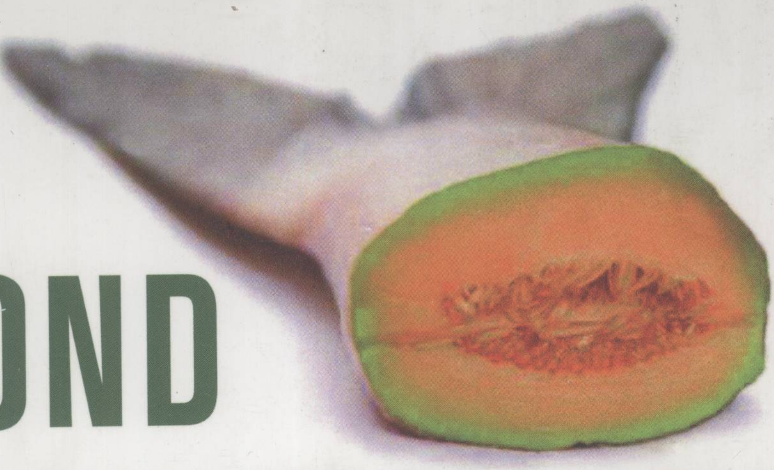

BEYOND BIOTECHNOLOGY

THE BARREN PROMISE OF GENETIC ENGINEERING

RAIG HOLDREGE AND STEVE TALBOTT

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Beyond Biotechnology

Culture of the Land

A Series in the New Agrarianism

This series is devoted to the exploration and articulation of a new agrarianism that considers the health of habitats and human communities together. It demonstrates how agrarian insights and responsibilities can be worked out in diverse fields of learning and living: history, science, art, politics, economics, literature, philosophy, religion, urban planning, education, and public policy. Agrarianism is a comprehensive worldview that appreciates the intimate and practical connections that exist between humans and the earth. It stands as our most promising alternative to the unsustainable and destructive ways of current global, industrial, and consumer culture.

Preface

In Part I of this book we look at agricultural biotechnology. Our main concern is to show that we cannot understand genetic engineering and its implications unless we begin to view it within larger biological, organismic, ecological, economic, and societal contexts. Many of the problems of genetic engineering arise because we lack an awareness and understanding of these broader contexts. In fact, we live in illusions if we imagine genetic engineering as a way of making neat and discrete changes in organisms that contribute to just as neat and discrete programs for, say, solving the world's hunger problem. Without recognizing how our technical interventions are embedded within a complex web of relations, such "solutions" to problems cause even greater problems.

Genetic engineering is based on the premise that a gene is a clearly defined entity carrying out a specific function and, when transferred into a different organism, will perform the same function in the new context. That such manipulation often does not work according to plan can be viewed, theoretically, as a technical problem to be overcome. But it is actually a symptom of what scientists doing basic genetic research over the past decades have come to recognize: that the gene itself is context-dependent. This is the theme of Part II. The simple, straightforward gene that always does its job, oblivious to whether it is in a root cell or a leaf cell, a bacterium or a plant, an animal or a human being, does not actually exist. In fact, a good part of the "art" of genetic engineering entails limiting the implanted gene's responsiveness to its new and ever-changing context.

All genetic engineering is carried out with a specific living organism as the "medium" for gene expression. And, more generally, we speak of the human being, the dog, or the rose that "has" genes and consider these genes as fundamental to heredity and to the formation of the organism's characteristics. Through the single-minded focus on discovering the building blocks of heredity, the organism itself—as a whole, coherent being—recedes into the background. It becomes merely the carrier of genes or the result of genetic effects. This perception is one-sided and an artifact of the scientific, technological process that focuses on understanding and manipulating details (parts) as a way to effect changes in wholes. If you work in this way long enough you may forget what you are dealing with. But while the whole living organism may disappear from consciousness, it does not disappear from reality.

So in Part III we turn our attention to organisms. The discussions of the cow, the sloth, and (in Part IV) the skunk cabbage are attempts to portray, in a concrete way, the fundamental qualities of wholeness and integration that characterize each organism, but each in its own individual way. Each of these studies is only a beginning, but a beginning that is significant, since it entails a shift in awareness from "entities" to relations, qualities, and contexts—precisely the kind of awareness that is missing in what drives genetic engineering and, more broadly, our egocentric, utilitarian approach to the world.

When we make this shift, then the world no longer appears to us in the same way. In a subtle manner, more or less everything changes. We see ourselves, as we discuss in chapter 14, as participants in an ongoing, evolving conversation with the world. And every true conversation involves a back and forth between the conversing parties. So our fellow creatures, as partners in a conversation, elicit our interest, and we try to understand them from their perspective. There are no easy answers and no pat solutions to how such an interaction could or should play itself out. But it makes all the difference in the world that we become aware of our involvement in a participatory process, which calls on us to develop ever new capacities of perception, insight, and responsiveness. In this process we leave behind the all-too-comfortable stance of viewing and treating our fellow creatures as things to be manipulated.

The kind of shift we're speaking of is radical. To get at the roots of fundamental change you have to look at thought—deep-seated habits of thought that inform our every action. As David Bohm states, "The whole ecological problem is due to thought, because we have the thought that the world is there for us to exploit, that it is infinite, and so no matter what we did, the pollution would all get dissolved away. . . . Thought produces results, but thought says it didn't do it" (Bohm 1996, 11).

Since thought *does* do it, we take a careful look, especially in chapter 13, at some assumptions and habits of thought that inform modern science. These assumptions and thought-forms have opened up immense fields of inquiry. But at the same time they are sorely limited, and this limitation becomes problematic when contemporary scientific practice and theory become the standard for what counts as real knowledge. When this happens, other modes of inquiry are marginalized, and we don't even realize that immense fields of investigation lie fallow, because traditional scientific methodology ignores them. So while all science presupposes qualities, which form the fabric of human experience and inform our every action, it has given us no tools to better understand those qualities. Nonetheless, the application of science in technology qualitatively changes things in the world, but within the dominant paradigm we have no way to assess what we're doing.

It is not so hard to recognize that you can't solve problems with the same kind of thinking that causes the problems you're trying to address. It's another matter to change that thinking at its source. In Part IV we are concerned with an evolution of science—and more generally, human understanding—to encompass the qualities of the world. So while these epistemological considerations, taken in isolation, may seem distant from the pressing problems we discuss in the earlier chapters, they are not. Our social and environmental "fixes" will remain tenuous, always at risk of reversal, if we do not work to eradicate the problems at their source: in our view of the world and our habits of thought. After all, it required at least several hundred years for us to become the alienated culture we are today; we can only change direction through profound shifts in our most fundamental assumptions.

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Part I

Genetic Engineering and Agriculture

Chapter 1

Sowing Technology

Drive the Nebraskan backroads in July, and you will encounter one of the great technological wonders of the modern world: thousands of acres of corn extending to the vanishing point in all directions across the table-flat landscape. It appears as lush and perfect a stand of vegetation as you will find anywhere on earth—almost every plant, millions of them, the same uniform height, the same deep shade of green, free of blemish, emerging straight and strong from clean, weed-free soil, with the cells of every plant bearing genetically engineered doom for the over-adventurous worm.

If you reflect on the sophisticated tools and techniques lying behind this achievement, you will likely feel some of the same awe that seizes so many of us when we see a jet airliner taking off. There can be no doubt about the magnitude of the technical accomplishment on those prairie expanses. And yet, the question we face with increasing urgency today is whether this remarkable cornucopia presents a picture of health and lawful bounty, or instead the hellish image of nature betrayed.

Actually, it is difficult to find much of nature in those cornfields. While nature always manifests itself ecologically—contextually—today's advanced crop production uproots the plant from anything like a natural, ecological setting. This, in fact, is the whole intention. Agricultural technology delivers, along with the seed, an entire artificial production environment designed to render the crop largely independent of local conditions. Commercial fertilizer substitutes for the natural fertility of the soil. Irrigation makes the plants relatively independent of the local climate. Insecticides prevent undesirable contact with local insects. Herbicides discourage social mixing with unsavory elements in the local plant population. And the crop itself is bred to be less sensitive to the local light rhythm.

Where, on the farm shaped by such technologies, do we find any recognition of the fundamental principle of ecology—namely, that every habitat is an intricately woven whole resisting overly ambitious efforts to carve it into separately disposable pieces?

But all this represents only one aspect of agriculture's abandonment of supporting environments. The modern agribusiness operation in its entirety has been wrenched free from the rural economic and social milieu that once sustained it. The farm itself is run more and more like a self-contained factory operation. And the trend toward vast monocultures—where entire ecologies of interrelated organisms are stripped down to a few, discrete elements—has become more radical step by step: first a single crop replacing a diversity of crops; then a single variety replacing a diversity of varieties; and now, monocultures erected upon single, genetically engineered traits.

As the whole process drives relentlessly forward, the organism itself becomes the denatured field in which genes are moved to and fro without regard to their jarring effect upon the living things that must endure them. Want to make a tobacco plant glow in the dark? Easy—inject a firefly gene! Want a frost-resistant strawberry? Try a gene or two from a cold-water flounder.

Yet, despite such chimera-like prodigies, the overriding question about biotechnology is not whether we are for or against this or that technical achievement, but whether the debate will be carried out in just such fragmented terms. In focusing on technological wonders to improve agriculture, are we losing sight of the things that matter most—the diverse, healthy, and complex communities and habitats we would like to live in? The question to ask of every technology is how it serves, or disrupts, the environment into which we import it.

Is Genetic Engineering New?

The natural setting whose integrity we need to consider first of all is that of the individual organism. The challenge we're up against here emerges in the frequently heard argument that genetic engineers are only doing what we've always done, but more efficiently. Writing in the *New York Times,* Carl B. Feldbaum, president of the Biotechnology Industry Organization, objected to the claim by critics that "what [traditional breeders] do is 'natural' while modern biology is not": "Archaeologists have documented twelve thousand years of agriculture throughout which farmers have genetically altered crops by selecting certain seeds from one harvest and using them to plant the next, a process that has led to enormous changes in the crops we grow and the food we eat. It is only in the past thirty years that we have become able to do it through biotechnology at high levels of predictability, precision and safety" (Feldbaum 1998).

But the concern about genetic engineering today isn't that it enables us to commit altogether new mistakes. Rather, it is that it perfects our ability to commit old ones. No one should suggest that the abuse of our technical powers began with the discovery of the double helix. Using conventional techniques, breeders have, for example, produced Belgian cattle with such overgrown muscles that they cannot be delivered naturally—birth requires Caesarian section. Likewise, there are hobbyist chicken breeders who—to judge from the pictures in their magazines—are more interested in bizarre effects that tickle human fancies than in the welfare of the chickens themselves.

The difference is that with genetic engineering we can now manipulate living organisms much more efficiently and more casually than ever before. The technician need scarcely be distracted by the animal itself. There's none of the Frankenstein drama and messiness. We can construct our monsters in a clean and well-lit place. The reassuring familiarity of the laboratory doubtless contributes to the illusion of precision and safety.

We begin to recognize the illusion when we observe how Feldbaum's claim completely glosses over what *is* unprecedented about genetic engineering: that it selects isolated genes, not entire healthy organisms. Writing in *Science,* geneticist Jon W. Gordon (1999) assesses the failed attempts to create heavier farm animals by inserting appropriate genes. In pigs, the addition of growth hormone–producing genes did not result in greater growth, but unexpectedly lowered body-fat levels. In cattle, a gene introduced to increase muscle mass "succeeded," but the growth was quickly followed by muscle degeneration and wasting. Unable to stand up, the experimental animal had to be killed. So much for precision.

Such results are hardly surprising when you consider the isolated and arbitrary intrusion represented by single-gene changes. By contrast—and this is what Feldbaum ignores—traditional breeding allows everything within the organism to change together in a coordinated way. As Gordon writes, "Swine selected [by traditional methods] for rapid growth may consume more food, produce more growth hormone, respond more briskly to endogenous growth hormone, divert proteins toward somatic growth, and possess skeletal anatomy that allows the animal to tolerate increased weight. Dozens or perhaps hundreds of genes may influence these traits."

If there's a logic to ecological relationships that says, "Change one thing and you change the whole," the same applies to the interior ecology of the organism. Responsible traditional breeding is a way of letting everything change without violating the whole—because it is the organism *as a coherent and healthy whole* that manages the change. Isn't it reasonable to assume that there's a wisdom at work amid all the complexity of the evolved organism that we cannot lay claim to with our largely trial-and-error manipulations?

Do Organisms Need Preserving?

In traditional breeding the integrity of the organisms themselves places limits upon what can be done—limits you could reasonably call "natural." For example, you could not cross a strawberry with a cold-water fish in order to obtain strawberries with "anti-freeze" genes.

The problem now is that we can break through these limits, but we have not replaced the safeguard they represented. Today, such a safeguard can come only from our own intimate, respectful understanding of the organism as a whole and of the ecological setting in which it exists.

This is the decisive question: does the organism possess a wholeness, an integrity, that demands our respect? And can we gain a deep enough understanding of it to say, "*This* change is a further expression of the organism's governing unity, and *that* change is a violation of it?" (See also Part III of this book.)

It is a difficult challenge, and not one we have trained ourselves to meet. You have to see a plant or animal in its own right and in its natural environment in order to begin grasping who or what it is. But given what ecologists David S. Wilcove at Environmental Defense and Thomas Eisner at Cornell University have called the "demise of natural history" in our time (Wilcove and Eisner 2000), there is not much hope of greater familiarity with the organisms whose natures we manipulate—certainly not by those laboratory- and test tube–bound researchers who are doing the manipulating.

Nevertheless, some things are fairly obvious. It's hard to understand how the mad cow debacle could have occurred if anyone had bothered to notice the cow. How could we possibly have fed animal parts to ruminants? *Everything* about the cow, from its teeth to its ruminating habits to its four-chambered stomach, fairly shouts at us, "*Herbivore!*" (See also chapter 10 on the cow.) Can we violate an organism's integrity in such a wholesale manner without producing disasters—for the organism, if not also for ourselves?

What the mad cow episode illustrates is that our notions of safety are relative to our understanding of the organism. And nothing has tended to fragment our view of the organism as powerfully as genetic engineering. Instead of a coherent whole expressing an organic unity through every aspect of its being, the engineers hand us a bag of separate traits and molecular instrumentation.

Are Bioengineered Products Adequately Tested?

Only such a fragmenting mentality could suggest (in the words of former U.S. Secretary of Agriculture Dan Glickman) that "test after rigorous scientific test have proven these [genetically engineered] products to be safe" (Glickman 1997). This suggestion is simply false on its face (see Smith 2007). The application to cows of bovine growth hormone (rBGH) produced by genetically engineered bacteria was approved primarily on the basis of tests with rats—not cows, and not people who consume cow products. Genetically altered Bt corn was approved without being tested for its effects on beneficial species such as green lacewings or on "incidental" species.

But the more fundamental problem is that, because the organism is an organic unity, its assimilation of foreign DNA potentially changes *everything.* Gene expression and protein levels are altered in ways that have proven consistently unpredictable. About 1 percent of genetic transfers yield the looked-for result; the other 99 percent are all over the map. For example, when scientists engineered tomatoes for increased carotene production, they indeed got some plants with more carotene—but those plants were unexpectedly dwarfed (Fray et al. 1995). No one expected this experiment to yield dwarfed plants.

So even the 1 percent statistic paints too optimistic a picture. This "success" rate reflects a focus on the particular trait that was looked for; but even when this trait is obtained and the resulting organism is used