What technology did the American public embrace more rapidly than the telephone, radio, television, personal computer or mobile phone? Genetically engineered foods. More than a quarter of American farmers snatched up seeds for genetically engineered soybeans, corn and cotton (the source of cottonseed oil) within three years of their commercialization. By contrast, it took more than 13 years after the cellphone was available for a quarter of Americans to own one, and 26 years after the widespread availability of TV for it to achieve that same feat. Last year, 90 percent of corn and cotton acreage was planted with a genetically engineered variety; at 94 percent, soybeans managed even greater market penetration.

In Defense of Frankenfoods

BY JAYSON LUSK

It is a bit of a misnomer, of course, to say that the American public embraced genetically engineered foods. Most people didn't know they were eating them. However, a flood of publicity (both hostile and celebratory) is waking up consumers to the fact that much of the food they buy contains ingredients that have been genetically altered.

The term "genetically engineered" is a more accurate descriptor than the more common monikers, "genetically modified organism" or "GMO."

STEVE BJORKMAN


NO!

That's because all living creatures' genes have been modified over time though the pressure of natural selection – and in the case of virtually all plant foods, by human intervention to increase and stabilize yields and to raise quality.

The story of genetically engineered foods would be just one of myriad gee-whiz tales of technological change in agriculture were it not for the controversy this technology has sparked. A variety of concerns about potential health and environmental effects gained traction in Europe when genetically engineered crops first came on the market in the mid-1990s. European regulators adopted a precautionary approach to those crops, failing to approve many of them in a timely fashion despite a paucity of scientific evidence pointing to health or environmental risks. And they mandated labels for foods made from GE crops, a deterrent to their use that is discussed in detail below.

Under threat of sanctions blessed by the World Trade Organization, the European Union has since approved many of the genetically engineered crops that are grown in the United States. But the initial reluctance led to more public skepticism and less adoption than is the case on the other side of the Atlantic.

But that is not the end of the story, at least in the United States. Their consciousness raised by sensationalized documentaries and organized protests against Monsanto (one of the largest producers of seeds for GE crops), many American consumers have become alarmed to learn that they were eating genetically engineered foods. The consequence: some states are considering mandatory labeling for such foods, and some local governments have even banned cultivation of GE crops within their borders.

This is not any easy subject for consumers to master, and many have been swayed by sound bites. Indeed, scientists in favor of genetically engineered foods, as well as businesses with a commercial stake in such foods, have made little headway in advancing their case amid the swirling claims about the technology. That is more than merely unfortunate, because the stakes are so high. For GE crops hold out the best hope of sustaining the productivity growth in agriculture needed to feed the global population at reasonable cost without further polluting the planet. Here, I offer a short primer aimed at cutting through the confusion.

JUST THE FACTS

We would scarcely recognize the ancient ancestors of our modern agricultural commodities. Ten thousand years ago, the plant we know today as corn was about the size of your thumb. Rice and wheat were little more than wild grasses sprouting fragile, barely edible seeds. Only by eating the seeds and replanting the ones that merited the effort did our ancestors – first quite crudely, then more systematically – modify the plants' genes to produce the bountiful harvests we now enjoy.

There is a common view that we should only use those seed varieties and animal breeds that God (or the secular equivalent) gave us. Yet, nature is a moving target. And if one acknowledges man as a part of nature, it is difficult to categorize any of the developments in plant breeding as "unnatural." None of this is to say that new scientific developments shouldn't be subject to safety and environmental evaluations, as is now required of genetically engineered crops, only that the con-

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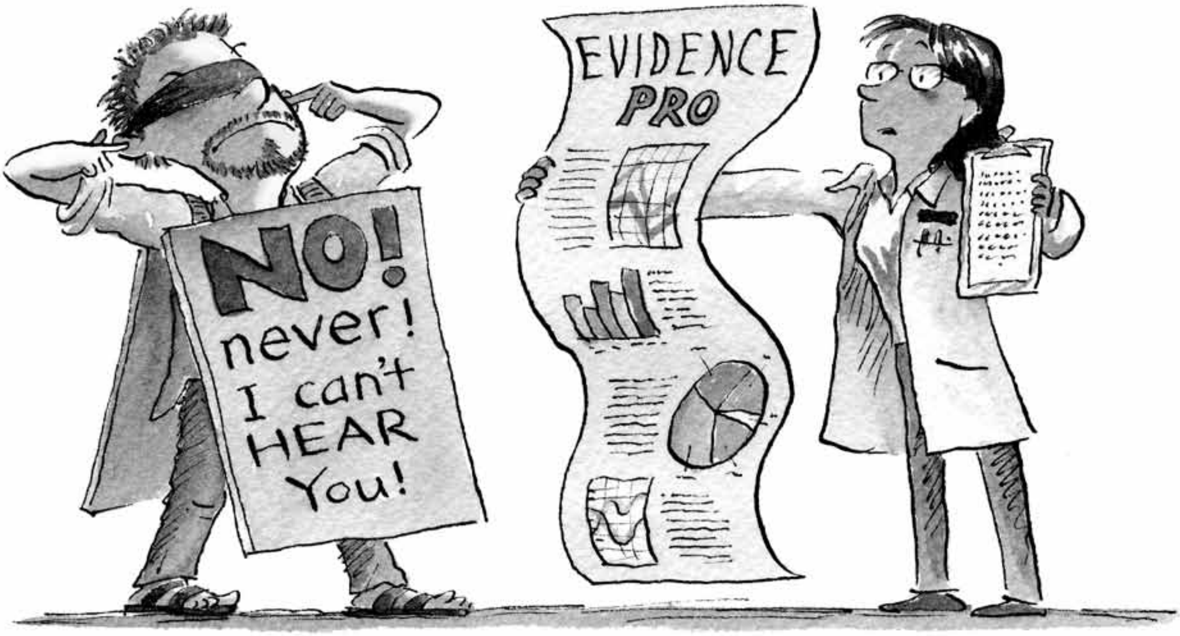


cept of naturalism has little bearing in the historical reality of food and agriculture.

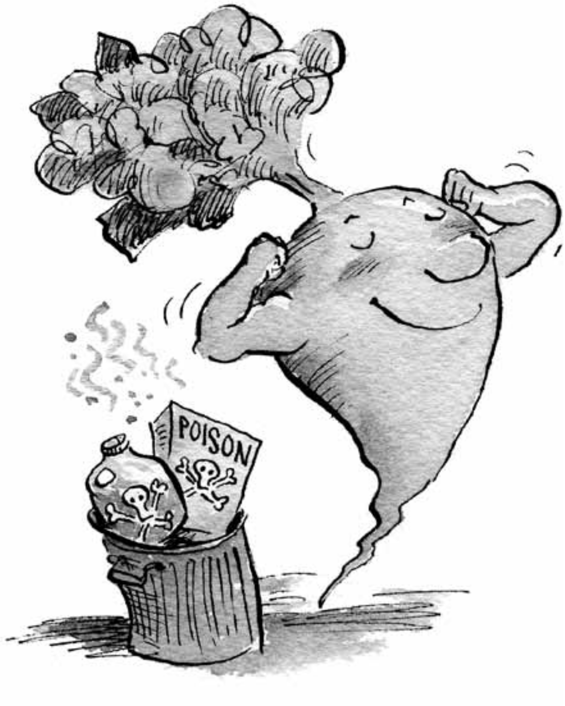
It's easy to take for granted the amount of change that has occurred. Looking just at recent history – say, from the early 1900s to today – corn yields have increased by around 500 percent. Some of the bounty is a result of better farming practices and increased availability of inputs like nitrogen delivered with fertilizers. But much of it has resulted from improved genetics.

That 500 percent increase in yield means that today's farmers could grow the same amount of corn as their great-grandfathers did on one-fifth the acreage or quintuple the output on the same acreage. Indeed, American farmers are now producing much more food than they were in the middle of the 20th century despite the fact that there is less land in production. Not only is this growth vital to keeping the food supply in synch with world population, but it is also sparing millions of environmentally sensitive acres from cultivation.

Yield growth is increasingly dependent on genetic engineering. Use of the commercially available varieties of genetically engineered corn, soybeans and cotton does not increase yields per se (and, in fact, can sometimes reduce yields if the modifications are not introduced into hardy cultivars well suited for local conditions). Rather, these varieties protect against insects and weeds that can reduce yields. Thus, the yield gains in part reflect the ability of GE crops to mitigate downside risks. Risk reduction is valuable to farmers, as are the other benefits that existing genetically engineered crops provide, including labor savings, a reduced need to apply insecticides and the ability to use less-toxic and less-environmentally damaging herbicides.

While the advent of genetically engineered foods has no doubt benefited agribusiness giants, including Monsanto, DuPont and Bayer, the fact that genetically engineered seeds have penetrated the market so rapidly implies that farmers think the higher prices for the seeds are worth it. Though it is less obvious, consumers have benefited too, since more stable

STEVE BJORKMAN



STEVE BIORKMAN

yields lead to greater, less-volatile supplies and thus lower market prices for food.

The primary GE commodities now on the market in the United States have been engineered to survive applications of herbicides that kill weeds or to resist insects by giving plants the ability to produce chemicals that drive them away. Herbicide-resistant varieties of alfalfa, canola, corn, cotton, soybeans and sugar beets are in use. A variety of papaya that has been engineered to resist a virus that was devastating the industry in Hawaii is also in production. Many more plants with commercially useful traits are under development.

THE SCIENCE

Genetic engineering involves the transfer of a gene (or multiple genes) from one species to another through synthetic means. Just because the process occurs in a lab, it doesn't follow that the resulting seeds couldn't have been produced by "natural" means. Of course, some combinations – like the introduction of a fish gene into tomatoes, which was actually done – would never have occurred naturally, and some beneficial natural combinations might never have been noticed.

Resistance to certain herbicides, for example, can also be attained, albeit at a slower rate, via traditional plant breeding. Indeed, many strains of rice grown today are conventionally bred to be resistant to herbicides. Traditional plant breeding requires the breeder to find wild or unusual cultivars that display the trait of interest and repeatedly crossbreed them with a commercial variety until getting an offspring that is similar to the original commercial variety yet exhibits the desired trait. Genetic engineering, by contrast, attempts to speed up the process by moving only those genes of interest into the commercial variety.

Sometimes these genes come from wild variants of the same species (using so-called cisgenic technology) or from entirely different species (using transgenic technology). As the comparison of cisgenic and transgenic technologies suggest, the dividing line between what is and what is not genetically engineered is fuzzy and somewhat arbitrary: Transgenic is often considered genetic engineering, whereas cisgenic is not, despite the fact that both approaches use the same methods and differ only in the origin of the genes transferred.

Some of the unusual cultivars used in aforementioned conventional crossbreeds are created by mutagenesis – that is, exposing seeds to radiation or to chemicals in hopes of random, beneficial, mutations. This approach has been used for more than half a century and is not considered genetic engineering, nor is it regulated as such. In fact, certified organic seeds can arise from varieties produced via mutagenesis.

THE DEBATE

From consumers' perspective, the primary issue with genetically engineered food is its safety. And here, there is near unanimity among scientists that eating such food has no impact on health. The most respected scientific authorities on the subject – among them, the U.S. National Academies of Science, the American Medical Association and the American Association for the Advancement of Science – have concluded that currently approved genetically engineered foods are no riskier than foods bred through conventional means.

It's true that there are a couple of studies, widely publicized by activists who oppose genetically engineered food, like one by Gilles-Eric Séralini, the crusader against genetically engineered food, purporting to show that rats fed genetically engineered corn develop tumors. In this (now retracted) research, however, Séralini used a strain of rat known by researchers to develop tumors in advanced age even under normal conditions. Moreover, the study must be put in the context of a large body of scientific literature. There are literally hundreds of animal-feeding studies (not funded by the genetically engineered food industry) showing no adverse effects from eating genetically engineered foods. American consumers have been eating GE corn and soy for almost 20 years with no scientifically valid evidence of harm.

Critics of genetically engineered food point to rising autism and obesity rates, but these are purely illusionary correlations. Obesity rates were rising well before the advent of those GE foods, and rates of increase in obesity prevalence have slowed in recent years. This sort of naïve correlational thinking must also (absurdly) conclude that the rising number of farmers' markets has also contributed to obesity.

Ultimately, it must be recognized that genetically engineered foods are not a single "thing." To broadly claim that they cause harm lacks precision (not to mention evidence). One needs to tie a specific genetic alteration to a specific type of harm. It is possible to imagine genetic modifications that could trigger allergies (the purely hypothetical example of inserting a peanut gene into corn comes to mind). But most of the commercially used applications on the market today are not of this sort, and new GE crops that were couldn't pass regulatory muster.

Certain varieties of genetically engineered corn convey insect resistance by producing the bacterium *Bacillus thuringiensis*, which kills many sort of insects, but is far less toxic to humans than many insecticides approved for agricultural use. In fact, that bacterium is an approved and widely used pesticide in organic agriculture. The Food and Drug Administration requires that new genetically engineered crops meet standards of "substantial equivalence" – that is, they must be the same as the non-genetically engineered crop except for the trait of interest. And the new traits of interest are checked against a library of known allergens before approval is granted.

Whatever might be said about the advantages and disadvantages of the U.S. regulatory approval process for GE crops (which requires clearances from not only the FDA, but also the Agriculture Department and the Environmental Protection Agency), it is important to note that genetically engineered crops have been approved by many major governments all over the world, with different political and regulatory processes. The United States is the largest producer of GE crops in the world, but they are also extensively grown in Argentina, Brazil and Canada, and have been approved

and grown in smaller volume in Australia, Germany, Spain and the Czech Republic.

THE GREAT LABELING FIGHT

Despite the fact that genetically engineered corn and soybeans have been widely grown since the mid-1990s, momentum to require mandatory labeling of GE foods in the United States did not gain much traction until quite recently. Although a mandatory-labeling ballot initiative failed in Oregon in 2003, California's Proposition 37 reignited the issue in 2012. Early polling indicated that the measure would sail to victory, but a blitz of advertising by anti-Proposition 37 groups (mostly funded by large food and biotech companies), along with unfavorable editorials in major newspapers and opposition from scientific organizations, stemmed the tide. Proposition 37 failed, though narrowly, receiving almost 49 percent of the vote. The following year, there was a similar ballot initiative in Washington State, which failed in another squeaker.

Those narrow defeats have encouraged labeling advocates, who are backed financially by several large "natural" and organic food companies in addition to some consumer-advocacy groups. And they have had some success with state legislatures. Connecticut and Maine passed labeling laws in 2013 that will go into place if a threshold number of other states pass similar laws. This year, Vermont became the first state to pass a mandatory labeling law for genetically engineered food, and shortly thereafter two Oregon counties passed ballot measures *banning* the cultivation of genetically engineered crops within their borders.

It is uncertain whether Vermont's law will withstand challenges in federal court. Ten years ago, Vermont passed a similar, but narrower, law requiring labels on milk from cows that had been given a productivity-enhancing bioengineered hormone called bovine somatotrophin. The law was overturned in 1996, with a federal court concluding that the labeling requirement violated producers' First Amendment speech rights since the FDA had found that milk from cows treated with the hormone was not substantively different from milk from untreated cows.

Polls conducted in Vermont while the labeling law was in place are revealing. They showed only about half of consumers even noticed the change on the label, and of those who did notice, 79 percent interpreted the label incorrectly.

But legal and psychological uncertainties aside, mandatory labeling is increasingly looking like a winner in state legislatures. That explains why, in April, the food, farm and biotech lobbies have changed strategy, backing their own federal legislation – the Safe and Accurate Food Labeling Act (HR4432) – that would pre-empt state laws. The law, introduced by Kansas Republican Mike Pompeo, would reassert the authority of the FDA to determine both safety and the need for labeling. It would only require labeling if the FDA deemed there to be a "material difference" between the bioengineered and conventional food that entailed a health or safety risk. The bill posits that the use of bioengineering, in itself, does not constitute a material difference, and it would place proof requirements on food companies making claims that their products had no genetically engineered ingredients. It is unclear at this point whether the bill will get anywhere.

Labeling advocates often assert consumers' right to know what is in their food. It is a bit unclear how far these rights should extend – is there also a right to know, for instance, which seed variety was used or the location of the farms that produced the crops – or whether such rights should be balanced against the

costs of providing the information? However, the right-to-know argument has proved compelling for many, and it certainly makes for appealing sound bites.

Labeling proponents also argue that labeling costs would be small (only the cost of ink), and point out that food companies routinely change packaging for other reasons. They are correct: The cost of adding a label would, indeed, be trivial for most consumers if – and this is a big if – food companies choose to respond to the requirement by continuing their ingredient sourcing as usual and simply slap a "may contain genetically engineered ingredients" label on their products.

But food companies have argued that they will be eager to avoid the label (fearing consumer backlash and losing market share to competitors who eschew genetically engineered ingredients) and will switch to more expensive non-genetically engineered ingredients. If labeling policies create this sort of dynamic, the costs for the average household could be substantial, and would be likely to disproportionately affect the poor, because they spend a higher share of their income on food.

At present, it is impossible to know whether the costs would be closer to the cost of ink or to the several-hundred-dollars-annually figure that has been tossed around by anti-label groups. Some who believe the latter point to the European example to predict what might be expected in the United States. European countries already mandate labeling, and food companies there have largely decided to avoid ingredients made from genetically engineered plants. As a result, it is difficult to find less-expensive genetically engineered foods in most European countries. (The law, by the way, does not apply to meat from animals fed genetically engineered crops, and the European Union imports large amounts of GE soybeans from the United States for animal feed).

This would suggest that mandatory labels would substantially drive up costs and limit choice on this side of the Atlantic. However, the situation is less analogous than it might initially appear because Europeans had a preexisting labeling law, and farmers and food companies simply chose not to adopt GE crops. By contrast, in the United Sates, genetically engineered crops are the rule rather than the exception, and dropping them could entail substantially more disruption. Moreover, GE corn is likely to be grown regardless of the desires of food retailers, because more

STEVE BIORKMAN

than 40 percent of the U.S. corn crop is currently devoted to ethanol-fuel production.

The most substantive legal issue in the labeling debate relates to the question of when, and under what conditions, the government can compel food companies to "speak" (that is, to add certain labels and disclosures). A legitimate argument could be made that such labels could be justified for ingredients that demonstrably affect human health, as is the case for, say, sugar, salt and fat content – all of which must be posted on nutritional-fact panels on food packages. However, the best scientific evidence available suggests no such safety or health risks from currently approved GE crops, and more generally, that the use of genetic engineering is a technological process, not a food-safety outcome.

One related concern with mandatory labels is that their mere presence might imply a safety risk, when, in fact, the evidence suggests there is none. This perspective was well articulated by Cass Sunstein, a University of Chicago law professor and President Obama's former regulatory czar, who is certainly not a political conservative. In a *Bloomberg View* column last year he wrote:

> GM labels may well mislead and alarm consumers, especially (though not only) if the government requires them. Any such requirement would inevitably lead many consumers to suspect that public officials, including scientists, believe that something is wrong with GM foods – and perhaps that they pose a health risk. Government typically requires labeling because it has identified such a risk (as in the case of tobacco) or in order to enable people to avoid or minimize costs (as in the case of fuel-economy labels). A compulsory GM label would encourage consumers to think that GM foods should be avoided.

THE POLITICS OF GENETICALLY ENGINEERED FOODS

Given the contentious nature of policies governing GE food – and the growing plague of political partisanship – it isn't surprising that the debate has taken on ideological dimensions. Many of the early protests over genetically engineered food in the United States

STEVE BJORKMAN

originated with environmental groups that have historically been aligned with the left. The fact that today's most popular GE crops were commercialized by large agribusiness and chemical companies has also tended to situate opposition to the technology among anti-corporate sentiments on the left.

While it is possible to be pro-biotechnology without being pro-Monsanto, such a nuanced position is difficult to maintain in the current atmosphere. It seems that many suffer from what might be called Monsanto Derangement Syndrome, buying into all sorts of conspiracy theories. Yet genetically engineered foods are no more synonymous with Monsanto than hamburgers are with McDonald's. When anti-Monsanto became de facto anti-biotechnology, many left-leaning commentators chose to swim with the tide. Thus emerged a (justifiable) belief that many on the left were anti-science on the issue of biotechnology. In the words of journalist Keith Kloor (writing for *Slate*), opponents of genetically engineered food "are the climate skeptics of the left."

Although there is some truth to this observation, the political reality is more complex. Indeed, it is possible to find strong sentiments against GE food expressed by some members of the far right. Often, this can be tied to populist attitudes, naturalistic-purity motives (sometimes religiously driven), or concerns about the viability of family farms in the age of genetic engineering.

An important distinction is the greater willingness of those on the left to regulate business than those on the right. Stated differently, there are questions of science: What are the risks of climate change or eating genetically engineered food? And then there are normative questions: Given that risk, what should be done about it? Even if the left and the right agreed on the level of risk, accord on the degree of government intervention shouldn't necessarily be expected. By analogy, thoughtful criticisms of climate-change policies on the right aren't criticism of the quality of the science, but rather skepticism about the ability of government to intervene fairly and effectively.

In surveys I led that were conducted in California leading up to the vote on Proposition 37, liberals were much more likely to be in favor of mandatory labeling laws than were conservatives. However, other research has shown mixed results on the question of whether liberals or conservatives are more likely to think that eating genetically engineered food is unsafe. In a tracking survey I've run for the past 15 months that has recorded more than 15,000 responses, consumers in the United States are asked to rate a series of issues in response to the question, "How concerned are you that the following pose a health hazard in the food that you eat in the next two weeks?"

One of the issues is "genetically engineered food." The results reveal a slight tendency for conservatives to be less concerned about GE food than liberals (liberal respondents report, at most, an 8 percent higher level of concern than conservative respondents, holding constant other socio-economic characteristics). However, closer investigation reveals liberals are more concerned about *all* the food issues included on the survey (among them, salmonella and mad cow disease); concern about GE foods relative to all other food issues was no different among liberals and conservatives.

One paradox of sorts that has arisen from the desire for stricter regulation of genetically engineered crops is that large agrichemical companies would be handed a ticket to increased market power. Many universities and non-profits lack the resources and know-how to navigate the regulations required to develop and commercialize GE crops. To the dismay of many, universities have entered into partnerships with seed and agrichemical companies precisely because of the difficulties associated with regulatory and commercialization costs.

It is tempting to believe that stricter biotech regulations hurt corporate interests, but such regulations often make it hard for non-incumbents to break down barriers to getting their innovations to market. Established agribusinesses that have teams of lawyers and lobbyists are often in a better position to absorb the regulatory costs than smaller competitors. The goal shouldn't be to keep large agribusinesses out of the seed and biotech market, but rather to make sure that the barriers to entry are low enough that anybody can compete with them.

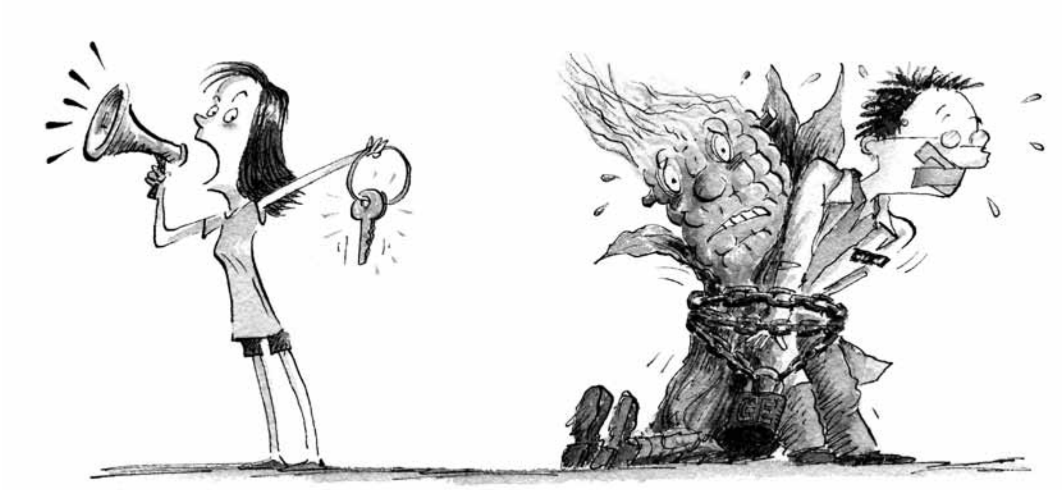
THE FUTURE

The dramatic swings in support for labeling of GE food that were seen during the ballot initiatives in California and Washington reveal that public opinion on the issue remains malleable. However, as the issue is increasingly discussed in the news, attitudes are likely to harden. Research shows that once people form opinions about a complicated issue, they often ignore evidence that conflicts with their beliefs. So the next few years could prove critical in charting the future of genetically engineered food.

One promising sign: The elite media has begun to express more nuanced (and positive) views about food biotechnology than was the case in the past. Even many critics have conceded that eating genetically engineered foods is safe and have shifted concerns to issues of market power, monoculture cropping and development of pesticide resistance, despite the fact that genetic modification is not intrinsically linked to any of these issues. No doubt, some of the shift reflects a desire to gain some distance from the label of anti-science that has been (rightly) pinned on the anti-vaccine and climate-change-denial movements. But, it is also recognition of the potential benefits that biotechnology can provide to society, as well as to agribusiness.

My view is that the biggest costs of policies restricting or mandating labeling of genetically engineered foods are not the likely impact on prices at the supermarket, but the possible creation of a climate hostile to agricultural innovation – a climate that retards technological change. Surveying the landscape of genetically engineered crops currently in development by university scientists, non-profits and biotech firms suggests just how much is at stake. A few examples:

- Staple crops grown in developing countries are being engineered to produce micronutrients missing in the diets of some of the world's poorest citizens. Golden rice and golden bananas, for example, are genetically engineered to produce beta-carotene, which can address vitamin A deficiencies that lead to hundreds of thousands of deaths and cases of blindness every year. Other examples include high-iron beans and nutritionally enhanced cassava and sweet potatoes.
- Insect resistance is being incorporated into staple crops in developing countries. For example, *Bacillus thuringiensis* cowpeas are being studied for use in western Africa. Built-in insect resistance would allow subsistence farmers who do not have access to traditional chemical pesticides to reduce volatility in yields.
- Nitrogen use can be reduced. For centuries, farmers have routinely applied nitrogen-rich fertilizers to increase crop production. Indeed, these fertilizers are critical to maintaining the sorts of crop yields we've come to depend on. But fertilizer runoffs compromise



STEVE BIORKMAN

The biggest costs of policies restricting or mandating labeling of genetically engineered foods are the possible creation of a climate hostile to agricultural innovation, a climate that retards technological change.

the quality of groundwater and threaten the environmental stability of streams and lakes. Some legumes, like soybeans, are able to grab nitrogen from the air, and thus have no need for nitrogen fertilizer. And scientists are attempting to engineer other staple crops, including corn, to do the same. Other research is focused on genetic modifications that improve the nitrogen and phosphorous utilization of crops, reducing the amount that farmers need to apply.

• There are other potential environmental benefits from genetic modification. Crops are being engineered to be more drought-tolerant and to make better use of scarce water supplies. Methane production by cows, which contributes to climate change, might be cut by feeding specially engineered grasses to the animals. Speaking of grasses, homeowners will soon be able to buy herbicide-resistant seeds for their lawns.

• Some genetic modification is focused on making higher-quality products. The Flavr Savr tomato, which had a longer shelf life and thus could be allowed to ripen on the vine, was sold briefly in the mid-1990s before being withdrawn. Apple breeders are on the cusp of introducing the Arctic apple, which does not turn brown when it is cut up and exposed to air. High-oleic edible oils, which are low in saturated fat and have zero transfats, have been engineered to improve the shelf life and healthfulness of packaged foods.

Biotechnology is not the answer to all of the world's food problems. And proponents of genetically engineered food have, at times, been guilty of overpromising. But given the confluence of tightening water supplies, climate change, rising demand for meat in emerging-market countries like India and China, and a growing world population, genetic engineering will be necessary if we are to feed future generations at reasonable cost.