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Frankenfoods

If you've ever eaten popcorn, you've eaten genetically modified food. Actually, almost all of the foods we eat, many of the clothes we wear, and even the pages on which these words are printed come from plant or animal species that have been genetically modified. Virtually all living things that form a pivotal role in our lives—including our household pets—have genetic structures today that have been shaped by conscious human decisions to make them that way.

Let's return to popcorn, because corn is probably the first living organism whose genetic structure was consciously modified by humans to suit their wishes. Beginning about 9000 years ago, the inhabitants of the Balsas River basin of southern Mexico began the process of transforming a plant called teosinte into corn (maize). Over the ensuing 3000 years they undertook breeding experiments that

- softened the hull of the kernel, so that it was more digestible;
- made the kernel stick more tightly to the cob, to reduce wastage; and
- transformed the architecture of the plant from many branches to one stalk, facilitating harvesting.

Eventually, the human experimentation even yielded a product that was more suitable for making tortillas. By 6000 years ago, teosinte had disappeared from fields, replaced with a crop very much identifiable as an ancestor of today's corn.

Although corn was first, human genetic experiments on cattle, rice, trees, horses, peas, wheat, cotton, pigs, and literally thousands of other plants and animals have formed the foundation for much of modern agriculture. The results of such genetic engineering, ranging from crossbreeding to plant grafting, now feed and clothe the world. In recent years, however, people around the globe have begun objecting to advances in the genetic modification of species. Genetically modified (GM) foods—often referred to as **Frankenfoods,** an allusion to Mary Shelley's fictional Frankenstein—are said to pose a threat to human health and the ecological system in which we live. Why, after 9000 years of success with genetic engineering, should people suddenly start to worry that it might yield catastrophic results? Just as importantly, what would be the likely results if we decided to bring genetic engineering to a halt, or even just slow its pace significantly?

The answer to the first question likely centers on the relatively new methods that are being used to produce today's GM plants (and even animals). Instead of crossbreeding two existing plants, scientists are selecting individual genes, sometimes from species far removed, and inserting them into a plant of interest. The result is called a **transgenic species,** because its genes comes from two or more different species. For example, so-called "Bt cotton" is a form of cotton that has had inserted into it a toxin-producing gene from a soil bacterium known as *Bacillus thuringiensis*. The poison contained in the cotton is delivered only to bugs that eat cotton. The delivery of the toxin is so efficient that farmers who plant Bt cotton can use far less pesticides on their fields—pesticides that are toxic not merely to bugs, but also potentially life-threatening to many other species, including *Homo sapiens*.

The concern among people who object to the creation of such GM plants is that they are unlike anything seen before in the 9000 years of genetic engineering on record. There is simply no way to interbreed bacteria and plants. Unlike, say, peas, where crossbreeding of plants with red and white flowers reasonably can be expected to yield plants with pink flowers, when a gene from one species is inserted into another, radically different species, there is no possible way of predicting the result.

Therefore, say the opponents of modern genetic engineering, the results of today's GM experiments might yield transgenic crops that spread from fields into forest or other wildlands, becoming environmental nuisances along the way. Or they might cross-pollinate with neighboring wild plants, producing "superweeds" that could devastate huge swaths of previously productive agricultural lands. Indeed, say GM opponents, we might even end up with transgenic killers, species capable of threatening the continued existence of entire species, perhaps even human beings.

Are such outcomes possible? Yes, say scientists, something very unpleasant and very costly *might* result from modern gene-splicing techniques. But the likelihood is very small, probably even smaller than with traditional methods of genetic engineering, including those dating back 9000 years. The reason is that the current methods are highly targeted, involving the insertion of a single gene, with a known property, into a specific location in the genetic makeup of the recipient species. As a general rule, only *one* change in the recipient species is the result. This is in sharp contrast with older methods, in which a random "shotgun" approach is tried: interbreed two plants (or animals) and see what happens. Sometimes nothing (observable) happens, and sometimes many things change, but it is very difficult to predict just what will happen and whether or not it will be beneficial or harmful.

Given that we have been in the business of modern gene-splicing for about 8980 years less than we have been interbreeding by traditional means, it seems prudent to proceed with some caution, recognizing that there *may* be costs of the new methods that we have not thought of yet. At the same time, however, it is important to recognize that genetic engineering is absolutely central to the economic *and* environmental well-being of the world today, and that its beneficial future is likely to grow, if we let it.

Let's first consider the history of the so-called "Green Revolution," which started 40 years ago. In the mid-1960s scientists used genetic engineering to develop high-yielding varieties of rice and wheat that were subsequently released to farmers in Asia and Latin America. These crops spread rapidly in tropical and subtropical climates that had good irrigation systems or reliable rainfall, literally transforming the state of agriculture—and human nutrition—in dozens of developing nations.

On the nutritional side of the equation, crop yields soared, food prices fell, and both the caloric and nutritional intake of hundreds of millions of people improved sharply. Had there been no Green Revolution, food prices would have been roughly 50 percent higher, and caloric intake in the affected developing nations would have been nearly 15 percent lower. Significantly, both malnutrition and infant and child mortality rates would have been markedly higher.

On the environmental side of matters, the impact of the Green Revolution may have been even more profound. Because the GM rice, wheat, and other crops had much higher yields (in terms of bushels produced per acre), farmers were able to reduce the number of acres planted and still earn higher profits with the crops. Between about 1965 and 1990, for example, it is estimated that genetically engineered Green Revolution crops saved more than 100 million acres of wildlands in India. In recent years, the higher yields from GM crops have reduced forest-clearing in Honduras and the Philippines.

On a global scale, estimates have been made of the total impact of farming techniques and changes in yields since 1950. One expert, Dennis Avery of the Hudson Institute, says that absent these improvements, the world would have lost to agricultural cultivation an additional 20 million square *miles* of wildlife habitat, much of it forest. Given that there currently are 16 million square miles of forests in the world today, this implies that improvements in techniques and crop yields "have saved every square mile of forest on the planet," according to Avery.

Now, not all of this was due to GM crops, but a significant portion was, and the challenges we face in the future may be even greater. Many experts believe that most of the really big yield enhancements from traditional GM techniques have been exhausted. To be sure, improvements using crossbreeding are still being made, but no one believes they will be able to feed the additional 3 billion people who are likely to inhabit the earth by the year 2050. Modern gene-splicing techniques—and their resulting Frankenfoods—have that potential, however. Perhaps just as importantly, modern Frankenfood techniques promise to substantially *improve* the quality of the environment along the way.

Consider Bt cotton, which we mentioned earlier. In the United States, where farmers successfully have used pesticides to protect cotton, switching to Bt cotton has not significantly improved yields. What it has done, however, is permit farmers to drastically reduce their use of pesticides. This reduction in pesticides not only protects nontarget insects and other species in and around the cotton fields, it means there is much less pesticide runoff into streams and lakes. In India the benefits come in a different form. Cash-constrained farmers there use relatively little pesticides, so Bt cotton has enabled them to save only about $10 to $15 per acre on pesticide costs. But because of the low pesticide use, insect-caused crop losses in India historically have been huge. Thus the key impact of Bt cotton is on the yield side: Crop yields per acre in India are pushed up 60 percent when Bt cotton is planted. Higher yields not only raise the income of farmers and help push down prices for consumers, they also protect wildlands from further agricultural intrusion.

In a similar view, a variety of soybeans called Roundup Ready is transforming agricultural methods in the United States and elsewhere. These transgenic soybeans tolerate Roundup, an herbicide that kills many types of weeds and then quickly breaks down into environmentally harmless by-products. When farmers plant Roundup Ready soybeans, which now amount to one-third of the U.S. crop, they are able to switch from far more toxic chemical herbicides to Roundup. Moreover, they often no longer have to use plowing to aid them in controlling weeds. Less plowing means less soil erosion and less damaging runoff into adjacent bodies of water.

The promise of transgenic crops extends far beyond pesticides and plowing, however. For example, salt-resistant tomatoes and other crops have been developed that permit agriculture to take place on otherwise sterile lands, saving fertile savannahs and forests for wildlife. Similarly, crops are being developed that are able to tolerate aluminum, an element that is eminently useful in making airplanes but serves as a crop-killing contaminant in many soils around the world. There are even transgenic crops bred to thrive on the toxic wastes found in the worst industrial dump sites, crops capable of transforming such areas from wastelands to wildlife habitats.

Given the uncertainties and unknowns in any new field of scientific inquiry, it is certainly true that the potential costs of transgenic species—environmental as well as economic—should be carefully monitored and taken into account. Yet it is also important to remember the fate that likely would have befallen humankind had genetic manipulation been stopped in its tracks 9000 years ago. Instead of munching popcorn in front of wide-screen televisions, we might well be tilling teosinte in southern Mexico.