2004, a step the US is fighting before the World Trade Organization (WTO). In response, Europe has petitioned a United Nations-backed organization to draft labeling recommendations for GE food ingredients.

Experience suggests that GE labeling is a worthy idea. In 2002 the University of Illinois conducted an animal experiment by injecting sows with cow genes to increase their milk production. A synthetic gene was added to the mix to help the piglets digest the altered milk, enabling them to grow fatter in a shorter time. But instead of destroying the altered animals as required, the university sold the 386 piglets to livestock brokers, and the transgenic IGF-altered animals were eaten by unsuspecting consumers.

More GE animal experiments are underway: GE fast-growing salmon, GE hens that lay low-cholesterol eggs, GE cows with disease-resistant strains, GE chickens that produce anti-cancer drugs, etc. Rather than evaluating the altered animals under consumer-friendly food-additive laws, the FDA reviews them under rules governing the administration of drugs to animals. This allows the FDA to make its decisions in private without public input or hearings, and for all government input to be governed by trade-secrecy laws. Information kept from consumers includes the types of animals in question, how they will be altered, possible consequences to human health and safety, and even the company names. Because GE may involve trans-species gene transfers, allergic consumers may be unable to protect themselves. Unlike the EPA, the FDA lacks authority to deny a GE animal application based upon an environmental assessment, and has no written safety regulations applicable to researchers.

As for EPA jurisdiction over GE plants, the prospects do not appear much brighter. In November 2003, the agency approved the first stacked GE Bt corn-hybrids. This corn is grown from two inbred lines, and no data exist as to how the two might function together in either the corn or other, cross-pollenated, plants. The agency previously approved another GE variation of Bt corn for rootworm control. This product expresses the GE Bt toxin at fairly high levels in both the pollen and grain, doing little to fight root borers, but potentially exposing consumers and/or animals to fairly high levels of GE Bt toxin through both ingestion and pollen inhalation. Some scientists fear that this GE Bt corn could prove more dangerous than GE StarLink corn. That product was recalled from the market because its foreign protein took longer than normal to digest, allegedly causing damage to the digestive organs of those who ate it. [27.]

The federal lifeline of GE farming is comprised of taxpayer-funded research and huge farming subsidies. The continuation of these programs appears highly probable. Some uncertainty is created by global resistance to GE foods, GE failures overseas, and questions about GE's long-term economic viability. In addition to corporate lobbying and campaign contributions, a third, little-known, explanation exists for the government's role in the GE rush to market: USDA employees – the same people who approve and regulate GE crops – gain financially from the sale of GE-patented seed that the USDA helps to develop by receiving royalties of up to $150,000 per year! [28.]

GE Marketing Claims and Testing History

GE companies, public relations experts, and industry-friendly scientists have claimed that GE foods will improve public health, cure disease, reduce herbicide and pesticide use, make agriculture sustainable by reducing crop susceptibility to diseases and pests, and help eliminate world hunger.

In the wake of new studies showing the superior benefits of sustainable agriculture (see last section below), seed companies and their supporters have put forth two additional marketing approaches: first, that GE foods are the solution to global "hidden hunger", and second, that plant breeding is a "dangerous technology". The Hudson Institute's Center for Global Food Issues (CGFI) recently stated that, "current organic practices and policies are counter to the safe and proven technologies such as biotechnology and no-till farming (a method used with GE herbicide-tolerant crops)..." CGFI accused some in the organic farming movement of "misleading marketing which plays to consumer fears." [29.] Ironically, the US government and large biotech firms are heavily promoting GE crops as American consumer spending on organic foods, the fastest-growing and only consumer-driven food sector, is increasing by about 21 percent per year! In Europe the increase is even greater, with consumer demand for organic products doubling within the past 5 years.

Of all the USDA money awarded for biotech research, only 2 percent is allocated for risk assessment. Many farmers, consumer groups, and scientists agencies question whether GE food is safer or more effective than its natural counterpart. [30.] GE foods do not taste better, have greater nutritional value, or substantially reduce pesticide use, and they invariably require substantially more herbicides.

The track record for GE safety testing is not reassuring. In November 2003, a Japanese study determined that a safety assessment application submitted to the Japanese Health Ministry in support of GE soybeans was “inadequate and incomplete”. The Japanese scientists found that data were misrepresented, animal feeding experiences were insufficient, “inappropriate” data was intentionally neglected, and testing proteins not derived from the GE plant were included.

For example, the GE herbicide-tolerant plants (and their parents) were not sprayed with the herbicide in question during cultivation, contrary to the manufacturer’s instructions to seed buyers and growers. Aided by two generations of non-sprayed plants, the firm did herbicide testing for residual herbicide only– not for the herbicide-tolerant transgene’s effects on plant metabolic pathways. The protein analyzed was from E. coli, not from GE (herbicide-tolerant) soybeans, and only 15 E. coli amino acids were sequenced – 3.3 percent of the total 455 expected. Apparently the real sequence of GE soy protein is still unknown! No tests showed whether inserted genes behaved identically in soy as in E. coli. The submitting company also made the assumption that GE soy proteins were identical to non-GE soy proteins. [31.]

When the submitter did not get the results it wanted by heating the GE soy to 108 degrees Celsius for 30 minutes, it heated the soy three more times, denaturing and inactivating all the proteins until the desired result was achieved, “showing” that the GE and non-GE proteins were the same. Had the GE proteins been identical to the non-GE proteins, heat presumably would have affected them all in an identical manner and reheating would not have been necessary.

Animal feeding experiments consisted of 10 rats fed GE soy for 28 days: neither chronic nor cross-generational toxicity was measured. Even so, rats fed the GE soy weighed less. [32.]

In English farm-scale trials, non-GE crops were repeatedly sprayed with atrazine, a soil-sterilizing chemical that will be banned in Europe next year: GE crops were sprayed only once, with another herbicide.

Scientific, Corporate, and Religious Objections to GE Foods

Many scientists have protested the transition to GE foods until adequate safety provisions are installed. Dr. Michael Antoniou, a British molecular scientist, warned that gene-splicing has already resulted in the “unexpected production of toxic substances ... in genetically engineered bacteria, yeasts, plants, and animals with the problem remaining undetected until a major health hazard has arisen.” Other scientists warn that horizontal gene transfer and recombination is a chief cause of virus and bacteria creation that can lead to disease epidemics. Since GE’s predominant tools include bacteria, antibiotic-resistant genes, and viruses, many believe that GE is an inherently risky science. [33.]

Scientific groups weighing in on GE include: Union of Concerned Scientists [34.]; National Research Council of the National Academy of Science [35.]; Council for Responsible Genetics; British Medical Association; The Ecologist [36.]; and Institute of Science in Society. [37.] Independent scientists such as Dr. Arpad Pusztai have also called for caution.

Others voicing opinions about GE include: consumer organizations such as Consumers Union and Organic Consumers Association; trade associations such as Pacific Coast Federation of Fishermens Associations, International Salmon Farmers Association, Canadian Aquaculture Industry Alliance, Grocery Manufacturers Association, and National Food Processors Association.; physicians such as Dr. Joseph Mercola [38.]; governmental entities such as the European Union and Supreme Court of India; and religious leaders from around the globe. At the extreme outer fringes are zealous activists who set fire to GE fields (India), or pull GE crops up by the roots (New Zealand and Europe).

Scientific Objections

Scientific worries about GE include the following: 1.) transplanted antibiotic-resistant genes could raise human antibiotic-resistance levels; 2.) anti-microbial proteins in antibiotic-resistant genes could cause digestive disorders and/or alter intestinal flora; 3.) gene-splicing using viral vectors could cause new transgenic viruses to be released; 4.) consumers could have allergic reactions to GE’s foreign proteins; 5.) GE farming could result in wide-scale genetic pollution of existing crops, including organic crops; 6.) GE’s highly-increased herbicide use could result in human and environmental harm such as: health risks from increased herbicide residue; death of beneficial plants, insects, and soil organisms; growth of super-weeds; and increased ground-water contamination; 7.) GE and GE-affected crops could fail due to unknown and unpredictable consequences – for example, contrary to original intent, male terminator genes seem to spread both male sterility suicide genes and herbicide-tolerant genes; 8.) consumers and farm workers may face new health risks from GE and bio-pharmaceutical crops; 9.) animals and beneficial insects that eat GE farm crops with plastics or bio-pharmaceutical drugs may be injured; 10.) animals that eat GE fish bred to contain metal-sequestering proteins may be damaged; 11.) traditional, varied seed supplies may disappear if farmers are forced to purchase non-replicating GE seeds; 12.) using toxic vectors to switch on normally inactive genetic pathways in targeted plants may motivate them to release previously-dormant toxic substances or to produce new toxins; 13.) using GE to remove intrinsic plant material, such as caffeine, may eliminate built-in mechanisms that protect plants from fungal and other toxins; 14.) using GE genes to remove heavy metals like mercury from the soil may concentrate them in plant tissues, potentially harming farmers, food handlers, and consumers.

Religious Objections

Religious leaders and faith-based organizations have raised ethical and sociological objections about GE foods and farming methods: 1.) in the long run, GE farming could result in the unhealthy dependency of small-scale, mostly poor, farmers upon large multinational corporations, particularly in third-world countries; 2.) small-scale GE farmers would make even less profit if they risked patent infringement actions and/or other sanctions (including the loss of property), could no longer save their seeds or had to buy more seeds, pesticides, herbicides, and other agricultural necessities; 3.) no regulatory liability framework exists to compensate farmers or others damaged by GE seeds, crops, and foods; 4.) conventional, time-honored agricultural methods could become severely limited as GE monoculture replaces sustainable farming practices; 5.) targeted and cross-pollenated plant genomes could be disturbed in unpredictable ways and suffer genetic erosion; 6.) GE technological advancement and corporate financial incentives could take precedence over human health and environmental concerns; 7.) GE practices seek to patent life-forms for profit, an inherently unbiblical principle; 8.) plants and animals should not be treated as mere pharmaceutical factories or manufactured products; 9.) food and water are not merely marketable commodities but global common goods essential to life and culturally sacred to all people, and should be safeguarded in a way that best promotes human dignity; 10.) the world has a food surplus: people are hungry because they do not have the money to buy the food they need; 11.) GE promotion only distracts from addressing underlying economic, social, and political inequities that result in unfair food distribution, the true cause of global hunger; 12.) money, where it exists, should be given to promote traditional, ecologically-proven, and environmentally-safe farming methods that do not endanger human, animal, or plant health. [39.]

GE Track Record in Terms of Animal and Human Safety

Even long-term animal studies may not reveal all the consequences of GE. In 1996, Nebraska researchers testing against human blood serum discovered that a Brazil-nut gene spliced into GE soybeans could be potentially fatal to persons with nut allergies. The animal studies had shown no such danger. Persons with fish allergies eating flounder genes with their GE strawberries or tomatoes could have similar reactions.

In other GE animal studies, the animals have reacted. In England, rats fed GE Bt potatoes spliced with DNA from the snowdrop plant and CaMV had an increased thickening in the lining of their stomachs and intestines, and a weakening of their immune systems. Egyptian rat studies using GE peas showed similar results. [40.] The snowdrop gene produces a lectin, an agglutinin protein that is used to reduce susceptibility to insects. [41.]

In fact, research has shown most assumptions about CaMV to be contradicted by experience. First, about half the relevant studies suggest that CaMV can cause DNA chemical instability and breakage, enabling it to transfer to animals that eat it rather than being plant specific, an indirect way of saying that you are – or become – what you eat. Second, CaMV can turn on genes over long distances on the DNA strand, and even switch on genes in different chromosones, creating a potential for introducing even more foreign proteins. Third, CaMV can remain intact in the body tissue of animals that eat it for days after ingestion. [42.] These three issues raise the question of whether CaMV can activate dormant viruses.

GE antibiotic-resistant vectors are particularly worrisome. First, while trans-species transfer seemed unlikely in theory, studies suggest that it does in fact occur. Second, Bt toxins seem to survive digestion, passing through the gut wall and binding to tissues in the alimentary tract, triggering immunological reactions, and from there migrating into the bloodstream, triggering liver responses. [43.]

GE viral promoters may travel farther than expected. In 2002, soy and non-GE corn became contaminated by GE corn that produced an experimental pig vaccine. [44.] The pig-corona virus, upon which the vaccine was based, is related to SARS.

GE food may adversely affect the animals that eat it. In a British experiment, chickens fed GE maize had erratic weight gains, and twice as many GE-fed chickens died as chickens fed ordinary grain. [45.] In Hesse, Germany, twelve cows died after eating GE maize for 4 years. [46.] The GE Bt protein, found intact in cow stomachs, intestines, and excrement in other studies, is apparently more slowly degraded than previously thought. A GE maize that is both herbicide- and pesticide-tolerant – and intended for human consumption – forms the same protein.

Cattle straying into GE fields seem to shun GE maize, though it was originally developed for cattle feed. Anecdotal evidence suggests that hogs, deer, and cattle will not eat GE maize when given a choice, and that pigs that feed on Bt maize experience a substantial reduction in their reproductive capacity [47.] Whether GE food adversely affects humans is still open to investigation. Thirty-nine villagers on the Philippine island of Mindanao living next to a GE Bt maize plantation suffered fevers and respiratory, intestinal, and skin ailments. Four horses that ate the GE Bt corn died. Four families who left the area recovered, but exhibited the same symptoms when they returned. Blood samples taken from the villagers showed increased levels of 3 different target antibodies of the GE maize, suggesting an immunological reaction to the GE Bt toxin. Contrary to GE theory, a GE virus promoter appears to have been found in the villagers' cells. The findings, by the Director of the Norwegian Institute of Gene Ecology, Dr. Terje Traavik, have been disputed by the GE seed company and the Philippine government. [48.] Tests are ongoing.

GE Environmental Track Record and Concerns

The risk that GE horizontal gene transfers could lead to bacteria mutations seems confirmed by a German study, which found that an alien gene used in GE canola had transferred to bacteria living inside the guts of honey bees. Europe recently lost about 90 billion honey bees, with one-third of all registered hives disappearing in France alone. While this tragedy may not be GE-related, it is a reminder of the fragility and interdependency of our eco-system. Dr. Mae-Wan Ho, a British geneticist, warns that horizontal gene transfers of GE antibiotic-resistant material could leave us unable to treat serious illnesses.

Unlike other forms of pollution, genetic contamination is irreversible; moreover, it is exascerbated by pollenation. GE Bt corn has been found in remote areas of Mexico, birthplace of native corn; Mexico lacks the money to establish a genetic seed bank to protect its 59 species of heirloom maize. In Canada, 32 of 33 non-GE certified seed stock were found to be GE-contaminated, threatening to undermine Canada's organic industry. [49.] In one case, GE DNA was found to persist in the soil over one year after initial exposure.

But GE contamination can occur without pollenation. In Nebraska in 2002, about 500,000 bushels of soy were contaminated with GE bio-pharmaceutical corn planted the previous year: the two co-mingled during storage. [50.] Small amounts of Starlink corn were found in almost ten percent of 110,000 grain tests performed by federal inspectors a year after it was taken off the market; four years later, traces of the corn can still be detected. [51.] Continual decontamination of farm equipment and of transportation, sorting, storage, milling, and production facilities to prevent GE's further spread is financially prohibitive.

GE crops may damage the soil. [52.] Oregon scientists found that a GE soil micro-organism, Klebsiella planticola, completely killed essential soil nutrients. The EPA warned about GE-induced soil damage in 1997, when it protested the government's approval of a GE soil bacterium called Rhizobium melitoli.

Lab and field tests suggest that common pests, like cotton bollworms, could soon evolve into super-pests that are immune to environmentally-sustainable sprays like natural, non-GE, Bt. An Indian study suggests that insect resistance offered to GE cotton by Bt is effective for 6 years at best. Within 6 generations, the bollworm develops a 31-fold resistance to the GE toxin.[53.] In China the suspected resistance was slightly longer: 7 to 10 years. GE Bt cotton has 70 insect adversaries, compared to 7 that threatened non-GE cotton crops 3 decades ago.

Herbicide-resistant weeds, such as wild mustard plants, are already beginning to emerge. In Canada, GE gene-stacking from various cross-pollenated GE crops has given rise to volunteer plants that are triple herbicide-resistant. In South Africa, glyphosphate-resistant ryegrass has grown in vineyards. Other herbicide-tolerant plants now difficult to control include: ryegrass in New South Wales (Australia), a grass weed in Malaysia, a broad-leaf weed in Delaware, ryegrass in California, weeds in US GE cotton and soy fields, and horseweed in the US eastern corn belt areas. At the same time, about 74 plant species worldwide may be threatened with extinction due to glyphosphate exposure. [54.]

GE farmers already use considerably more herbicide than non-GE farmers – up to 20 million additional pounds per year on American soy crops alone, with accompanying damage to soil bacteria, farm animals, and humans. For the first 2 or 3 years, a farmer's herbicide use may decrease, but in subsequent years the need for more herbicide increases substantially. Atrazine as well as glufosinate now must be used on GE maize. [55.] Since GE seed companies also manufacture herbicides, there is little incentive to reverse this pattern. The small reduction of insecticide use with GE crops – about 2 to 2.5 million pounds per year – is inconsequential compared to these herbicide increases.

Chemicals aside, some studies raise questions about the hardiness of GE seeds and crops. In February 2001, a University of Missouri press release concluded that GE soybean seed germination rates were "down sharply" from their prior levels, a possible indication of a lack of hardiness and/or susceptibility to disease. The Northwest Science and

Environmental Policy Center questioned whether GE soybeans are more susceptible to plant diseases such as sudden-stress syndrome because of damage to an important plant-chemical pathway.

GE soybeans' per-acre yield is about 10 percent lower than traditional soy varieties. [56.] The industry's efforts to produce a higher-protein potato and vitamin A-enriched rice have fared poorly. Trials to develop a GE virus-resistant sweet potato in Kenya have utterly failed: GE sweet potato yields there did not nearly equal those of traditional sweet potatoes in Uganda, nor did they show enhanced viral resistance. According to GE-Free New Zealand, a virus-resistant sweet potato has been created by non-GE means.

Economic and Sociological Implications of GE

GE producers probably would lose clout if there were no American farm subsidies – federal money offered for ranching, dairy farming, or to grow "major program crops" such as corn, wheat, soy, cotton, rice, sorghum, and canola. Large corporate farmers now reap the vast majority of this annual assistance – over 70 percent of the annual $26 billion awarded. Large-scale monoculture also dominates US government-funded agricultural research, leaving only 496 of America's 886,000 research acres for organic farming. Mechanized agriculture's additional financial incentives, such as cheap water and migrant labor, make it possible for these crops to be produced at about half their actual cost, giving their producers an enormous economic advantage on a global scale – particularly in third world countries without subsidies.

In some cases, small non-GE American farmers are also at a competitive disadvantage. About half of all American farmland is held by banks, insurance companies, commodities brokers, or chemical corporations, partly because farmers unable to pay their pesticide, herbicide, fertilizer, equipment, and mortgage bills have lost their land. Many of those who are left are no longer financially independent, and must supplement their income with off-farm employment. Their independence is challenged in other ways as well: dairy farmers have been sued for labeling their products as rBST-free, and grain farmers who saved and replanted GE seeds have had to pay royalties and defend against piracy claims.

A nearby example which perhaps best personifies the GE farming disparity is found in Percy Schmeiser, a Canadian canola farmer. Schmeiser, whose non-GE crops were contaminated by seed from a GE farming neighbor, was sued for patent infringement when private detectives wandered onto Schmeiser's property to find traces of GE crops that had inadvertently pollenated and taken root there. Though Schmeiser did not exploit the GE seed producer in any way and did not benefit from the contamination, he has been ordered to pay damages to the seed producer – in effect rewarding the polluter. The Goliath versus David litigation against Schmeiser lasted about 7 years, with the Supreme Court of Canada affirming the decision against Schmeiser. [57.]

Examples of GE's lop-sided economic reach exist elsewhere as well. The European Patent Office recently awarded a biotech company an exclusive patent for a strain of Indian nap hal wheat used for centuries to make chapatis. The Indian government may lack the resurces to fight the patent, which claims not only the wheat, but the flour, dough, and all edible products resulting therefrom. Similarly, a Dutch biotech firm has sought and claimed joint intellectual property rights in Ethiopian teff and its by-products. Some fear the enforcement of such claims under WTO rules because: 1.) farmers whose fields are contaminated with GE products could be held criminally liable, owing fines and royalties; 2.) defending against a claim before the WTO is very expensive; and 3.) WTO proceedings are conducted in secret, without public or consumer input.

GE has affected India in other ways. Indian farmers growing GE Bt cotton had lower yields, increased pesticide use, and lower crop quality. As a result, many small-scale GE farmers committed suicide after facing financial ruin; others sold their kidneys to support their families. [58.] As for industry claims that GE would help India's hungry, many doubt that vitamin A-enriched Golden Rice would help: India currently has a food surplus of 65 million metric tonnes per year. Its malnourished population lacks 2 square meals per day, and malnourished people may be unable to absorb vitamin A in the form GE scientists propose. Given the proper food intake, the vitamin A deficiency would probably disappear on its own.

Argentina, once an agriculturally-diverse and sustainable breadbasket, has nearly become a GE soybean monoculture. [59.] Many farmers affected by falling prices and herbicide contamination have been forced off their land and into the cities, leaving rural villages abandoned or nearly empty. Land ownership is now more concentrated than at any time in Argentina's history. A US agricultural economist predicted that within a few years, Argentina's agricultural sector will not be sustainable. [60.] Brazil recently opted to open areas near the Amazon to GE farming; it remains to be seen whether Argentina's experiences will be repeated there.

GE food exports are often promoted under the banner of free trade. But when foreign agricultural tariffs are compliantly removed, import surges of cheaper, subsidized GE crops may displace thousands of poor, unsubsidized native farmers. For this reason, third-world traditional farmers are often uneasy about competing with GE crops. Most of the world's poorest people are peasant farmers.

The US government has actively promoted GE crops for export. In some cases, US, World Bank, or IMF aid is dependent on GE crop importation by the receiving country. Zambia has refused GE maize despite severe drought and even though US aid was contingent upon its acceptance. Relying on the Cartagena Protocol, Sudan has requested that imported food aid be certified as GE-free; the US refused and cut off all shipments despite near famine and a decades-old civil war. Malawi, Mozambique, Lesotho, and Zimbabwe, also fearing GE crop pollenation, wish to accept only GE flour products.

But GE promoters face challenges, too. England’s largest insurers recently declared that they will not insure the GE crop industry. GE maize was recently temporarily approved for one year by the UK, but under conditions that may make it uneconomic. Scotland and Wales, along with several areas in England, oppose the crop. An English advisory panel has recommended against commercialization of GE canola and sugar beets. Much of Europe is still balking at GE importation and cultivation. Many on Prince Edward Island wish to remain GE-free, and Canada has joined Algeria, Western Australia, Egypt, parts of the European Union, Indonesia, Japan, South Korea, Malaysia, the Philippines, Sri Lanka, and Thailand in rejecting one or more GE crops. Consumers in Japan are urging the abandonment of GE rice, many Indian farmers are unhappy about GE cotton, and some farmers are questioning whether GE crops – even on adjacent property – could lower their property values. One company stopped selling GE soy seeds in Argentina after farmers either could not or would not pay for them.

Some US farmers are becoming hesitant as well. For over a year, a GE seed seller promised American and Canadian wheat growers that it would not introduce GE wheat into either country unless both agreed: farmers in both nations felt that a one-nation GE presence would automatically give the other a competitive advantage in consumer markets strongly opposed to GE foods. Now facing stiff Canadian opposition, the company is pressuring reluctant US farmers to change their minds, suggesting that their refusal may cause it to abandon research into other wheat technologies. [61.]

There is still strong hope for the industry. China – a huge market – issued permanent safety certificates for 1 soy, 2 GE corn, and 2 GE cotton crops, giving GE promoters an enormous boost. Mexico became the first GE grain-importing country to agree to loose-labeling standards: conventional corn may contain up to 5 percent GE organisms, and accidentally-contaminated corn would not have to be labeled. Australia has approved GE canola, though state bans currently prevent its planting.

Why Not Sustainable Agriculture?

By its very nature, GE agriculture permits farmers to indulge in unsustainable agriculture. To date, not one GE seed producer has developed improved varieties of third-world staples such as rice, cassava, or yams. Just conceivably, well-meaning scientists brewing up pharma crops in hermetically-sealed laboratories may know less than God [62.] about designing food and less than farmers about growing it. Even hybrid seeds almost by definition entail the expenditure of costly and dangerous pesticides and fertilizers, luxuries ill-afforded by most of the world's poor farmers.

And why should farmers spend extra money on GE? New tillage methods, multi-year crop rotations, cover crops, and bio-intensive weed management, combined with other techniques, are assisting organic growers in producing competitive, good-tasting foods. Reliable data from 89 projects world-wide show that sustainable agriculture has higher production rates and yields than chemical farming. Notable success stories stem from such diverse places as Burkina Faso, Ethiopia, Guatemala, Honduras, Indonesia, Sri Lanka, Vietnam, and other areas. In the Philippines, a decline in pesticide use was accompanied by an increase in rice productivity of almost 50 percent, coupled with substantial savings to individual farmers. The International Rice Research Institute recently concluded that pesticides are unnecessary! In a California experiment, tomato crop losses to insects did not increase despite the withdrawal of chemical pesticides. And in east Africa, pests were kept under control by the deployment of trap crops.

These sustainable farmers are reducing soil erosion and improving soil composition, structure, and moisture retention, as well as creating higher soil nitrogen levels and greater soil biological activity. [63.] Their farming methods entail less nitrate and phosphorous leaching to groundwater tables and less water pollution from surface runoff, as well as lower emissions of nitrous dioxide, a greenhouse gas implicated in ozone depletion. Finally, organic farmers create greater agricultural biodiversity without the expensive chemical and mechanical infrastructure required by large-scale monoculture chemical farming.

By definition, sustainable farmers are more independent, relying on their own seeds, skills, and choices, rather than those of outside, more powerful entities. In addition to their added freedom, they can make more money and live more healthfully on what they produce.

Conclusion

There is little certainty about either the risks or benefits of GE crops – qualified and well-intentioned people have argued both sides of the issue. One thing is sure: GE is forcefully promoted and its technology is being implemented rapidly on a global scale. Because of constant developments in both science and politics, some aspects of this article may be obsolete by its publishing date, But no matter how this story unfolds, GE is a volatile issue – a real food fight – that is here to stay.

Footnotes

1. See www.ucsusa.org for a wealth of GE science presented in readable form.
2. See www.i-sis.org.uk for further details.
3. The Independent–U.K., 3-30-03.
4. See http://www.anbp.org/impact.htm; London Times 22 Oct. 1997, cited at http://home.intekom.com/tm_info/rw80129.htm.
5. For further information about both glyphosphate and glufosinate ammonium, see www.purefoodpartners.org/HHofGMFs.pdf.
6. See www.purefoodpartners.org/HHofGMFs.pdf.
7. San Francisco Chronicle 17 April 1996, sec. A:12.
8. The chemical name for EPSPS is 5-enolpyruvylshikamate-3-phosphate synthetase.
9. See http://www.ento.vt.edu/hypernews/get/forums.
10. See http://naturalhealthline.com/newsletter/HL980901.htm.
11. See http://www.psrast.org/virhaz.htm.
12. See http://virology-online.com/questions/92-4.htm.
13. See New Scientist, 30 Jan. 1999) European Union authorities are considering a ban on all GE foods with ARM genes.
14. Montague, "Genetic Engineering Based on Faulty, 40 Year-Old Theory", Our Toxic Times, Mar. 2002: 3-5.
15. See http://www.mindfully.org/GE/GE4/DNA-Myth-CommonerFeb02.htm.
16. See http://www.globalchefs.com/column/archive/col005can.htm.
17. See http://www.organicconsumers.org.
18. See http://www.consumersunion.org/food/bghny899.htm.
19. See http://vvv.com/healthnews/milk.html.
20. Stedman's Medical Dictionary, 2000 ed.
21.See The Great Con_Ola, by Mary G. Enig, Ph.D., at www.mercola.com/2002/aug/14/con_ola1.htm.
22. For a thorough discussion of the dangers of lectins, see pp. 83-84 of The Nutrition Solution: A Guide to Your Metabolic Type, by Harold J. Kristal, D.D.S. & James M. Haig, N.C., NorthAtlanticBooks, 2002. 23.See http://www.rawchef.org/resources/art_go_organic;http://www.hain.org/healthalert2001/ha04282001.
24. See http://www.tripod.com/131002e.htm.
25. See http://www.organicconsumers.org/ge/gaia031104.cfm.
26. A list of safe, non-GE foods can be found at www.safe-food.org. Also, see references at www.greenpeace.org; click on site-map, genetic engineering, and links. For scientific articles and updates about GE rice and GE wheat, see www.amberwaves.org or click on bookstore at www.gene-watch.org, a website for the Council for Responsible Genetics. For a series of articles by top scientists, see www.biotech-info.net.

For further details, read Gone To Seed: Transgenic Contaminants in the Traditional Seed Supply, by Dr. Margaret Mellon, Director of Food and Environmental Programs, Union for Concerned Scientists, available at www.ucsusa.org.
27. See http://www.vegparadise.com/otherbirds33.html.
28. See http://www.gene.ch/genet/2004/Feb/msg00049html.
29. Cited in http://www.organicconsumers.org.
30. See http://www.globalissues.org/EnvIssues/GEFood.asp.
31. See www.gene.ch/genet/2003/Nov/msg00066.html; www.organicconsumers.org.
32. For further details about GE-testing methods and procedures, see www.organicconsumers.org and www.purefoodpartners.org/HHofGMFs.pdf.
33. See Genetic Engineering Super-Viruses, by Dr. Mae-Wan Ho, at www.mindfully.org/GE/GE2/Super-Viruses-Ho.htm; see also, The Biowarfare Threat of Emerging Genetic Technologies, at http://www.geinfo.org.nz/112003/06.html.
34. For further details see www.ucsusa.org.
35. A 280-page report can be downloaded at www.nap.edu.
36. See http://www.theecologist.org/article.html?article=4.
37. Independent Science Panel on GM Final Report, at http://www.i-sis.org.uk.ispr-summary.php.
38. Look up Dr. Mercola's position at www.mercola.com.
39. For a detailed list of these and other objections, see http://www.mindfully.org/GE/GE3/catholic-bishops-statement14nov01.htm.
40. The study is discussed in www.mindfully.org/GE/2004/Cauliflower-Mosaic-Virus-CaMV24feb04htm.
41. See http://home.intekom.com/tm_info/rw01026.htm.
42.See
www.mindfully.org/GE/CaMV-Promoter-RecombHotspot.htm;www.organicconsumers.org.
43. Referenced at www.organicconsumers.org.
44. Discussed in vol. 21 Nature Biotechnology 3 (2003).
45. Cited at www.organicconsumers.org.
46. Discussed in www.biotechimc.org/or/topic/animals/archive.shtml.
47. Acres USA Special Report, Sept. 18, 1999, available at www.mindfully.org/GE/Sprinkel-Corn-Hits-Fan.htm.
48. See www.guardian.co.uk/gmdebate/story/0,2763,1160789,00.html.
49. www.foodfirst.org/progs/global/ge/isp/summary.html.
50. The Three-Mile Island of Biotech?, Nichols, The Nation, 30 Dec. 02. 51. Referenced at www.organicconsumers.org. 52.See discussion at http://www.mindfully.org/GE/Soil-Fertility-Threat-PSRAST.htm.
53. See www.mindfully.org/GE/2004/India-Bt-Cotton14feb04.htm.
54. Discussed at http://www.creativehealth.netfirms.com/50harm2.shtml.
55. See http://www.foodfirst.org/progs/global/ge/isp/summary.htm.
56. "Against The Grain," Rachel's Environment & Health Weekly #637, 11 Feb. 1999.

57. See www.mindfully.org for further information about the case. 58. Discussed further at www.organicconsumers.org. 59. See http://www.greens.org/s-r/33/33-07.html.
60. See discussion at www.organicconsumers.org.
61. See http://www.forbes.com/mkts/newswire/2004/03/16/rtr1301018.html.
62. Speaking of the Real seed Designer, the Hebrew biblical admonition against planting two different kinds of crops in one field may be translated literally as, “do not sow two things of diverse kinds, or heterogeneous, or separated, things in your field.” (Lev. 19:19) The root of the word translated as diverse literally means prison, referring to something that would normally be locked in and retained, or forbidden and held back. In no setting could this prohibition be more apropos than for genetically-engineered crops.
63. Independent Science Panel On GM Final Report, 5 June 2003, available at www.i-sis.org.uk/ispr-summary.php and www.mercola.com. On Friday, December 3, 2004, at 02:10 PM, Elite Alternatives, Inc. wrote: