Biotech Basics by Rachel Massey

GeneticEngineering.net

Part 1

Genetic engineering is the process by which genes are altered and transferred artificially from one organism to another. Genes, which are made of DNA, contain the instructions according to which cells produce proteins; proteins in turn form the basis for most of a cell's functions. Genetic engineering makes it possible to mix genetic material between organisms that could never breed with each other. It allows people to take genes from one species, such as a flounder, and insert them into another species, such as a tomato -- thus, for example, creating a tomato that has some of the characteristics of a fish.

Starting in the 1980s and accelerating rapidly in the past decade, companies have begun using genetic engineering to insert foreign genes into many crops, including important foods such as corn and soybeans.[1] Just in the past few years, genetically engineered ingredients have begun appearing in many foods in U.S. supermarkets; they have been detected in processed foods such as infant formulas, drink mixes, and taco shells, to name a few examples.[2] These foods are not labeled, so consumers have no way to know when they are eating genetically engineered food.

Genetic engineering is an extremely powerful technology whose mechanisms are not fully understood even by those who do the basic scientific work. In this series, we will review the main problems that have been identified with genetically engineered crops.[3]

Most genetically engineered crops planted worldwide are designed either to survive exposure to certain herbicides or to kill certain insects. Herbicide tolerant crops accounted for 71% of the acreage planted with genetically engineered crops in 1998 and 1999, and crops designed to kill insects (or designed both to kill insects AND to withstand herbicides) accounted for most of the remaining acreage. A small proportion (under 1%) of genetically engineered crops planted in 1998 and 1999 were designed to resist infection by certain viruses.[4]

Genetically engineered herbicide-tolerant crops are able to survive applications of herbicides that would ordinarily kill them. The U.S. food supply currently includes products made from genetically engineered herbicide-tolerant crops including "Roundup Ready" canola, corn, and soybeans which are engineered to withstand applications of Monsanto's Roundup (active ingredient, glyphosate), as well as crops engineered to survive exposure to other herbicides.[1]

Genetically engineered pest-resistant (or pesticidal) crops are toxic to insects that eat them. For example, corn can be engineered to kill the European corn borer, an insect in the order lepidoptera (the category that includes butterflies and moths). This is accomplished by adding genetic material derived from a soil bacterium, BACILLUS THURINGIENSIS (Bt), to the genetic code of the corn. BACILLUS THURINGIENSIS naturally produces a protein toxic to some insects, and organic farmers sometimes spray Bt on their crops as a natural pesticide. In genetically engineered "Bt corn," every cell of the corn plant produces the toxin ordinarily found only in the bacterium.

Unfortunately, genetically engineered crops can have adverse effects on human health and on ecosystems. And by failing to test or regulate genetically engineered crops adequately, the U.S. government has allowed corporations to introduce unfamiliar substances into our food supply without any systematic safety checks.

Here are some of the reasons why we might not want to eat genetically engineered crops:

** Ordinary, familiar foods can become allergenic through the addition of foreign genes.

Genetic engineering can introduce a known or unknown allergen into a food that previously did not contain it. For example, a soybean engineered to contain genes from a brazil nut was found to produce allergic reactions in blood serum of individuals with nut allergies. (See REHN #638.) Allergic reactions to nuts can be serious and even fatal. Researchers were able to identify the danger in this particular case because nut allergies are common and it was possible to conduct proper tests on blood serum from allergic individuals. In other cases, testing for allergenic potential can be much more difficult. When genetic engineering causes a familiar food to start producing a substance previously not present in the human food supply, it is impossible to know who may have an allergic reaction.

** Genetic engineering has the potential to make ordinary, familiar foods become toxic.

In some cases, new characteristics introduced intentionally may create toxicity. The Bt toxin as it appears in the bacteria that produce it naturally is considered relatively safe for humans. In these bacteria, the toxin exists in a "protoxin" form, which becomes dangerous to insects only after it has been shortened, or "activated," in the insect's digestive system. In contrast, some genetically engineered Bt crops produce the toxin in its activated form, which previously only appeared inside the digestive systems of certain insects.[5] Humans have little experience with exposure to this form of the toxin. Furthermore, in the past humans have had no opportunity or reason to ingest any form of the Bt toxin in large quantities. When the Bt toxin is incorporated into our common foods, we are exposed each time we eat those foods.[6, pgs. 64-65.] And of course, a pesticide engineered into every cell of a food source cannot simply be washed off before a meal.

Toxicity can also result from characteristics introduced unintentionally. For example, a plant that ordinarily produces high amounts of a toxin in its leaves and low amounts in its fruit could unexpectedly begin to concentrate the toxin in its fruit after addition of a new gene. (See REHN #696.)

Unpleasant surprises of this sort can result from our ignorance about exactly how a foreign gene has been incorporated into the engineered cell. Foreign genes can be added to cells by various methods; among other options, they can be blasted into cells using a "gene gun," or a virus or bacterium can be used to carry them into the target cells.[7] The "genetic engineer" who sets this process in motion does not actually control where the new genes end up in the genetic code of the target organism. The "engineer" essentially inserts the genes at a random, unknown location in the cell's existing DNA. These newly-inserted genes may sometimes end up in the middle of existing genetic instructions, and may disrupt those instructions.

A foreign gene could, for example, be inserted in the middle of an existing gene that instructs a plant to shut off production of a toxin in its fruit. The foreign gene could disrupt the functioning of this existing gene, causing the plant to produce abnormal levels of the toxin in its fruit. This phenomenon is known as "insertional mutagenesis" -- unpredictable changes resulting from the position in which a new gene is inserted.[8] Genetic engineering can also introduce unexpected new toxicity in food through a well-known phenomenon known as pleiotropy, in which one gene affects multiple characteristics of an organism. (See REHN #685.)

** Genetically engineered crops can indirectly promote the development of antibiotic resistance, making it difficult or impossible to treat common human diseases.

Whatever method is used to introduce foreign genes into a target cell, it only works some of the time, so the "genetic engineer" needs a way to identify those cells that have successfully taken up the foreign genes. One way to identify these cells is to attach a gene for antibiotic resistance to the gene intended for insertion. After attempting to introduce the foreign genes, the "engineer" can treat the mass of cells with an antibiotic. Only those cells that have incorporated the new genes survive, because they are now resistant to antibiotics.

From these surviving cells, a new plant is generated. Each cell of this plant contains the newly introduced genes, including the gene for antibiotic resistance. Once in the food chain, in some cases these genes could be taken up by and incorporated into the genetic material of bacteria living in human or animal digestive systems. A 1999 study published in APPLIED AND ENVIRONMENTAL MICROBIOLOGY found evidence supporting the view that bacteria in the human mouth could potentially take up antibiotic resistance genes released from food.[9] Antibiotic resistance among disease-causing bacteria is already a major threat to public health; due to the excessive use of antibiotics in medical treatment and in agriculture, we are losing the ability to treat life-threatening diseases such as pneumonia, tuberculosis, and salmonella.[10] (See REHN #402.) By putting antibiotic resistance genes into our food, we may be increasing the public health problem even further.

The British Medical Association, the leading association of doctors in Britain, urged an end to the use of antibiotic resistance genes in genetically engineered crops in a 1999 report. "There should be a ban on the use of antibiotic resistance marker genes in GM [genetically modified] food, as the risk to human health from antibiotic resistance developing in micro-organisms is one of the major public health threats that will be faced in the 21st Century. The risk that antibiotic resistance may be passed on to bacteria affecting human beings, through marker genes in the food chain, is one that cannot at present be ruled out," the Association said.[11]

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[1] Union of Concerned Scientists, "Foods on the Market," available at http://www.ucsusa.org. Choose "biotechnology" in the bar at the bottom of the screen, then click on "Foods on the Market."

[2] Consumers Union, "CONSUMER REPORTS: Genetically Engineered Foods in Your Shopping Cart," Press Release, August 23, 1999. Available at http://www.consumersunion.org/food/gefny999.htm.

[3] For one recent overview, see Environmental Media Services (EMS), REPORTERS' GUIDE: GENETIC ENGINEERING IN AGRICULTURE, Edition 1 (October 2000), available from EMS, Washington, D.C., (202) 463-6670 or at http://www.ems.org. Also see Pesticide Action Network North America (PANNA), "Genetically Engineered Crops and Foods: Online Presentation," available at http://www.panna.org/panna/resources/geTutorial.html.

[4] Clive James, "Global Review of Commercialized Transgenic Crops: 1999" ISAAA BRIEFS No. 12:

Preview, produced by International Service for the Acquisition of Agri-Biotech Applications (ISAAA). Available at http://www.isaaa.org/
Global%20Review%201999/briefs12cj.htm.

[5] See Michael Hansen, "Potential Environmental and Human Health Problems Associated with Genetically Engineered Food." Presentation delivered at CREA International Seminar on Transgenic Products, Curitiba, Brazil, October 11, 1999. Available from Consumer Policy Institute, Yonkers, N.Y.: 914-378-2455.

[6] National Research Council, GENETICALLY MODIFIED PEST-PROTECTED PLANTS: SCIENCE AND REGULATION (Washington, D.C.: National Academy of Sciences, 2000). ISBN 0309069300.

[7] Union of Concerned Scientists, "Fact Sheet: Genetic Engineering Techniques." Available at http://www.ucsusa.org. Choose "biotechnology" in the bar at the bottom of the screen, then click on "Genetic Engineering Techniques."

[8] See Food and Drug Administration, "Premarket Notice Concerning Bioengineered Foods," FEDERAL REGISTER Vol. 66, No. 12 (January 18, 2001), pg. 4710.

[9] Derry K. Mercer and others, "Fate of Free DNA and Transformation of the Oral Bacterium STREPTOCOCCUS GORDONII DL1 by Plasmid DNA in Human Saliva," APPLIED AND ENVIRONMENTAL MICROBIOLOGY Vol. 65, No. 1 (January 1999), pgs. 6-10.

[10] See World Health Organization (WHO), OVERCOMING ANTIMICROBIAL RESISTANCE (Geneva, Switzerland: World Health Organization, 2000). Available at http://www.who.int/infectious-disease-report/2000/.

[11] British Medical Association Board of Science and Education, "The Impact of Genetic Modification on Agriculture, Food and Health -- An Interim Statement," May 1999. Summary statement available at http://www.bma.org.uk/public/science/genmod.htm.

Part 2

In the last issue, we looked at hazards associated with eating genetically engineered foods: unexpected allergic reactions; unexpected toxicity; and the development of antibiotic resistance.[1] It is increasingly clear that genetic engineering is neither precise nor predictable; "genetic engineers" are tampering with the instructions for basic cell functions, without understanding fully how those instructions work.

** One source of unpredictable effects is the use of "promoter" genes. As we saw in REHN #716, the aim of genetic engineering is to take a gene from one organism and insert it into another organism. However, organisms have elaborate defense mechanisms to prevent foreign genes from affecting them, so a gene moved from a bacterium to a plant will not automatically work in its new host. To overcome the target organism's defenses and make the new gene function, it is necessary to add a "promoter" gene -- a genetic switch that "turns on" the foreign gene.

The promoter of choice in most cases is derived from a plant virus called the cauliflower mosaic virus. Known as the CaMV 35S promoter, this genetic sequence causes hyperexpression of other genes. A gene is hyperexpressed when the proteins for which it contains instructions are produced in excessive amounts --perhaps ten to a thousand times as great as normal levels. Because the CaMV 35S gene is so powerful, in addition to "turning on" the target gene, it may also "turn on" other genes near where it is inserted, causing the engineered cell to display unpredictable new features.[2]

** Plants can defend themselves against the intrusion of foreign genetic instructions through the phenomenon of "gene silencing," in which the cell blocks expression of the foreign DNA. Silencing may occur in unpredictable ways in genetically engineered plants. For example, a recent study found that infection with the cauliflower mosaic virus could trigger silencing of a newly inserted trait for herbicide tolerance, which was linked to the CaMV 35S promoter. Apparently, the plant defended itself against the infection through silencing of the viral genes. At the same time, it silenced other newly-inserted genes.[3]

** Genetically engineered foods may also produce unexplained health effects in laboratory animals. An article published in THE LANCET by Stanley Ewen and Arpad Pusztai reports on a study of laboratory rats fed genetically engineered potatoes.[4] The potatoes were designed to produce a substance known as GALANTHUS NIVALIS agglutinin (GNA), which is ordinarily found in snowdrops (a type of flower). The purpose of adding GNA to potatoes was to increase resistance to certain insects and other pests.

Ewen and Pusztai worked with three groups of rats. One received the genetically engineered potatoes designed to produce GNA; the second received ordinary, non-engineered potatoes, without GNA; and the third group received ordinary, non-engineered potatoes mixed with a dose of GNA. Ewen and Pusztai studied the changes that occurred in the digestive systems of the rats in each group.

The researchers found that eating engineered or non-engineered potatoes with GNA was associated with certain changes in the rats' stomachs. In addition, the engineered GNA potatoes were associated with certain intestinal changes NOT found in the rats fed ordinary potatoes laced with GNA. The researchers do not know the reason for these additional changes. They could be due to a "positioning effect" -- the foreign gene may have been inserted at a location in the existing genetic material that caused it to disrupt normal functioning of an existing gene. Or it could be due to the activity of other genetic material inserted along with the target gene, such as the promoter.

Pusztai was forced to retire from his research position at the Rowett Research Institute in Scotland after he spoke publicly about the results of his work. (See REHN #649.) His article in THE LANCET is one of only a few animal feeding studies that have been published on the altered foods that are now present, unlabeled, in our grocery stores.

** In some cases, genetically engineered crops can have altered nutritional content. One study found that glyphosate-tolerant soybeans had significantly altered levels of naturally occurring compounds known as isoflavones, which are thought to have some health benefits.[5] The consequences of changes like this could be minor in some cases and serious in others. The important lesson is that when we eat soy, corn, or other important foods that have been genetically altered, we may not be getting the nutrient mix we could expect in the past. As long as these altered foods are unlabeled, we do not have the information we need to make informed choices about the foods we eat.

Last fall, corn products in U.S. supermarkets were found to be contaminated with "StarLink" corn, a genetically engineered variety approved only for use as animal feed due to concerns about possible allergic reactions in humans.[6] The contamination was detected by a non-governmental organization, Friends of the Earth, working as part of a national collaborative effort, the Genetically Engineered Food Alert coalition. Had Friends of the Earth not taken responsibility for testing foods -- a function that should be performed by government -- we could have continued to consume unapproved StarLink corn with no way to trace the health consequences. We do not know what other errors may already have occurred; and since we do not know when we are eating genetically engineered foods, we have no way to watch for links between eating these foods and developing certain illnesses. Those who favor the rapid and unregulated introduction of genetically engineered foods into our food supply often say genetic engineering is really nothing new; it is simply an extension of conventional agricultural breeding techniques. In fact, as Michael Hansen of Consumers Union explains in a review article, there are some obvious differences.[2]

** Gene transfers across natural boundaries: Conventional breeding transfers genetic information among organisms that are related to one another -- members of the same species, or related species, or (rarely) of closely-related genera. (Genera is the plural of genus; a genus is a biological grouping that includes multiple species.) Genetic engineering, on the other hand, may transfer genes from any organism to any other organism (fish to fruit, bacteria to vegetables, etc.).

** Location of gene insertion: Variations of a gene are known as alleles. Genes are carried in chromosomes, and each gene has a specific place in a chromosome. Conventional breeding shuffles alleles of existing genes. In general, conventional breeding does not move genes from one place to another in a chromosome. Genetic engineering, on the other hand, inserts genes that were not in the original chromosome of the target organism. These genes may be inserted in unpredictable locations in the chromosome, producing unforseeable changes in the plant.

** Extra genetic material: Genetically engineered foods contain extra genetic material that is unrelated to the target characteristics. This extra genetic material can include vectors, which are added to move genes across natural barriers; promoters, added to "turn on" the foreign genes; marker genes, added to show the engineer whether the target gene has been successfully inserted; and random extra genetic material that the engineer inserts unintentionally. Here is a brief discussion of each of these categories:

a) Vectors: Genetic engineering often uses "vectors," genetic sequences derived from viruses or bacteria, to move genes into the target cell. One vector used frequently is derived from AGROBACTERIUM TUMEFACIENS, a bacterium that causes tumors in plants by inserting DNA from its own genetic code into the genetic code of the plant. A study published in PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES in January 2001 reported that AGROBACTERIUM may be able to insert DNA into human cells as well.[7]

When AGROBACTERIUM infects a plant under natural conditions, the genes are incorporated only into the infected part of the plant; they do not move throughout the plant and are not passed on to subsequent generations. In contrast, when AGROBACTERIUM genes are used as vectors in genetic engineering, the resulting plant includes AGROBACTERIUM genes in all its cells. Conventional breeding does not require the use of vectors.

b) Promoters: As we have seen, most genetically engineered crops include the CaMV 35S "promoter" gene to "turn on" the foreign gene and overcome normal cell defense mechanisms. Viral promoters are not necessary for conventional breeding.

c) Marker genes: As we saw in REHN #716, genetic engineering often involves the insertion of antibiotic resistance marker genes. This does not occur in conventional breeding.

d) Unintentional additions: Sometimes genetic engineers introduce additional genetic material into the target cell without knowing it. Last spring, for example, newspapers reported that Monsanto's Roundup Ready (glyphosate-tolerant) soybeans contained extra fragments of DNA that the company's genetic engineers were not aware of having introduced.[8]

On the basis of these points, some people would say that genetic engineering is "very different" from conventional breeding, whereas others would say that it is only "somewhat different." Either way, the differences have obvious implications for the ways in which governments should regulate genetically engineered foods. At a minimum, governments should require companies to conduct pre-market safety tests related to the special hazards associated with genetic engineering, and any altered foods allowed onto the market should be labeled.

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[1] For a thorough collection of resources on agricultural biotechnology, see AgBioTech InfoNet, maintained by Benbrook Consulting Services at http://www.biotech-info.net.

[2] Michael K. Hansen, "Genetic Engineering is Not an Extension of Conventional Plant Breeding; How Genetic Engineering Differs from Conventional Breeding, Hybridization, Wide Crosses, and Horizontal Gene Transfer," available at http://www.consumersunion.org/food/widecpi200.htm. Also see Michael Hansen and Ellen Hickey, "Genetic Engineering: Imprecise and Unpredictable," in GLOBAL PESTICIDE CAMPAIGNER, Vol. 10, No. 1, April 2000, available from Pesticide Action Network (415-981-1771; panna@panna.org).

[3] Nadia S. Al-Kaff and others, "Plants Rendered Herbicide-Susceptible by Cauliflower Mosaic Virus-Elicited Suppression of a 35S Promoter-Regulated Transgene," NATURE BIOTECHNOLOGY Vol. 18 (September 2000), pgs. 995-999.

[4] Stanley W. B. Ewen and Arpad Pusztai, "Effect of Diets Containing Genetically Modified Potatoes Expressing GALANTHUS NIVALIS Lectin on Rat Small Intestine," THE LANCET Vol. 354, No. 9187 (October 16, 1999), pgs. 1353-1354.

[5] Marc A. Lappe and others, "Alterations in Clinically Important Phytoestrogens in Genetically Modified, Herbicide-Tolerant Soybeans," JOURNAL OF MEDICINAL FOOD Vol. 1, No. 4 (July 1999), pgs. 241-245.

[6] Andrew Pollack, "Case Illustrates Risks of Altered Food." NEW YORK TIMES October 14, 2000. Available at http://www.biotech- info.net/altered_food.html

[7] Talya Kunik and others, "Genetic Transformation of HeLa Cells by AGROBACTERIUM," PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, published online before print (January 30, 2001). Full text available for U.S. $5 at

http://www.pnas.org/cgi/doi/10.1073/pnas.041327598.

[8] James Meikle, "Soya Gene Find Fuels Doubts on GM Crops," THE GUARDIAN (London) (May 31, 2000). Available at http://www.guardianunlimited.co.uk/gmdebate/Story/0,2763,326569,00.html Also see "Monsanto GM Seeds Contain 'Rogue' DNA," SCOTLAND ON SUNDAY (May 30, 2000). Available at http://www.biotech- info.net/Rogue_DNA.html

Part 3

As we saw in REHN #716, genetically engineered crops now planted in the U.S. and worldwide are mostly designed to tolerate herbicides or to kill insects or other pests. A small percentage is designed for other purposes such as resisting infection by certain viruses. Here we will look at some of the threats genetically engineered crops pose to ecosystems.

Pesticidal crops may be toxic to nontarget organisms - organisms they were not designed to kill. For example, BT corn designed to kill the European corn borer can also be toxic to other closely related insects, including butterflies and moths.

Monarch butterfly larvae feed on milkweed, which often grows in or near corn fields. In a laboratory, scientists found that monarch larvae feeding on milkweed dusted with BT corn pollen grew more slowly and died at a higher rate than larvae that were not exposed to the toxic pollen.[1] Another study found these effects were likely to occur outside the laboratory as well. Researchers placed potted milkweed plants in fields of BT corn and measured the number of BT pollen grains that were deposited on the milkweed leaves. Monarch larvae exposed to BT corn pollen at these levels had high death rates compared with larvae exposed to non-engineered corn pollen or placed on milkweed leaves with no pollen.[2]

The U.S. Environmental Protection Agency (EPA) now expresses concern about the effects of BT corn pollen on monarchs and other butterfly species, including the endangered Karner Blue butterfly.[3] EPA has asked companies to submit data on these effects, but this "data call-in" occurred four years AFTER EPA allowed BT corn to be used on U.S. farms.[2,pg.13]

BT corn may also harm the green lacewing, a beneficial insect that eats agricultural pests. The lacewing may be affected by the toxin in the digestive systems of insects that have eaten BT corn but have not been killed by it.[4] This example shows how non-target effects may interfere with a chain of predator-prey relationships, disrupting the natural balance that keeps pest populations under control.

BT crops may also affect non-target organisms by changing soil chemistry. A 1999 article in NATURE reported that the roots of BT corn plants released BT toxin into soil. The researchers found that 90 to 95% of susceptible insect larvae exposed to the substance released from the roots died after 5 days.[5]

The use of BT crops can also promote the development of BT-resistant pest populations. As we saw in REHN #716, organic farmers use BT sprays occasionally as a natural insecticide to combat severe pest outbreaks. BT crops, in contrast, generally expose insects to BT toxins day after day, whether or not there is a major infestation. These conditions increase the likelihood that BT-resistant insects will evolve. The widespread appearance of BT-resistant insect pests would mean the loss of one of the most valuable tools available to organic farmers for dealing with serious pest outbreaks.[6,pg.139]

Herbicide-tolerant crops are designed to make it easier for farmers to use certain herbicides. A 1999 study of soybean farming in the U.S. midwest found that farmers planting Roundup Ready soybeans used 2 to 5 times as many pounds of herbicide per acre as farmers using conventional systems, and ten times as much herbicide as farmers using Integrated Weed Management systems, which are intended to reduce the need for chemical herbicides.[7,pg.2] Glyphosate, the active ingredient in Roundup, can sometimes persist in soil over long periods of time[8] and may affect the growth of beneficial soil bacteria, among other environmental effects.[9] A recent, unpublished study conducted at the University of Missouri suggests that applications of Roundup to Roundup Ready crops may be associated with elevated levels of soil fungi that sometimes cause plant diseases.[10]

More hazards may lie ahead as new products of genetic engineering come to market. According to the NEW YORK TIMES, Scotts Company is collaborating with Monsanto to develop Roundup Ready grass for lawns.[11] Studies suggest that Roundup exposures can be harmful to human health. For example, exposure to glyphosate herbicides may be associated with increased occurrence of non-Hodgkins lymphoma, a cancer of white blood cells.[12] (See REHN #660.) And a study published last August in ENVIRONMENTAL HEALTH PERSPECTIVES found that in a laboratory, Roundup exposure interfered with sex hormone production in cells of testicular tumors taken from mice.[13] If the introduction of Roundup Ready grass leads to increased use of Roundup on lawns, children's exposure to the herbicide could rise.

In some cases, genetically engineered crops might become problem weeds, disrupting existing ecosystems. A recent study published in NATURE found that some genetically engineered crops are unlikely to become problem weeds. Researchers planted genetically engineered crops that were available in 1990 and monitored their growth for ten years. Many of the plants simply died out, and those that did survive showed no signs of spreading.[14] But some crop plants, such as canola, survive well on their own without human intervention. In Canada, genetically engineered canola plants designed to resist various herbicides appear to have exchanged genetic material so that some canola plants now can survive exposure to two or three herbicides. These plants with multiple herbicide resistance can be difficult for farmers to control.[6,pgs.122-123]

Genetically engineered virus-resistant crops are supposed to reduce problems from viral infections, but in some cases they could make those problems worse. Virus-resistant crops are created by adding virus genes to the plant's existing genetic material. If a genetically engineered crop resistant to one virus is infected by another virus, the genetic material from the two viruses may sometimes interact to produce new virus types, which could be more harmful or could infect a wider range of plants than the original.[15,pgs.59-68]

All the hazards discussed above are compounded by the problem of genetic pollution. Many crop plants disperse genetic material through pollen, which may be carried by the wind or by pollinators such as bees. This means genetically engineered plants may "share" their genetic material with other, non-engineered plants. For example, pollen from genetically engineered corn can blow into a neighboring field and pollinate conventional corn. Because of genetic pollution, some organic farmers whose fields border genetically engineered crops may no longer be able to certify their crops as organic.[6,pg.127]

In animals, sexual reproduction between different species is usually impossible. In a few cases, reproduction between closely related species can occur but the offspring are generally sterile. For example, a horse and a donkey can mate to produce a mule, but mules cannot reproduce. In contrast, many plants are able to reproduce sexually with related species, and the offspring of these combinations are often fertile. When crop plants grow near wild plants to which they are related, they may reproduce with these plants. This means that genetic material inserted into a crop plant can find its way into wild plant populations.

A recent article in SCIENCE reviews the literature on "ecological risks and benefits" of genetically engineered crops and confirms what advocates of precaution have been saying for years: we lack basic information on how genetically engineered crops may affect ecosystems.[16] Here are a few examples of what scientists do not know about ecological effects of genetically engineered crops:

** No published studies have looked at whether novel genes introduced into crops have become established in populations of wild relatives.[16, pg. 2088]

** We know that BT toxin can be released from the roots of BT corn plants, but no published studies have looked at the ecological consequences of adding BT toxin to soil in this way. [16, pg. 2089]

** As we have seen, BT toxin in the digestive systems of plant-eating insects may affect the predator insects that eat them. Right now it is impossible to model how an ecosystem might change due to these effects on predators, the authors say.[16, pg. 2089]

** Scientists are currently unable to estimate the likelihood that planting genetically engineered virus-resistant crops will lead to the development of new types of plant viruses. [16, pg. 2089]

A precautionary approach would require that we investigate these questions before, rather than after, permitting large-scale commercial cultivation of genetically engineered crops.

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[1] John E. Losey and others, "Transgenic Pollen Harms Monarch Larvae." NATURE Vol. 399, No. 6733 (May 20, 1999), pg. 214.

[2] Laura C. Hansen and John J. Obrycki, "Field Deposition of BT Transgenic Corn Pollen: Lethal Effects on the Monarch Butterfly," OECOLOGIA Vol. 125, No. 2 (2000), pgs. 241-248.

[3] U.S. Environmental Protection Agency, "Biopesticide Fact Sheet: BACILLUS THURINGIENSIS Cry1Ab Delta-Endotoxin and the Genetic Material Necessary for Its Production (Plasmid Vector pCIB4431) in Corn [Event 176]," April 2000. EPA Publication No. 730-F-00-003. Available at http://www.epa.gov/pesticides/biopesticides/factsheets/fs006458t.htm.

[4] A. Hilbeck and others, "Effects of Transgenic BACILLUS THURINGIENSIS corn-fed prey on Mortality and Development Time of Immature CHYSOPERLA CARNEA (Neuroptera: Chrysopidae)." ENVIRONMENTAL ENTOMOLOGY Vol. 27, No. 2 (April 1998), pgs. 480-487.

[5] Deepak Saxena and others, "Insecticidal Toxin in Root Exudates from BT Corn," NATURE Vol. 402, No. 6761 (December 2, 1999), pg. 480.

[6] Royal Society of Canada, ELEMENTS OF PRECAUTION: RECOMMENDATIONS FOR THE REGULATION OF FOOD BIOTECHNOLOGY IN CANADA (Ottawa: Royal Society of Canada,

January 2001). ISBN 0-920064-71-X. Available from the Royal Society at (Ottawa, Canada) phone: (613) 991-6990 or at http://www.rsc.ca/foodbiotechnology/GMreportEN.pdf.

[7] Charles Benbrook, "Evidence of the Magnitude and Consequences of the Roundup Ready Soybean Yield Drag from University-Based Varietal Trials in 1998," AgBioTech InfoNet Technical Paper #1, July 13, 1999. Available at http://www.biotech-info.net/RR_yield_drag_98.pdf.

[8] U.S. Environmental Protection Agency, "Pesticide and Environmental Fate One Line Summary: Glyphosate," May 6, 1993.

[9] See T. B. Moorman and others, "Production of Hydrobenzoic Acids by BRADYRHIZOBIUM JAPONICUM strains after treatment with glyphosate." JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY Vol. 40 (1992), pgs. 289-293. For a review of other relevant studies, see Caroline Cox, "Herbicide Factsheet: Glyphosate (Roundup)" JOURNAL OF PESTICIDE REFORM Vol. 18, No. 3 (Fall 1998), updated October 2000, available at http://www.pesticide.org/gly.pdf

[10] R.J. Kremer and others, "Herbicide Impact on FUSARIUM spp. and Soybean Cyst Nematode in Glyphosate-Tolerant Soybean." American Society of Agronomy study abstract, available at http://www.biotech-info.net/fungi_buildup_abstract.html. Also see University of Missouri press release, "MU Researchers Find Fungi Buildup in Glyphosate-Treated Soybean Fields" (December 21, 2000), available at http://www.biotech-info.net/fungi_buildup.html.

[11] David Barboza, "Suburban Genetics: Scientists Searching for a Perfect Lawn," NEW YORK TIMES July 9, 2000, pg. A1.

[12] Lennart Hardell and Mikael Eriksson, "A Case-Control Study of Non-Hodgkin Lymphoma and Exposure to Pesticides," CANCER Vol. 85, No. 6 (March 15, 1999), pgs. 1353-1360.

[13] Lance P. Walsh and others, "Roundup Inhibits Steroidogenesis by Disrupting Steroidogenic Acute Regulatory (StAR) Protein Expression," ENVIRONMENTAL HEALTH PERSPECTIVES Vol. 108, No. 8 (August 2000), pgs. 769-776.

[14] M. Crawley and others, "Transgenic Crops in Natural Habitats." NATURE Vol. 409, No. 6821 (February 8, 2001), pgs. 682-683.

[15] Jane Rissler and Margaret Mellon, THE ECOLOGICAL RISKS OF ENGINEERED CROPS (Cambridge, Mass.: MIT Press, 1996).

[16] L. L. Wolfenbarger and P.R. Phifer, "The Ecological Risks and Benefits of Genetically Engineered Plants." SCIENCE Vol. 290 No. 5499 (December 15, 2000) pgs. 2088-2093.

Part 4

As corporate power grows without limit, governments at all levels are abandoning their responsibility to enforce laws. Instead, they are relying on "voluntary compliance" by corporations. Under these circumstances, the role of whistle-blowers assumes increased importance; often they are the public's only protection against dangerous violations of law. Whistle-blowers are "insiders" in private firms and government agencies who dare to speak out against waste, fraud, abuse and threats to public health, often at great personal risk.[1]

Here are a few recent examples of whistle-blowers:

** In August, 2000, 40 members of the Los Angeles Police Department sued in court alleging that their superiors enforced a "code of silence" among police officers by punishing whistle-blowers who reported police misconduct.[2]

** In October, 1994, a 20-year career federal safety inspector, Steve Jones, was fired for reporting more than 500 safety violations at a chemical weapons incinerator operated by a private contractor at Utah's Tooele Army Depot. Taylor said the contractor (his employer) had ignored and covered up releases of toxic nerve gas that put workers in immediate danger.[3]

** In November, 1998, employees of private health care firms blew the whistle on a scheme by over 200 hospitals to bilk the federal Medicare program out of billions of dollars by filing false expense reports over a 14-year period.[4]

** In 1996, EPA (U.S. Environmental Protection Agency) biologist Dr. David Lewis was silenced by his EPA supervisors when he warned that sewage sludge approved by EPA for use on farm land is a threat to human health because it is contaminated with dangerous pathogens including E. coli, salmonella, and the hepatitis virus.[5]

These are only a few examples of whistle-blowers protecting the public interest.

This week we have whistle-blower William Sanjour a long-time employee of U.S. Environmental Protection Agency (see REHN #350, #392, #484, and #612) reviewing a new book written for whistle-blowers and their lawyers by Steven Kohn[6], founder of the National Whistleblower Center in Washington, D.C.[7]

--Peter Montague

A Textbook for Whistle-blowers

by William Sanjour [8]

Anyone who has blown the whistle on corporate or government waste fraud or abuse, or is contemplating blowing the whistle or any activist or union organization which encourages or advises whistle-blowers needs to know the laws governing the protection of whistle-blowers. And there are plenty of laws; good laws, strong laws, enforceable laws. But there are also plenty of flaws and pitfalls to undo the unprepared.

Steve Kohn is the nation's outstanding whistle-blower lawyer and he's written a first-rate book on the state and federal whistle-blower protection laws. His book is written mainly for attorneys but it offers guidelines for laymen to avoid the flaws and pitfalls and take advantage of the protection afforded by the laws.

In my own experience there are several misconceptions of the law which prevent would-be environmental whistle-blowers from taking action, or from choosing the best action, or which prevent whistle-blowers from seeking legal protection from retaliation.

The first misconception is the fear that they would not be able to prove that an adverse action taken against them by their employer was indeed retaliation for blowing the whistle. Short of firing, retaliation against a whistle-blower usually takes the form of harassment such as transfer to a dead-end position or reassignment to a hostile work environment. Management usually gives a rational-sounding explanation for these actions (e.g., the worker's performance has fallen below par or the needs of the organization require the whistleblower's transfer), so whistle-blowers often think that the burden of proof is on them to show that the action is harassment in retaliation for the whistle-blowing activity. Often whistleblowers are cowed by the enormity of the burden. In fact, under most circumstances, that burden hardly exists. Kohn cites, for example, a decision from the U.S. Court of Appeals for the Seventh Circuit (pg. 82):

"[T]he plaintiff, on the one hand, can make out a prima facie case of retaliation, and shift the burden of persuasion to the defendant, with circumstantial evidence that her disclosure was a contributing (not necessarily a substantial or motivating) factor in the adverse personnel action taken against her; and the defendant, once the burden has shifted, must prove not merely by a preponderance but by clear and convincing evidence that it would have taken the same action against the plaintiff even in the absence of her protected disclosure."

By keeping good records an employee can establish evidence of discriminatory motives on the part of the employer and thereby shift the burden. Kohn cites 32 examples (pgs. 268-270) of factors, which have been successfully used. A few of these are:

** high work performance rating prior to engaging in protected activity, and low rating or "problems" thereafter;

** discipline, transfer, or termination shortly after the employee engaged in protected activity;

** change in attitude of management before and after employee engaged in protected activity, and attitude of supervisors toward whistle-blowers;

** absence of previous complaints against employee;

** differences between the way the complainant and other employees were treated;

** absence of warning before termination or transfer;

** willingness to deviate from established procedure;

** contradictions in an employer's explanation of the purported reasons for the adverse action.

This misconception about the burden of proof is often shared by the employer as well. Frequently employers arrogantly believe they can do anything they want to punish or silence a whistle-blower just by inventing reasonable-sounding excuses for doing so. This can work to the advantage of the whistle-blower if he or she understands the law.

The whistle-blower can even get the employer to incriminate himself if he knows the law and the employer does not. For example, when I was transferred to a meaningless position shortly after blowing the whistle on EPA's decimation of the hazardous waste regulations, my boss called me into his office to explain his rationalization for my transfer. I recognized that the reasons he gave me were contrary to EPA rules but I kept quiet and let him talk. After the meeting I sent him a memorandum politely summarizing his comments and he returned it with a few minor corrections. This document later became the basis of my successful challenge to the transfer. In all but 7 states it is also legal to tape record conversations with your boss without your boss knowing it.

The second misconception is the uncertainty of a whistleblower or would be whistle-blower that the act that he is concerned about may not actually be illegal. After all, environmental law is a very convoluted and tricky business, perhaps intentionally so. For example an employee may be witness to the fact that his company is dumping toxic waste into a municipal landfill. His efforts to get the company to stop the practice are futile. His management assures him that the waste is not "technically" a hazardous waste because of loopholes in the EPA regulations. He doesn't know if that's true, but regardless, he believes that the practice is dangerous. He would like to blow the whistle on the dumping but he doesn't know if he'd be legally protected against retaliation if the dumping is lawful or if the company can convince the authorities that the dumping is harmless. Kohn points out he needn't be concerned (pg. 264):

"Under most whistleblower protection laws, an employee is under no obligation to demonstrate the validity of his or her substantive allegations. Although the safety or legal concern that resulted in the initial whistleblower disclosure need only be based on a good faith belief that an actual violation occurred, this 'good faith' belief must be based on 'reasonably perceived violations' of the applicable law or regulations. Employees are under no duty to demonstrate the underlying veracity or accuracy of their safety allegations."

A third misconception, perhaps brought about by movies such as SILKWOOD, is that retaliation has to be overt and severe before the whistle-blower can hope for any protection under the law. In fact the courts have recognized many lesser forms of retaliatory action (pg. 243):

"Under the nuclear, trucking, and environmental whistleblower laws, the DOL [Department of Labor] has 'broadly construed' the definition of adverse action to 'prevent the intimidation of workers through retaliation.' Various employer practices have been held to be illegal discrimination, including the elimination of a position, causing embarrassment and humiliation, transfers, and demotions; 'constructive discharge' (or making working conditions so difficult as to force a resignation); blacklisting; issuance of a disciplinary letter; a reassignment to a less desirable position (even with no loss of salary or grade); negative comments in an evaluation; a retaliatory order to undergo a psychological 'fitness for duty' examination; .... denial of promotion; threats; .... transfer to a position where employee could not perform supervisory duties; circulation of 'bad paper' comments and other forms of 'bad mouthing;' moving an office and denying parking and access privileges;..." and many, many other negative actions by employers (see pgs. 241-247).

However, none of this should lead to complacency. There are many pitfalls. If the courts are generous to whistle-blowers in applying the rules of evidence, they are very fussy about procedures. The U.S. Supreme Court is not the only court where deadlines are more important than justice. Kohn explains (pg. 5):

"One major weakness in many statutory whistleblower protection laws is the short statute of limitations..... Failure to comply with the statute of limitations is a common defense [by employers] in whistleblower cases, and the statute is generally held to start running at the time that an employee learns that he or she will be retaliated against, not on the last day of employment."

In most cases the statute of limitations is only 30 days. In other words, if a whistle-blower feels an adverse action has been taken against him, he must file a complaint with the appropriate authority within 30 days. Very often if the adverse action is something as amorphous as an unjust criticism or a change in work pattern it may take a while for the whistleblower to even recognize that it was an adverse action and an even longer time to seek counsel and file the correct papers with the appropriate authority.

Federal employees are protected by many laws, the strongest of which are seven environmental and nuclear laws. However another pitfall for the unwary civil servant is to seek redress instead under the mislabeled federal Whistleblower Protection Act. In the experience of many whistle-blowers, including myself, this act and the Merit System Protection Board it created exist more for the protection of the government. Thus a whistle-blower must carefully choose the law under which to file a complaint.

My personal advice to any whistle-blower is to make sure his or her lawyer has a copy of Kohn's book and has read it.

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[1] The U.S. Department of Labor maintains a "whistle-blower collection" online at http://www.oalj.dol.gov/libwhist.htm where you can learn about recent whistle-blower cases.

[2] LOS ANGELES TIMES Aug. 25, 2000, pg. unknown. See http://www.mapinc.org/drugnews/v00/n1236/a06.html.

[3] See http://www.hcn.org/servlets/hcn.Article?article_id=578

[4] See http://www.usnews.com/usnews/issue/981102/2wstl.htm.

[5] See http://www.hcn.org/servlets/hcn.Article?article_id=578 and see http://www.whistleblowers.org/Browner7-13-00.htm.

[6] Stephen M. Kohn, CONCEPTS AND PROCEDURES IN WHISTLEBLOWER LAW (Westport, Conn., Quorum Books, 2001). ISBN 1-56720-354-X.

[7] The National Whistleblower Center web site can be found at http://www.whistleblowers.org/index.html.

[8] The Collected Papers of William Sanjour can be found at http://pwp.lincs.net/sanjour.