Chapter 22

Philosophy of Biotechnology: Sheldon Krimsky

Before I get to Krimsky (whose biographical materials I will give later), some general comments are in order about the current state of philosophical thinking on biotechnology. Though I have presented the following material elsewhere, most recently at the 2005 SPT conference in Delft, it has not previously been published. So I present it here as new.

Philosophical work to date has followed traditional lines, beginning with ethics.

One of the earliest attempts by a philosopher—an analytical philosopher in this case—to be balanced in his approach was that of Jonathan Glover, in his *What Sort of People Should There Be?* (1984); there Glover gives a cautious green light to some sorts of genetic engineering. At about the same time, a Heideggerian, Wolfgang Schirmacher (1987) offered his reflections on the early debate in Germany; Schirmacher's endorsement was even more positive, arguing that we have a responsibility to use genetic manipulations to improve human behavior, so often less than moral up to now.

I have found at least four books with "genethics" or a variant in their titles: David Heyd, *Genethics: Moral Issues in the Creation of People* (1992); Kurt Bayertz, *GenEthics: Technological Intervention in Human Reproduction as a Philosophical Problem* (1994); reflects the same German debates as Schirmacher; David T. Suzuki, *Genethics: The Clash between the New Genetics and Human Values* (1989); more critical; and David T. Suzuki, *Genethics: The Ethics of Creating Life* (1988).

Nor does this exhaust the list. There are at least two collections with similar titles: Justine Burley and John Harris, *A Companion to Genethics* (2002); contributions mostly by philosophers; and M. Khoury, W. Burke, and E. Thomson, eds., *Genetics and Public Health in the 21st Century: Using Genetic Information to Improve Health and Prevent Disease* (2000); mostly non-philosophers and mostly optimistic.

In addition (and finally, because my intent is not to be exhaustive), there are two textbooks on related subjects: Michael Boylan and Kevin E. Brown, *Genetic Engineering: Science and Ethics on the New Frontier* (2001); and Michael C.

Brannigan, *Ethical Issues in Human Cloning: Cross-Disciplinary Perspectives* (2001), which includes an interesting range of perspectives from religious ethicists.

Politics would be the next heading, and many things have been written about the politics of various aspects of genetics, including the exporting of genetically modified foods and seeds to various countries. But one philosopher has had the field almost to himself in providing balanced, judicious assessments of all aspects of biotechnology. That philosopher is Sheldon Krimsky, and I will take up his work at length later in this chapter.

Next would come philosophy of science approaches to biology, though for the most part philosophers of biology—though that subfield is flourishing—have had little to say about biotechnology. On the other hand, they have had much to say about genetics, where one big issue has been whether genetic explanations are (rightly or wrongly) reductionist.

The basic science (accessible to an intelligent lay reader) can be found in Michel Morange, *The Misunderstood Gene* (2001). Morange is not a philosopher but a biologist and historian of science; however, his treatment of genetics is judicious and balanced enough to satisfy any philosopher. He also, conveniently, has authored a *History of Molecular Biology* (1998).

The basic reductionist text is Richard Dawkins's *The Selfish Gene* (1989). Kim Sterelny, *Dawkins vs. Gould* (2001), summarizes one controversy. And Richard Lewontin, in *It Ain't Necessarily So: The Dream of the Human Genome and Other Illusions* (2000a), and *The Triple Helix: Gene, Organism, and Environment* (2000b), provides the best-known anti-reductionist counterpoint.

Many traditional philosophers of science, including philosophers of biology, are critical of social-constructionist interpretations of the sciences, including the biomedical sciences. (See Chapter 25 below.) The major social constructionist who has worked closely with biological research communities and provided detailed quasi-anthropological accounts of what goes on there is Karin Knorr-Cetina, beginning with her *The Manufacture of Knowledge* (1981), but continuing in such studies as "Image Dissection in Natural Scientific Inquiry" (1990, with Klaus Amann). Knorr-Cetina's work neither takes sides in the reductionism controversy nor deals directly with biotechnology, but it could support the claim that much of what passes for pure science in biology is closely akin to goal-directed biotechnology as found in the industrial genetics labs studied by Krimsky (below).

Finally I'd like to raise the issue as to whether there ought to be a philosophy of biotechnology proper in any kind of general sense. Here I will pick up several threads from Chapter 15 above on philosophy of engineering. One of the reasons why traditional philosophers of biology have little to say about biotechnology beyond the issue of genetic reductionism is that they often (at least implicitly) buy into the notion of biotechnology as simply applied biology. So that is a good begining here.

The philosopher who has identified technology (in general) with applied science is Mario Bunge, and he has spelled out his approach to biotechnology explicitly in his *magnum opus, Treatise on Basic Philosophy* (multivolume, each volume with a different date, beginning in 1983; the material on biotechnology is in volume 7, 1985, pp. 246ff.).

Bunge begins: “This section deals with biotechnology” (p. 246); and it becomes obvious very quickly what Bunge’s approach is: “Iatrophilosophy, or the philosophy of medicine . . .”—where he identifies philosophy of biotechnology with philosophy of medicine. Unfortunately, according to Bunge, not much “serious iatrophilosophy” has been published yet, so there is “much that analytically oriented philosophers could do to prepare the terrain” (p. 246).

Bunge continues: “Medicine [recently tapping biology in general and molecular biology in particular] . . . is now on the right track, though it has a long way to go before attaining the rigor and effectiveness of engineering” (p. 246).

For Bunge, “Therapeutics [is] a branch of biotechnology” (p.2 48). And he provides what for him is a telling example: “Once . . . a [biochemical] mechanism [of a pathogen] has been unveiled, the technical problem of designing drugs inhibiting the pathogen can be posed in precise terms” (p. 249). So medicine can become a science, and medical cures are straightforward “engineering” applications of that science.

If this seems too narrow and deterministic, Bunge admits that, “Over the past decades, medicine has gradually . . . adopted the *systemic* model of man as a biopsychosocial entity” (p. 249)—so the range of medical sciences to be applied in bioengineering and biotechnology has been broadened considerably. But whatever the branch of medical science and therapeutics as straightforward bioengineering, the model is the same: science applied equals engineering or technology. For more detail, see Martin Mahner (with Bunge), in *Foundations of Biophilosophy* (1997).

As we saw in Chapter 15 (as well as in Chapter 5 on Bunge), there are many critics of the application model. Historians of science and technology, for more than 25 years, have attacked the notion that technology (or engineering) is simply applied science (see, for example, Edwin Layton, "A Historical Definition of Engineering," 1991, where Layton summarizes his own previous work and that of other historians). But I am not aware that any of them have challenged Bunge on biotechnology. Philosophers similarly have challenged the applied science model. For example, in the same volume in which Layton's historical critique appears, philosopher Steven Goldman (1991) argues that the nature of engineering has been obscured by both scientists and engineers (along with managers and the public), who think along the lines laid out by Bunge. By cloaking their work in the mantle of praise for science—nearly always adding "for the public good"—engineers and their defenders, according to Goldman, are able effectively to mask the "social determinants of technological action" that actually drive modern engineering at every level, including the level of what counts as engineering knowledge. Using example after example of how engineering decision makers almost never pursue the "technical best," deferring instead to managerial decisions about what to pursue and how far, Goldman concludes: "Engineering thus poses a new set of epistemological problems deriving from a rationality that is different from that of science. The rationality of engineering involves volition, is necessarily uncertain, transient and nonunique, and is explicitly valuational and arbitrary. Engineering also poses a distinctive set of metaphysical problems. The judgment that engineering solutions "work" is a social judgment, so that sociological factors must be brought directly into engineering epistemology and ontology" (Goldman, 1991, p. 140).

These "captive" experts tend to see nothing wrong with the "applied science" model. Goldman attributes this to a kind of cultural blindness: "The purported value neutrality of the technical is an ideologically motivated strategem." (Goldman says engineers voluntarily go along with their managers, with whom, on this point at least, they share the ideology.) "It serves," Goldman goes on, "to insulate from criticism the social factors determining technological action" (p. 141).

Goldman's conclusion is controversial, but it seems to me that both critics and defenders of engineering agree on the "captivity" of engineering practice. Defenders seem to claim that engineering, freed of its constraints, could be more objective—this is clearly Bunge's hope. Critics like Goldman say, instead, that we have to judge engineering—even engineering's epistemology or knowledge claims—not by what it might be, but as it is in the real world.

None of Goldman's examples has anything to do with biotechnology, but so many of the large biochemical and pharmaceutical corporations have their research and development departments involved in biotechnical development that it is easy to see how Goldman's view would be instantiated there as "captive biotechnology."

As I said in Chapter 15, because I think engineering is a key component of any adequate philosophy of technology (see also Durbin, 1991, introduction), I pause for a moment to consider the philosophizing of an engineer, Billy Vaughn Koen (1985, 1991, 2003), who believes both that engineering has been almost totally ignored by philosophers and that he has captured the essentials of *the* engineering method. It also happens that, in his latest book (2003)—which ambitiously turns his engineering method into *the* universal method of human problem solving—Koen also includes a brief comment on the current state of bioengineering, as we will see in a moment.

The essence of the engineering method that Koen thinks he has discovered can be summarized briefly (too briefly?) under two headings: heuristics, and "sota" or state of the art. Koen concludes: "My Rule of Engineering is in every instance to choose the [always fallible] heuristic from what my personal sota takes to be the engineering sota at the time I am required to choose" (Koen, 1991, p. 57).

And: "If . . . all engineers in all cultures and all ages are considered, the overlap [among their sotas] would contain those heuristics absolutely essential to define a person as an engineer" (p. 58).

Again as noted in Chapter 15, Koen has little use for definitions like that of Bunge, that engineering is applied science—though he readily admits that engineers' sotas do include scientific knowledge. Nor does Koen agree wholeheartedly with Goldman's anti-Bunge "captive engineering" view, though he does emphasize that the state of the art in any engineering project clearly must include managerial and other non-engineering constraints (including public and political input). What Koen wants us to see is that good (he would even say the best) engineering practice always contains the fallibility of heuristics (he thinks unlike science), *but* it is also always bound by best practices of the time, the sota or state of the art.

I mentioned that Koen is willing to go far out on a weak branch to generalize: "The responsibility of each *human as engineer* [is] clear. Everyone in society should develop, learn, discover, create, and invent the most effective and beneficial heuristics. In the end, the engineering method is related in fundamental ways to human problem solving at its best" (Koen, 1991, p. 59).

And Koen's latest book, *Discussion of the Method* (2003), attempts to turn this generalization into *the* universal method of human problemsolving, following in a long line of philosophers (and others) who have attempted to discover such a universal method. And what is relevant here is Koen's few comments (2003, p. 249) that apply his universal method to an assessment of the state of the art today in bio-engineering: "Both behavioral and genetic engineers recognize that they want change in a highly complex, unknown system and, not surprisingly, instinctively appropriate the title engineer. Saying you are an engineer, however, doesn't necessarily mean that you are a very good one.

"The present state of the art of both the behavioral and genetic engineer contains the appropriate heuristics for behavioral modification, but few of the heuristics of engineering. . . . Neither has the slightest notion of the importance of making *small changes in the sota, attacking the weak link*, or *allowing a chance to retreat*."

This is a serious indictment of genetic (and behavioral) engineering, as currently practiced, and here it comes from an engineer/philosopher, not from one of the public critics of bioengineering and biotechnology.

But Koen's assessment (however brief) of the current state of bioengineering can be challenged. Doing so provides a third step toward a general philosophy of biotechnology. To repeat one more item from Chapter 15, Ana Cuevas Badallo, in an ambitious doctoral thesis (2000), discussed the role of the so-called *engineering sciences* in a new philosophy of technology that would be more adequate than any offered so far. After listing more than a dozen engineering sciences, classical and modern, she chose to focus on the most traditional, so-called Strength of Materials. But her basic list (pp. 79–80), a very standard list in engineering education, extended from strength of materials to aeronautic engineering, systems of control, management as a part of engineering, and—our focus here—bioengineering and genetic engineering. And she ends her thesis this way: “Here I have analyzed only one theory among the engineering sciences, so the future is open to see if the proposed characterization is correct in relation to other cases—a task beyond our present scope. The conceptual framework presented here needs to be refined through studies of other engineering sciences and their relationships to other natural sciences, to mathematical sciences, and even to the social sciences” (p. 372; my translation).

I believe Cuevas offers a worthwhile qualification on Koen's offhand dismissal. Are there engineering sciences (not unlike cookbook formulas, but at a higher theoretical level) in biotechnology? Cuevas does not say, but her conclusion (above) hints that her thesis might be applicable in that area of engineering every bit as much as in structural engineering. To support this hint, I refer to four crucial discoveries in genetic engineering: cutting DNA strands using *restriction enzymes*; *recombining them*; proliferation of useful genetic materials through *polymerase chain reactions*; and so-called “knockout” or *gene inactivation* studies for the purpose of determining gene activities in a precise way. All of these discoveries are complex and have led to what outsiders might view as cookbook formulas somewhat parallel to strength of materials equations, but it is interesting that people have been awarded major *science* prizes for their discovery, however inseparable the discoveries are from practical goals. I make no claim to being a bioengineering or biotechnology expert, but those who are refer to these breakthroughs as *both* scientific *and* practically oriented in the sense described by Cuevas: Michel Morange says, “The experiment carried out at Stanford by David Jackson, Robert Symons, and Paul Berg and published in l972 in the *Proceedings of the National Academy of Sciences* marked the beginning of genetic engineering. In this article, Jackson, Symons, and Berg describe how they obtained *in vivo* a hybrid molecule containing both the DNA of the SV40 oncogene and the DNA of an altered form . . . that already included the *E. coli* galactose operon” (Morange, l998, p. 187).

According to Morange (1998, p. 186), others disagree and credit earlier work—of Werner Arber, Hamilton Smith, and Daniel Nathans, summarized by Arber (1979)—on the use of restriction enzymes to cut or cleave DNA at precise points, of which the Berg group’s work was a “natural development.”

The fact that Berg did not receive a Nobel Prize and his predecessors did does not detract from the point made here. Both accomplishments have been recognized (Berg won other prestigious prizes) *both* as important scientific breakthroughs *and* as key techniques for future practical work in genetic engineering.

Still following Morange (1998, p. 231), we come next to PCR, the polymerase chain reaction technique—which Morange says (p. 242), “More than any other technique, has changed the work of molecular biologists.” Here is Morange’s summary of how it has done so: “In 1983 Kary B. Mullis developed a technique for amplifying DNA called the polymerase chain reaction (PCR). [See Mullis, 1990.] PCR can amplify virtually any DNA fragment, even if it is present in only trace amounts in a biological sample, thus allowing it to be characterized. It can aid forensic medicine by characterizing DNA molecules present in biological samples such as hair, traces of blood, and so on. It is sufficiently sensitive to permit the detection and characterization of the rare DNA molecules that persist in animal or human remains thousands of years old. This technique also makes possible a genetic diagnosis on the basis of a single cell. . . . Finally, it permits the early detection of bacterial or viral infections” (p. 231).

All these practical applications led one seemingly jealous previous Nobel Prize winner to call PCR “a mere technical trick” when Mullis won his Nobel in 1993. But Morange (1998, p. 242) clearly thinks it *was* a significant scientific breakthrough as well as a significant breakthrough in genetic engineering.

In a more recent book, Morange (2001, pp. 64ff.) talks about a completely different technique, or set of techniques. The book focuses on gene *function* rather than genes in the abstract or genetic engineering; indeed, Morange says: “My description of gene function is . . . as concrete as possible, giving a precise image of their functions in the most fundamental life processes: development, aging, learning, behavior, the establishment of biological rhythms, and so on” (Morange, 2001, p. 4).

And in that context one particular technique, so-called “gene knockouts,” seems particularly important to him. “Inactivating [a] gene makes it possible to see in which tissues and organs its action is necessary. Conversely, when the product of a gene has been sufficiently studied . . . [even] fully described, it may seem unnecessary to verify the function *in vivo* by a knockout experiment. However, knockout experiments . . . have produced more surprises than even the most enthusiastic partisans of this new technique expected" (p. 64).

In this case (these cases), the practical payoff is not usually bioengineering but some scientific discovery that may have an impact, say, on clinical medicine. So I may be stretching in bringing this in here, but it does seem to me that such gene knockout experiments represent another case of the kind of theory-practice combination that might exemplify what Cuevas would be seeking in a more complete philosophy of biotechnology.

Summarizing what I have here suggested are first steps toward a comprehensive philosophy of biotechnology, I will first refer to a more recent paper of Cuevas (forthcoming), in which she takes great pains to show that many contributions need to be taken into account in an adequate philosophy of technology (in general). Even Bunge's applied science model sometimes works, as do approaches that make scientific advances dependent on technological or instrumental advances (e.g., Pitt, 2000)—and a whole host of other approaches; Cuevas is, reluctantly, even willing to say that "technoscience" constructivist approaches (see Hughes, 1988) are sometimes useful. Her point is not that her engineering sciences approach is better than the others. All are necessary, and complementary, for an adequate and complete philosophy of technology in general or any particular technology or set of technologies.

Here I have emphasized, in my approach to an adequate philosophy of biotechnology (including bioengineering), the ethics and politics of biotechnology and genetic engineering, debates about genetic reductionism, and approaches to an *engineering* philosophy of biotechnology for which I have borrowed ideas from Goldman, Koen, and Cuevas. Biotechnology, if we combine these views, is a part of "captive" engineering (Goldman); is necessarily related to the state of the art at any given time (Koen says current genetic engineering is deficient in this regard); and involves key bioengineering theories/techniques (where I have supplemented Cuevas with references to historian of genetics Michel Morange). As Cuevas Badallo says for *any* technology, I would say *biotechnology* is highly complex and has a variety of complicated relationships with genetics and other biological sciences.

A final surprise in all of this can be seen if we turn to the public furor over biotechnology. Far from being illegitimate, public concerns about biotechnology and genetic engineering ought to be expected—even welcomed. Biotechnology may be "the wave of the twenty-first century" (as some say), but if the twentieth century has taught us anything, scientific and technological developments are fraught with social consequences. Originators of the Human Genome Project were wise to try to deal in advance with the ethical, legal, and social implications of the venture (the so-called ELSI program; see Marshall, 1996; and National Human Genome Research Institute, 1997); and promoters would do well to consider the same for bioengineering, genetic engineering, and biotechnology generally. If developments in biotechnology are to be truly valuable for society, there ought to be public input into their evaluation and management. This does not mean we have to take seriously every outspoken critic of biotechnology or genetic engineering; only that, in a democratic society, public discussion of such issues is welcome.

Sheldon Krimsky's writings open the door to exactly this, and after this long introduction, it's time now to get to Krimsky. He is a product of the Boston University philosophy department in the heyday of Marxists Robert Cohen and Marx Wartofsky (see Chapter 4, above), but he found his academic home at Tufts University in an environmental policy program. He was active in Cambridge-area efforts to control recombinant-DNA developments in the 1970s, and this led to long association with the Federal government's Recombinant-DNA Advisory Council (RAC). See the following Krimsky books: *Genetic Alchemy: The Social History of the Recombinant DNA Controversy* (1982); *Biotechnics and Society: The Rise of Industrial Genetics* (1991); and *Agricultural Biotechnology and the Environment: Science, Policy, and Social Issues* (1996).

What follows is long, selected, and severely truncated, and is taken from Krimsky's *Biotechnics and Society* (1991), Chapter 11 (pp. 205ff):

Biotechnology Assessment: Dilemmas and Opportunities

"Before the introduction of a new biotechnological product or licensing of a new technological production plant, its impact on the general welfare, health, economy, labour situation, culture and sociooeconomic structures, etc. should be studied. –Cary Fowler et al., 1988, Rural Advancement Fund International

"Biotechnology is a global issue. It cannot be assigned such attributes as positive, negative, or neutral. Like any other technology, it is inextricably linked to the society in which it is created and used, and will be as socially just or unjust as its milieu . . . rational biotechnology policy must be geared to meet the real needs of the majority of the world's people and the creation of more equitable and self-reliant societies while in harmony with the environment. –The Bogeve Declaration, 1987

“Previous chapters in this book have shown how the industrialization of applied genetics has contributed to a new generation of social, ethical, legal and ecological problems. The R&D and industrial sectors in biotechnology have aggressively sought product opportunities in the tradition of other high-tech ventures like microelectronics, computers, and robotics. But these industrial revolutions cannot compare to the commercialization of genetics in the public apprehension associated with their successes. Geneticist Steve Gendel asks: 'Why has biotechnology become such a focus for ethical, social, and economic debate while other technologies are all but ignored?' His answer focuses on the subject matter. 'Clearly biological issues touch a sensitive aspect of our culture and lead to deeper and more passionate examination of issues than do issues raised by any other technology.' I would argue that part of the difference lies in the fact that traditional ways of addressing the externalities of industrialization. These challenges are confounding to government regulators and entrepreneurs who place their confidence in the established norms of social governance. . . .

Political Ideology And Biotechnology

“Environmental Traditionalists. Environmentalism, as distinguished from political and social ecology, is rooted in the constellation of laws that protect humans and segments of the ecosystem from the products and processes of industrialization. The vast majority of these laws that have been enacted at the federal level came in response to public concerns over the hazards of the chemical, nuclear, and fossil fuel industries. Environmental traditionalists advocate a modification of the current regulatory system to address the problems of biotechnology. Some modifications, additions, and adaptations to the established regulatory regime of FIFRA, TSCA, and to a lesser degree the Food and Drug Acts, have already been made in response to biotechnology. The vast body of environmental law has not been amended by Congress. However, minor modifications of the existing statutory framework are well within the purview of the traditionalist response to the biotechnology revolution.

“Reactionism. Among those who reject environmental traditionalism are individuals who advocate a libertarian model of technological innovation. According to this view, society should not assume the technology is hazardous before it is *proven* hazardous. Secondly, it is argued that the costs of pursuing

'phantom hazards' is too great for society to bear. They cite ice minus as an example. It took five years and millions of dollars of regulatory review and litigation before an outdoor field test was permitted for an organism with a 'mere' single gene deletion. The tradition of reactionism has attracted those who would eliminate the Delaney amendment for food additives, do risk-benefit balancing in assessing technological hazards, and place more emphasis on tort law and less on regulatory bureaucracy.

"Social Ownership. Proponents of social ownership or social directorship of biotechnology argue their case from either a capitalist or socialist perspective. From the capitalist perspective, social investment should reap social benefit, while private investment should reap private benefit. Since the entire field of biotechnology arose directly from federal funding of molecular biology, under the logic of the economic system the public sector should be a key beneficiary in the outcome. In support of this view Barry Commoner stated: 'We have to ask ourselves about the morality of allowing publicly produced knowledge to be taken over by the owners of capital.' This view is antithetical to the patenting of life-forms or the private appropriation of federally supported discoveries.

"From a socialist perspective, society will get the most out of biotechnology if its productive resources are directed by a state planning group or decentralized planning councils representing broad constituencies in society. Proponents of social ownership cite the direction that biotechnology takes under free market conditions. Profitability, and not social needs, dictates product development.

"Commoner, who advanced a similar argument for the direction of the energy industries, cited public control of technology at the sources of innovation and production as the solution. 'A fundamental question that any of us concerned with biotechnology have to deal with is the problem of governing the development of a new industry. I'm not talking about regulating its impact on the environment. I am talking about the social governance of the means of production.'

"Without socially directed industrial development, Commoner and others argue, biotechnology will serve the interests of large established industrial corporations (petro-chemical and agribusiness) and leave to pure chance the match between the productive capacity of the new technology and its contributions to the central problems of civilization (malnutrition, disease, environmental degradation, lack of inexpensive and clean sources of energy, prohibitively expensive health care).

A Fourth Way: Market Innovation And Social Selection

“Socialist solutions to the problems of postindustrial capitalism have lost much of their currency since the Reagan-Gorbachev era. With the world's major socialist economies (China and the USSR) exploring market alternatives, the rhetoric of centralized planning has far less appeal, even among democratic socialists. There is still much to be socialist about beyond the command economy and state ownership of the modes of production, particularly the public's role in determining the size and allocation of the federal budget for social needs. But state economic socialism does not provide a sensible solution to harnessing biotechnology for the masses—at least not in the advanced capitalist nations.

“What alternatives are there beyond the three cited for the governance of bio-technology? I shall describe a system of social guidance that I refer to as 'market innovation-social selection.' It is based on five premises.

1. The innovation sector and the social guidance sector shall be distinct. The main purpose of the former is to create new marketable ideas—to always be innovating—while the latter must evaluate these ideas within a highly articulated system of social directives.

2. The state shall expand its role in the assessment of new technologies. All new technologies must be evaluated on health and safety, ecological, equity, and ethical criteria.

3. Public participation in the assessment of new technologies shall involve all levels of political jurisdiction.

4. The state shall support maximum innovation in the private sector, but by a conscious process of selection, reinforce those innovations that meet important social needs and provide selective negative pressures against unneeded or unwanted innovations.

5. Only in cases where a robust system of private initiatives fails to meet public needs shall the state assume the role of innovator. However, in such cases (e.g., orphan drugs or recycling projects), innovation and social governance shall be the function of independent government

bodies.

"This system of social guidance for technology is modeled on Darwinian principles where two opposing processes (mutation and selection) provide the basis of growth, change, and balance. Innovation is essential for technological change. But the state's role in selecting among competing technologies has been too limited and weak, and leaves too much to the control and self-interest of the innovation (production) sector. The current system is too product-centered. As a consequence it fails to account for technological directions. Social choices about the broad goals of technology are often the result of, or held hostage to, microeconomic decisions. The position I am advocating builds on a nascent form of technology assessment that began nearly two decades ago."

Krimsky devotes a long section of his chapter to this fourth possibility, under the heading "Critical School of Technology Assessment," and in that section he looks at three "critical" approaches to particular biotechnological innovations, beginning with BGH or Bovine Growth Hormone.

"A technology is undesired by some constituency when it is perceived to offer a greater balance of negative to positive utility. The public responds to undesired technologies exclusively through the marketplace. As an example, suppose a new technology is developed for sex selection of children. It may be argued that this technology is not needed by society (there are no sound reasons for selecting the sex of a child) and that it is also unethical as it may create imbalances in the world population or reinforce misogynic social mores. But this argument will not convince everyone and there will most assuredly be a demand for sex selection if it is available. The 'mixed' column in Table 11.3 [omitted here] illustrates this scenario. Alternatively, there are technologies that some experts believe society needs but popular opinion is against, such as nuclear power. For commercial genetics, the social discussions over technology have become increasingly complex. In some instances, debates are fruitless because proponents construct basically incommensurate arguments derived from the different variables for technology assessment. A characteristic of such debates is that claims and counterclaims fall on unreceptive ears. There are ideological niters within each camp that treat information or analysis derived from the other as illegitimate. I shall illustrate these along with other issues of technology assessment by applying the assessment parameters in Table 11.2 to several early and promising products of biotechnology. The first case I shall consider is bovine growth hormone (BGH). . . ."

Krimsky then adds similar detailed discussions of herbicide-resistant plants and of developments involving human growth hormone (HGH). He then comes to a final conclusion: “Biotechnology has been responsible for a myriad of technological innovations covering multiple sectors of the economy. These innovations have been amply summarized in this and other works. At the root of these innovations is the conscious rearrangement of biological forms (biotechnics) through genetic controls (gentechnics). Microchanges in the fundamental chemical units of living entities are reflected m the macrochanges taking place in the reconfiguration of the industrial sector. The new symbols applied to genetic science speak to a mechanistic and instrumentalist vision of living things. Yanchinski’s terminology 'setting genes to work' and Yoxen's 'life as a productive force' are expressive of the links between the science of living forms and the technology of manufacture that have become the signature of the biotechnological revolution. Goodman et al. use the term 'bio-industrialization' to describe the 'increasing transfer and interchangeability of both industrial processes and inputs between the food, chemicals, and pharmaceuticals sectors.'

“Innovation investment, and development in applied genetics have been robust. The fervor of bio-industrialization is as strong in private as in public sector institutions. It can be felt at the state, federal, and international levels. Not since the discovery of antibiotics has there been this level of expectation associated with biomedical developments. Not since the introduction of hybrid seeds has there been as much excitement within industrial agriculture. The aggressive exploitation of genetic science for practical ends is by and large a healthy development. But equally important are the processes and social mechanisms through which selection of potential applications is carried out. I have argued that the current methods of assessing the impacts of biotechnology and for choosing among alternative technological paths have not been commensurate with the incentives to develop and market new products and to transform methods of production. There are several reasons for this.

“First, there is a confusion of roles. Technological innovation of commercial products should reside primarily with the private sector. The public sector roles should serve to protect society from misdirected technologies. Currently, public sector institutions are too closely identified with the development side of biotechnology. This has resulted in conflicts within federal and state governments over the appropriate regulatory stance.

“Second, universities have lost their role as independent sources of analysis, valuation, and assessment of new biotechnologies. The academic research community in applied genetics has become integrated into a system of commercial development that has brought industry, government, and the university into an unprecedented peacetime partnership.

“Third, the biotechnology revolution has emerged at a time when the social demands on technology are far more complicated than they once were. The social guidance systems have not kept pace with social attitudes. Productivity is only one of several competing values that form part of the public's assessment agenda for technological change. Greater attention is being placed on secondary impacts of technology beyond its direct effects on human health. A new powerful metaphor, Gaia, the organism of earth, is placing new demands on innovations in manufacture and production.

“There is also a new global economic perspective on the effects of technological change. If we modify our packaging materials or develop a microbial process for making cocoa, we may inadvertently but predictably accelerate the rapid depletion of the world's rain forests. These considerations, once the province of fringe ecotopians, have become normalized into public values. Thus, our assessment methods for technology are deficient because social expectations have changed. Periodically, there are examples where the regulatory sector is baffled by a public outcry over what is viewed as an orderly and statutorily correct response to a problem. For example, ALAR, a chemical used to control the ripening time of apples and shown to cause cancer in animals, was eliminated from use when significant segments of the public refused to purchase produce sprayed with the chemical. A similar reaction prompted emergency restrictions on the use of the pesticide ethylene dibromide (EDB) in grain products.

“I have shown that some of the concerns expressed about products derived by genetic engineering techniques fall outside the responsibility of regulatory bodies. Where a product has questionable or potentially negative human health effects or is a clear and present ecological hazard, it has issue-legitimacy within the existing regulatory sectors. However, for those products or technologies with second-order environmental effects, redistributive effects, or that raise ethical dilemmas there are no natural places toward which public debate is channeled. Our federal structure is not currently designed for the public to direct the course of technology, for constituencies to question the social utility of products that are not otherwise deemed hazardous, to evaluate the ecological impacts of innovations in production, to propose directions for technological development or to solve complex ethical problems associated with new technologies. A market-dominated innovation system makes it extremely difficult for socially guided R&D programs to evolve. There is little guarantee, thus far, that the potential biotechnology offers will correlate with the hierarchy of social needs. Our examples are selective and do not tell the whole story. There are many applications of biotechnology that are not problematic and contribute quality or efficiency to systems of manufacture or the treatment of disease. Those are not the outcomes of biotechnology that place our current system of technology assessment to the test. The cases chosen in this analysis illustrate the complex problems of technological choice that biotechnology puts before us.

"Too many questions related to the effects of biotechnology are defined outside the responsibility of government. Too many of our agencies of government conceive of their role as promoting innovation and development rather than assessment and selectivity. Too many of those in whom we expect objectivity have vested interests in the financial success of a technology. The inevitable outcome of this situation is that organized efforts by nongovernmental groups give up working with federal agencies and work directly with the public and scientists lose their special status in society. We need new institutional models to examine the total system impact of innovations in biotechnology in a manner that responds to multiple constituencies. The assessment of innovations in biotechnology must rise above the current fragmentary approach defined by the regulatory sphere. Comments I made nearly a decade ago are as relevant today 'The developments in a field bursting with innovative ideas and [unexplored] potential will put to the test the social guidance systems we presently have. But more so, they will test the moral and scientific wisdom of technologically advanced countries on their capacity to counteract the adverse effects of genetic technology before they are realized and become part of the social and economic infrastructure of society.'"

In terms of *controversies*, this seems to involve a set of quadrants at least similar to ones in previous chapters:

Environmental Traditionalists

Reactionism

Social Ownership

A Fourth Way: Critical School of Technology Assessment=From Technology Assessment to Social, Guidance