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Genes in the Food!

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The Ecological Risks ofEngineered Crops
Jane Rissler and Margaret Mellon
MIT Press, 168 pp., $19.95 (paper)

Stolen Harvest: The Hijacking of the Global Food Supply
Vandana Shiva
South End Press, 140 pp., $14.00 (paper)

Pandora's Picnic Basket: The Potential and Hazards of Genetically Modified Foods
Alan McHughen
Oxford University Press, 277 pp., $25.00

Genetically Modified Pest-Protected Plants: Science and Regulation
a report by the Committee on Genetically Modified Pest-Protected Plants, Board on Agriculture and Natural Resources, National Research Council
National Academy Press, 263 pp., $44.95

1.

If the nineteen recent books and fifteen-pound stack of articles that confront me as I write are any measure, then nothing is more productive of food for thought than thoughts about the production of food. The introduction of methods of genetic engineering into agriculture has caused a public reaction in Europe and North America that is unequaled in the history of technology. Not even the disasters at Three Mile Island and Chernobyl were sufficient to produce such heavy and effective political pressure to prohibit or further regulate a technology, despite the evident fact that uncontained radioactivity has caused the sickness and death of very large numbers of people, while the dangers of genetically engineered food remain hypothetical.

It is out of the question to review this vast literature in its entirety, so I have chosen four recent characteristic examples from the pile. One is a report and set of recommendations from the font of American scientific legitimacy, the National Academy of Sciences/National Research Council. A second, *The Ecological Risks of Engineered Crops*, is a partisan but temperate case for the dangers of genetic engineering in agriculture, produced under the auspices of a long-established political action group, the Union of Concerned Scientists. The third, *Stolen Harvest*, is an unremitting indictment of genetic engineering, on moral, cultural, and economic grounds, especially as it applies to the third world. The fourth, *Pandora's Picnic Basket*, is the only example I could find of the opposite prejudice. It is a defense of genetic engineering in agriculture and a bitter attack on the apparatus of government regulation written by an agricultural scientist, an inventor of transgenic varieties whose life was made difficult by government regulation.

Whatever fears I might have of possible allergic reactions to food produced from genetically modified organisms, they are not more unsettling than the allergies induced in me by the quality of the arguments about them. What are we to make of a major issue of science and public policy in which a physicist bases her opposition to genetic engineering on "the recognition in the *Isho Upanishad* that the universe is the creation of the Supreme Power meant for the benefits of (all) creation"[1]; or a professor of agricultural economics who, in the course of trying to convince us that technology is good for farmers, conveniently makes the elementary error of confusing total household income of farm families with income *from* farming[2]; or a senior research scientist working in plant breeding at a major public university who ridicules the need for regulatory oversight of new kinds of foods by citing the introduction of macaroni and cheese on a stick that was announced in his local newspaper[3]? And these examples are, alas, characteristic of what has been written. Even the most judicious and seemingly dispassionate examinations of the scientific questions turn out, in the end, to be manifestoes. We are presented with a paradigm of Julien Benda's *trahison des clercs*; but *The Treason of the Intellectuals* was concerned with the corrupting effects of ideological passions on intellectuals. Ideological passions about potatoes? It gives one to think.

The uproar about so-called genetically modified organisms (GMOs) has been the direct consequence of the development of a radically new way to manipulate heredity. Human beings have been genetically modifying organisms since the first domestication of plants and animals. The results of those ancient modifications have been organisms that are not only very different from their wild ancestors, but are in many characteristics the very opposite of the organisms from which they were derived. The compact ear of maize with large kernels adhering tightly to the cob is very useful in a grain that needs to be gathered and to be stored for long periods, but a plant with such a seed head would soon disappear in nature because it could not disperse its seed. The history of domestication is precisely the history of the genetic modification of organisms to make them most "unnatural."

Until recently the method for producing new varieties of plants or animals has been to search for desirable variants and to propagate them selectively. The naturally occurring variation within species can also be augmented by matings with closely related species that do not ordinarily interbreed in nature, but will do so under conditions of domestication. So classical methods of plant and animal breeding have included "unnatural" transgression of species boundaries. But the use of the genetic variation available only from closely related organisms limits what can be accomplished precisely because they are closely related and therefore quite similar. Moreover, introducing genetic variation by crossing between organisms is imprecise. A cross between two varieties is indiscriminate in the hereditary characteristics that are transmitted. Thus if one attempts to introduce disease resistance into an especially high-yielding variety of wheat by crossing that variety with one that has the disease resistance but not the high yield, the result will be a variety with improved resistance but lower yield. The ideal of the plant or animal engineer is to be able to remake the heredity of an organism to order, so as to produce just those variants that the occasion seems to require.

Apparently the secret of genetic engineering was known to the ancients. Genesis 30 tells us that in order to retain the services of his son-in-law Jacob, who was apparently quite good at animal husbandry, Laban agreed to let him keep all the speckled and streaked goats and sheep that were born in the flocks that he tended. Jacob, the ur-biotechnologist, then peeled some twigs to make them speckled and streaked and held them up before the eyes of the plain-colored ewes just as they were about to conceive. This produced the desired result and Jacob became very rich indeed.

Being of little faith, we seem to have lost the twig trick, but have invented a new one. Modern genetic engineering consists in extracting the DNA corresponding to a particular gene from a donor organism and then inserting it into the cells of a recipient in such a way that it becomes incorporated into the recipient's genome. This insertion can be carried out by coating tiny metal particles with the DNA and shooting them into the recipient cells or by first putting the DNA into microorganisms and then infecting the recipient with them. If the source of the DNA is a distant species that cannot be intercrossed with the recipient, the engineered result is said to be a transgenic organism. The donor and recipient need not be anything like each other for the trick to work.

Thus the human gene for insulin has been successfully inserted into the genome of bacteria, and these bacteria, grown in industrial vats, are now churning out human insulin for the market. Despite the fears about the human ingestion of the products of genetic engineering, no one appears to be worried about the large number of diabetics who are injecting bacterially produced insulin twice a day. As far as anyone knows, no one has been harmed by this product of genetic engineering; but then, as far as anyone knows, no one has yet been harmed by any product of genetic engineering.

The chief use of transgenic DNA transfers in agriculture up to the present has been to provide crop plants with resistance to insect pests or to make the plants resistant to herbicides used to control weeds. The resistance to insects has been created by in-serting into plants the genes codingfor powerful toxins, the Bt proteins, from a bacterium, *Bacillus thuringensis*. When insects begin to nibble the plants, they ingest the Bt toxin and die. Resistance to herbicides has also been transferred into a variety of crop plants from bacteria, as well as from a variety of unrelated plants that happen to be resistant to particular chemicals. One of the ironies of the current struggle over GMOs is that advocates of organic farming practices who strongly oppose the introduction of transgenic crops containing the Bt genes have for many years promoted the dusting of the bacteria themselves on plants as an organic substitute for chemical insecticides.

While an irony, it is hardly the contradiction that proponents of GMOs suggest. The dusting of a toxin on the outside of plants, from which it could be washed away, is not the same thing as having the plants manufacture it internally. Although pest and herbicide resistance have been the main focus of transgenic engineering until now, anything seems possible. What makes the technique so attractive and so productive of anxiety is that any gene in any species can be transferred to any other species. Of course, some of these transfers will be harmful or even lethal to the recipient organism so that no practical use can be made of them; but there are no general rules to tell us what will work.

The critical point is that there is no limit to what could be done if it were worth someone's while to do it. Hundreds of plant varieties created by genetic engineering have been tested under guidelines approved by federal agencies, and several dozen transgenic varieties are commercially available, including corn, cotton, squash, potatoes, canola, soybeans, and sugar beets. It has only been six years since the first transgenic crops were planted commercially, yet now more than 20 percent of maize acreage in the United States is planted in transgenic corn and worldwide there are about 100 million acres sown in a variety of transgenic crops, including cotton and soybeans.

The usual reaction of the federal government to widespread public agitation about public health and environmental issues is to tinker with already existing regulatory procedures. When scientific questions are involved, federal agencies or Congress will often request that the National Academy of Sciences, through its research arm, the National Research Council, produce an expert report to guide regulatory policy. Sometimes, however, the Academy will act even without such a request. The National Academy of Sciences is a self-perpetuating body of the American scientific elite that provides technical advice to the government. Its leadership, conscious of its legitimacy as a font of supposedly disinterested and expert opinion on scientific questions, will sometimes arrange for National Research Council reports unbidden, on the assumption that their weight of authority will have an effect on public policy.

The NRC has issued, without a formal request, several reports on genetic engineering since 1974, when it became clear that recombinant DNA techniques would be important as tools of genetic research and technology. Three of those reports have been directly concerned with the application of the techniques in agriculture, one in 1987 on the release of GMOs into the environment, one in 1989 on the safe field testing of transgenic varieties, and, in 2000, *Genetically Modified Pest-Protected Plants*, which includes a discussion of both the environmental issues and threats to human health.

The creation of a scientific report on a contentious issue presents a special difficulty. On the one hand the drafting committee must include representatives of various constituencies with opposing views. So the committee that wrote the new report included academics involved in genetics, economics, and agriculture, a representative of a public interest environmental action group, a lawyer who helps clients to obtain regulatory approvals, and a state government environmental regulator. On the other hand, there cannot be a majority and a minority report, since after all we are dealing with Objective Science, and scientists either know the truth or they don't. NRC reports always speak with one voice. Such reports, then, can produce only a slight rocking of the extremely well gyrostabilized ship of state, no matter how high the winds and waves. Any member of the crew who mutinies is put off at the first port of call.

While usually artfully concealed, the machinery of forced consensus is apparent in the pest-protected plant report. The economist on the committee, Erik Lichtenberg, clearly felt that the sorts of regulation recommended by the report were not worthwhile and, indeed, would have costs not justified by any claimed benefits. He and his cost-benefit analysis are quarantined in an appendix and referred to only in a footnote: "This appendix was authored by an individual committee member and is not part of the committee's consensus report. The committee as a whole may not necessarily agree with all of the contents of appendix A." Of course, appendix A is merely economics, while the "committee as a whole" must "necessarily agree with the contents" of the rest of the report or it wouldn't be a scientific report. In fact, the committee could have discounted the appendix on substantive grounds. Like so much of cost-benefit analysis, it fails to take account of the fact that the costs, possible ill-health, fall on different parties than the benefits, profits to corporate entities who produce the inputs into agriculture. More fundamentally, it avoids the deep problem that to provide a quantitative balancing of the books, the costs and benefits would have to be assessed in the same currency, while it has never been possible to come to a general agreement on the dollar cost of sickness and death.

2.

There are five general issues that are in contention in the struggle over GMOs. Three of these, threats to human health, possible disruption of natural environments, and threats to agricultural production from a more rapid evolution of resistant pests, comprise the agenda of the NRC report. The other two, disruption of third- world agricultural economies and principled objections to "unnatural" interventions, are deliberately excluded. Page 2 of the report states in italics: "*The study does not address philosophical and social issues surrounding the use of genetic engineering in agriculture, food labeling, or international trade in genetically modified plants*." In analyzing the risks of GMOs the committee follows a general principle established in previous Academy reports, a principle that it regards as fundamental, namely that it is the product and not the process that matters. For the NRC it is irrelevant whether a variety has been produced by conventional genetic manipulations or by transgenic transfer of DNA. What counts is whether the new property of the resultant organism is harmful to health or the environment.

The NRC authors point out, quite properly, that the conventional methods of breeding, including sexual crosses between species that do not ordinarily cross in nature, might produce varieties with some heightened toxicity to humans or other species, or with unusual invasive abilities, or with greater resistance to pests that would hasten the evolution of more effective pest species. Jane Rissler and Margaret Mellon, in their extremely informative *The Ecological Risks of Engineered Crops*, give many examples of new troublesome weeds that have arisen from the hybridization of crop plants with their wild relatives and several where rare wild species have been driven to extinction by hybridization with crop plants.

Indeed, the only examples we have so far of the adverse effects of agricultural varieties on any animal or plant species in nature, including on human health, have been from conventionally bred organisms or from the introduction of invasive species from distant geographical areas, or from foods like peanuts or milk to which some people are naturally allergic. So if the usual products of agricultural practice already provide numerous examples of adverse effects, why is there the massive popular and political anxiety centered on genetically engineered crops in particular? None of the authors of the reports and books seems to have noticed that if it were really only the product and not the process that matters, then nothing has changed. The NRC report itself provides a protocol for protecting consumers against new food toxins and allergens (i.e., substances causing allergies) that applies irrespective of the genetic method used in variety development and which makes use of the already existing federal apparatus for the approval of new plant varieties.

First, one asks whether a new substance is found in parts of a plant that consumers eat or with which workers come in contact. If not, the substance is "exempt from health concerns." If it is found in such parts, then does it have chemical properties common to many allergens? If it does, then safety assessment is needed. If not, then is it similar to other substances that people eat? If not, then again we need safety assessment. The real problem revealed in the NRC report, although it did not seem to bother the panel, is that the data on which "safety assessment" is currently based are not produced by the federal agencies themselves but are provided by the very parties who are asking for approval to distribute the new variety in the first place. Moreover, no one seems to have noticed that there is, in fact, an aspect of the process of genetic engineering that does make that process unusually likely to produce unpredictable results.

All the attention has been paid to the physiological effect of the gene that has been put into the recipient, but none to the effect of where it is inserted in the recipient's genome. Genes consist of two functionally different adjacent stretches of DNA. One, the so-called structural gene, has information on the chemical composition of the protein that the cell will manufacture when it reads the gene. The other, the so-called regulatory element, is part of a complex signaling system that concerns where and when and how much protein will be produced. When DNA is inserted into the genome of a recipient by engineering methods it may pop into the recipient's DNA anywhere, including in the middle of some other gene's regulatory element. The result will be a gene whose reading is no longer under normal control.

One consequence might be that the gene is never read at all, in which case it will probably be bad for the recipient and will never be part of a useful agricultural variety. But another possibility is that the cell will now produce vast amounts of a protein that ordinarily is produced in very low amount, and this high concentration could be toxic or be involved in the biochemical production of a toxin. Yet another possibility is that a toxic substance that used to be produced only in one part of a plant, not ordinarily eaten, could now be manufactured in another part. Tomatoes are delicious, but you would be ill-advised to eat the leaves and stems because they contain toxins. It is not impossible that a genetically engineered tomato might, by bad luck, start to produce these toxins in the fruit. Thus the process of genetic engineering itself has a unique ability to produce deleterious effects and, contrary to the recommendations of the NRC report, this justifies the view that all varieties produced by recombinant DNA technology need to be specially scrutinized and tested for such effects. Exactly how one would go about doing that, in view of the unknown nature of the danger, is uncertain. Even extensive testing on a variety of animals provides no guarantee of safety since there are plant substances that are toxic to some species and not to others.

As yet no one that we know of has been poisoned by a transgenic plant. There have been a couple of close calls, however. The most widely cited case is the Brazil nut protein produced by a transgenic soybean. In some subsistence agricultural communities, for example in West Africa, diets are severely deficient in an essential amino acid, methionine. Brazil nuts produce a protein that is rich in methionine and so it was thought that inserting the appropriate gene from Brazil nuts into soybeans would provide an easy fix for West African malnutrition. Unfortunately the Brazil nut protein is known to be allergenic and the transgenic soybean proved to be so as well, so the variety was never released.

Proponents of recombinant DNA technology like Alan McHughen point to this case as a proof that self-policing by a variety developer can be counted on to avoid disaster. One's confidence in self-policing is somewhat diminished, however, by the realization that the allergenic properties of the protein were well known before the Pioneer Hi-bred seed company ever started to develop the variety in the first place. At some point they must have realized that the Food and Drug Administration would have refused approval of the variety even under our present system of regulation. How one wishes for a transcript of the discussions in the company board room.

A major part of the NRC report and the entirety of Rissler and Mellon's book are concerned with ecological issues in the broad sense. One anxiety is that "superweeds" will be produced, dominant plants that will spread en masse either through cultivated fields or through natural habitats. Sometimes what is meant by "weeds" is unwanted species that are growing in cultivated fields. At other times these are confused with introduced invasive species like the European purple loosestrife that has taken over so many American wetlands. There are no known examples of hybrids between cultivated plants and wild relatives becoming superweeds that have destroyed natural habitats, largely because too many of the characteristics selected during domestication make cultivars—cultivated varieties of plant species—dependent on the tender loving care given to them by farmers. Nor will the addition of a gene conferring herbicide resistance or pest resistance change that dependence. Plants growing in natural habitats are not subject to herbicides, nor are they attacked regularly by the hordes of predatory insects attracted to the concentrated free lunch offered in cultivated fields.

On the other hand, more difficult weeds of cultivated fields certainly will evolve if herbicide resistance becomes incorporated by natural crossing into species that are already weeds. The fear of superweeds is promoted by the metaphor of "escape" used to describe the passage of an engineered gene into a wild species. The image is of the mad scientist (or not-so-mad germ warfare biologist) who has created a virulent disease organism, ready at any moment to create a major epidemic unless it is rigorously confined to the laboratory or, better yet, destroyed. But transgenes are not spread like microbes, entering the body from outside. They are transmitted by reproduction of the entire genome of an organism, and if a cross occurs between an engineered plant and a wild relative, the result is an offspring that is hybrid in every respect, including all those characteristics that make cultivated varieties so ill-adapted to survival in nature, such as their demands for unnaturally high levels of nitrogen fertilizer.

The opponents of GMOs are not alone in the misuse of the image of "escape." McHughen, in his manifesto against the regulation of biotechnology, claims that spatial isolation of fields in which transgenic crops are growing is utterly useless because the transgenes have already escaped onto roadsides and other fields through seed that is inevitably spilled from sacks, trucks, and machinery in the very process of transportation and planting. But this small amount of spilled seed is irrelevant. What is properly of concern is not the escape of a virulent infection, but that a constant rain of millions of pollen grains produced by hundreds of acres of a transgenic crop will over and over produce hybrids with weedy species at the margins of cultivated fields and eventually result in a new weedy form that will be unusually invasive or competitive.

3.

Most of what is written about GMOs is quite parochial, concentrating on their effects in North America and Europe. While we expect nothing more from the National Research Council or from an indignant Canadian plant engineer, the general lack of interest in the effects of biotechnology on the third world seems in contradiction to the rather moralistic tone of the public discourse. Predictably, the most famous example of a piece of biotechnology that is supposed to be good for subsistence agricultures is cited by McHughen, but, unfortunately, it does not do the work intended. A serious problem of nutrition in some rice-producing regions, causing blindness, is a lack of vitamin A. A transgenic variety, Golden Rice, has been created with the promise that if it is ever cultivated, it will provide the missing vitamin. But Golden Rice—not to be confused with Green Revolution rice—does not, in fact, provide vitamin A. It is enriched in beta carotene, a precursor of the vitamin (hence the golden color), which can only be converted to vitamin A in the body of an already well-nourished person. The developers of Golden Rice have not dealt with this problem in their publicity releases. Rissler and Mellon have a brief final chapter entitled "International Implications," but these are largely the extension of the ecological risk arguments already made for the United States and do not deal with promised nutritional benefits.

The only recent book that deals with the effect of agricultural biotechnology in the third world and embeds it in a more general discussion of agricultural technology in general is Vandana Shiva's *Stolen Harvest*.[4] Shiva is what is called a "cult figure" for opponents of GMOs, but her book will give a detached observer more the impression of a cheerleader. She might have used her knowledge of Indian agriculture and her immense prestige among environmentalists to provide a credible up-to-date analysis of the effects of agricultural technology and market structures on third-world economies. Instead, she has produced a conjunction of religious morality, undeveloped assertions about the cultural implications of Indian farming, unexplained claims about the nature of the farm economy in India and how biotechnology destroys it, and unanalyzed or distorted scientific findings. *Stolen Harvest* is an opportunity squandered.

So with no further elucidation we are told that seeds and biodiversity are "gifts from nature and their ancestors" that Indian farmers have received; that "food security is not just having access to adequate food. It is also having access to culturally appropriate food"; that "the smoke from the mustard oil used to light the *deepavali* lamp acts as an environmental purifier." While Shiva makes the undoubtedly correct claim that conversion to high-yield Green Revolution varieties has resulted in less fodder for cattle and less green manure for fields and has displaced the culture of legumes, other vegetables, and fruits, she nowhere explains why Indian farmers have engaged in this self-destructive activity and how the global structuring of agricultural trade in combination with the internal economy of India has driven them to it. Indeed, she never shows that Indian farmers are worse off than before the introduction of agricultural technology.

Most disheartening of all, Shiva's reports of facts are not always as complete as they need to be. In a discussion of genetically engineered soybeans she writes that "infants fed with soy-based formula are daily ingesting a dose of estrogens equivalent to that of 8 to 12 contraceptive pills." It turns out, however, that the soybeans contain a nonsteroidal estrogen whose physiological activity is less than one thousandth the activity of the standard hormone. I learned this fact, not men-tioned by Shiva, by consulting the very article from which she says her dosage figure was calculated.

The real present danger to third-world agriculture from transgenics is elsewhere. Much of the agricultural economy of these countries depends on growing specialty commodities like lauric acid oils used in soaps and detergents, once found only in tropical species. Now, with recombinant DNA, these are produced by canola. Why buy palm oils from the politically unstable Philippines, where 30 percent of the population depends on it economically, when we can grow it in Saskatchewan? Caffeine genes have been put into soybeans. Why not Nescafé from Minnesota?

No unequivocal conclusions can be drawn about the overall effect of genetic engineering technologies. It is clear that any manipulation of organisms, whether by conventional means or by genetic engineering, poses some danger to human health, to present systems of agricultural production, and to natural environments. All of these potential effects have led to a fairly effective apparatus of government regulation whose chief deficiency is its dependence on data supplied to it by parties whose prime concern is not the public good but private interest. Nothing is significantly changed in this situation by the introduction of genetic engineering. The technology provides a method for transferring a specific gene into a crop, rather than the uncontrolled mixture of entire genomes that takes place when two varieties or species are crossed. On the other hand the random disruptions of regulatory genes of the recipient that may take place are totally uncontrolled. On balance, it is impossible to say whether we have achieved greater or lesser control over the unintended consequences of mucking around with nature.

We find ourselves in a puzzling situation. None of the books on the subject of GMOs gives us any reason to think that the known dangers to human health and natural ecosystems posed by agriculture have become radically greater because of the introduction of genetic engineering as a technique. Nor do we even have a single case of a catastrophe that might have engendered widespread public anxieties.

Yet in North America, and much more so in Europe, there is a widespread, passionate, and politically effective opposition to the use of recombinant DNA techniques in agriculture. Only a rare defensive newspaper advertisement paid for by the Council for Biotechnology Information speaks against the general consciousness, and we all know whom they represent. Is this just another chapter in MacKay's *Extraordinary Popular Delusions and the Madness of Crowds*? A hint at the answer can be found in a series of full-page newspaper advertisements created by the Turning Point Project, a coalition of over sixty political action organizations including Food First, the Sierra Club, and Greenpeace. One set of advertisements had as headlines:

Unlabeled, untested...and you're eating it
Biotechnology = Hunger
Genetic Roulette
Who plays God in the 21st century?

Just the usual anti–genetic engineering stuff? Consider another set:

Can industrial agriculture feed the world?
The myth of efficiency
America's last family farms?

Well, it's not just genetic engineer-ing that is being opposed. It's really part of the organic food ideology. The next set of headlines makes a new connection:

Global Monoculture
Globalization *vs*. Nature
Invisible Government

Somehow we have moved from DNA to the WTO, but we are not finished. The progression is completed with

Monocultures of the mind
If computers in schools are the answer, are we asking the right question?
The Internet and the Illusion of Empowerment
E-Commerce and the Demise of Community
Techno-Utopianism

Now we understand the Turning Point Project. They're a bunch of Luddites. Right century, but wrong movement. The followers of the unseen King Ludd and Captain Swing from 1811 to 1830 were industrial and rural laborers thrown out of work or trying to live on poverty wages, who destroyed knitting and threshing machines that had displaced their labor. Their objection to technology was not ideological but pragmatic. If we want to find the nineteenth-century equivalent of the sources of Turning Point consciousness, we must find it in the movement that began with Blake and ended with Rossetti, Ruskin, and the pre-Raphaelites, in the call to arms against the dark Satanic Mills:

Bring me my bow of burning gold!
Bring me my arrows of desire!
Bring me my spear! O clouds, unfold!
Bring me my chariot of fire!
I will not cease from mental fight,
Nor shall my sword sleep in my hand,
Till we have built Jerusalem
In England's green and pleasant land.

That nineteenth-century discontent was the reaction of a middle class repelled by the spiritual and physical ugliness created by a surging industrial capitalism to which they sensed no attachment. One might think that because the rise of industrial capitalism occurred so long ago and the culture it created has become so much the basis of European and American life, any truly popular new romantic movement against it would be inconceivable. But what was then a struggle against the rise of its dominance is now a struggle against its last consolidation in spheres of life that seemed set apart.

Until twenty years ago there were four intimate aspects of our personal lives that we assumed to be produced by individual artisanal activity. They were medicine, entertainment, sport, and vegetables. Some penetration of capital into those spheres had, of course, occurred but they were invisible to us. Since then our family physician has become a corporate health care practitioner; television, popular music, books, and film are owned by a few major conglomerates; baseball players are paid millions by owners who are paid millions by television networks who are paid millions by advertisers; and now Monsanto wants to tell me what to eat.

One consequence has been the creation of a false nostalgia for an idyllic life never experienced. I once bought a new computer in a large computer supermarket in a shopping mall in Boston. The salesman offered to carry the machine out to my car in the parking lot and as we approached the rear of the car, he spotted my green and white Vermont license plate. "Vermont!" he said, "That's where I really want to live." "Oh," I replied, "have you spent much time in Vermont?" "Oh, no," he said, "I have never been there." The independent family farmer, tilling the soil, in touch with nature, making decisions about what and when to plant and harvest from his craft knowledge, sitting down at dinner to a groaning board of home-grown victuals prepared by his aproned wife, is our last connection with an authentic life. We want to preserve it. Unfortunately, we are a hundred years too late and GMOs are the wrong target. To understand the situation we need more mental fight and fewer arrows of desire.

The history of American and European agriculture over the last hundred years has been a history of the increasing dominance of industrial capital over farming. In 1900 the inputs into farming were predominantly self-produced. The farmer saved seed from the previous year's crop to plant, the plow and tillage machinery was pulled by mules fed on forage grown on the farm, 40 percent of planted acreage was in feed crops, and livestock produced manure to go back on the fields. Now the seed is purchased from Pioneer Hi-bred, the mules from John Deere, the feed from Exxon, and the manure from Terra. The rise in purchased industrially produced inputs has had two effects. A major increase in yields per acre has driven down the price paid to farmers for their product. Simultaneously the farmers' costs of production have risen. There has been no escape from this dilemma for an individual farmer. Because the price paid for a farm product is determined by the aggregate production from all farms, no individual farmer can push prices up by holding down production. Thus he must increase production when other farmers do, but the result of all these individually economically rational acts is mass suicide. Smaller and smaller margins between farm income and expenses have led to increasing farm debt and bankruptcies.

The consequence of the growing dominance of industrial capital in agriculture for the classical "family farm" has been the progressive conversion of the independent farmer into an industrial employee. More and more farm operators and their spouses are only part-time farmers, trying to support their farming from outside income. That is why the confusion between farm family income and income from farming in the appendix to the NRC report is so misleading. In 1997, 60 percent of farm operators were also employed off the farm and 40 percent worked at alternative employment for more than two hundred days a year. They work as truck drivers, salespeople, secretaries, and factory workers. Car companies now put their assembly plants in the rural counties of the farm belt to take advantage of this labor force. It is not Jerusalem that has been built in the green and pleasant land, it is the dark Satanic Mills.

The creation and adoption of genetically modified organisms are the latest steps in this long historical development of capital-intensive industrial agriculture. Roundup Ready herbicide-resistant soybeans have been created by Monsanto so that farmers will be able to use its powerful herbicide, Roundup, while at the same time buying Monsanto seed. The farmers accept the cost of the new variety and its chemical partner because the use of such a powerful general weed killer will reduce the number of herbicide treatments or mechanical tillage passages through the fields, freeing them for the hours in the automobile assembly plant that they need to keep their farms. For the farmer there is no escape from engineering, whether it be mechanical, chemical, electrical, or genetic.

Notes

[1]Vandana Shiva, *Stolen Harvest*, p.17.

[2] NRC report, *Genetically Modified Pest-Protected Plants*, Appendix A, p. 220.

[3] Alan McHughen, *Pandora's Picnic Basket*, p. 198.

[4] The classic work on the effects of biotechnology in the third world is Calestous Juma's *The Gene Hunters* (Princeton University Press, 1989), which remains the basic source for an economic and historical analysis of the effect of agricultural technology in Africa and Asia. Because the work is a dozen years old, it antedates most of the actual development of GMOs and the immense growth of public discourse and anxiety about the subject.

Genetically Modified Foods Genetic modification employs recombinant deoxyribonucleic acid (rDNA) technology to alter the genes of microorganisms , plants, and animals. Genetic modification is also called biotechnology, gene splicing, recombinant DNA technology, or genetic engineering [1].Â Genetically modified foods. The production of genetically modified foods has provoked an ethical debate about whether it is right to use technology to create new forms of plant and animal life that otherwise would not exist. However, throughout human history agricultural crops have been genetically modified. There is nothing "natural" about food crops because most of them would be unable to propagate or survive without human intervention. While a handful of food-gene interactions have been studied beforeâ€”lactose intolerance, for instance, is known to be caused by a variation in the lactase geneâ€”most are only now being charted. â€œWhat constitutes good nutrition is actually a very individual prescription, depending on your particular set of genes,â€ says Jose Ordovas, a biochemist at Tufts University who has studied the nutritional genomics of cardiovascular disease. In certain men, for instance, eating a low-fat diet may actually increase the risk of heart disease. This occurs because a polymorphismâ€”a minor change in one geneâ€”caus One set of genes currently being explored are those that affect food preferences. Did you know that there are genetic variations in taste and smell receptors? Receptors are a type of nerve found in the body. One of their jobs is to send signals from the gut to the brain. Individual differences in these receptors may contribute to why some of us identify as having a sweet tooth and others prefer salty flavors.Â Genes related to the sense of smell, called olfactory genes, come into play with the taste of cilantro. Individuals with an aversion to cilantro possess both the gene that detects the soapy flavor and a variant of an olfactory gene. This olfactory gene variant may make them more sensitive to bitter tastes and be a factor in why individuals find the herb unpleasant tasting. What's a cilantro hater to do? Gene expression refers to the process where information from a gene's DNA sequence is translated into a substance, like a protein, that is used in a cell's structure or function. "We have found that a diet with 65% carbohydrates, which often is what the average Norwegian eats in some meals, causes a number of classes of genes to work overtime," says Berit Johansen, a professor of biology at NTNU. She supervises the project's doctoral students and has conducted research on gene expression since the 1990s.Â The key lies in insulin's secondary role in a number of other mechanisms. A healthy diet is about eating specific kinds of foods so that that we minimize the body's need to secrete insulin.