Chapter 15: Essay

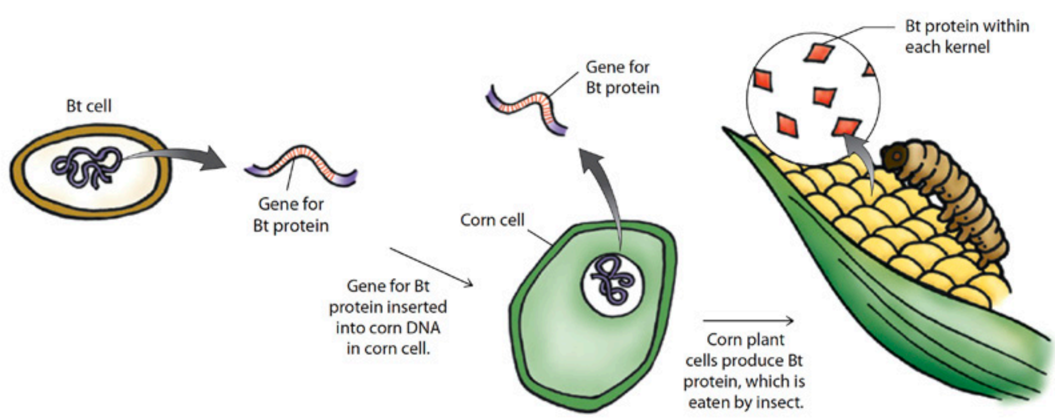
Genetically modified Foods

Over the past couple of decades, advances in our understanding of genetics have led to profound developments in agriculture. For centuries, farmers have improved crops and domestic animals by breeding for desirable traits. This uncertain and often lengthy process can now be performed relatively quickly and with great certainty using the tools of modern molecular biology to introduce genes for desired traits into plants and animals. The resulting organisms are called *transgenic organisms* because they contain one or more genes from another species. In the media and marketplace, transgenic organisms are also known as *genetically modified organisms,* or GMOs for short.

As an example, consider that transgenic bacteria have been engineered to mass-produce a variety of valuable proteins, including bovine growth hormone (BGH). When this hormone is injected into dairy or beef cattle, it raises milk production or improves weight gain. It has passed U.S. government-sponsored safety standards and is now being used extensively on dairy herds in the United States. European and Canadian governments, however, do not allow its use in cattle. One reason is that BGH increases the rates of infections among cattle. This prompts farmers to overuse antibiotics that end up being consumed by humans.

Most of the progress in transgenic agriculture has been with plants. Several major crops have been engineered with genes that create proteins having insecticidal properties. The insect pest is killed only when it feeds on the crop. **Figure A** illustrates this technique for corn. With such a mechanism, most—although not necessarily all—nontarget benevolent organisms are left unharmed and the need for pesticide application is reduced.

Other major crops have been engineered with genes that make them resistant to the herbicide glyphosate, meaning that the herbicide kills weeds in a field but doesn't threaten the crop planted there. Researchers have also inserted into



Λ Figure A

The bacterium Bacillus thuringiensis (Bt) produces proteins that are toxic to insects such as the corn borer, a devastating corn pest. The external application of Bt proteins on corn, however, cannot control the corn borer once it is inside the stalk. Corn is made resistant to the corn borer by splicing the gene for the Bt protein into corn DNA. The resulting corn plant produces the Bt protein in its cells and is thus fully resistant to the corn borer.

sweet potato plants a gene coding for a dietary protein. This protein contains significant amounts of the amino acids essential to adult humans. **Figure B** shows these protein-rich sweet potatoes, which are easy to cultivate and hold special value for developing nations, where high-quality protein foods are hard to come by.

Λ Figure B

Gene transfer has made sweet potatoes a better protein source.

Worldwide, over 70 million acres of farmland are cultivated with transgenic crops. As a result, about one-third of the world corn harvest and more than one-half of the world soy-bean harvest now come from genetically engineered plants.

The examples just described involve the transposing of only one gene or a couple of genes into the transgenic organism. Many desirable traits, however, involve clusters of genes. An important example is the ability to fix nitrogen. Intense research is currently under way to transpose all the genes necessary for nitrogen fixation into plants that do not naturally fix nitrogen. With such a transgenic species, the expensive production and application of nitrogen fertilizers becomes unnecessary.

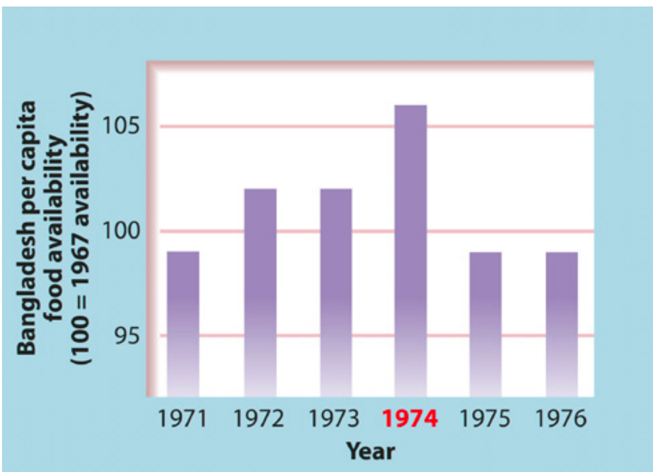
There is heated debate about genetically engineered agricultural products. Some argue that producing transgenic organisms is only an extension of traditional cross- breeding, such as the procedure that has given us new and interesting products as the tangelo (a tangerine– grapefruit hybrid). In general, the Food and Drug Administration has held that if the result of genetic engineering is not significantly different from a product already on the market, testing is not required. On the other side of the argument are those who see creating transgenic organisms as radically different from hybridizing closely related species of plants or animals. There is concern, for example, that genetically engineered crops might grow too well, ultimately reseeding themselves in areas where they are not desired and thus becoming "superweeds." Transgenic crops might also pass their new genes to close relatives in neighboring wild areas, creating offspring that would be difficult to control.

Stay tuned for developments in the area of transgenic agriculture, such as the promising development of golden rice discussed at the beginning of this chapter. The power of genetic engineering, however, demands that we move cautiously with all necessary safeguards in place. One of the more important safeguards, no doubt, will be a well-informed general public.

But are transgenic organisms really necessary to feed our growing human population? Demographers project that the human population will begin to stabilize within a century at about 14 billion inhabitants. Will we be able to feed ourselves at that point? The answer is probably yes, but the assumption here is that our food supply expands in a way that does not destroy the natural environment. For agriculture to be sustainable, a steady stream of new technologies that minimize environmental damage must be developed. Transgenic organisms are likely to play a significant role.

Interestingly, the most critical problems faced by those seeking to counteract world hunger are more likely to be social rather than technical. Above all, efforts toward stabilizing the world population must continue in earnest. Already, most of the world's farmable land is now under cultivation. As the population grows, more food will be required while at the same time more farmable land will be lost to residential and business development. In tropical areas, economic pressures to slash and burn rainforests for the formation of additional farm-land will probably continue.

Even with a stable world population, it cannot be assumed that a large-enough food supply will lead to the end of world hunger. Today, the abundance of food is at an all-time high, and yet millions of individuals, most of them young children, die each year from a lack of adequate nutrition. Amartya Sen, a leader in the fight against world hunger and the 1998 Nobel laureate in Economics, points out that in most circumstances, malnutrition arises not from a lack of food, but from a lack of appropriate social infrastructure, as **Figure C** shows. Backed by strong evidence, Sen argues that "public action can eradicate the terrible and resilient problems of starvation and hunger in the world in which we live." Efforts toward optimizing the food yields from agriculture must therefore be matched by efforts to build social, political, and economic systems that give those people facing starvation the means for survival. World hunger is not inevitable.



Λ Figure C

The Bangladesh famine of 1974 occurred during a period when the amount of food available per person in that country was at a peak. It was unemployment, hoarding, and inflated food prices that drove millions to their death

CONCEPT **CHECK**

Why is it so difficult to develop a transgenic corn variety that fixes its own nitrogen?

CHECK YOUR ANSWER Developing a transgenic corn variety that fixes its own nitrogen is difficult because many genes are involved.

Think and Discuss

1. How might genetic engineering be used to counteract the negative effects of salinization?

2. Bovine growth hormone was made available to dairy farmers in the early 1990s. At that time, there was no shortage of milk, nor was there any anticipated shortage of milk. Why did the farmers then start using this growth hormone on their cows? Who benefited most? Many physicians are concerned about a possible, although not yet proven, link between growth- hormone-induced milk and certain cancers in humans. Knowing this, are you willing to drink milk from a cow whose milk production has been increased by injections of bovine growth hormone? Why or why not?

3. Should transgenic foods be labeled as such in the stores where they are sold? Would you be reluctant to buy this food? What if the food were processed and in a box, such as a box of crackers? What if the food were fresh produce on display next to organic fresh produce? What if the GMO fresh produce looked healthier than the organic fresh produce and were less expensive?

4. Why might environmentalists welcome the introduction of corn genetically engineered to fix its own nitrogen? Why might they be opposed to it?

Author Responses to Think and Discuss

1. Some plants are already fairly tolerant of salty soils. The gene or genes that allow for this greater tolerance might be inserted into other plants that normally have a low tolerance for salty soils.

2. Farmers started using it so that they could have fewer cows (lower maintenance costs) producing the same amount of milk. The cows they no longer needed were sold to slaughterhouses. A disadvantage to this approach is that it stresses the remaining milk producing cows. These cows are more susceptible to utter infections, which leads to more pus being introduced to the milk. Furthermore, these cows become more prone to delivering calves with birth disorders. Perhaps the greatest benefactor is the corporation producing the growth hormone.

3. It might be more viable to label non-transgenic foods, which are becoming less common. The average citizen lacks the time and resources to keep up with the state of genetically modified foods and will thus continue to rely on experts in order to form their opinions. For many, the simplest solution will be to "just say no".

4. Environmentalists would likely be in favor of it because of the reduced need for fossil-fuel dependent fertilizers, which consume energy resources, generate greenhouse gases and other contaminants in production, and create pollution in agricultural runoff. They would likely be opposed to it due to the potential for cross-breeding with other crops, the potential for mutagenesis, and other unforeseen consequences.