

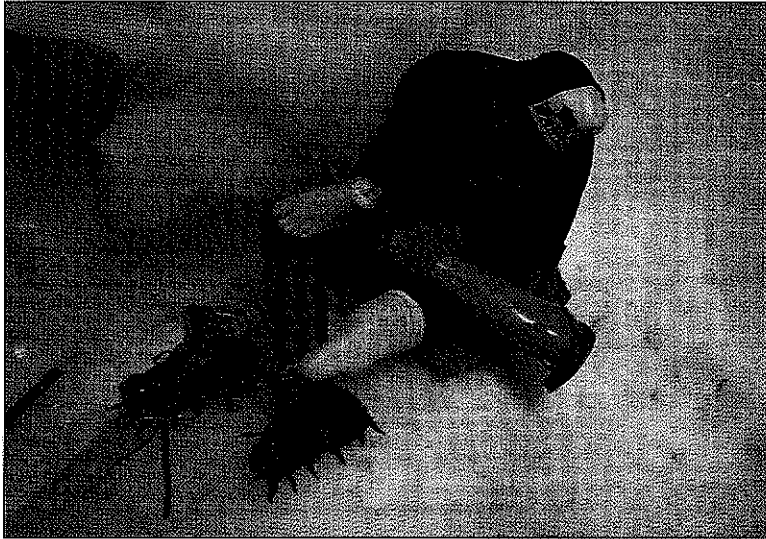
# Who's in Charge of the Gene Genie?

Jane Maienschein

***Although humanity's growing direct mastery of the genetic stuff of life gives us the power to modify our biological selves, mold the human genome, and radically alter the environment, that power is effectively unregulated because we have yet to learn how to harmonize our conflicting values.***



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■ **Left:** Society cheers many products of engineering, such as artificial limbs. **Opposite:** In response to genetic engineering's progeny, however, no broad consensus has emerged, and some groups, such as these protesters destroying a field of genetically modified crop, clearly oppose them.

In 1976, Sen. Edward Kennedy expressed concerns about genetic engineering at a Senate hearing, saying that "the implications of technological advances must be carefully considered early on, and must be considered in public processes with wide participation from as many diverse elements of society as possible. . . . The real problem is to understand the social consequences of what science can now enable us to do" (quoted in June Goodfield, *Playing God: Genetic Engineering and the Manipulation of Life*, Random House, 1977, p. 153).

It was the first successful genetic engineering, involving recombination of DNA from one organism into another, that elicited his call for Congress to take the lead in ensuring broad public debate of the risks and benefits of such technological innovations. For the first time, scientists had developed molecular techniques to

snip pieces of DNA from one organism and splice those pieces into the DNA of another organism. These researchers worked with bacteria that did not seem to threaten humans immediately, but geneticists had let this genie out of its bottle.

Geneticists imagined cheap and effective sources for products normally made only by genes in "natural" organisms, and that previously had to be recovered at great expense from animals. Soon, they speculated, we might be splicing genes that code for, say, insulin into bacteria that would then serve as factories to produce insulin. Or, some imagined, we might be able to use the molecular tools to remove a "defective" gene from a fertilized egg and replace it with a "normal" one.

The prospects for genetic engineering excited those who foresaw wonderful medical and agricultural applications. Genet-

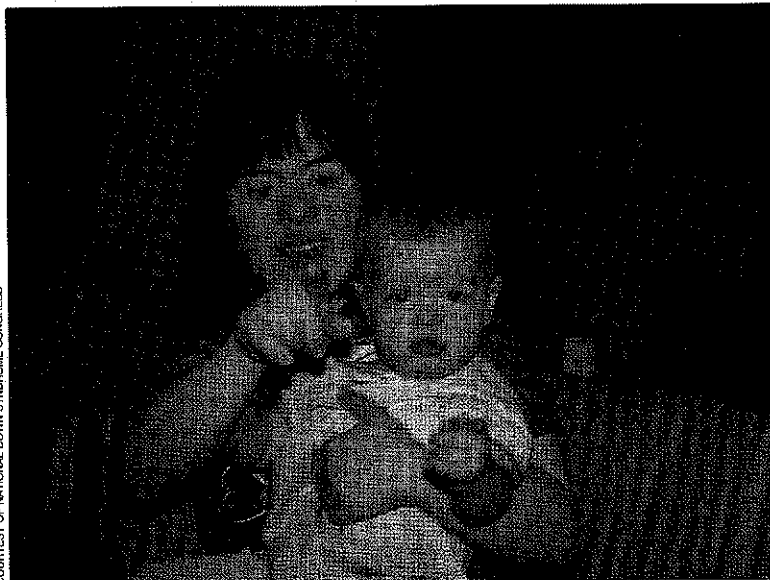
ic engineering companies popped up overnight like mushrooms and seemed to grow best in the dark, without any actual products for the first year and in the face of fears about possible unpredicted negative effects. Investments soared even while critics asked whether scientists should be allowed to "play God" in this way.

Two and a half decades later, we still feel the same hopes, enthusiasms, uncertainties, and questions. Though we have made tremendous advances with our scientific knowledge and technical applications, we still have not met the challenge to address the social consequences.

### **Mixed reactions**

Americans have always cheered the advances of engineering, saying that engineering is good, that building better bridges, housing, airplanes, computers, water and sewage systems, transportation systems, and on and on are all good. Replacing injured arms or legs, diseased kidneys, and hearts—these are also good, as is producing more abundant food and water. Developing countries look to the United States for technological leadership, and our advances seem to offer all the

COURTESY OF NATIONAL DOWN SYNDROME CONGRESS



■ As technology intrudes on the complex world of genetics, it is important to remember that genetics isn't everything. Embraced by a loving family, children with Down syndrome, for example, can bring joy to the family and grow up to become contributing members of society.

medical, agricultural, and economic success that people everywhere want. So what's the problem? All these existing and accepted technologies involve "playing God" in the sense of using human initiatives to make life better for those who are injured, malnourished, or whatever. Is genetic engineering really any different?

European consumers have recently expressed their fears about foods genetically modified with foreign genes spliced into otherwise normal food products. One of these, the Bt gene, taken from a bacterium, codes for a molecule that is toxic to insect pests of such food crops as potatoes and corn. European consumers are worried about their own personal health and also the unpredictable effects on the environment. They do not trust large companies that stand to profit,

nor the scientists who work there, when they offer assurances that this is all tested and "safe." These consumers, and the market that reflects their opinions, have one answer: Yes, genetic engineering is different, because it has the potential not only to disrupt and genetically alter our environment but change our very biological selves.

These are reasonable concerns, but not all the fears expressed by critics are warranted by the scientific facts. For example, it is ridiculous to imagine, as some have, that isolated genes could somehow escape from a genetically engineered crop and fly around the ecosystem wreaking havoc. This is science fiction—and bad science fiction at that, since genetic recombination does not work that way. Yet it is quite possible for genes to be transferred accidentally and in unpre-

dictable ways from one species to another, or to become augmented and do something they were not able to do before. Just because the original recipient (potatoes or corn or a small baby) of a transferred gene is safe, and just because we splice in a gene that is safe in itself, does not mean that there could not be possible unpredictable negative consequences when the two are put together. Therefore, as Kennedy urged, we should at least stop and think about what we are doing and, insofar as possible, the likely consequences.

Genetic engineering means the human, and hence "artificial" (as in the sense of nature doesn't do this without our help), manipulation of genes. This may involve, as in the case of genetically modified foods, manipulating genes in individual organisms, one at a time. Of course, scientists do not sit there and place new genes by hand into every single potato. There are ways to do this in large batches at a time. But the expectation is that someday not too long from now we will place genes by hand, one at a time, into human fetuses or individual patients to correct deficiencies or replace "bad"

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genes that cause particular diseases. This sort of individual manipulation is what many people imagine when they hear the term *genetic engineering*.

Manipulation of the gene pool, or the total of all genes of all the individuals in a population, is also genetic engineering. New techniques have recently allowed fertility clinics to determine with a high statistical probability of success whether a fertilized egg is likely to be male or female. If a couple wants only females, perhaps because the parents carry genes that cause disease only in male offspring, then the clinic can pick out the females and implant only those in the mother. This is genetic engineering, the engineering of the genetic outcome of reproduction. Imagine that a clinic allows parents to choose the "smartest" or "prettiest" or "strongest" genes and throw away the others. That is also genetic engineering. And it raises additional questions.

What we tend to forget is that genetics is not everything. Genetics alone is not destiny, because development and the environment make a great difference in how genes are expressed. Parents of children with Down syndrome (also known as trisomy 21), for example, remind us that

children with traits deemed to be a disability can be a real blessing to a loving family and become contributing members of society.

Engineering the gene pool through systematic selections does affect who we are as a species and what potential we have for the future. If we could systematically eliminate all "defective" genes and did so every chance we had, then those societies wealthy enough to do so would become more and more limited in their genetic potential, while poor societies that could not afford such manipulations would retain the full range of genetic potential. In the long run, as environments change and humans face new challenges, this could have profound effects. We should think about such possibilities. These are special questions raised by genetic engineering.

### **Competing values**

For those who adopt the view that life is essentially mechanistic, made of material and acting in a largely machinelike way, there are no special questions. Life involves a succession of individual organisms through history, each of which follows mechanistic principles and laws. One generation gives rise to the next guided by heredity, in the form of

genetic "information" passed along through DNA and its magnificent dance of replication and expression of new form through embryonic development. Individual organisms belong to species, and these are interbreeding groups that evolve through time in response to environmental conditions. This is the virtually unchallenged view held by biologists. Evolution, genetics, and the development of the individual organisms that not only represent their species but also exhibit their individual variations are taken as givens. As a description of a process, the materialistic biologists' view is the very best available science, however much skeptics from outside the discipline may complain about evolution or materialism.

Yet there are areas of legitimate disagreement about what follows from the science. In fact, there is considerable room for value assessments that lie outside science and cannot be understood scientifically. We cannot demonstrate scientifically, for example, that it is "better" to replace genes that would normally cause a child to die a painful death by age 10 with genes that would allow the child to live. On the face of it, the preference for replacing a diseased gene with a healthy one is obvi-

■ The fears that genetically modified food crops will escape and wreak havoc on the environment, even as they debilitate people who eat them, is epitomized by this Frankenstein protester informing shoppers of the soybean component of some foods.

ous, especially if the risks of replacement could be reduced to an acceptably low rate. Yet, what we are doing in this case is not "natural" in the simplest sense. We might decide to embrace the unnatural because it leads to improvement, as we have accepted many technological innovations in the past. For those who do prefer the natural to the non-natural, we must invoke an additional, extrascientific, set of values.

One common approach is to adopt the seventeenth-century Protestant argument that there is a God, and that God gave man the ability to reason and use science and technology to organize and control our environment. Therefore, it is right and proper to do so. In effect, God told us to "improve" on nature. Though not everyone accepts this line of reasoning, of course, humanists and scientists may follow similar lines of reasoning that place the "imperative" to use our intelligence and scientific abilities with evolution or the need for survival, for example. Either line of reasoning supports the accepted use of "artificial" medicines, surgeries, and other procedures that extend and improve the quality of our lives.

Does this argument hold for



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genetic engineering? Or have we finally crossed some line such that this is no longer allowable? What would count as knowing such a thing? The argument on the prodevelopment side is the same as the above: We can, and indeed have a moral imperative to, use our knowledge to make life better where we can. This ability "to improve" or "make progress" has come to be accepted as a key characteristic of the good life that philosophers talk about and presumably everyone would prefer.

The so-called GM foods (genetically modified foods) do seem different to some, especially to many Europeans who may have been made more nervous by recent food scares having nothing to do with genetic engineering. The ability to splice genetic sequences into living organisms where they would not normally be found raises fears that we are somehow creating Frankenstein-

like versions of corn or unleashing something that we will not be able to control. This is what bothers people, suggesting that we are crossing some natural boundary that has protected us in the past. Certainly it is wise and sensible to ask about whether and where such boundaries might exist. But to know that we have reached such a special boundary we need a clear argument about what is different. We have fears and concerns, but these are not grounded in compelling logic or clear reasoning. Why should genetically modified foods raise special questions when medical procedures do not?

Here we come to questions about the relevant constituencies. In Europe, much more than in the United States, there is a strong "green" orientation, and "the environment" becomes a constituent with legitimate legal and social interests to be protected.

For "green" Europeans, the environment is taken as something natural, and as much as possible undisturbed by human interventions, and advocates for the environment lobby against human actions that can threaten what is natural. For them, genetic modification of crops is unnatural and hence to be rejected. We should not arrogate unto ourselves the power to change and disturb what is natural, the reasoning goes, for we are instead intended to exercise stewardship over other species and natural surroundings.

Historians and sociologists suggest that the relative lack of a natural environment in Europe leads to a heightened awareness and concern about protecting nature there. Americans, by contrast, have not so widely or so militantly adopted such an environmentalist view, perhaps because we have so much apparent wilderness that we feel buffered from assaults on what is natural. Nature abounds, after all—in our national parks, our forests, and even our backyards as deer and coyotes expand their territories into suburban neighborhoods. Looking beyond Europe and the United States, we see that in the poor countries the scramble to

survive seems to preclude investments of time or energy in efforts to save "nature."

### *Who is right?*

Given the differences between Europe and the United States, who is right? It does matter, after all, since economic markets are affected by value judgments and resulting regulations concerning what is allowed. If the European or Japanese markets will not accept genetically modified foods, then it might be more profitable not to grow them. But GM foods can be cheaper and more productive, requiring fewer pesticides and less physical intervention during the growing process, which is at least an obvious short-term advantage. Thus, the larger market forces and values that affect them do matter. If the market is the judge, then it looks as though those opposing GM foods may be "right." It remains to be seen whether the fears of environmen-

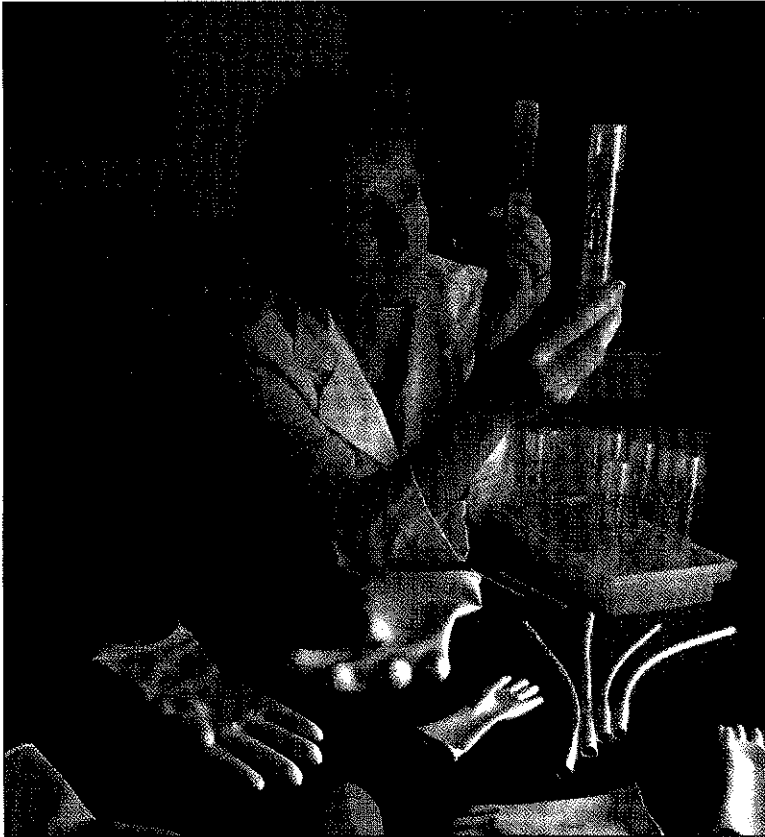
tal damage are real, however.

What about genetically modified animals? We now have mice with augmented "smart genes" that make them apparently more intelligent—in the sense of being able to perform particular defined tasks more successfully. The joke about why anybody would want smarter mice notwithstanding, this is real, and it is being done. There has been no outpouring of negative opinion or concern. Rather, the media have reported the results with enthusiasm and sometimes breathless wonder at how long it will be before we can do the same in humans.

What about genetically modified humans? Opinion polls show that Americans are enthusiastic about the prospects for curing cancer or whatever disease, with breakthrough discoveries that research funded by the National Institutes of Health (NIH) will bring us—well, just any day now. If only we invest enough in mission- and disease-oriented

■ While genetically modified food plants have been met by growing protests in many countries, genetically modified animals, such as this mouse whose genes were modified to enhance its memory and learning, have generally been favorably received.





JACK DYKINIA / COURTESY OF AGRICULTURAL RESEARCH SERVICE, USDA

■ The work of the gene genie is flourishing regardless of debates about regulating its powers. One of the myriad applications is the effort to genetically engineer guayule, a small shrub, to be a better source of rubber.

research, popular opinion seems to say, we can solve the problems. We can create wonderful babies for otherwise infertile couples by removing eggs and sperm and combining them. Along the way, at some point in the future, we will presumably have techniques to make better humans. In principle, we should be able to engineer the genetic composition of each individual, and therefore the population, by selecting only those genes and then those individuals that we want to have live and eliminating the rest—through fetal surgery, selective implantation, or targeted abortion. While

the discussion usually centers on the medical procedures, these manipulations are also fundamentally about genetic engineering. There are choices of which genes and which combinations of genes (which individuals) to allow to live.

Astonishingly, this work is largely unregulated. Most occurs in fertility clinics, and Congress has left the clinics to develop their own value systems and to make their own assumptions. The best have clear guidelines and protocols that they follow carefully, while the worst, as in any industry, are sloppy and careless. Our

take-home point here is that the practices in these clinics are based on different values.

The clinic that chooses to increase the chances of a pregnancy by fertilizing many eggs and then implanting them all in the mother exhibits little concern for the possibility all the eggs will die because the mother cannot carry them to term. This clinic also shows little concern for the possibility that if the mother does carry all the eggs to term, as has happened recently with seven and then eight births, it will be at great medical cost—and someone will have to pay that cost. By contrast, the clinic that fertilizes and implants only a small number—and perhaps chooses those that have the “best genes”—acts more responsibly by accepting the risk of lower pregnancy rates and disappointed clients, but avoiding the heartbreak of miscarriages and problems of multiple fetuses. The values guiding these decisions are social, ethical, political, and economic—not scientific. The ways of going about knowing what is possible and judging what is right begin with a variety of competing underlying values and assumptions about what matters and what counts as evidence in favor of any given claim. At the root, we

## *We need intelligent social discussion of the competing values, as well as intelligent and reflective social negotiation across differences.*

have different and competing epistemologies.

### **So what?**

What follows from this recognition that life is messy and full of conflicting values and competing epistemologies? Surely we knew that already? Yes, of course, but did we face what it means to accept this? It means that we cannot turn to just one source as the ultimate authority, whether the church (and there are, after all, many competing alternatives even here, or even competing interpretations of the Christian Bible), the king (since very few of us have one anymore anyway), the Congress or Parliament or other ruling group (since increasingly few of us vote or respect our elected representatives anyway, according to polls in many countries), or any one expert (and who is an expert anyway?). It cannot be the scientist-as-expert who will decide how to use genetic engineering, even though it is scientists who must tell us what is possible and how the technology works.

The reaction to those first cases of recombining DNA in the 1970s is instructive. The scientists themselves quickly saw that applying the techniques could lead to the irreversible creation of "unnatural" genetic "monsters."

They did not anticipate disaster, but they called for careful consideration of what they knew and what values should guide application of the knowledge. They organized a special meeting in Asilomar, California, in 1975 to consider the scientific realities, the prospects, and the implications of genetic recombination. After intense discussion with lawyers and members of the press, they issued a statement. They called for a moratorium on certain kinds of research thought to carry the greatest risks until we gained further knowledge, and some of them worked with the NIH to develop a set of guidelines.

Learning from experience since then, we have established ethics committees and protocols for reviewing the impact of scientific and technological innovations. A set of physical and biological protections has been put in place for particular kinds of genetic engineering research carried out with public funding. And when new technologies arise, we appeal to ethics advisory committees. James Watson, as first director of the Human Genome Project, thought it politically expedient to develop a program to explore the ethical, legal, and social implications of genetic discoveries.

Yet our reactions remain largely uncoordinated and not

deeply reflective or productive. In the face of new advances such as cloning or genetic modification of foods, Congress typically fusses around and calls hearings. But we have no acknowledged leaders or procedures for resolving conflicts between competing systems of values and epistemologies.

Values beyond scientists' desire to pursue knowledge at all costs should influence our social choices concerning how to use technologies like genetic engineering. Yet the fearful Luddites who oppose all innovation should not prevail without clear reason. We need intelligent social discussion of the competing values, as well as intelligent and reflective social negotiation across differences. Not everything is equally good, but we have no way of knowing that one particular set of values ought to prevail. The decisions are a matter of social convention and negotiation, but we have not yet established the rules to guide this negotiation. Kennedy was right in saying that "the real problem is to understand the social consequences of what science can now enable us to do." We just don't know how to do that. ■

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