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TRESPASS

Claire Hope Cummings

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TRESPASS

"I have the feeling that science has transgressed a barrier that should have remained inviolate."
—Dr. Erwin Chargaff, biochemist and the father of molecular biology

Claire Hope Cummings

Hidden inside Hilgard Hall, one of the oldest buildings on the campus of the University of California at Berkeley, is a photograph that no one is supposed to see. It's a picture of a crippled and contorted corncob that was not created by nature, or even by agriculture, but by genetic engineering.[1] The cob is kept in a plastic bin called "the monster box," a collection of biological curiosities put together by someone who works in a secure biotechnology research facility.

What the photo shows is a cob that apparently started growing normally, then turned into another part of the corn plant, then returned to forming kernels, then went back to another form—twisting back and forth as if it could not make up its mind about what it was. It was produced by the same recombinant DNA technology that is used to create the genetically modified organisms (GMOs) that are in our everyday foods. When I saw this photo, I knew it was saying something very important about genetic engineering. I thought it should be published. But the person who owns it is frankly afraid of how the biotechnology industry might react, and would not agree. In order to get permission even to describe the photo for this article, I had to promise not to reveal its owner's identity.

What the distorted corncob represents is a mute challenge to the industry's claim that this technology is precise, predictable, and safe. But that this challenge should be kept hidden, and that a scientist who works at a public university should feel too intimidated to discuss it openly, told me that something more than just a scientific question was being raised. After all, if the new agricultural biotech were really safe and effective, why would the industry work so hard—as indeed it does—to keep its critics cowed and the public uninformed? Was there something about the way genetic engineering was developed, about how it works, that was inviting a closer look—a look that the industry would rather we not take? I had gone to Berkeley to see for myself what was going on behind biotechnology.

The University of California at Berkeley ("Cal") is the stage on which much of the story of genetic engineering has played out over the last 25 years. The biotechnology industry was born here in the San Francisco Bay area, and nurtured by scientists who worked at Berkeley and nearby universities. Critical controversies over the role genetic engineering and related research should have in society have erupted here. Even the architecture of the campus reflects the major scientific and policy divisions that plague this technology. Two buildings, in particular, mirror the two very different versions of biology that emerged in the last half of the twentieth century, and reflect two very different visions for agriculture in the future.

Hilgard Hall was built in 1918, at a time when mas-

[1] Although I use the terms "biotechnology" and "genetic engineering" interchangeably, along with references to "transgenes" and "genetically modified organisms," I am, in all cases, referring to recombinant DNA technology used to cross species boundaries. I am not using the term "biotechnology" in its general sense, which can include natural processes. This analysis of genetic engineering will focus *only* on its agricultural applications. It does not address issues that might apply to medical or other uses.

From the *USDA Yearbook of Agriculture, 1940, Farmers in a Changing World.*

tering the classical form and celebrating beauty were important, perhaps even integral, to the accepted function of a building. Hilgard's facade is exquisitely decorated with friezes depicting sheaves of wheat, beehives, bunches of grapes, cornucopias, and bas relief sculptures of cow heads surrounded with wreaths of fruit. Above the entrance, carved in huge capital letters are the words, "TO RESCUE FOR HUMAN SOCIETY THE NATIVE VALUES OF RURAL LIFE." The massive front door opens to a grand two-story hall graced with granite, marble, and carved brass. But behind that elegant entrance is a building left in disrepair. Getting around inside Hilgard means navigating worn marble staircases and dark corridors laced with exposed pipes and heating ducts. The room where the monster box photograph is kept is small and dank. This building is home to the "old" biology—the careful observation of life, living systems, and their complex interactions. Being inside Hilgard is a visceral lesson in how Cal is neglecting the classic study of the intimate inter-relationships among agriculture, the environment, and human society.

Nearby, and standing in stark contrast to Hilgard's faded splendor, is a newer, modern office building, Koshland Hall. Koshland is not unattractive, with its pitched blue tile roof lines and bright white walls lined with blue steel windows, but it was built in the mid-1990s in a functional style that, like most new campus buildings, has all the charm and poetry of an ice cube. The interior is clean and well lit. Next to office doors hang plaques that name the corporations or foundations that fund the activities inside. This is the home of the "new biology"—the utilitarian view that life is centered in DNA and molecules can be manipulated at will. Molecular biology is clearly doing well at Cal.

Koshland Hall was named after a distinguished member of the faculty, Daniel Koshland, former editor of the journal *Science* and chair of Berkeley's Department of Biochemistry, now a professor emeritus. He has the unique distinction of having been present at the two most important scientific revolutions of our time: he participated both in the Manhattan Project, which developed nuclear weapons, and in the early development of molecular biology. He is credited with "transforming" the biological sciences at Berkeley.

THE NEW BIOLOGY

One hundred years ago, no one had heard of a "gene." The word was not recognized until 1909, and even after that it remained an abstraction for decades. At the time, scientists and others were making an effort to find a material basis for life, particularly heritability, the fundamental function of life. The story of genetic engineering in the United States begins with the decision to identify genes as the basis of life. But the ideological roots of this story go even deeper, into the nation's earlier history and attachment to the ideas of manifest destiny, eugenics, and social engineering.

Early in the twentieth century, the new "science" of sociology made its appearance—along with the highly appealing belief that social problems were amenable to scientific solutions. In time, sociology began to combine with genetic science, giving strong impetus to technocratic forms of social control, and particularly to eugenics—the belief that the human race could be improved by selective breeding. Until the 1930s, the science of genetics had not developed much beyond Mendelian principles of heredity, but eugenics was already being promoted as the solution to social problems. As the idea that genes determined traits in

[2] Kay, Lily E. *The Molecular Vision of Life, Caltech, the Rockefeller Foundation, and the Rise of the New Biology*, Oxford University Press, 1993, p. 23.

people took hold, eugenics twisted it to foster the concept that there were "good" genes and "bad" genes, good and bad traits. Eugenics eventually gained a powerful foothold both in the popular imagination and in the U.S. government, as well as in Nazi Germany. Even today, these notions underlie the decisions biotechnologists make about what genes and traits are beneficial, what organisms are engineered, and who gets to decide how this technology will be used.

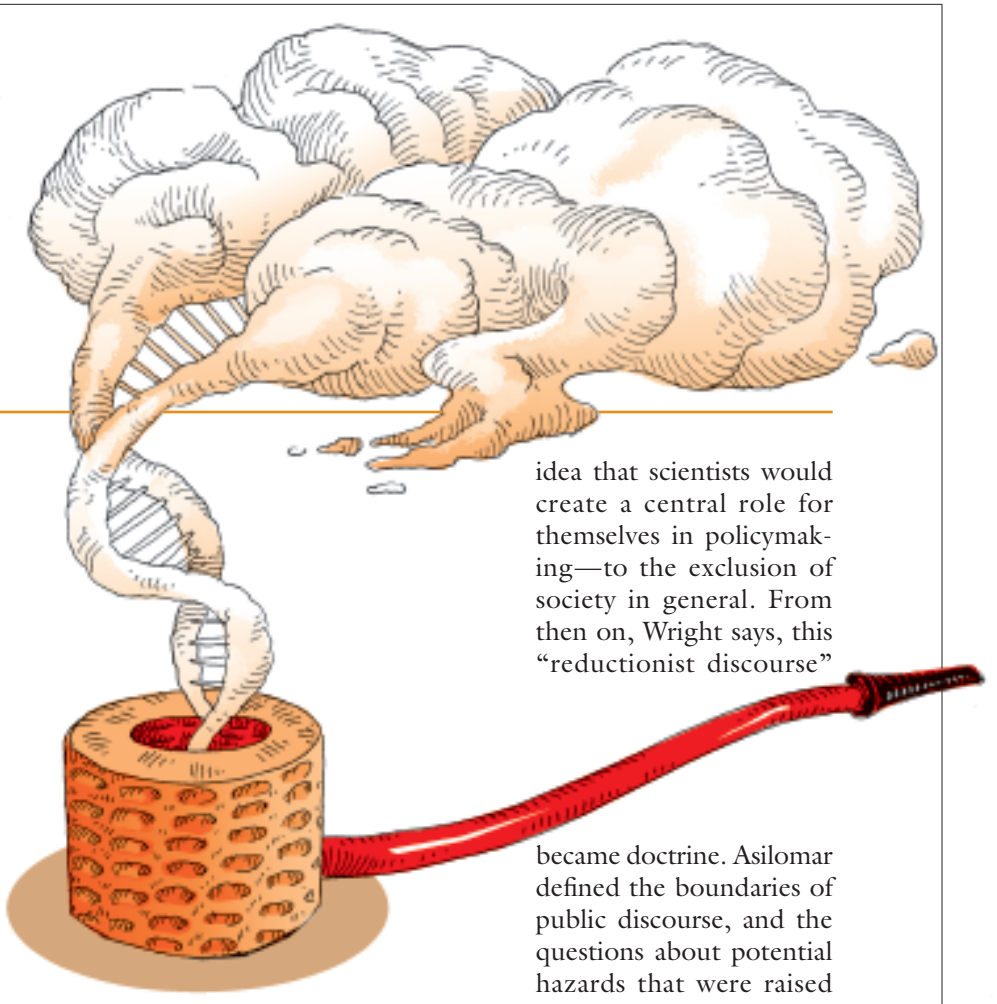
According to Lily Kay, an assistant professor of the history of science at Massachusetts Institute of Technology, genetic engineering came about as the result of the concerted effort of a few scientists, who, along with their academic and philanthropic sponsors, had a shared vision about how they could use genetics to reshape science and society. In her book *The Molecular Vision of Life: Caltech, the Rockefeller Foundation, and the Rise of the New Biology,* Kay writes that this vision was not so much about underlying biological principles as it was about social values. The new biology that evolved from this thinking was founded on a strong belief in "industrial capitalism" and its perceived mandate for "science-based social intervention." The potential for this idea, and the intentional strategy to use it for social purposes was clearly understood from the outset, says Kay. The developers of "molecular biology" (a term coined by the Rockefeller Foundation) were confident that it would offer them a previously unimagined power and control over both nature and society.

Science was molded to this agenda in 1945, when Vannevar Bush, the head of President Franklin D. Roosevelt's wartime Office of Scientific Research and Development, wrote "Science, The Endless Frontier"—a landmark report that outlined how science could better serve the private sector. As Kay tells the story, at that point the search for a science-based social agenda began in earnest. It was funded and directed by business corporations and foundations acting together as "quasi-public entities" using both private and public funds to harness "the expertise of the human sciences to stem what was perceived as the nation's social and biological decay and help realize the vision of America's destiny." Eventually, the combined efforts of corporate, academic, and government interests began to bear fruit and "the boundary between individual and corporate self-interest, between private and public control, would be increasingly blurred."[2]

The story of how James Watson and Francis Crick described the structure of the DNA helix in 1953 is well known. Less known, but of considerable consequence, is what followed. With little hesitation, they announced that DNA is "the secret of life"—and began to promote what was to become known as "the central dogma"—the notion that genetic information flows in only one direction, from DNA to RNA to a protein, and that this process directly determines an organism's characteristics. This dogma was, as described by geneticist Mae-Wan Ho, author of *Living with the Fluid Genome,* "just another way of saying that organisms are hardwired in their genetic makeup and the environment has little influence on the structure and function of the genes." In her book, Dr. Ho argues that the central dogma is too simplistic. She observes that not all DNA "codes for proteins" and that the genome is fluid and interactive. Similarly, in a 1992 *Harper's Magazine* article, "Unraveling the DNA Myth: The Spurious Foundation of Genetic Engineering," Queens College biologist Barry Commoner writes that "the central dogma is the premise that an organism's genome—its total complement of DNA genes—should fully account for its characteristic assemblage of inherited traits. The premise, unhappily, is false."

Still, the singular view of "life as DNA" dominated biology in the late twentieth century, in part because its very simplicity provided the biological rationale for engineering DNA. Technological advances in other fields—the study of enzymes that cut DNA, and bacteria that recombine it—were teamed up with high speed computers that provided the computational muscle needed. And yet, even as the old biology became the "new and improved" molecular biology, it was promoted with a social pedigree about how it would serve the public. Its mandate was the same one that was used to colonize the "new world" and to settle the Wild West—the promise that *this* progress would provide everyone a better life.

Judging by his comments, if James Watson had had



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his way, research would have proceeded undeterred by any concerns over the hazards that genetic engineering posed. He said he'd always felt that the "certain promise" of this revolutionary new technology far outweighed its "uncertain peril." But others, such as Paul Berg of Stanford University, were calling for a more measured approach. In 1975 Berg joined other scientists concerned about the risks of genetic engineering in a meeting held at the Asilomar conference center, near Monterey, California. It was a rare collective action, with participants coming from a spectrum of universities, government agencies, and research institutes.

In his introductory remarks, David Baltimore of MIT noted that the participants were there to discuss "a new technique of molecular biology," one that "appears to allow us to outdo the standard events of evolution by making combinations of genes which could be unique in natural history." He went on to say that they should design a strategy to go forward that would "maximize the benefits and minimize the hazards." They produced a 35-page report that detailed their concerns about creating new pathogens and toxins, the emergence of allergens and disease vectors that could cause cancer or immune disorders, as well as "unpredictable adverse consequences" and the specter of "wide ecological damages."

Then, in the last hours of the meeting, on the very last night, a couple of the participants pointed out that the public had the right to assess and limit this technology. What happened next was pivotal. These scientists believed they were entitled to benefit from the extraordinary potential of genetic engineering and they argued that they could find technological fixes for any problems that might emerge. Susan Wright, author of *Molecular Politics*, a history of biotech regulatory policy, recalls that there was virtual unanimity for the idea that scientists would create a central role for themselves in policymaking—to the exclusion of society in general. From then on, Wright says, this "reductionist discourse" became doctrine. Asilomar defined the boundaries of public discourse, and the questions about potential hazards that were raised there went unanswered.

PUBLIC POLICY: THE ENDLESS FRONTIER

The inoculation that Asilomar gave biotechnology against the ravages of government control was given a booster shot a few years later when executives from the Monsanto Corporation visited the Reagan White House. The industry sought and obtained assurance that they would not be blindsided by regulation. After all, these early developers of GMOs were agrochemical companies like Dow Chemical, DuPont, Novartis, and Monsanto, who were the sources of pervasive chemical pollution that resulted in the environmental laws that were passed in the 1960s. This time, they were intent on getting to the lawmakers before the public did.

The resulting "regulatory reform" was announced in 1992, by then Vice President Dan Quayle, at a press conference in the Indian Treaty Room near his office. It was custom-made for the industry. The new policy left just enough oversight in place to give the industry political cover, so that they could offer assurances to the public that the government was watching out for the public interest when in fact it was not. The regulatory system that was adopted, which is essentially what is still in place today, is basically voluntary and pas-

sive. It's a "don't look, don't tell" arrangement whereby the industry doesn't tell the government about problems with its products and the government doesn't look for them.

Quayle said that government "will ensure that biotech products will receive the same oversight as other products, instead of being hampered by unnecessary regulation." The rationale for this policy was a concept called "substantial equivalence," which means that GMOs are not substantially different than conventional crops and foods. The science journal *Nature* dubbed substantial equivalence a "pseudo-scientific concept…created primarily to provide an excuse for not requiring biochemical and toxicological tests." Nevertheless, it was adopted by all three agencies responsible for food and agriculture—the United States Department of Agriculture, the Environmental Protection Agency, and the Food and Drug Administration—and it is the reason there have been no safety studies of GMO foods, no post-market monitoring, no labels, no new laws, no agency coordination, and no independent review.

Henry Miller, head of biotechnology at FDA from 1979 to 1994, told the *New York Times* in 2001 that government agencies did "exactly what big agribusiness had asked them to do and told them to do." During Miller's tenure at the FDA, staff scientists were writing memos that called for further testing and warning that there were concerns about food safety. But the man in charge of policy development at FDA was Michael Taylor, a former lawyer for Monsanto. And, according to Steven Druker, a public-interest lawyer who obtained three of these internal FDA memos, under Taylor "references to the unintended negative effects of bioengineering were progressively deleted from drafts of the policy statement."

Taylor went on to become an administrator at the USDA in charge of food safety and biotechnology, and then became a vice-president at Monsanto. All three agencies continue to employ people who are either associated with biotech companies or who formerly worked for them. At least 22 cases of this "revolving door" between government and industry have been documented. Biotech lawyers and lobbyists serve in policy-making positions, leave government for high paying jobs with industry, and in some cases return to government to defend industry interests again. Still, dismantling regulatory oversight was only part of industry's overall strategy to commercialize GMOs.

BREAKING THE BIOLOGICAL BARRIERS

All the big agrochemical seed companies—DuPont, Monsanto, Pioneer Hi-Bred, and Dekalb—were betting the farm on genetic technologies in the 1980s. But just one crop, corn, stood in their way. Corn was becoming the "Holy Grail" of agricultural biotechnology because these companies knew that if this idea was ever going to be commercially viable, it had to work with corn—which is of central importance to American agriculture. As they raced to find a way to genetically engineer corn, they perfected the complicated steps required to transform plants into transgenic crops. It all came together in June 1988, when Pioneer Hi-Bred patented the first viable and replicable transgenic corn plant.

In the end, the secret of recombining DNA was found not so much through a process of tedious, repetitive experimentation as of that traditional, Wild-West way of getting what you want—using stealth and brute force. The primary problem genetic engineers faced was how to get engineered DNA into target cells without destroying them. For some plants, like tobacco and soybeans, the problem was solved by the use of stealth. A soil microbe that produces cancer-like growths in plants was recruited to "infect" cells with new modified DNA. This *agrobacterium* formed a non-lethal hole in the wall of a plant cell that allowed the new DNA to sneak in. But that method did not work with corn. For corn, a more forceful cell invasion technique was called for, one that resulted in the invention of the gene gun.

One day in December 1983, during the Christmas break at Cornell University, three men put on booties, gowns, and hair coverings, picked up a gun, and entered the university's National Submicron Facility. John Sanford, a plant breeder at Cornell, and his colleagues, the head of the facility and a member of his staff, were about to shoot a bunch of onions to smithereens. For years,

they had been looking for ways to speed up the conventional plant breeding process using genetic transformation techniques. Like other researchers, they had had difficulty forcing DNA fragments through the relatively thick walls of plant cells. They'd tried using lasers to drill mini-holes in cell walls and everything from ion beams to microscopic needles to electric shocks, but these methods either failed to deliver the payload or destroyed the cells in the process.

Then one day, while waging a backyard battle with some pesky squirrels, Sanford got the idea of using a gun. He figured out how to load the gun with specially coated microscopic beads, and then he and his friends tried the idea out on the onions. Soon, pieces of onion were splattered everywhere and the smell of onions and gun powder permeated the air. They kept up this odorous massacre until they figured out how to make it work. It seemed implausible, even laughable, at the time. But the gene gun, which uses .22-caliber ballistics to shoot DNA into cells, is now found in biotechnology laboratories all over the world.

Although it is clearly a "hit or miss" technique, transferring DNA is actually straightforward. The tricky part is getting the target plant to accept the new genes. That requires overcoming billions of years of evolutionary resistance that was specifically designed to keep foreign DNA out. You simply can't get a fish and a strawberry to mate, no matter how hard you try—or at least you couldn't until now. Genetic engineers are now able to take a gene that produces a natural anti-freeze from an arctic flounder and put it into a strawberry plant so that its fruit is frost resistant. But this feat can only be accomplished through the use of specially designed genes that facilitate the process. Along with the trait gene, every GMO also contains genetically engineered vectors and markers, antibiotic resistance genes, viral promoters made from the cauliflower mosaic virus, genetic switches and other constructs that enable the "transformation" process.

Once all these genes are inserted, where they end up and what they may do are unknown. The only precise part of this technique is the identification and extraction of the trait DNA from the donor organism. After that, it's a biological free-for-all. In genetic engineering, failure is the rule. The way you get GMO crops to look and act like normal crops is to do thousands and thousands of insertions, grow the ones that survive out, and then see what you get. What you finally select for further testing and release are those "happy accidents" that appear to work. The rest of the millions of plants, animals and other organisms that are subjected to this process are sacrificed or thrown out—or end up in some lab technician's monster box.

PROCESS, NOT PRODUCT

The public controversy over GMOs has focused largely on the products, on how they are marketed, and on what is planted where. But it now appears that the process used to make them, and the novel genetic constructs used in the process, may constitute greater threats to human and environmental health than the products themselves. There are documented reports of allergenic reactions to GMO foods. According to a report in *Nature Biotechnology,* for example, the commonly used cauliflower mosaic virus contains a "recombination hotspot" that makes it unstable and prone to causing mutations, cancer, and new pathogens. The British Medical Association and the U.S. Consumer's Union have both warned about new allergies and/or adverse impacts on the immune system from GMO foods. And public health officials in Europe are concerned that antibacterial resistance marker genes in GMOs could render antibiotics ineffective. There have been only about 10 studies done on human health and GMOs, and half of them indicate reasons for concern, including malformed organs, tumors, and early death in rats.

There are also increasing reports of a phenomenon previously thought to be rare, "horizontal gene transfer," which happens when genes travel not just "vertically" through the normal processes of digestion and reproduction, but laterally, between organs in the body or between organisms—sort of like Casper the Ghost floating through a wall. Geneticist Mae-Wan Ho, who has been documenting this phenomenon, says it's happening because the new technology "breaks all the rules of evolution; it short-circuits evolution altogether. It bypasses reproduction, creates new genes and gene

3 "Genome Scrambling—Myth or Reality? Transformation-induced Mutations in Transgenic Crop Plants" by Drs. Wilson, Latham, and Steinbrecher is available at www.econexus.info.

combinations that have never existed, and is not restricted by the usual barriers between species."

In 2001, the world's most widely grown GMO, Monsanto's Round-up Ready soybean, was found to contain some mysterious DNA. Monsanto claimed it was native to the plant. When it was shown instead to be the result of the transformation process, Monsanto couldn't explain how it got there. And it has been shown that the nutritional profile of the transgenic soybean is different than that of the conventional variety.

A new report, based on peer-reviewed scientific literature and USDA documents,[3] has found that significant genetic damage to the integrity of a plant occurs when it is modified, including rearrangement of genes at the site of the insertion and thousands of mutations and random modifications throughout the transgenic plant. Another study, by David Schubert of the Salk Institute for Biological Studies in La Jolla, California, found that just one transgenic insertion can disrupt 5 percent of the genes in a single-cell bacterium. Translated into plant terms, that means 15,000 to 300,000 genes get scrambled. Industry was given a blank check by government allowing it to commercialize the technology prematurely, before science could validate the techniques being used or evaluate the safety of the products being developed.

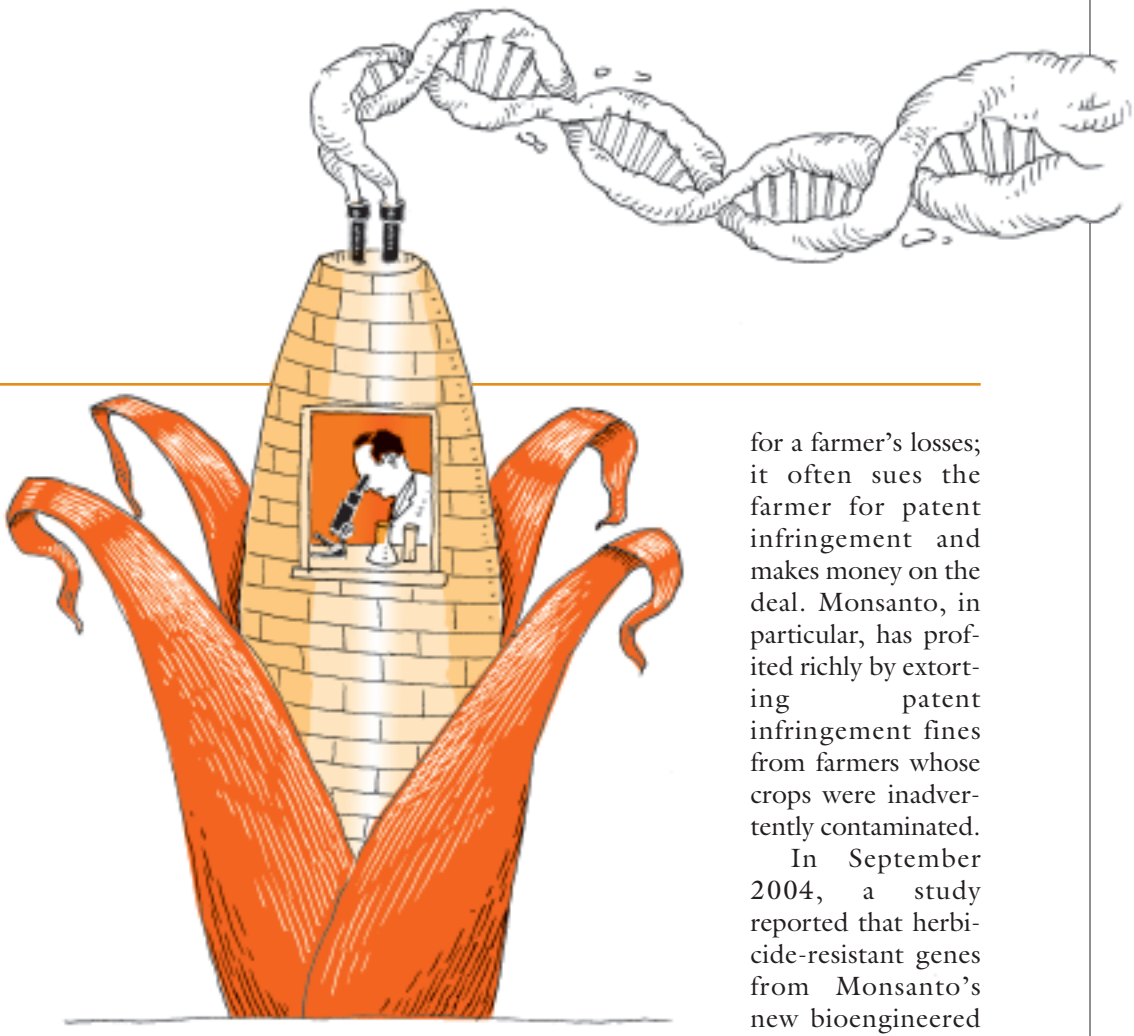
STRATEGIC CONTAMINATION

Even before GMOs were released in the mid-1990s, they were thought by some scientists to be promiscuous. Now that GMO contamination is running rampant, it's hard to believe that the biotech industry wasn't aware of that risk. The industry would have had to ignore early warnings such as a study done at the University of Chicago which found one transgenic plant that was 20 times more likely to interbreed with related plants than its natural variety. But now, because herbicide-tolerant genes are getting into all sorts of plants, farmers have to contend with "super-weeds" that cannot be controlled with common chemicals, and American agriculture is riddled with fragments of transgenic material. The Union of Concerned Scientists recently reported that the seeds of conventional crops—traditional varieties of corn, soybeans, and canola—are now "pervasively contaminated with low levels of DNA originating from engineered varieties of these crops." One laboratory found transgenic DNA in 83 percent of the corn, soy, and canola varieties tested.

GMO contamination is causing mounting economic losses, as farmers lose their markets, organic producers lose their certification, and processors have to recall food products. The contamination is even beginning to affect property values. Consumers are eating GMOs, whether they know it or not, and even GMOs not approved for human consumption have shown up in our taco shells. New "biopharmaceutical" crops used to grow drugs have leaked into the human food supply. And across the nation, hundreds of open field plots are growing transgenic corn, rice, and soybeans that contain drugs, human genes, animal vaccines, and industrial chemicals, without sufficient safeguards to protect nearby food crops.

It's not only food and farming that are affected. Part of what makes GMOs such an environmental threat is that, unlike chemical contamination, GMOs are living organisms, capable of reproducing and recombining, and once they get out, they can't be recalled. Now that there are genetically engineered fish, trees, insects, and other organisms, there's no limit to the kind of environmental surprises that can occur. The widespread ecological damage discussed at Asilomar is now a reality. In just one example of what can happen, a study found that when just 60 transgenic fish were released into a wild population of tens of thousands of fish, all the wild fish were wiped out in just 40 generations. And what will happen when there are plantations of transgenic trees, which can disperse GMO pollen for up to 40 miles and over several decades? Without physical or regulatory restraints, GMOs pose a very real threat to the biological integrity of the planet. As GMO activists say, it gives "pollution a life of its own."

The unasked question that lingers behind all the stories of GMO contamination is: what is the role of industry? How do the manufacturers of GMOs benefit from gene pollution? The fact is, the industry has never lifted a finger to prevent it and the biological and political system they have designed for it encourages its spread.



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The industry calls contamination an "adventitious presence," as if it were a benign but unavoidable consequence of modern life, like background radiation from nuclear testing.

In the United States, there are no legal safeguards in place to protect the public—not even labels. Labels would at least provide the consumer with a means for tracing the source of any problems that occur. Plus, without liability laws, the industry avoids accountability for any health or environmental damage it causes. It opposes independent testing and then takes advantage of the lack of data to make false assurances about its products' safety. The *Wall Street Journal* reported in 2003 that "makers of genetically modified crops have avoided answering questions and submitted erroneous data" on the safety of their products to the federal government. They have spent hundreds of millions of dollars on massive public relations campaigns that use sophisticated "perception management" techniques all aimed at falsely assuring the public, and government agencies, that their products are useful and safe.

Beyond their not having to label and segregate GMOs, biotech companies can manufacture, sell, and distribute them without having to take expensive precautions against contamination. They do not have to monitor field practices or do any post-market studies. When farms or factories are contaminated with GMOs, the industry is not held responsible for clean-up costs, as would be the case with chemical contamination. Instead, massive GMO food and crop recalls have been subsidized by taxpayers. Industry not only doesn't pay for a farmer's losses; it often sues the farmer for patent infringement and makes money on the deal. Monsanto, in particular, has profited richly by extorting patent infringement fines from farmers whose crops were inadvertently contaminated.

In September 2004, a study reported that herbicide-resistant genes from Monsanto's new bioengineered creeping bentgrass were found as far away as measurements were made—13 miles downwind. Monsanto's response was that there was nothing to worry about; it had proprietary herbicides that could take care of the problem, assuring more the sale of its products than a limit to the contamination. By assiduously avoiding any responsibility for the proliferation of GMOs, and by defeating attempts by the public to contain them, the agricultural biotechnology industry has thus virtually ensured that GMO contamination will continue unabated. A biotech industry consultant with Promar International, Don Westfall, put it this way: "the hope of industry is that over time the market is so flooded that there's nothing you can do about it. You just sort of surrender."

The most alarming case of GMO contamination is the discovery of transgenes in corn at the center of the origin of corn in Mexico. From the time GMO corn was first planted in the U.S. Midwest, it took only six years it to make its way back home in the remote mountainous regions of Puebla and Oaxaca, Mexico. Ignacio Chapela, a Mexican-born microbial biologist, was the scientist who first reported this contamination in 2001. Early in 2002, I visited the area with Dr. Chapela to investigate the cultural and economic implications

4 The full story of how GMOs got into native corn in Mexico is told in "Risking Corn, Risking Culture," by this author, Claire Hope Cummings, *World Watch*, November/December 2002.

5 Quist, D. and Chapela, I., "Transgenic DNA Introgressed into Traditional Maize Landraces in Oaxaca, Mexico," *Nature*, 414:541–543 November 29, 2001.

of his findings. While I was there I got a first-hand look at the complicity of government and industry in the spread of GMO contamination.

The genetic diversity of corn, the world's most important food crop after rice, has been fostered for thousands of years by Zapotec and hundreds of other indigenous farming communities who have lived in these mountainous areas since before the Spanish arrived. Now their traditional land-based ways of life, the sacred center of their culture, and the source of their economic livelihood, corn, has been imperiled by this new form of colonization. The farmers I talked to there were well informed, but worried about their cultural and economic survival. What they did not understand was how transgenic corn got into their fields. [4]

Early press reports blamed the farmers themselves, based on the observation that in order to help support their families and communities, some of them travel to the U.S. to work as migrant workers. But in fact, it turned out that the cause of the contamination was the Mexican government and "free trade" rules. Although Mexico had banned the commercial planting of transgenic corn, under pressure of NAFTA and the biotech industry it was importing corn from the U.S. that it knew was contaminated. It then distributed this whole-kernel corn to poor communities as food aid, without labels or warnings to rural farmers that it should not be used for seed. This highly subsidized corn, which is being dumped on third world farmers at prices that are lower than the cost of production, undermines local corn markets. But instead of taking steps to stop the spread of this contamination, or to protect its farming communities, or even to guard its fragile biodiversity, the Mexican government, the international seed banks, and the biotech industry all deflected public and media attention to a convenient scapegoat—Dr. Chapela.

THE SUPPRESSION OF SCIENCE

Chapela and his graduate student, David Quist, had published their findings in the peer-reviewed Journal *Nature*. [5] They had actually made two findings: first, that GMOs had contaminated Mexico's local varieties of corn—in technical terms, that "introgression" had occurred. And second, they found that once transgenes had introgressed into other plants, the genes did not behave as expected. This is evidence of transgenic instability, which scientists now regard with growing concern. But allegations of such instability can be dangerous to make because they undermine the central dogma's basic article of faith: that transgenes are stable and behave predictably. Not surprisingly, the industry attacked the first finding, but was foiled when the Mexican government's own studies found even higher levels and more widespread GMO contamination than the *Nature* article had reported. The industry then focused its attack to the finding of transgenic instability.

For over a year, the industry relentlessly assailed Quist and Chapela's work, both in the press and on the Internet. As the debate raged on, scientists argued both sides, fueled, Chapela says, by a well developed and generously funded industry public relations strategy that did not hesitate to make the attacks personal. Monsanto even retained a public relations firm to have employees pose as independent critics. The outcome was unprecedented. The editor of *Nature* published a letter saying that "in light of the criticisms…the evidence available is not sufficient to justify" the publication of the original paper. This "retraction" made reference to the work of two relatively unknown biologists, Matthew Metz and Nick Kaplinsky. At the time, Kaplinsky was still a graduate student in the Department of Plant and Microbial Biology at UC Berkeley. Metz had finished his work at Berkeley and was a post-doctoral fellow at the University of Washington. What few knew was that their role in the *Nature* controversy was linked to another dispute that they, Quist, and Chapela, had been involved in. That earlier dispute, too, was about the integrity of science. And in that case, Chapela had led the faculty opposition—and Quist had been a part of the student opposition—to private funding of biotechnology research at UC Berkeley.

THE PIE ON THE WALL

The University of California at Berkeley is a "land grant" institution, meaning that it was created to support California's rich agricultural productivity. But by

6 In that speech Savio said that there comes a time when "the operation of the machine becomes so odious, makes you so sick at heart, that you can't take part. You can't even passively take part and you've got to put your bodies upon the gears and upon the wheels, upon the levers, upon all the apparatus, and you got to make it stop...."

the late 1990s, Cal had all but abandoned its original mission. Berkeley had become the national leader in collecting royalty payments on its patents, many of which related to the development of genetic engineering. This development was facilitated by the passage of the Bayh-Dole Act of 1980, which allowed universities to patent their research, even if it was publicly funded. By the fall of 1998, the private funding of research at Berkeley was in its full glory. That year, the dean of the College of Natural Resources, Gordon Rausser, announced that he had brokered an unprecedented research deal with the Novartis Corporation, then a multinational Swiss agrochemical and pharmaceutical giant.

Novartis was giving just one department of the College, the Department of Plant and Microbial Biology, $25 million over a 5-year period. The deal was fraught with conflicts of interest, not the least of which was that Novartis employees served on academic committees and got first license rights to the Department's research products. Novartis proudly announced that "the ultimate goal" of the agreement was "to achieve commercialization of products." This took private intrusion into the public sector to a new level, allowing private investors to profit directly from public investment in research, and arousing concerns about the increasing privatization of public research institutions across the country.

In true Berkeley fashion, the controversy erupted into protests. When the deal was announced in November 1998, I covered the press conference. It was held in a packed room upstairs in Koshland Hall, home of the Department of Plant and Microbial Biology. Novartis executives stood shoulder to shoulder with UC Berkeley administrators and leading faculty. They all looked on benevolently while the agreement was formally signed. Then the speeches started. Steven Briggs, president of Novartis Agricultural Discovery Institute, the foundation that funnels corporate money to the university and gets government research and tax credits for Novartis, signed the deal on behalf of Novartis. Briggs, who is an expert on the corn genome, called the agreement—without the least suggestion of irony—"the final statement in academic freedom."

The person most responsible for the Novartis deal, Dean Rausser, was proud of his considerable connections in the private sector. While he was dean, he built a consulting company worth millions. During the press conference, he stood at the front of the room with the other key participants. The press and other guests were seated in folding chairs facing them, and students sat on the floor along the walls. Hefty security men in blue blazers with wires dangling from their ears were lined up along the back wall. I was in the front row. Suddenly I felt a commotion erupting behind me. Something rushed past my head, missed its intended target, and splattered on the wall behind the front table. Then another object followed, grazed Dean Rausser, and landed on the floor at his feet. It all happened fast, but I soon realized that I was in the middle of a pie-throwing protest. In their hallmark style, which is humorous political theater, the "Biotic Baking Brigade" had tossed two vegan pumpkin pies (it was Thanksgiving week, after all) at the signers of the Novartis agreement.

As campus security guards wrestled the protesters to the floor and then pulled them out of the room, the AP reporter who was sitting next to me jumped up and ran out to call in her story. I stayed and watched Dean Rausser, who had been speaking at the time. He just looked down, brushed some pie off his suit, then smiled and shrugged. I got the distinct feeling he was enjoying the moment. He went on with his presentation, and for the rest of the time he was speaking, pie filling drooled down the wall behind him.

As a child of the '60s and a member of the UC Berkeley class of 1965, I was reminded of the winter of 1964, when Mario Savio gave his famous "rage against the machine" speech 6 on the steps of the campus administration building. When it began, the Free Speech Movement was about academic freedom but it enlarged into demonstrations against the war in Vietnam and support for the civil rights and women's movements. A lot was achieved, especially in terms of environmental protection. But it was always about who controls the levers of "the machine," as Savio called it. By 1998, however, the conservative backlash that was provoked by these protests was in full bloom. Private interests had successfully dismantled the regulatory

7 The stories of four such scientists and their reflections on their experiences can be heard on a recording of a remarkable conversation among them called "The Pulse of Scientific Freedom in the Age of the Biotech Industry" held on the UC Berkeley campus in December, 2003. A link to the web archive is available at http://nature.berkeley.edu/pulseofscience/pix/conv.txt1.html.

system, invaded the ivy tower, and taken over the intellectual commons. The corporate executives and their academic beneficiaries who were there to celebrate the Novartis agreement clearly had nothing to fear—a fact that was neatly affirmed by Dean Rausser's shrug.

The Novartis funding ended in 2003. By then, faculty and graduate students who were on both sides of the debate had gone their separate ways. Dr. Chapela stayed, and continued to teach at Berkeley. As 2003 drew to a close, he was up for a tenure appointment. Even though he'd garnered extraordinary support from faculty, students, and the public, his role in opposing corporate funding on campus apparently cost him his teaching career. After an unusually protracted process, the University denied him tenure. In 2004, a 10-person team at Michigan State University that had spent two years evaluating the Novartis-Berkeley agreement concluded that the deal was indeed "outside the mainstream for research contracts with industry" and that Berkeley's relationship with Novartis created a conflict of interest in the administration that affected their tenure decision against Dr. Chapela.

Instead of applauding the bravery of scientists who question biotechnology, or at least encouraging further scientific inquiry, the industry and its cronies in the academic world denounce their critics. Dr. Chapela has now joined a growing number of scientists who have paid a high price for their integrity. Others have lost jobs, been discredited in the press, told to change research results or to repudiate their findings.[7] And for each victim whose story is told publicly, there are others who have been silenced and cannot come forward. The implications of the trend toward the privatization of research and the repression of academic freedom go far beyond the question of where the funds come from and who decides what gets studied. It's a trend that deeply undermines the public's faith in science, and the result is that society will lose the means to adequately evaluate new technologies. It may also mean that we adopt a view of the natural world so mechanistic that we will not even recognize the threats we face.

If science were free to operate in the public interest, it could provide the intellectual framework for innovations that work with nature, instead of against it. There already are technologies that use natural solutions to heal the wounds of the industrial age, formulate sustainable food production and energy solutions, create new economic opportunities through the imaginative use of ecological design, and build local self-reliant communities that foster both cultural and biological survival. So we do have a choice of technologies, and nature remains abundantly generous with us. What we do not have, given the perilous environmental state of the planet, is a lot of time left to sort this out. And as long as the critics are silenced, we can be lulled by the "certain promises" of genetic engineering, that it will provide magic answers to those age old problems of hunger and disease, and in doing so, be diverted from attending to its "uncertain perils."

THE NATURE OF TRESPASS

Trespass, in legal parlance, means "an unlawful act that causes injury to person or property." It connotes an act of intrusion, usually by means of stealth, force, or violence. It also implies the right to allow or to refuse an intrusion. A trespass occurs when that right has been violated. Genetic engineering technology is a trespass on the public commons. This is because of the way transgenics are designed and the way "the molecular vision" has been pursued. This vision required that science be compromised to the point where it would overlook the complex boundary conditions that form the very foundation of life. It had to have the hubris to break the species barriers and place itself directly in the path of evolution, severing organisms from their hereditary lineage. And it requires the use of stealth and violence to invade the cell wall, and the implanting of transgenic life forms into an involuntary participant with organisms that are especially designed to overcome all resistance to this rude intrusion.

This trespass continues when ownership is forced on the newly created organisms in the form of a patent. The patenting of a life form was widely considered immoral, and until the U.S. Supreme Court approved the patenting of life in 1980, it was illegal. With that one decision, private interests were given the right to own every non-human life form on earth. We clearly are, as Pres-

Keith Weller/USDA ARS

Not genetically engineered: naturally occurring exotic Latin American samples collected for the Germplasm Enhancement for Maize Project of the USDA

ident Bush recently declared, "the ownership society." Now, when GMOs enter the borderless world of free trade and permeate every part of the web of life, they carry within them their owner's mark and effectively privatize every organism they infiltrate. This is made all the more unacceptable because this expensive technology is so unnecessary. Most of what agricultural biotechnology sells, such as insect-resistant plants and weed-control strategies, is already available by other means. Traditional plant breeding can produce all these advances and more—including increased yield, drought or salt resistance, and even nutritional enhancements. The whole point of the commercial use of the genetic engineering technology is the patents, and the social control they facilitate. The reason GMOs were inserted into crops is so that agbiochemical companies could own the seed supply and control the means and methods of food production, and profit at each link in the food chain.

Genetic engineering is a manifestation—perhaps the ultimate manifestation—of the term "full spectrum dominance." In this case, the dominance is achieved on multiple levels, first by exerting biological control over the organism itself, then by achieving economic control over the marketplace and then through "perceptual" control over public opinion. GMOs are disguised to look just like their natural counterparts, and then are released into the environment and the human food chain through a matrix of control that identifies and disables every political, legal, educational, and economic barrier that could thwart their owners' purpose. Arguably, this description suggests a more sinister level of intention than really exists. But the fact remains that denial of choice has been accomplished and it is crucial to this strategy's success. As a Canadian GMO seed industry spokesperson, Dale Adolphe, put it: "It's a hell of a thing to say that the way we win is don't give the consumer a choice, but that might be it."

Agricultural genetic engineering is dismantling our once deeply held common vision about how we feed ourselves, how we care for the land, water, and seeds that support us, and how we participate in decisions that affect us on the most intimate personal and most essential community level. The ultimate irony of our ecological crisis, says David Loy, a professor and author of works on modern Western thought, is that "our collective project to secure ourselves is what threatens to destroy us." But still, there are problems with making moral arguments like these. One is that we lack a practical system of public ethics—some set of common standards we can turn to for guidance. Another is that it does not address the most serious threat to our security, which is that no amount of science, fact, or even moral suasion is of any consequence when we are left with no options.

At the end of my inquiry I came to the conclusion that genetic engineering, at least as it is being used in agriculture is, by design, inherently invasive and unstable. It has been imposed on the American public in a way that has left us with no choice and no way to opt out, biologically or socially. Thus, the reality is that the evolutionary legacy of our lives, whether as human beings, bees, fish, or trees, has been disrupted. We are in danger of being severed from our own ancestral lines and diverted into another world altogether, the physical and social dimensions of which are still unknown and yet to be described.

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