

THE PHARMAGEDDON RIDDLE

Did Monsanto just want more profits, or did it want to save the world?

BY MICHAEL SPECTER

Each fall, the environmental group Greenpeace holds a conference, in an effort to make its priorities as clear to corporate executives and investors as they are to its two and a half million members. The gathering, at a London hotel, is a chance for one of the world's most determined environmental organizations to remind skeptics about its goals, and to let people know what it is willing to do to achieve them. For its latest event, in October, the organizers had scheduled appearances by the two principal antagonists in one of the most unsettling issues of our age: the production and use of genetically modified foods.

No controversy—nuclear power, global warming, or even the eerie possibility of cloning human beings—occupies a larger space in that disturbing arena where science, social values, and commerce collide. Lord Peter Melchett, an organic farmer and a former Labour minister, who has led Greenpeace's efforts to stop the use of biotechnology in agriculture, was enlisted to debate Robert B. Shapiro, the chairman and C.E.O. of the international conglomerate Monsanto, who is the technology's chief evangelist. It was a perfect moment for such a conversation: genetically modified foods, with few labels to identify them, have become the most widely adopted products in modern farming history. A decade ago, no transgenic crops were commercially available anywhere on earth; in 1995, four million acres had been planted; by 1999, that number had grown to a hundred million. In the United States, half of the enormous soybean crop and more than a third of the corn are the products of biotechnology.

Shapiro believes that altering the seeds of soybeans, beets, and cotton to resist herbicides is the barest beginning of what he and many others consider a revolution in agriculture, food, and, ulti-

mately, human health. This new science, he says, is the principal reason that "there now exists an opportunity to create a genuine science of nutrition, something that has never existed in human history." But, where Monsanto sees unlimited promise, Greenpeace has found little more than profit motive and peril. In Europe, and particularly in the United Kingdom, opposition to agricultural biotechnology has become almost a religion—one endorsed vigorously by Prince Charles. "I happen to believe that this kind of genetic modification takes mankind into realms that belong to God, and to God alone," he has said. Lord Melchett, for his part, will stand trial this week for mowing down an experimental government crop of genetically modified maize, in Norfolk, not far from his estate.

Just a few days before the conference, Shapiro called to say that he couldn't make it. Instead, his image was beamed from America onto a video screen. Shapiro appeared grim, defensive, and defeated. After more than a year of protests, Europe was shutting Monsanto out of its markets. So, for the most part, was Brazil. Two of Monsanto's biggest competitors—the Swiss pharmaceutical giant Novartis and the British drug-maker AstraZeneca—were about to combine their agricultural divisions into one business and sell it, essentially abandoning their involvement in crop biotechnology. Japanese companies had decided to stop using genetically altered products, and Mexico's largest tortillamaker had ended its reliance on modified corn. Under pressure from Greenpeace, Novartis stopped using gene-modified soy and corn in its Gerber brand of baby food. Heinz announced it would do the same.

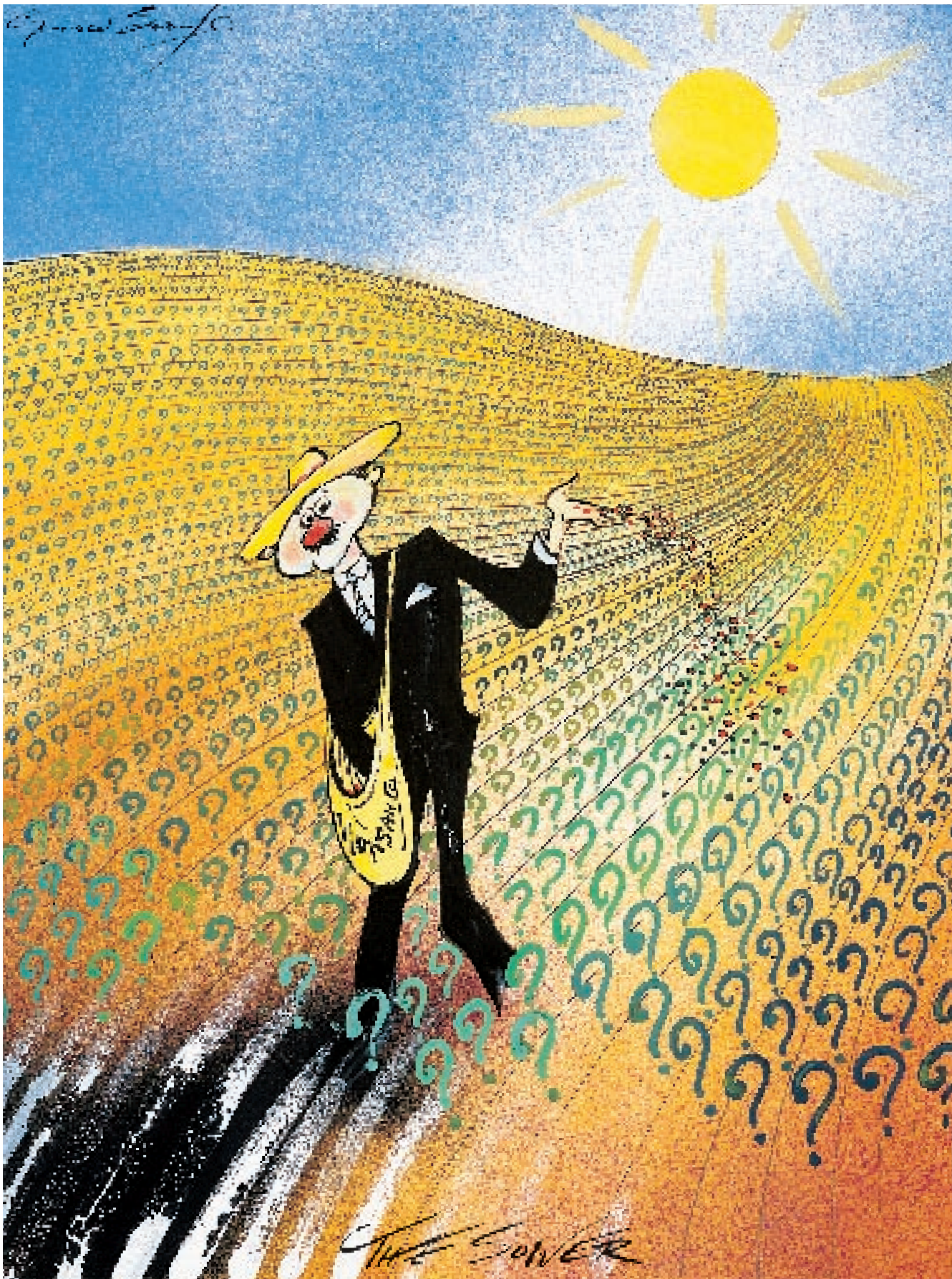
By last fall, the tension in Europe had spread to America. A highly publicized—though very preliminary—report from a researcher at Cornell sug-

gested that the eggs of monarch butterflies (the great fluttering pandas of the insect world) might not survive on the pollen of modified corn. American farmers began to fear that European ports would send their tankers full of grain back to sea, and late last summer the world's most prominent miller—Archer Daniels Midland—instructed its confused and disheartened clients to segregate modified crops from all others and haul them to market in separate containers. In November, the Food and Drug Administration was set to begin its first full series of hearings on the use and safety of genetically altered foods.

Shapiro's faith in the technology remained absolute, though. He told the Greenpeace audience that without biotechnology farmers would never meet the world's rapidly growing demand for food. At the same time, Shapiro was surprisingly contrite, sounding like one of those Chinese leaders who during the Cultural Revolution were made to walk through the streets in a dunce cap. "Our confidence in this technology and our enthusiasm for it has, I think, widely been seen, and understandably so, as condescension or indeed arrogance," he said. "Because we thought it was our job to persuade, too often we forgot to listen."

Lord Melchett didn't know how to respond, so he delivered his prepared remarks. He said that Greenpeace was ready to join arms with Monsanto if only the corporation would renounce its use of agricultural biotechnology and embrace organic farming as the principal solution to the world's crop needs. It was a bit like offering moral support to General Motors, if only the automobile-maker would abandon the internal-combustion engine in favor of the bicycle. At one point, Shapiro was asked if he felt like a bully imposing unwanted foods upon the

GERALD SCARFEE



To opponents, Monsanto has become a cauldron of evil, a place where people have manipulated nature to create " Frankenfoods."



“And now, if I may, I’d like to put You on hold for a moment while I have a few words with Mammon.”

world. “Well, if I’m a bully,” he replied dryly, “I certainly don’t feel myself to be successful at it.”

The Monsanto Company, which was founded in St. Louis in 1901, became one of the world’s most successful chemical concerns, starting out with products like saccharin, aspirin, acrylic, and fertilizers, and eventually selling PCBs, plastics, dioxin, and the defoliant Agent Orange. When Robert Shapiro took control of the company, in 1995, it had more than twenty thousand employees in dozens of countries. Shapiro quickly made it clear that he intended to start over. Within three years, the company had spun off its chemical operations and committed itself to biotechnology and a cleaner world. Its new, officially stated goal was to help people “lead

longer, healthier lives, at costs that they and their nations can afford and without continued environmental degradation.”

Monsanto’s herbicide Roundup has been one of its best-selling products for more than twenty-five years. In 1996, the company introduced Roundup Ready seeds, which were engineered to resist the herbicide, and the seeds have dominated every market in which they are sold. Under Shapiro’s direction, Monsanto established marketing agreements with some of its largest competitors in the seed business; in other cases, it simply bought the company. In 1996, Monsanto and DeKalb Genetics signed a contract to share the licensing of corn and soybean seeds; the same year, Monsanto bought Agracetus, a cotton-and-plant biotechnology company. In 1997, Monsanto purchased the soybean com-

pany Asgrow Agronomics and Holden’s Foundation Seeds. Monsanto also formed partnerships with the giant grain company Cargill and with Millennium Pharmaceuticals, which specializes in genomics and gene-sequencing technology. By last year, after an eight-billion-dollar spree, Monsanto had made a greater commitment to producing genetically modified crops than any other organization in the world. It seemed like a wise investment. Monsanto was not only leading the race for new genetically engineered foods but its stock price had doubled. Most analysts on Wall Street predicted that the growth would continue.

Shapiro, who is sixty-one, had ambitions that extended far beyond selling seed to farmers. When he took over the company, he had looked at the four main strands of its business—agriculture, pharmaceuticals, food, and chemicals—and decided that by abandoning chemicals he could combine the other parts into one. More clearly than his competitors, he understood that common foods could reduce cholesterol, that fruits could be turned into life-saving vaccines, and that genetics could improve the staples that millions rely on for daily sustenance. A lawyer and a former urban-affairs professor, Shapiro had become the unlikely Johnny Appleseed of genetic modification, promoting his vision of a world where there are not simply foods and drugs but foods that take the place of drugs. “This is an important moment in human history,” Shapiro told me the first time we met, in Monsanto’s offices at Chicago’s Merchandise Mart. “The application of contemporary biological knowledge to issues like food and nutrition and human health has to occur. It has to occur for the same reasons that things have occurred for the past ten millennia. People want to live better, and they will use the tools they have to do it. Biology is the best tool we have.”

In some ways, the shift wasn’t all that profound: for centuries, farmers have been saving seeds and breeding them over generations to make better plants. All the plants we eat (corn, wheat, potatoes, rice) and many that we don’t (orchids, roses, Christmas trees) have been manipulated in an effort to make them last longer, flower later, look better, taste sweeter, or grow more vigorously in stubborn soil. (Cabbage, broccoli, cauli-

flower, and kale, for example, all come from the same wild ancestor, although hundreds of years of breeding have turned them into four entirely different foods.) In the nineteenth century, Luther Burbank, America's first great plant breeder, spent his life crossing the seedlings of plants in order to create hybrids robust enough to thrive. Gregor Mendel's experiments with peas started to change all that. He proved that there was a system to inheritance. Some traits are more powerful than others, and those always win out.

But modern agriculture, modern medicine, and the information society itself didn't really begin until 1953, when James Watson and Francis Crick discovered the structure of the DNA molecule, which carries the information that cells need to build proteins, and to live. Today, it's as if scientists in half the laboratories on earth spent their time cutting bits of DNA from one cell and splicing them into others. Nature may be random, but genetic modification allows plant breeders to be specific.

This type of manipulation has long been accepted in medicine, largely because the risks seem well contained and the benefits easy to understand. Insulin produced since 1983, for example, has been largely based on a synthetic gene that is a replica of one found in humans. Yet playing with the molecular foundations of the food supply has seemed to many people like the agricultural equivalent of cloning a lamb—it crosses some unacceptable boundary. It is one thing to mix different varieties of potato or cassava, but researchers have now advanced genetics to a point where they have implanted specific genes from a fish that can swim comfortably in the icy Atlantic into the cells of others that cannot, and even, in experiments, into a strawberry, in order to help it ward off a frost. For some people, that's taking science a step too far.

Even many of those who believe in biotechnology are plainly afraid of it, especially in Europe, which has always been more skeptical about genetic research than America. To critics, the technology seemed to embody the worst excesses of American industry—fancy gadgets that solve no problems. Worse than seeming gimmicky, however, the technology was usually invisible. "If Monsanto had spent a lot of money and pro-

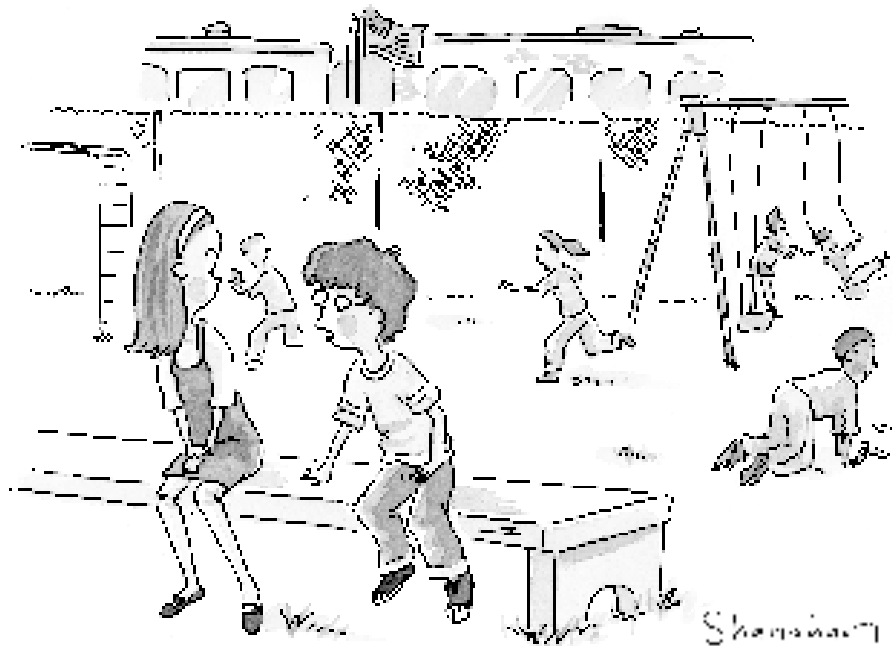
duced an egg with no cholesterol, I just don't think we would be having these problems today," Michael Lipton, an economist at the Poverty Research Unit of the University of Sussex, told me. Lipton is an expert on nutrition, farming, and demographics in the Third World, and believes that genetically modified products will help feed the world. "I always say that electricity is a fantastic invention," he continued, "but if the first two products had been the electric chair and the cattle prod, I doubt that most consumers would have seen the point."

The fear and the hope surrounding biotechnology are very much on display in Basel, a tidy, conservative city dominated by the pharmaceutical company Novartis. Not long ago, I had lunch in a company dining room there. A card was placed at every plate. On one side there was a color picture of an ear of rich, golden corn. On the back was a photograph of an ear of corn whose kernels were mossy and white. This corn was infected with a particularly hideous mycotoxin fungus, a disease that genetically modified corn is engineered to prevent. "This maize-product you are eating today is specially cooked for you and contains Bt corn from Germany," the card said, referring to corn that had been genetically modified with a bacterium, *Bacillus thuringiensis*, and continued,

"We should talk more about the real benefits of Bt corn than of potential negative effects for tomorrow."

The corn tasted fine, and shortly after lunch I met with the Novartis chairman and C.E.O., Daniel Vasella, a physician who is one of agricultural biotechnology's most eloquent supporters and one of Switzerland's most well-known corporate leaders. Vasella is an open man with an ever-present smile, but, when I asked him why he had decided to stop using genetically modified ingredients in Gerber baby food, he seemed tense. "We are not missionaries," Vasella said. "We sell things. No company can prosper by telling customers what is good for them." He went on, "This is not just about plants. It's about our myths, our history and culture. It's about what we put in our mouths and in our babies' mouths. When you go to somebody's house, they offer you food. That is a ritual of every life. What is more basic—and what could be more frightening—than playing with that? Of course, it scares people. How could something this important *not* scare people?"

Monsanto's success in altering the food supply had played into this fear and reinforced an image that Shapiro has worked tirelessly to shed, especially in Europe, where the company is seen as a symbol of corporate imperialism. Supporters of genetically modified agricul-



"Recess does things to a man."

ture like to stress the technology's potential to address hunger and disease, but Europeans are not hungry. What they initially got were herbicides they didn't want and long-lasting tomatoes they didn't need. Nor did it help that in 1998 Monsanto had tried to introduce its products to a continent still recovering from the shock of mad-cow disease, when signs of opposition to novel foods, and to science itself, were everywhere.

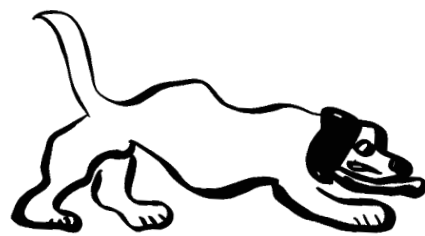
To its opponents, Monsanto has become a cauldron of evil—a place where people have manipulated nature to create grotesque “frankenfoods,” which they have shoved down millions of unsuspecting throats. “This whole world view, that genetically modified food is there so we have no choice but to use it, is absolutely terrifying,” Lord Melchett told me. “And it is wrong. There is a fundamental question here: Is progress really just about marching forward? We say no. We say it is time to stop assuming that discoveries only move us forward. The war against nature has to end. And we are going to stop it.”

Genetically modified plants have been around since the early eighties. There was opposition from the start, but the movement was never particularly strong until, on March 3, 1998, a patent was issued jointly to the United States Department of Agriculture and to the Delta & Pine Land Company, of Scott, Mississippi, America's biggest cottonseed producer. The patent's title—“Control of plant gene expression”—was too bland to draw much attention, but Monsanto noticed. So did the Rural Advancement Foundation International, an environmental organization, based in Canada, that monitors the loss of genetic diversity. The patent presented the best evidence yet that agricultural biotechnology could harness and reroute the basic elements of life. It also presented the dangers of doing so, and crystallized, as nothing had before, the deep emotions associated with this powerful new tool.

The patent refers to a set of molecular “switches” that can turn genes essential for reproduction on and off. The final step is particularly ingenious: a plant is forced to make a toxic protein that will sterilize its seeds after it is fully grown. In a brilliant stroke of public relations, the Rural Advancement Foundation Inter-

national called the new gene the Terminator, after the robotic killer played by Arnold Schwarzenegger, and sterile-seed technology quickly became a potent symbol for how genetically modified crops could cause a break in nature. Worse than that, such seeds could threaten more than a billion poor people throughout the developing world, for whom saving harvested seeds is essential.

Commercial farmers in America and Europe, by contrast, rely on hybrid seeds, whose vigor diminishes in every generation; to get the best possible crop, farmers must buy new seeds every year. For companies like Monsanto, the benefits seemed obvious. The ability to shut off a seed at the end of the year restricts its



EMPATHY

Once in a small rented room, awaiting
a night call from a distant time zone,
I understood you could feel so futureless
you'd want to get a mermaid

tattooed on your biceps. Company
forever. Flex and she'd dance.
The phone never rang, except for those
phantom rings, which I almost answered.

I was in D.C., on leave from the Army.
It was a woman, of course, who didn't call.
Or, as we said back then, a girl.
It's anybody's story.

But I think for me it was the beginning
of empathy, not a large empathy
like the deeply selfless might have,
more like a leaning, like being able

to imagine a life for a spider, a maker's
life, or just some aliveness
in its wide abdomen and delicate spinnerets
so you take it outside in two paper cups

instead of stepping on it.
The next day she called, and it was final.

use, and permits a company to protect it as intellectual property. Just as those cumbersome registration codes on computer software are intended to make it impossible for friends to swap copies of Microsoft Word or Lotus Notes, this would mean that a buyer could use the altered seed only once.

In addition, the technology has the potential to address a worrisome environmental issue: since such seeds can end a plant's life cycle, they may insure that unwanted traits do not cross-pollinate and spread to other species. The technology would also permit a producer to load a variety of characteristics into a seed; corn, for example, could have switches to fight drought or repel frost or kill a pest, like the often devastating European corn borer that appears every few seasons. Depending on the crop, the season, and the location of the fields, the technology could offer protection from the sun, or help the seed absorb its rays. A farmer could decide how much he wanted to pay for such a seed in the same way

I remember going to the zoo
and staring a long time

at the hippopotamus, its enormous weight
and mass, its strange appearance
of tranquillity.
And then the sleek, indignant cats.

Then I went back to Fort Jackson.
I had a calendar taped inside my locker,
and I'd circle days for which I
had no plans, not even hopes—

big circles, so someone might ask.
It was between wars. Only the sergeants
and a few rawboned farm boys
took learning how to kill seriously.

We had to traverse the horizontal ladder,
rung after rung, to pass
into mess hall. Always the weak-handed,
the weak-armed, couldn't make it.

I looked for those who didn't laugh
at those of us who fell.
In the barracks, after drills,
the quiet fellowship of the fallen.

—*Stephen Dunn*

that an air traveller chooses a ticket. In theory, you would get what you paid for.

Deploying genes in this way would essentially turn something physical into something intellectual, and that, Shapiro argues, is what the world today is all about. "The historical model, the industrial-revolution model we live by now, says that our quality of life has to do with possession of things, of stuff," he told me one day as we talked in his office. "But it turns out that information doesn't occupy a lot of stuff and can create enormous value." As he spoke, he waved his arms so energetically that he knocked the glasses from his face. "Biotech is a subset of information technology. It's a way of encoding information in nucleic acids as opposed to encoding it in charged silicon. It's a way to create value without creating more stuff. I put a gene, which is information, into a cottonseed, and I don't have to spray stuff on the crop in order to control insects. That strategy strikes me as the right one for agriculture, just as it strikes me as

the right one for post-industrial society."

In May of 1998, Monsanto offered \$1.9 billion for Delta and its vast cottonseed business. The strategy made perfect sense for a company aggressively pursuing every aspect of agricultural biotechnology, and every way to protect its inventions. But the Terminator seed also turned Monsanto, and its chairman, into even bigger targets.

People at Monsanto have never seemed to understand why the company has been damaged so badly in the public-relations war over biotechnology when other companies, such as Novartis and DuPont, have largely escaped the punishment. (They might have asked Greenpeace. "Of all the companies in this business," Lord Melchett told me, "Monsanto is the most committed to agricultural biotechnology. They are no worse than DuPont. But DuPont can survive without genetically modified organisms, and I don't think Monsanto can. So we have had an opportunity with them that we

did not have with anyone else.") The skittishness was evident throughout the company headquarters, in a sprawling complex in suburban St. Louis. Giant tunnels and perfectly trimmed paths connect the buildings; the place has a grim feeling, like a hospital. Although people were helpful and frank, you could see apprehension in their eyes. When I tried to bring a camera on a tour of an experimental greenhouse, permission was refused; when I met with an allergy researcher to talk about his work in genetics, he immediately mentioned poor morale, public rancor, and layoffs.

Shapiro was not in town. Although Monsanto headquarters are in St. Louis, he lives in Chicago, with his second wife and their two children, who are two and four. Shapiro's advisers had told him to stay out of the public eye, and he was difficult to reach, until one day an E-mail popped onto my computer screen telling me that, "in view of the confusion" that had characterized my attempts to see him, Shapiro wanted to make sure I knew how to find him. From that day, Shapiro—who has a reputation for being remote—became the most accessible person at Monsanto. He always replied to mail on the day it was sent, often within minutes. "As you can probably tell," he wrote in one message to me, "I'm less busy than the media accounts might have you believe."

Shapiro is one of America's best-paid executives. He earned nearly twenty million dollars in 1998, and more the year before. The three words I most often heard from employees and friends to describe him were "cold," "brilliant," and "intimidating." He can be all those things. Still, it would be hard to find a more unlikely symbol of American agriculture—or of corporate power. A thin, almost painfully contemplative Jew from the Upper West Side of Manhattan, Shapiro dresses in oversized designer sweaters and baggy, rumpled pants; he wears a tie about five times a year and appears to regret it each time. He seems almost uncomfortable with his power and influence.

Shapiro attended the Hunter School and Horace Mann and then joined the second class of students admitted directly to Harvard College as sophomores, in 1956. "That was a mistake," he told me. "There were twelve of us. And

I was immediately intellectually over my head, which is something that I couldn't quite admit to myself or to anyone else. I was used to being in places where I could be a star, and Harvard is the big leagues and I didn't feel like a star." Shapiro taught himself to play guitar and found refuge in music. "I was doing folk stuff back in the days when it was pretty cool to do," he said, smiling at the memory. "I was literally sitting in cafés and doing small shows all around New England." (Shapiro has two older children, from his first marriage, who took the music gene one step farther and started Veruca Salt, which, until it disbanded two years ago, was one of the Midwest's most successful alternative-rock bands.)

Shapiro displayed the type of political leanings one would expect from a child of West End Avenue. He protested the war in Vietnam and—like "the rest of my generation"—was not fond of chemical companies or of giant companies in general. I wondered what had brought an antiwar activist, who seems even now to have more in common with Joni Mitchell than with John Mitchell, to the leadership of a multinational corporation. "You mean when did I fall?" he asked, laughing.

After Harvard, Shapiro attended Columbia University Law School and stayed on to teach there. He became interested in urban problems and held jobs in the Johnson Administration, including one as a special assistant to the Under-Secretary of Transportation. He watched, first hand, as the Great Society failed to deliver on its promise, and he began to sense that government was not going to cure the world's ills. He returned to teaching for a while, at Northeastern, and then at the University of Wisconsin, before spending several years as general counsel at the General Instrument Corporation, which his father ran. In 1979, he moved to the pharmaceutical company G. D. Searle, as its general counsel. Shapiro, who loves games—he was for years obsessed with the Japanese board game Go—at first saw corporate life as a giant puzzle. "It was the best game I'd ever seen," he told me. "It was the most complicated game. It had so many moving parts and so many different kinds of skills you had to have in order to make it work. It took me a

while to realize that this is not a game. This is one of the realest things you get to do in life."

He learned that in 1982, when he became the head of the NutraSweet operation at Searle. "One of the moments in my evolution that I will always remember is after we had launched the product, and I was feeling really good because it seemed to be succeeding," he said. "It was the first business I'd ever been given a chance to try to create, and it was working well. So I was feeling proud of myself. But then I began getting letters from kids and from parents of kids, mostly diabetics, who had never before been able to have something like Kool-Aid or Jell-O. And I realized what was going on. We were doing something important for people. It wasn't just making a handheld calculator, as we had done in my previous incarnation. This thing actually mattered.

"That did it for me," he continued. "I mean, look, I am very well compensated, and I like that. It's nice to have some of the perks that make life easier. It is even nice when you talk with people that they probably laugh at your jokes more than you deserve because of who you are. But the thing I never would have guessed about this job is that it gives you a chance to make a difference in the world. When you go home at night and you talk to your family about what you're working on, it isn't like 'Gee, I designed a really cool paper clip today.' It's about the earth, it's about the environment, it's about food. It's about health and nutrition. Those are deep, ancient things for civilization, and they are for the people."

At that point, Shapiro stopped talking, because he was fighting back tears. It was our first meeting, and I wondered if this reserved and powerful corporate leader was acting. After a few moments, he apologized. "You asked me before how this makes me feel," he said, referring to the very personal opposition that he and Monsanto face almost every day. "There are two things that most of us feel. We feel hurt, and we feel angry." Later, he added to that: "We were really proud to get out front the way we did"—with biotechnology. "In retrospect, it seems incredibly naïve, but it's the truth. We had real leadership; we had worked hard to do it. We had shown faith in this science when others were dubious,

SHOWCASE BY WILLIAM KLEIN

RISING SON

The arrangements on Femi Kuti's new record, "Shoki, Shoki"—soaring horns, taut guitars, and half-spoken vocals—are a form of birthright. Femi is the oldest son of Fela Anikulapo-Kuti, the Nigerian bandleader, saxophonist, and activist who blueprinted the music known as Afro-Beat in the late sixties. Until his death, from AIDS, in 1997, Fela offered up a steady stream of resistance, musical and otherwise, to the oppressive Nigerian government, which responded with repeated jailings and beatings.

It's not easy to shine in the shadow of a dead father, especially one who has been deified. But, unlike such would-be messiahs as Julian Lennon and Ziggy Marley, Femi has the advantage of experience—at thirty-seven, he has spent half his life onstage—and of irrefutable talent. In comparing father and son, critics have seized mostly on matters of appetite. Fela was famous for his 1978 mass marriage, to twenty-seven brides. Femi has one wife. Fela smoked marijuana almost non-stop. Femi does not use the drug. The musical contrasts are subtler. While Fela recorded sprawling, jazzy anthems, Femi's dance-pop-influenced songs are concise and eclectic, and he forsakes journalistically specific jeremiads for generic anthems about sex ("Beng Beng Beng") and empowerment ("Blackman Know Yourself").

In 1998, Nigeria's military leaders banned "Beng Beng Beng" for its sexual content. When the country returned to civilian rule, many expected the ban to be lifted. It was not. The new President, General Olusegun Obasanjo, headed the Nigerian regime in 1977, when soldiers raided Fela's compound, cracked his skull, and threw his mother out a window. Governments, it seems, have birthrights, too.

—Ben Greenman



and it all seemed to be working. So we painted a big bull's-eye on our chest, and we went over the top of the hill."

In 1997, not long after Roundup Ready canola began to be planted widely, a farmer in Canada reported that some seeds had "escaped" and cross-pollinated with a related species of weeds which was growing on the edge of his fields. DNA testing proved him right, and genetically modified agriculture had produced its own public aberration: a hybrid "superweed" that included the genes engineered specifically to make a plant resistant to herbicides. If resistant crops managed to cross with nearby weeds, then herbicides—like Roundup—would become useless.

This kind of pollution did not start with modified seeds, and it is not likely to become a threat in the developed

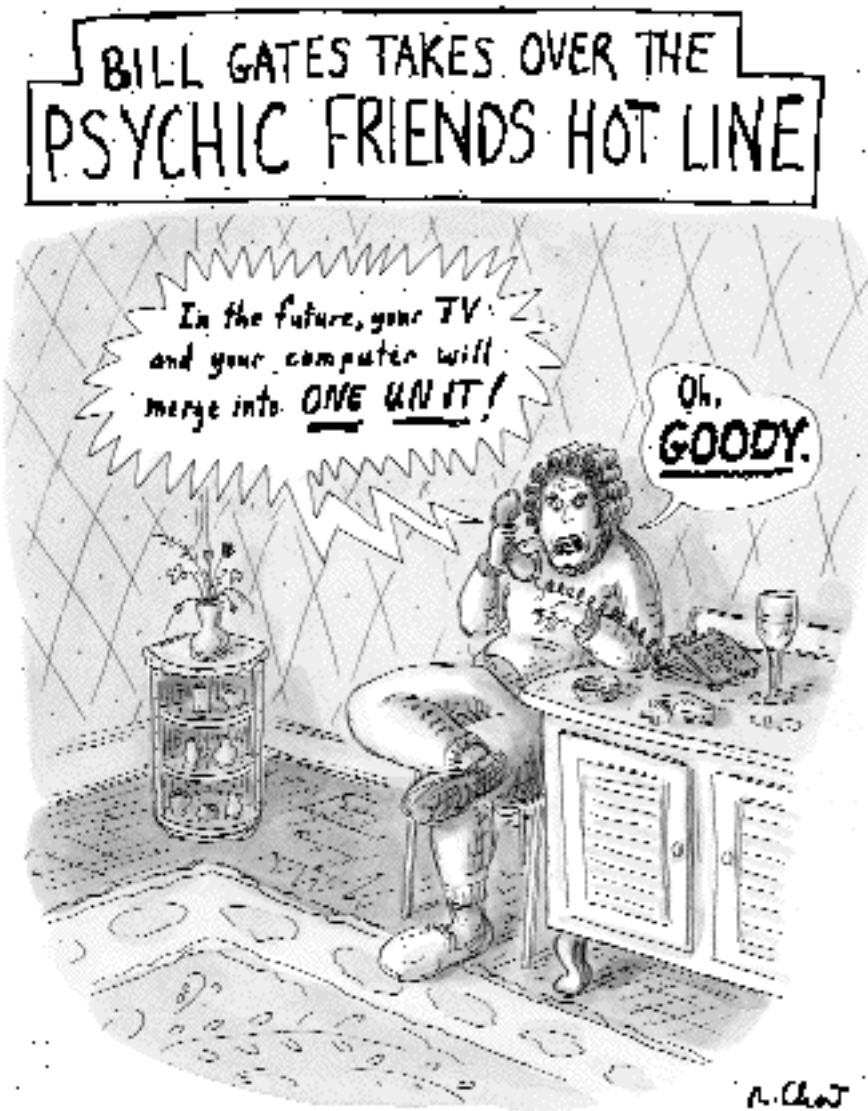
world, because most major crops have few relatives nearby. Yet the possibility that modified genes can "escape" and cross with neighbors in the fields has led to much discussion about the risks of moving DNA between species. The basic genetic structures of most species, even of species as apparently remote from each other as humans and, say, lettuce, have far more similarities than differences. Yet, when you move DNA from one species to another, there is always a possibility that the new combination will act unpredictably.

"I'm not going to tell you that an alien wave of superweeds will take over the planet," Rebecca J. Goldberg, a senior scientist at the activist organization Environmental Defense, told me. "I'm not going to tell you we can't address the problem. But we don't really know what the problem is. And we are moving

ahead so rapidly in thousands of ways with so many genes and so many products. And I do worry how you can accurately balance the risks, because we don't have the right information."

With the tremendous rush to market genetically modified seeds—nearly two billion dollars' worth were sold last year—many biologists worry that there still isn't enough known about transgenic crops. Many varieties of corn, tomatoes, soybean, and squash have been approved for unlimited use, and by some estimates there are now thought to be thirty thousand products made from modified crops. Anyone who has dipped sushi in soy sauce, eaten bread, pasta, ice cream, candy, or processed meats (not to mention cornflakes) has almost certainly consumed genetically modified food. And the speed with which the products have entered our lives concerns many people. "So confident are the technicians of the safety of their products that each one is seen as no more than an arbitrary mix of independent lengths of DNA," the popular British geneticist Steve Jones writes. "Their view takes no account of the notion of species as interacting groups of genes, the properties of one . . . depending upon the others with which it is placed." Virus-resistant crops, for example, contain viral genes in all their cells. But viruses can introduce genetic material to their host cells, which means that these crops may, in theory, be able to create new diseases rather than defend against them.

Jones and other scientists argue that the genetic engineering of seeds ignores a basic fact of evolution: the action of a gene—or any protein—can depend on the species in which it is located. The most vivid example of that involved research by the seed company Pioneer Hi-Bred, where, in 1995, scientists placed genes from a Brazil nut into a soybean, to help increase levels of the amino acids methionine and cysteine, which made the beans more nutritious for animal feed. The plan worked, but there was an unforeseen demonstration of what can happen in the food chain when just a few molecules of DNA are altered: many people are allergic to Brazil nuts. If one of these people were to eat a cake made with soy that contained the Brazil-nut protein, the results could be deadly. In this case, science succeeded.

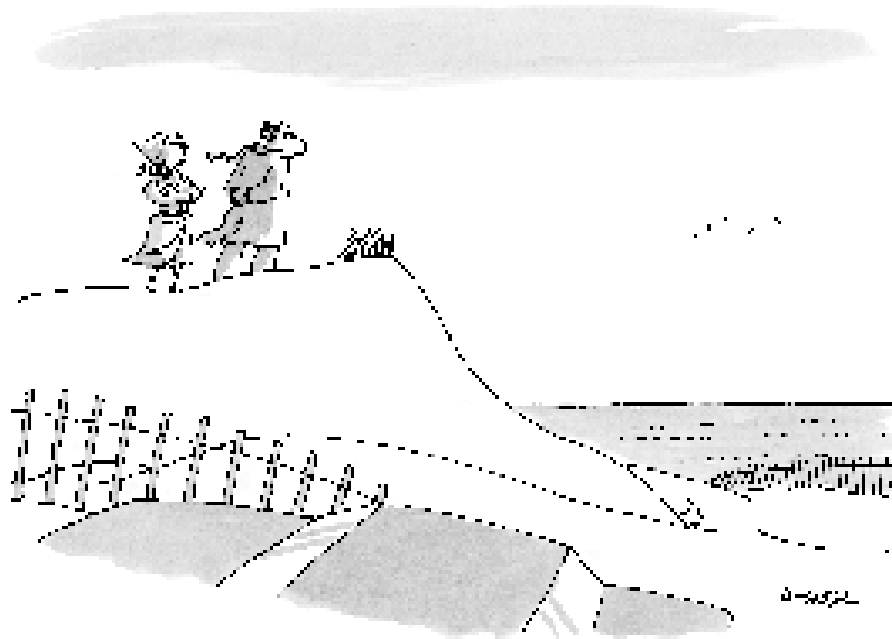


The Brazil-nut soybean was never eaten. Pioneer took blood from nine people in a laboratory, and stopped the experiments when the serum tested positive. Still, with such research occurring in countries that have weak regulatory systems, similar mistakes could have powerful consequences.

Shapiro understands the concern. "When you start talking about large-scale introduction of dramatic traits in combination with each other, you are dealing with systems that are so complicated that no one can effectively model them," he said. "You can start with running field trials, just as when you introduce a new drug you run clinical trials to see if people really keel over. But, just as the human body is a subtle and complicated thing, it may be that only one time in a million some side effect happens. And your testing won't reveal that. It has to be out there first. So what you have to keep asking yourself is: 'Suppose the worst happens, what are the consequences?'"

Many in the environmental movement have demanded that the "precautionary principle" be applied with special vigor to genetically modified foods, arguing that potential risks, no matter how remote, must be given more weight than any possible benefit, no matter how great. "It's the only safe way," Lord Melchett told me recently at the Greenpeace headquarters, in North London. "Because with all this stuff you are just dealing in speculation upon speculation. Hope upon whim. They talk about these great discoveries. But what do we really have?" The precautionary principle, when interpreted this way, would make it difficult to answer such a question, because it would prohibit investigation unless the outcome was known in advance.

But the most striking recent example of the precautionary principle involves the case of John E. Losey, an assistant professor of entomology at Cornell University, and his research on the monarch butterfly. Last year, the British science journal *Nature* published a short letter by Losey and two of his colleagues about the effects that Bt in a genetically modified type of corn had on the larvae of monarch butterflies. Bt is found commonly in soil, and it produces a toxin that can destroy the digestive tracts of worms and other pests but is harmless to



"Well, you've brought me down to the sea again, to the lonely sea and sky. Now will you take me back to Vegas?"

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mammals. Organic farmers use Bt spray liberally. Rachel Carson wrote supportively about it in "Silent Spring," and Lord Melchett told me that he has used it on his farm (he has also used Monsanto's Roundup). Bt spray, however, is chemically fragile and easily broken down by sunlight or washed away in the rain. So scientists decided to put it directly into plants; that way, plants create their own insecticides.

Losey examined how monarchs responded, in a laboratory, to Bt corn pollen, and in his study asserted that three-day-old monarch larvae that had been reared in a laboratory on milkweed leaves dusted with Bt pollen had a mortality rate of forty-four per cent. *Nature* rejected an article on Losey's study, but agreed to print a short "scientific correspondence" about his work. It was an instant sensation. The study was seized upon as "proof" that genetically modified organisms are deadly; one newspaper wrote, for example, about "butterflies bearing grenades." "It's the smoking gun," said Peter Roderick, who on behalf of the Friends of the Earth brought some of the first lawsuits in England against genetic modification. "What more needs to be said?" But a laboratory is not an open meadow, which is where

monarchs like to lay their eggs, and several studies have shown that the pollen diminishes rapidly within three metres of the cornfield's edge, and that corn pollination is usually complete before monarchs begin feeding.

"How many monarchs get killed on the windshield of a car?" asked Anthony M. Shelton, who is a professor of entomology at Cornell, and a colleague of Losey's. Shelton has long urged that farmers build a "natural" refuge, a sort of moat containing traditional crops, or crops without Bt genes, around a genetically modified field. That would insure genetic diversity: insects that become resistant to the insecticide for modified crops would mate with neighbors living on traditional plants nearby, and their offspring would then be susceptible to the insecticides.

The monarch study has made for some touchy personal relationships—what one administrator described to me as "Bt football"—at Cornell. Losey, a shy but self-possessed man in his mid-thirties, has been put in an awkward position; bickering with tenured members of one's department has never been a fast track to success. But he isn't in retreat, either. "I think it is easy to sit back and say we would have known this," he



"I can't understand a word you're saying, Roger. Have you got a gun in your mouth?"

told me. "But the study was not done before, and now we need to look at what it means. I take no side. I am supposed to look coldly and objectively at any pest-management tactic and assess its risks and benefits. When we did this paper, there was one other lab working on this issue. Now there are a dozen. That's the way it should be."

Because science and politics have become so entangled, it has been hard to pick rationally through the facts. The monarch-butterfly letter—or "killer corn" study, as it was often called—was released in the middle of the lengthy storm over the Terminator gene. The two were often lumped together. With the Terminator, Monsanto finally decided it couldn't win. In June, a few months before the Greenpeace conference, Gordon Conway, who is an agricultural ecologist and the head of the Rockefeller Foundation, publicly urged Monsanto to abandon the gene. Conway is a committed advocate of agricultural biotechnology, but he had decided that the gene carried with it too

much dangerous social baggage. So even though Monsanto did not yet own the company that holds the patent (and never would: at the end of 1999, Monsanto withdrew its proposal to purchase the Delta & Pine Land Company, after an antitrust inquiry by the Justice Department), and even though the technology does not yet exist, and nobody can say for sure whether it would even work, or when, Shapiro announced that Monsanto would not pursue, develop, or ever use the Terminator. It was among the first times in the history of science that such a prominent discovery was disavowed years before it was even clear what its value might be.

Late last fall, I asked Lord Melchett if he thought that Monsanto had hit bottom. "No, it hasn't, actually," he said, confidently. "Not by a long shot."

As the Dow rose in the last two years, Monsanto's stock fell from a high of sixty-three dollars to thirty-five dollars at the end of December. (Last week, it had recovered, to fifty.) Just before Christ-

mas, Monsanto even became something of an international joke, when the company's caterer in London announced with great fanfare that, for the safety of the employees, it had banned genetically modified food from the cafeteria at Monsanto's U.K. headquarters.

Shapiro's vision of a unified "life sciences" company that relied on biotechnology to create foods and drugs began to fade. Consolidation has become routine in both the agriculture and the pharmaceutical industries, and after more than a year of speculation that the company would break into pieces—and after many merger discussions with competitors—Monsanto announced, on December 19th, that it would join with Pharmacia & Upjohn. By the end of 1999, the company was worth less than twenty-five billion dollars—not much more than what most analysts say its pharmaceutical division, Searle, which Monsanto bought in 1985, would be worth by itself. (In 1998, Monsanto almost completed a merger with American Home Products, a deal that would

have valued it at more than thirty-four billion dollars.) At the same time, Monsanto's Celebrex, a painkiller for arthritis that may also play a role in cancer prevention, had just become the most profitable new drug in American history, earning more than a billion dollars in its first year on the market, and Monsanto herbicides were selling better than ever.

One of the many organizations that oppose Monsanto (the Internet is filled with web sites like "MonsantoSucks" and references to "MonSatan") quickly described the merger with Pharmacia as Pharmageddon for Monsanto. "The reason there is controversy about this has nothing to do with biotechnology," Shapiro told me last fall. "This is about power. It's about them saying that if you want to make changes in people's lives or introduce new technology, you . . . are going to have to go through us. And if we don't approve, we are going to bring you down."

If you drive out of Naples for more than ten miles, on any road and in any direction, you will roll past fields of fennel, apricots, lettuce, onions, artichokes, cabbage, olive trees, and tomatoes. Especially tomatoes. This region is home to several of the world's most prized varieties, and among them one stands out: the plum-shaped San Marzano. According to Neapolitan tradition, pizza was invented as a vehicle for the consumption of the San Marzano. Ash from the eruption of Mt. Vesuvius created a soil rich in potassium and other minerals which is not found anywhere else on earth. Like wine from Bordeaux or the tobacco in Cuban cigars, tomatoes grown there have a special taste.

Eduardo Angelo Ruggiero's family has grown tomatoes outside Naples since 1919. Ruggiero is a sweet-tempered forty-two-year-old man with short, dark hair and wire-rimmed glasses. He has three children who plan to grow tomatoes, too. They will have to do it somewhere else, though, because Ruggiero's farm no longer operates here. "The last ten years have been disastrous," he told me one day when I went to tour the barren fields with him. "In the eighties, this was the No. 1 tomato-producing region in Italy. Now it is No. 4 or 5."

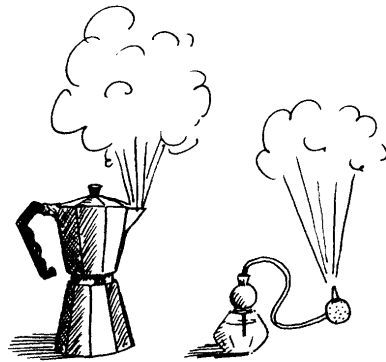
That's because a mosaic virus—a simple, common, but devastating dis-

ease—has taken over the fields. The infected plants become tall, stringy, and thin, making it hard for them to soak up water and impossible to protect the fruit from sun. "The tomato was born here," Ruggiero told me. "Now I think it's dying here. We understand that genetics could help, but the question is political. I myself have mixed feelings. I am afraid that if we grow tomatoes differently they will taste like every other tomato in the world. But there is also a truth. We have lost ninety per cent of our production in the past decade."

Ruggiero and others in the region sought from the government funding for genetically altered seeds, and researchers say it should be easy to create a plant that could withstand the virus. In Italy, however, as in most of Europe, there are regulations against such intervention. "TV every day is telling us the products are dangerous," he said, "and are being dumped on Europe against our will."

Not every country has had this experience. In Kenya, the national Agricultural Research Institute, with considerable help from Monsanto, has created a sweet potato that is protected against similar viral attacks. Sweet potatoes are an important food in Africa: they contain more calories and a greater array of micronutrients than any other crop. By inserting in the sweet potato viral proteins from the outer coat of the sweet-potato feathery-mottle virus, the researchers appear to have conferred immunity from a number of other common viruses as well. In Mexico, a similar approach has been used. In this case, Monsanto donated the genes to the Mexicans, but only after they agreed to insert them solely in varieties of potato used in Mexico.

In Italy, however, seed companies must present a certificate to farmers' cooperatives stating that their products



have not been genetically modified. At harvest time, farmers are required to do that, too. Then food processors, distributors, and, eventually, supermarket chains all have to provide signed affidavits showing that their products are, as the Italians say, "biological," because, Ruggiero told me, people there refuse to tinker with nature.

But tinkering with nature is what farmers do, and so in thinking about genetically modified crops one runs into a crucial question: Is a plant perfectly natural if its genes are formed in a combination that has been arrived at over generations of breeding but polluted and dangerous if those same genes—the identical little snippets of DNA—are shot into the plant walls with a tungsten-coated gene gun? "This just drives me insane," Susan McCouch, a rice specialist who also teaches at Cornell, told me. "If you look even briefly at the history of plant breeding, then you know that every crop we eat today is genetically modified. Every one. Human beings have imposed selection on them all. So don't ask me what is natural and what is not. Because I have no idea."

If genetically modified crops are to fulfill their promise, they will have to do it in the Third World. Developments that Europeans dismiss as a joke matter deeply there. (The delayed-ripening tomato, initially marketed by Calgene, a company now owned by Monsanto, is a perfect example. To take genes that control ripening in fruit and slow them down may mean little in countries where produce is plentiful, refrigeration is cheap, and the roads are always open, but in Africa and Asia up to forty per cent of all vegetables rot in the field or are lost to pests.) Still, none of these advances are likely without large increases of public funding for farmers. "There is not enough incentive," Gordon Conway, of the Rockefeller Foundation, told me. He has been singularly effective in arguing that biotechnology must play a critical role in raising the level of prosperity in the developing world. "You have these two giants locked in a horrible battle," he said. "The fight may hurt Monsanto, and it may hurt Greenpeace. But the real casualties are going to be truth and the poor."

The need for new solutions to feeding the world is almost the only issue on

which both sides seem to agree. New methods of farming, particularly the use of chemical fertilizers and herbicides, helped to more than double world food production over the past forty years. The number of hungry people fell drastically, despite a huge population increase. But this success came at the cost of tremendous erosion and loss of arable land. In addition, rapid urbanization has put new pressures on water resources; since the eighties, there has been a decline in the growth of crops-per-acre in most of Asia and Africa. Yet, according to a projection released last October by the International Food Policy Research Institute, the world demand for rice, wheat, and maize will increase forty per cent by the year 2020.

If the politics of genetically modified food has never been so anguished, the scientific prospects have never seemed more promising. Charles Arntzen and colleagues at Cornell's Boyce Thompson Institute for Plant Research, for example, are tantalizingly close to develop-

ing a vaccine for hepatitis B and one for diarrhea that could be incorporated into the cells of a banana. The benefits would be enormous, particularly in places where refrigerators, sterile needles, and hygiene are always in short supply. Bananas can be grown in the countries that need them. They are cheap, simple to distribute, and babies can eat them as easily as adults. Arntzen told me that it will soon be possible to grow enough bananas on a single four-acre plot to protect a mid-size African country—his example was Uganda—from hepatitis B.

The most important recent development involves the world's most important crop: rice. At least a third of the world's population depends on rice, but it is a poor source of vitamins. According to UNICEF, more than a hundred million children suffer from Vitamin A deficiency; millions lose their eyesight as a result, and at least two million die each year from related infections. But in January a team led by Ingo Potrykus, of the Swiss Federal Institute of Technology, in

Zurich, and Peter Beyer, of the University of Freiburg, in Germany, published a report showing how they had introduced into the rice plant three genes that complete the genetic pathway needed to produce beta-carotene—which is then broken down into Vitamin A. The result has been called Golden Rice, because of its color (beta-carotene turns the rice yellow), and also because of what it can accomplish. "When you can eat Vitamin A in your rice," Arntzen told me, "this one accomplishment of genetic engineering could alleviate more suffering and illness than any single medicine has done in the history of the world."

The gap between scientists and humanists has narrowed in the last fifty years, but it would be foolish to pretend that it has disappeared entirely. When I told Lord Melchett that I wanted, really, to write about the science of genetic modification, he was appalled. "If you write something, it shouldn't be about the science," he told me. "You'd be missing the point. People do things for all sorts of reasons that are rational, but they are not scientific or technical. Why does somebody buy a Rolls-Royce or a Mercedes? It's a box with four wheels. But nobody says you are completely irrational to buy an expensive car. If it's acceptable to choose your car based on emotion and not science, why should it be wrong to choose your food that way?"

I didn't ask him if he really thought it was acceptable to buy a Rolls. But I understood his fear. When frozen food was introduced, in the nineteen-twenties, people who were concerned about the effects of keeping food in a freezer for weeks or longer tried to ban it. Genetically modified products are new enough so that similar fears are easy to understand. The comparison that Greenpeace and many other opponents like to make is to nuclear power—a technology that seems to be in eclipse, despite having fundamentally changed the world. When it comes to promise, and potential peril, the pharmaceutical industry itself provides a better analogy: the development of antibiotics and vaccines has helped double life expectancy in most countries in the last century. Penicillin alone has saved millions of lives. But every technology has risks and benefits, and the same is true for food and drugs. People die from eating peanuts and shellfish



"I hate what we've become."

every day. Allergies to penicillin still kill a few people every year in the United States, and aspirin causes a wide range of serious illnesses, and even many deaths.

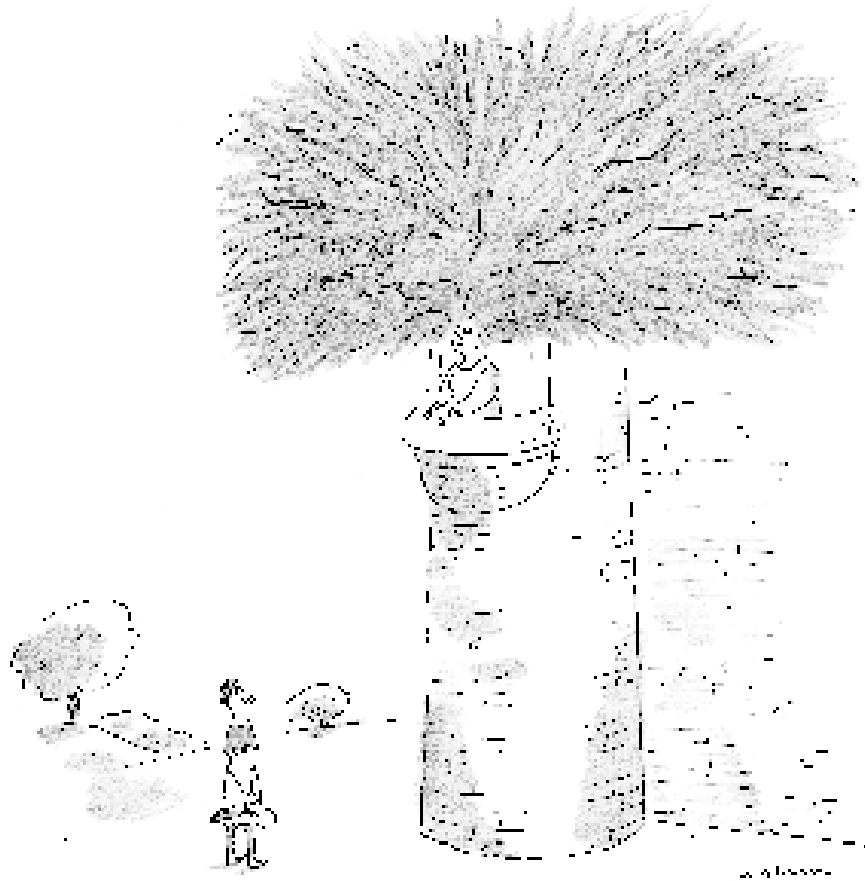
Politics, not science, is now guiding the discussion about genetically modified products, and that makes people like Gordon Conway impatient. When we discussed the zealous way the precautionary principle is currently being applied, for example, he said, "There could be no benefits for anybody, because it could never be proved in advance that there would be no risk. I can think of no better definition for the word 'Luddite.'"

On an overcast day at the end of March, Monsanto stockholders gathered in Skokie, Illinois, to vote on the merger with Pharmacia. Shapiro told me before the meeting that he didn't know what to expect: protests were possible and security was tight. Yet there wasn't one placard in sight, and only about a hundred and fifty people turned up for the meeting, which was held at the North Shore Center for the Performing Arts, a high-tech concert venue surrounded by a string of malls. Most of those present were retirees from Searle, which is just down the road.

Shapiro appeared on the stage in casual slacks, a blue cotton shirt, and no tie. The Monsanto motto, "Food, Health, Hope," was projected on a screen behind him. He whipped through the proceedings in nine minutes. He talked about "convertible perpetual preferred stock," and requirements to change the company name to the Pharmacia Corporation. The vote that ended the era of Monsanto as an independent company was approved, as one shareholder noted, "in less time than it's going to take me to find my car keys." Shapiro thanked everyone and pointed out that "this is a momentous day in the history of our company."

Afterward, I asked Shapiro if he felt at all wistful. He smiled bleakly. "You always feel that way when you change something special," he said. "It doesn't mean it's bad or wrong. It's just new."

The Monsanto name will now remain attached solely to the agricultural part of the business, which may eventually be sold, so that the new company can focus on pharmaceuticals. Shapiro



"I don't know about hair care, Rapunzel, but I'm thinking a good cream rinse plus protein conditioner might just solve both our problems."

will relinquish the title of chief executive in the new Pharmacia Corporation, staying on for the next eighteen months as non-executive chairman, a job in which he will work mostly to smooth the merger with the board. When that chore is finished, Shapiro's career at Monsanto will be over.

"You know, Bob Shapiro is probably the greatest visionary we have in American agriculture," Charles Arntzen told me. "But it's never easy being that far ahead of the pack. I've spent a lot of time in Texas in my life, and they have this expression there for a guy who is out on a limb; they say he's a ridge rider. And Bob Shapiro has been riding that ridge for a really long time. Sometimes those people get where they are going, but usually not. Usually, they get picked off."

After one of our final conversations, I realized that, for all I knew, Bob Shapiro, a native of the Upper West Side and a specialist in urban life, wouldn't

know which end of a shovel to plant in the earth. I assumed that to him this great game with seeds and chemicals was just that—a fantastic abstraction, like Go. So I sent him a note, asking if, as the head of one of America's biggest seed companies, he had ever planted a garden. It was a late winter Sunday, but he replied at once.

"Oddly enough, as I signed on to get my E-mail today I was (and am) surrounded by catalogs from White Flower Farm, Wayside Gardens, Shepherd's Seeds and Johnny's Selected Seeds," he said. "As soon as I finish my E-mail, I'm going on the web to place my spring orders. My father was an avid gardener, and so am I. We have a place in Michigan where I grow mostly flowering perennials, but also vegetables, fruit and berries. I love growing stuff, I love making compost—it all seems miraculous to me. It's also a rich source of metaphors for everything important in life." ♦