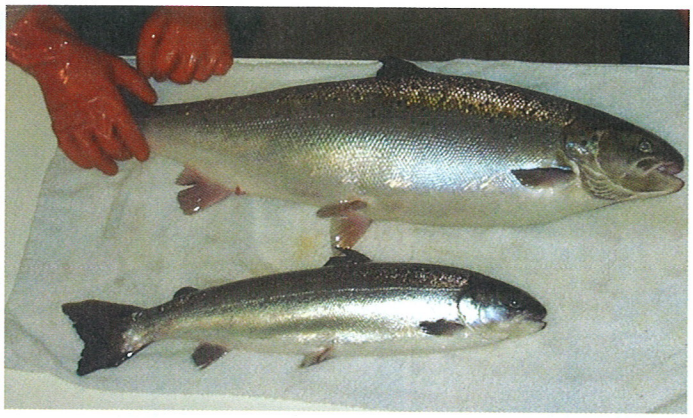

FIGURE 5-36 Bigger salmon. The larger salmon carries a growth hormone gene that keeps it growing year-round rather than in the summer only.

the first time, the U.S. Food and Drug Administration is close to approving for human consumption a genetically modified animal. The animal in question is a transgenic Atlantic salmon that carries a growth hormone gene from another species (Chinook salmon), along with a region of DNA from a third species (ocean pout) that acts as an "on" switch, facilitating transcription of the growth hormone gene. The transgenic fish, which is reported by its creators to taste the same as regular Atlantic salmon, grows much more quickly and reaches market size within 18 months rather than the usual three years (**FIGURE 5-36**).

The FDA has reported that the transgenic salmon "is as safe to eat as food from other Atlantic salmon." Numerous fisheries experts, food safety experts, environmental groups, and consumer groups, however, continue to express concerns about a wide variety of safety and environmental issues and the process by which the safety and environmental impacts of the transgenic species have been evaluated. Health concerns include the possibility that consuming the salmon will cause increased rates of allergic reactions, as well as unknown effects that may stem from potentially higher levels of hormones present in the fish.

Most troubling to environmental groups is the risk that the larger, faster-growing transgenic fishes will escape from their enclosed breeding facilities and back into their natural habitat—something that many experts believe is inevitable. If this occurs, environmentalists fear that the fish might harm wild salmon populations, many of which are listed as endangered, because the transgenic salmon can consume more resources and may grow too large to be consumed by its natural predators. It is unclear what the outcome would be.

TAKE-HOME MESSAGE 5·12

Biotechnology has led to important improvements in agriculture by using transgenic plants and animals to produce more nutritious food. Even more significant is the extent to which biotechnology has reduced the environmental and financial costs of producing food, through the creation of herbicide-resistant and insect-resistant crops. The ecological and health risks of such widespread use of transgenic species are not fully understood and are potentially great.

5·13 Fears and risks: are genetically modified foods safe?

Chickens without feathers look ridiculous (**FIGURE 5-37**). But such a genetically modified breed was developed with a valuable purpose in mind: "naked" birds are easier and less expensive to prepare for market, benefiting farmers by lowering their costs and benefiting consumers by lowering prices. These chickens, however, have turned out to be unusually vulnerable to mosquito attacks, parasites, and disease, and ultra-sensitive to sunlight. They also have difficulty mating, because the males are unable to flap their wings. Researchers currently are working to address these problems.

Naked chickens teach us an important lesson about genetically modified plants and animals. Although the new breed of featherless chickens was produced by relatively low-tech genetic engineering—the traditional animal husbandry method of crossbreeding two different types of chickens—rather than by more modern recombinant DNA technology, the new breed ended up having not just the desired trait of no feathers but also some unintended and undesirable traits. Now, as more genetically modified foods are created using modern methods of recombinant DNA technology, the same risks of also creating unintended and potentially harmful traits must be weighed. For these and other reasons—some legitimate and rational, others irrational—many people have concerns about the production and consumption of genetically modified foods (**FIGURE 5-38**). These concerns are outlined in the following discussion.

Featherless birds are cheaper for farmers and consumers. But there are unintended consequences, including vulnerability to mosquitoes and other parasites.

FIGURE 5-37 "Naked" birds. The breeding of featherless chickens has benefited farmers but led to some unanticipated consequences.

Organisms that we want to kill may become invincible. Pesticide-resistant canola plants were cultivated in Canada, making it possible for farmers to apply herbicides freely to kill the weeds but not the canola crop. But the pesticide-resistant canola plants accidentally spread to neighboring farms and grew out of control, because traditional herbicides could not kill them. Similarly, there is the possibility that insect pests will develop resistance to the Bt produced by genetically modified crops, which will also make these pests resistant to Bt pesticides applied to crops that are not genetically modified.

Organisms that we don't want to kill may be killed inadvertently. Monarch butterflies feed on milkweed plants. Recent research has demonstrated that if pollen from plants genetically modified to contain the insect-killing Bt genes accidentally lands on milkweed plants and is consumed by monarch butterflies, the butterflies can be killed, which may significantly reduce their populations. Although such an incident has not occurred outside experimental fields, it illustrates a risk that may be hard to control.

Genetically modified crops are not tested or regulated adequately. It is impossible to really know whether a new technology has been tested adequately. Still, scientists and lawmakers have been working toward an organized and responsible set of policies designed to ensure that sufficient safety testing is done. For example, laboratory procedures for working with recombinant DNA have been established, and researchers have developed techniques that make it impossible for most genetically engineered organisms to survive outside the specific conditions for which they are developed.

As an example of the degree of testing of genetically engineered foods, the Monsanto Company has had its strain of herbicide-resistant soybeans evaluated and approved by 31 different regulatory agencies in 17 different countries, including, in the United States, the Department of Agriculture, the Food and Drug Administration, and the Environmental Protection Agency. In a recent report on genetically modified animals, however, an expert committee of the U.S. National Academy of Sciences warned that GMOs still pose risks that the government is unable to evaluate. Technology is moving so fast that it is difficult to even know what the new risks might be.

> "And he gave it for his opinion, 'that whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together.'"
>
> —JONATHAN SWIFT, *Gulliver's Travels,* 1726

FIGURE 5-38 Consumer fears. Protesters voice opposition to the use of genetically modified organisms (GMOs).

Eating genetically modified foods is dangerous. In the 1990s, a gene from Brazil nuts was used to improve the nutritional content of soybeans. The genetically modified soybeans had better nutritional content, but they also acquired some allergy-causing chemicals previously present in the Brazil nuts but not in soybeans. This outcome illustrates the risk that some unwanted features might be passed from species to species in the creation of transgenic organisms. In this case, all of the genetically modified soybeans were destroyed and this research program was suspended. To date, no evidence has appeared to suggest that consumption of any genetically modified foods is dangerous.

Loss of genetic diversity among crop plants is risky. As increasing numbers of farmers stop using non-genetically modified crops in favor of one or a few genetically modified strains of crops, the genetic diversity of the crops declines. This can make them more vulnerable to environmental changes or pests. The Irish Potato Famine is an example of the value of genetic diversity in crops. In the mid-1800s, much of the population of Ireland depended on a diet of potatoes. Because most of the potato crops had been propagated from cuttings from the same plant, they were all genetically the same. When the crops were infected by a rot-causing mold, all of the potato plants were susceptible and most were wiped out, causing a famine responsible for the deaths of more than a million people.

Hidden costs may reduce the financial advantages of genetically modified crops. When seed companies create genetically modified seeds with crop traits desirable to farmers, the companies also engineer sterility into the seeds. As a consequence, the farmers must purchase new seeds for each generation of their crops. Such increases in long-term costs and dependency on seed companies must be factored in by the farmers.

Another argument sometimes made in opposition to genetically modified foods is that such organisms are not "natural" and, for that reason, must be harmful. This is one argument that is flawed and should not be a cause for concern. Smallpox, HIV, poison ivy, and cyanide, after all, are natural. The smallpox vaccine, on the other hand, is unnatural. Innumerable other valuable technological developments are equally unnatural. There simply is no value in knowing whether something is natural or unnatural when evaluating whether or not it is good and desirable.

In the end, we must compare the risks of producing genetically modified foods with the benefits. The cost-benefit analyses will have to include the potential to reduce food costs and the ability to reduce environmental degradation by agriculture. For example, with genetically modified, pest-resistant crops, farmworkers will greatly benefit from spending less time applying pesticides. These benefits of reduced pesticide exposure will be significantly greater for workers in the less-developed countries, where safety regulations for pesticide use are more frequently ignored. Unfortunately, the difficulties in establishing the risks of genetically modified foods—as well as the ecological magnitude of those risks—ensures that this important issue must be evaluated extremely closely and regulated carefully.

TAKE-HOME MESSAGE 5·13

More and more genetically modified foods are being created using modern methods of recombinant DNA technology. Numerous legitimate fears among the public remain, however, about the potentially catastrophic risks of these foods, given that their development relies on such new technology, and about the long-term financial advantages they offer.