

SECOND EDITION

FIRST ^{THE} SEED

THE POLITICAL ECONOMY OF PLANT BIOTECHNOLOGY



JACK RALPH KLOPPENBURG JR.

First the seed

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Jo Handelsman

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JACK RALPH KLOPPENBURG, JR.

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*Still the seed: plant biotechnology
in the twenty-first century*

Traditionally, we shrink from permitting small, authoritarian minorities to dictate our social agenda, including what kinds of research are permissible and which technologies and products should be available in the marketplace.

Henry I. Miller, Hoover Institution, and Gregory Conko,
Competitive Enterprise Institute (2001)

I view my job of public breeder as being public. Therefore, I am opposed to the commercialization of anything a public breeder creates. . . . I'm not necessarily against the science used to create GMO's, but there is potential for trainwrecks. What concerns me more are the practitioners, not the practice.

Stephen Jones, Washington State University wheat breeder,
quoted in Schubert 2001

The last – and perhaps the most important – of the risks that I want to examine is the effect of GM foods on sustainability. The single biggest concern in the developing world may be that millions of poor farmers will become dependent on a dozen or so multinationals for their future livelihoods.

Gordon Conway, president, the Rockefeller Foundation (1999)

Farmers' Rights was a fundamentally flawed argument that had been proposed by some who feared that to confront the robber who was already in the house might be to court conflict and disaster. A more discreet course, they thought, might be to "negotiate" terms which would permit him to proceed with his plunder but, at the same time, work out some sort of a "just" settlement that might placate his victims. In short, those defending plunder's victims armed themselves with the weapons of the enemy – the recognition of property rights, however legitimately or illegitimately that property had been acquired.

Erna Bennett (2002)

The reissue of *First the Seed* has given me the opportunity to add a chapter to the book. My history of plant breeding has, so far, taken its narrative and analytical structure from the interaction of scientific development with three themes of political economy: progressive commodification, the changing division of labor between public and private science, and asymmetries in

patterns of seed commerce and exchange between North and South. These themes will still undergird this new chapter, but the focus now will be on the recent emergence of hopeful prospects for significant redirection of the long-established historical trajectories that the book has so far described.

Much has changed since the initial publication of *First the Seed*. "Biotechnology" is now a familiar term and transgenic crops – now commonly referred to as GM ("genetically modified") crops or GMOs (genetically modified organisms) – are planted on some 145 million acres worldwide, and their by-products are found in some 70 percent of processed foods sold in the U.S. The possible negative effects of GM corn on both Monarch butterflies and human consumers of tacos have been front-page news. "Terminator Technology" designed to genetically sterilize seed saved by farmers has come to symbolize corporate greed and lack of concern for the social and environmental impacts of genetic engineering. Protesters dressed as Monarchs have become a common sight not just at rallies against corporate "Gene Giants,"¹ but at demonstrations opposing the trade and property regimes being installed by the World Trade Organization (WTO). In 2003 the United States filed a formal grievance with the WTO, hoping to overturn European Union (EU) regulations that since 1998 have effectively barred the importation of most GM grain by EU member nations. Agricultural biotechnology has moved to center stage in the most salient struggles of contemporary political economy.

How, then, should I resume the story after a hiatus of sixteen eventful years? I have chosen to reopen analysis through the explication of four quotes which I think exemplify some of the principal continuities and some of the ways circumstances have changed between 1988 and 2004. From these quotes I will draw out key themes, to which I will return in this chapter as I review the events of the last sixteen years and as I assess the prospects for achieving broader social control over plant biotechnology in the coming century.

The first quote, from conservative analysts Henry Miller and Gregory Conko, is a clear and succinct statement of the central conclusion that I hoped readers would take away from the first edition of *First the Seed*, and that I still hope they will take away from this version of the book. I quite agree: a small, authoritarian minority ought not to dictate what kinds of research are permissible and which technologies and products should be available in the marketplace. Yet this is precisely what is happening in the plant biotechnology sector as corporate capital has, since 1988, significantly extended and consolidated its capacity to shape how the new genetic technologies are used, who uses them, and for what they are used.

However, those corporations are emphatically *not* the "small, authoritarian minority" that Miller and Conko had in mind when writing their essay. Those who actually concern Miller and Conko are what they term a "consortium of radical groups" that "proselytize for illogical and stultifying reg-

ulation or outright bans on product testing and commercialization" of GMOs. That Miller and Conko should feel the need to write their polemic at all is indicative of a critically important distinction between conditions in 1988 and those in 2004: corporate biotechnologists must now deal with substantial opposition from civil society. Sixteen years ago, concerns about the manner in which biotechnology was being developed were limited to a small number of academics and a few far-sighted advocacy groups. Today, opposition to GMOs and GMO food is robust, globally distributed, increasingly well organized, and grounded in a broad range of issues. Further, it is also occurring in the context of a diffuse but powerful social movement that is resisting what has come to be understood as the project of corporate "globalization." Indeed, because of the material and symbolic potency of its constitutive elements and associations (e.g., "Frankenfood," "Golden Rice," "Terminator Technology," "biopollution," "biopiracy," "Gene Giants") agricultural biotechnology has become a key locus in this larger struggle.

The second quote, from Stephen Jones, illustrates a critical emergent dimension of the social composition of the opposition to corporate plant biotechnology. Jones is a wheat breeder at Washington State University who has resisted heavy pressures to incorporate proprietary genes from Monsanto and BASF into public wheat varieties. He explicitly notes the "public" character of his job and unambiguously embraces a commitment to service that rejects the patenting of plants and the private appropriation of the labor of public breeders. While the degree of Jones's defiance is unusual, his stance is emblematic of a developing undercurrent of widespread dissatisfaction among public scientists who are finding their appointed place in the division of labor in plant biotechnology to be more confining than they had anticipated.

In the concluding lines of the previous chapter of this book, I asked in 1988, "Will the new generation of plant breeders – or plant genetic engineers – acquiesce in their own emasculation? Or will agricultural science finally generate a cohort of internal critics?" I am pleased to report that in 2004 it appears this latter possibility is developing, and discontent is now beginning to coalesce into organized, collective action directed at reestablishing the vitality of a public plant science committed to public service. This is an exceedingly hopeful turn of events. The forms of civil society opposition that so exercise Miller and Conko *could* themselves be sufficient to alter the trajectories on which the development of biotechnology is now proceeding. The likeliness of such a redirection would be materially improved were those social elements to be allied with a set of public scientists willing to speak to both technical and social concerns with the uniquely potent authority with which the scientific enterprise is now imbued.

However promising, prospects for such an alliance are now constrained by the rather different viewpoints held by scientists and activists concerning

biotechnology itself. Jones's quote is especially instructive in this regard. He acknowledges the health and environmental risks – the “potential for train-wrecks” – associated with the use of genetic engineering. But he is careful to affirm that he is “not necessarily against the science used to create GMO's.” He goes on to make a point of absolutely fundamental importance: “What concerns me more are the practitioners, not the practice.” That is, he believes that the critical determinants of the impacts of biotechnology have to do more with who uses the tool than with the nature of the tool itself. Correctly, I think, Jones privileges *social* relations over *technical* relations.

In the third quote, Gordon Conway, president of the Rockefeller Foundation, suggests that further interrogation of the “practice” itself will also be useful. The passage is taken from a remarkable speech given in 1999 in which he outlined a variety of serious risks associated with the activities of multinationals involved in biotechnology research generally, and those of the Monsanto Corporation in particular. There are three points that I would like readers to take from his quote. First, chief among the risks Conway sees is not a technical problem but a social one: the deployment of biotechnology in such a way as to create a dependent relationship between farmers and a small set of companies. Corporate concentration in agricultural biotechnology has now proceeded so far that its menace is of concern even to individuals and organizations that, like the Rockefeller Foundation, are committed to maintenance of a liberal form of capitalism. The opposition to corporate control of the means of reproduction² now has a very broad base.

The second point is that, as Conway's explicit use of the term signifies, “sustainability” is now a rhetorical and ideological touchstone in contemporary constructions of what used to be called simply “development.” There are, of course, many versions of “sustainability.” Having achieved canonization as a kind of cultural shorthand for “the green and good,” the term is deployed by all sorts of organizations and actors who want to access the word's discursive potency but whose goals and interests are not necessarily compatible. Still, the very ubiquity of the word and its use in this context by Conway is an indicator that environmental and social struggles have opened up spaces and possibilities for positions and initiatives – organic, participatory, democratic, agroecological, alternative – that heretofore were consigned to the margins but are now engaged as legitimate.

The third point is that, for Conway, biotechnology is an essential tool for realizing what he has called a “Doubly Green Revolution, one that is as successful in productivity terms as the old Green Revolution, yet is environmentally friendly and equitable” (1999). He suggests that when removed from its corporate integument, biotechnology might well be used in the service of socially and environmentally sustainable objectives. For many in the activist community “sustainable biotechnology” is an oxymoron. But what is referred to generically as “biotechnology” is actually a sizeable and expand-

ing constellation of knowledges and technologies with different characteristics, capabilities, and uses. Biotechnology need not necessarily mean "genetic engineering" in the sense of interspecific gene transfer. Certainly, the techniques that fit under the rubric of "biotechnology" are uniquely powerful. Their development and deployment warrant special care. But blanket condemnation of the tools may, in fact, limit the capacity to understand and engage complex systems that will be the foundation of the truly *agroecological* science that needs to be developed. The challenge is to create the social conditions in which that expression of technics is possible.

In the final quote, that longest-serving veteran of the "seed wars," Erna Bennet, reminds us that changing social relations is no simple task. "Farmers' Rights" was to have conferred on peasants and indigenous peoples a moral and material recognition of the utility and value of the labor they had expended, and continue to expend, in the development and preservation of crop genetic diversity. But to the extent that Farmers' Rights mimics "breeder's rights" in its linkage to the market, suggests Bennett, it is not the alternative it was intended to be but a shadow of the very system it had been intended to challenge. Rather than insulating farmers and indigenous peoples from a predatory and expansionist capitalism, might it actually institutionalize a framework for their continued – but legitimized – expropriation? And thus we come full circle to the fundamental questions with which this book began. Are market-based arrangements for the exchange of genetic resources inevitably, as Bennett and Marx agree, "the tools of the enemy"? To what degree must the social formation be changed so that plant biotechnology, or any form of institutionalized knowledge production, can be used justly and sustainably?

Sixteen years ago, I did a pretty good job of defining the trajectories on which the plant sciences were moving. Today, I find reason to believe that events are giving rise to a conjuncture that might allow some quite different directions to be taken. In the pages that follow, I will note the incredible concentration of economic and scientific power that has been accumulated by a few companies. I will show that this very concentration of power, and its often-egregious expression, has given rise to a vital and broad-based social opposition. I will suggest that there are reasonable prospects for recruiting public plant scientists to that movement, and good strategic reasons for doing so.

The race to cash in on the genetic code: 1988–2004

If there has been one constant over the past sixteen years, it has been the remarkable persistence with which a narrowing range of companies has striven mightily, and with increasing urgency, to somehow squeeze profits from a set of technologies that have always seemed pregnant with commercial promise

but whose returns have always been a step away. The gestation period for profits in plant biotechnology turned out to be considerably longer than its corporate and academic proponents had anticipated during the 1980s. It was not until 1994 that Calgene's tomato, the inelegantly named 'Flavr Savr,' became the first transgenic plant to reach the market. It was rapidly withdrawn not as a result of popular protest against the technology, but because its "anti-sense" gene for delayed ripening didn't actually give the tomatoes any advantage in the field or in the market.

The next commercial release of GMO seed came in 1996 with regulatory approval of several corn varieties incorporating Bt toxins. These were followed shortly by "Roundup Ready" soy, cotton, and canola varieties containing bacterial DNA that provides resistance to the herbicide glyphosate (Monsanto's "Roundup"). The diffusion of those varieties has been exceedingly rapid. Between 1996 and 2003, the acreage planted to GM crops worldwide soared from less than 2 million acres to nearly 167 million acres (James 2003). Since high fructose corn syrup and soy, cotton, and canola oils are ingredients in a high proportion of processed foods, nearly every resident of the United States has consumed foodstuffs containing GMOs or their products. The rapid rate of adoption, unprecedented for an agricultural technology, has been touted as *prima facie* evidence of the desirability and benefits of GM crops, at least from the farmer's point of view. Similarly, the apparently unproblematic presence of GM components in many processed foods over several years in the United States has been taken as evidence of the safety of GM foods and their acceptability to American consumers.

Of course, statistics regarding the commercial deployment of GM crops can be made to tell different sorts of stories. Fully 98 percent of the acres planted to GM varieties in 2003 were located in only five countries: the United States (63 percent), Argentina (21 percent), Canada (6 percent), China (4 percent), and Brazil (4 percent). Moreover, only four crops accounted for virtually 100 percent of the area planted to GM varieties: soybeans (62 percent), corn (21 percent), cotton (12 percent), and canola (5 percent). And in all those plants on all those acres, only two GM traits were actually being expressed: herbicide tolerance (73 percent), Bt insecticidal action (18 percent), or a "stacked" combination of both herbicide tolerance and Bt action (8 percent) (James 2003). Thirty years after Cohen and Boyer produced the first biological chimera, farmers in a narrow range of countries plant a narrow range of GM seeds which incorporate only two agronomically relevant GM traits.

The rather constricted character of commercial agrobiotechnology reflects the narrowing range of companies that are now involved in that undertaking. What first drew me to the topic of this book was the wave of acquisitions of seed companies by agrichemical firms that swept the industry during the 1970s (see Table 6.3). That process has continued over the last sixteen

years and has even accelerated as the roster of desirable firms has been reduced. With one \$7.7 billion outlay in 1999, DuPont became the world's largest and leading seed company by purchasing Pioneer Hi-bred. Monsanto has been particularly active over the last decade with acquisitions of over a dozen companies including Asgrow, Holden's Foundation Seed, and DeKalb Genetics. Concentration has advanced to the point that even economists and federal regulators are concerned about the effects of growing monopoly power in the seed sector (Hayenga 1998; Oehmke and Wolf 2002). In 1999 the U.S. Justice Department went so far as to press Monsanto to withdraw its proposed merger with the leading cotton seed firm, Delta & Pine Land Co. Regulators' fears of anticompetitive behavior may well be justified. Recently, news reports have appeared suggesting that from 1995 to 1999 Monsanto executives sought, with varying success, to persuade other seed companies to fix the prices of GMO seeds at artificially high levels (Barboza 2004).

The "new biotechnology firms" (NBFs) that emerged in the 1980s have also been swept into the consolidation movement. With no product base and tenuous funding, the NBFs have been absorbed by multinationals. Agrigenetics and Phytogen were acquired by Dow, and Plant Genetic Systems has been bought by Aventis. Calgene and Agracetus are now units of Monsanto. Outside public agricultural research systems, there is little in the way of either agrobiotechnology research capability or commercial seed production capacity that is not now controlled by a small set of very large firms.

Given the historical trajectories described in previous chapters of this book, consolidation among seed companies and NBFs is not unexpected. What is surprising is the degree of cannibalism and recombination that has taken place since 1988 at the very top of the corporate biotech food chain. Compare the multinationals listed in Table 8.3 with those in Table 11.1. The companies that in the 1980s were leading actors at the intersection of biotechnology and seeds are, at first sight, apparently absent from the list of today's dominant "Gene Giants." Several firms listed in Table 8.3 have indeed reduced their seed or biotechnology holdings. Most, however, are still there but appear under new names as a result of having been involved in mergers and acquisitions. Syngenta was created in 2000 by a merger of the agrichemical and seeds units of AstraZeneca and Novartis, Novartis itself being the product of a 1996 merger between Ciba-Geigy and Sandoz. Aventis, acquired by Bayer in 2003, is the result of a 1999 merger involving Hoechst and Rhone Poulenc. In 2000 Monsanto merged with Pharmacia, but in 2002 it was spun off as an independent company.

This flux in industrial structure has several sources. One is simply the general character of this moment of global political economy, which is witnessing an incredible pulse of capital concentration across all sectors. In biotechnology, this general trend is reinforced by uncertainties associated

Table 11.1. *Top five gene giants 2003*
(with mergers and acquisitions)

Gene Giant	Mergers and Acquisitions
Syngenta	Novartis, AstraZeneca, Ciba Geigy, Sandoz, Imperial Chemical Industries
Monsanto	Asgrow, Calgene, DeKalb Genetics, Agracetus, Holden's Foundation Seeds
Bayer	Aventis, Rhône-Poulenc, AgrEvo, Hoechst, Schering
Dupont	Pioneer Hi-bred
Dow	Cargill North America

Sources: Author's compilation from numerous sources.

with how new genetic technologies may facilitate new connections and synergies across related production sectors. DNA has been revealed to be a common substrate for the pharmaceutical, medical diagnostic, chemical, veterinary, agricultural, and food industries. Firms specializing in those areas have explicitly tried to remake themselves into "life sciences companies" by acquiring – and sometimes divesting – holdings across multiple sectors. This process occurs unevenly and even chaotically as firms try to position themselves to take strategic advantage of rapidly changing technical possibilities, which are themselves far from assuming a determinate shape.

A further problem for companies involved in biotechnology generally has been the difficulty of developing marketable products. This problem has been particularly acute for firms with substantial commitments to agricultural biotechnology. From its inception, of course, commercial expectations for biotechnology have been high. Indeed, they consistently have been highly exaggerated. However misleading, over the last sixteen years, this public relations strategy has been eminently successful in generating an investment stream of absolutely massive proportions. During the 1990s, however, investors and Wall Street began to wonder when a reciprocal stream of revenue might begin to flow. Periodically, the business press has erupted with articles along the lines of the cover story of the September 26, 1994, issue of *Business Week*: "Biotechnology, why hasn't it paid off?" The need to maintain investment levels and stock prices has fostered enormous pressure on biotechnology companies to develop and deploy products as quickly as possible. The headline of a 1999 article in the Money & Business section of *The New York Times* accurately summarized the resulting dynamic as "The race to cash in on the genetic code" (Fisher 1999:BU1).

Despite this race to cash in, agricultural biotechnology is not yet paying off

in the way that corporate biotechnologists had expected or hoped. In large measure, this is because life is much more complicated than either they or their academic counterparts had anticipated. At the beginning of chapter eight, I cited a 1984 statement from Ciba-Geigy's (now Syngenta by way of Novartis) Mary-Dell Chilton: "The solutions are coming very fast now. In three years we'll be able to do anything that our imaginations will get us to" (quoted in Rossman 1984:84). Certainly, a great deal has been imagined in regard to desirable traits for genetically engineered plants: not just herbicide tolerance, but insect resistance, disease resistance, drought tolerance, frost tolerance, enhanced photosynthesis, nitrogen fixation, delayed ripening, improved flavor, and the metabolism of a whole raft of desirable biochemical products. Few of these ambitions have been realized. As of 1999, fifty-three transgenic crops had been approved for unregulated release in the United States, but half of those are herbicide tolerant or Bt insecticidal varieties of corn, soy, cotton and canola (Shoemaker 2001:18). All the other approved GM varieties – e.g., virus resistant squash and papaya – are planted, if at all, on a negligible number of acres.

So few of the anticipated or imagined commercial applications of genetic engineering have been developed because identifying what genetic sequences ought to be moved, getting them moved, and getting them to function as intended in their new locations are not simple matters. The term "*genetic engineering*" implies a level of precision and routinization that is far from being achieved. In principle, it is indeed possible to move any gene out of any organism and into any other organism. In practice, it is very difficult to determine what genes, combinations of genes, or gene fragments are of interest or utility.

Relatively few single genes are associated with a single character, and traits of economic or agronomic importance are mostly multigenic. The "molecular ecology" of how genetic material (e.g., genes, alleles, gene fragments, promoters, DNA and RNA sequences, allegedly "junk" DNA) interacts and functions is very poorly understood. The set of robust techniques for gene transfer is fairly narrow, relying on brute force (e.g., the "gene gun" which literally shoots gold-covered pieces of DNA into a target cell) or on a few widely used plasmid or viral DNA vectors (e.g., *A. tumefaciens*). These transfer mechanisms can move genetic constructs between species, but their action is unpredictable in regard to the incidence of successful transformation and random as to the location at which insertion occurs. Even when transformation is achieved, the positioning of the transgene in a novel genomic environment may "silence" or alter its expression, or the transgene itself may disrupt or change the operation of its host chromosome in unexpected ways. In *Science*, Harvard molecular biologist William Gelbart (1998:659) has described himself and his colleagues as "functional illiterates" when it comes

to reading the genome. No wonder actual products of agricultural biotechnology have been slow in coming.

The recalcitrance of life to easy manipulation, combined with pressures to provide tangible returns on investments, have given the race to cash in on the genetic code some interesting features. The need to bring products to market has reinforced the impetus to acquire seed companies which not only are necessary to any commercialization of crop genetic engineering but also carry the appeal of already having established product lines. It was the failure of the NBFs to develop marketable products that made them vulnerable to takeover. And the need to commit very large sums of money to research over many years is one of the major factors that has led to the consolidation which has left us with the handful of Gene Giants (see Table 11.1) that are willing to stay the course and continue the race to make biotechnology pay off.

Being big and having deep pockets has allowed a narrowing range of firms to stay in the race, but this has also made the stakes higher. In order to defray the high cost of bringing a refractory biology to heel and to allay the concerns of investors, companies focused an enormous effort on what was technically feasible in the short run in crops with large markets. What was easiest and most potentially profitable was the incorporation of herbicide resistance and Bt toxin into commodity crops such as corn, soy, cotton, and canola. Although both herbicide resistance and Bt toxicity are single gene traits, engineering even these "simpler" genetic constructs took a decade and entailed the expenditure of large financial and scientific resources under circumstances of heated inter-firm competition. As corporate executives struggled through this process toward commercialization, they were disinclined to accept any delay in introducing their products into the market. At Monsanto, the message was "We do not have the luxury of doing this the right way. We are going to do this the way that gets it done the quickest, because our entire future depends on the success of this program" (Charles 2001:67).

This urgency has manifested itself most clearly in the approach of the industry to regulation in the United States. Corporate lobbyists, with assistance from prominent academic biologists and NSF bureaucrats, had engineered promulgation of the Coordinated Framework for Regulation of Biotechnology in 1985. The Framework mandated no new regulations for biotechnology and determined that release, use, and consumption of GMOs would be governed by existing laws and agencies. This principle of "substantial equivalence"³ between GM and non-GM crops and foods, reaffirmed formally by the FDA in 1992 (Food and Drug Administration 1992), has been the cornerstone of policy ever since. With few exceptions, the companies have been relentless in defense of substantial equivalence, fighting off multiple initiatives for more stringent health and environmental safety testing, and for labeling of foods containing GMOs or their products.⁴ According to Henry

Miller, the FDA's point man on regulation of biotechnology from 1979 to 1994, "In this area, the U.S. government agencies have done exactly what agribusiness has asked them to do and told them to do" (Eichenwald et al. 2001). This corporate insistence on doing it their way surely facilitated the earliest possible introduction of GM crops, but the fragmented, transparently thin, and sometimes illogical oversight structure that it engendered has also fueled an emerging popular concern with corporate involvement in agricultural biotechnology (Pollan 1998).

Pressed to bring products to market as quickly as possible, the characteristics of the technologies the companies had available for deployment did not lend themselves to easy or enthusiastic embrace by the public. In 1993, after intensely pushing its propaganda for a decade, Monsanto received FDA approval to begin selling its recombinant bovine growth hormone (rBGH) to a dairy sector already glutted with milk. Consumers saw neither lower prices nor an increase in milk quality. The introduction of rBGH did, however, galvanize farm and environmental groups to active opposition, which in turn led to broad public dissemination of possible problematic effects of the hormone on the health of both people and cows (DuPuis 2000). Bans on the use of rBGH in the European Union (1994) and Canada (1999) highlighted the different ways scientific data can be interpreted. The foundering of the 'Flavr Savr' tomato shortly after its debut in 1994 – despite Calgene's advertised promise of "a bite of summer every time . . . exceptional taste . . . whether it's summer, spring, winter or fall" – did not enhance the stature of biotechnology nor the believability of corporate claims.

Into this uncertain environment, in 1996 and 1997, were pushed Roundup Ready soybeans and Bt corn. As with rBGH, these GM crop varieties carried no direct nor tangible benefit for consumers. Insect resistance and herbicide tolerance are *input* traits; they affect the agronomic performance of the varieties but contribute little to the utility or quality of the end product. Apart from some hypothetical and trivial reduction in the cost of food, GM corn and soybeans carry no intrinsic appeal for consumers. GM varieties could, however, be discursively constructed to carry various sorts of risks to community, human, and environmental health. As a growing variety of activist organizations worked to publicize those alleged hazards, a number of events transpired which tended to reinforce negative associations with crop biotechnology for the U.S. public.

In 1999 a Cornell University study (Losey et al. 1999) suggesting that pollen from Bt corn varieties could pose a threat to the Monarch butterfly became front-page news (Yoon 1999). In October came the WTO protests, and the cameras trained on the "Battle in Seattle" brought images of demonstrators dressed as Monarchs into many American homes. That year, too, Monsanto was forced to pledge not to commercialize its "Terminator" seed

technology after global criticism of the ethical implications of engineering a "sterile spring" for farmers, especially those in the developing world. In 2000 Aventis's StarLink Bt corn, a type not then approved for human consumption and destined for animal feed, was found to have been inadvertently mixed with food-grade corn that had been shipped to a number of millers. Extensive news coverage of the subsequent recall of Taco Bell taco shells and Aventis's \$100 million buy-back of the entire StarLink crop underlined for the public the weakness of regulatory mechanisms and the uncertainties regarding the human health effects of GMOs (Pollack 2000a).

In 2001 it became clear that not only was Bt corn commonly cross-pollinating with non-GMO corn varieties in the United States, but that it had also somehow crossed with the landraces of campesinos living in the mountains of Mexico, lending weight to charges that such "biopollution" will inevitably accompany the use of GMO crops (Quist and Chapela 2001). While the companies touted the potential of Bt corn for displacing harmful synthetic pesticides, their arguments that Roundup Ready crops would reduce herbicide use seemed much less plausible given that the point of herbicide resistant varieties is to make it easier to spray. The prospect of more widespread use of one particular herbicide and one particular insecticidal toxin also brought attention to the possibility of accelerating pesticide resistance in both weeds and insects.

If they were not given much material reason to welcome the advent of GM crops, American consumers attentive to news reports did have a variety of opportunities to be exposed to the problems, real and potential, associated with the rapid introduction of transgenic corn and soybeans. A growing number of activist organizations opposed to GM crops and foods also employed a variety of public relations channels to reinforce and extend those negative associations.⁵ Awareness of GMOs is now fairly widespread. A national poll commissioned by the Pew Initiative on Food and Biotechnology found in 2001 that 44 percent of Americans say they have heard some or a great deal about genetically modified foods (Toner 2002). Whatever the quality of the information on which they are basing their opinions, it is clear from the many polls conducted over the past decade that consumers are uncertain about the value and safety of GM crops and overwhelmingly support labeling of foods derived from them.⁶ Mandatory labeling is exactly what agribusiness wants to avoid, believing that marking their product in such a way will be taken as an implicit warning of risk or lower quality. Attempts by activists to mobilize what both they and the companies regard as a very large but latent popular opposition have had some success. In a preemptive move to protect its french fry market, McDonald's single-handedly sank Monsanto's market for its 'New Leaf Bt-potato' by quietly informing suppliers that they wanted no GM potatoes. Several other companies, including Gerber (ironically, a

Table 11.2. *Public controversies over biotechnology*

Monsanto introduces rBGH (1993)
Calgene introduces Flavr Savr tomato (1994)
European Union bans rBGH (1994)
Brazil nut allergen in GM soybean (1995)
Mad cow disease (1996)
Dolly the sheep is cloned (1996)
Novartis (now Syngenta) deal with UC-Berkeley (1998)
Celera announces it will beat Human Genome Project (1998)
USDA withdraws proposal for GMs in organic definition (1998)
European Union implements de facto moratorium on GM crops (1998)
Canada bans rBGH (1999)
Cornell study of Monarch butterfly and Bt corn (1999)
Monsanto no-“Terminator” statement (1999)
Death of Jesse Gelsinger in gene therapy (1999)
Turning Point Project advertisements in <i>The New York Times</i> (1999)
WTO meeting protests in Seattle (1999)
Celera/Human Genome Project announce sequencing of human genome (2000)
Aventis’s Starlink Bt corn contaminates food-grade corn (September 2000)
GM corn bio-pollution in Mexico (2001)
Percy Schmeiser/Monsanto patent infringement court decision (2001)
ProdiGene biopharm escape (2002)
Oregon GM labeling initiative (2002)
Cancer in French children shown related to gene therapy (2003)

Sources: Author’s compilation from numerous sources.

Novartis subsidiary) and Heinz, have declared that they will not use GM ingredients in their products. Public awareness of the issues has been maintained by substantial press and magazine coverage of the continuous stream of difficulties generated by industry in its rush to cash in on biotechnology (Table 11.2).

If the U.S. populace has remained predominantly skeptical of rather than hostile to GM corn and soybeans, European consumers were galvanized into extensive, active resistance by the appearance of these crops on their shores (Margaronis 1999). For complex historical and cultural reasons, the transformation of food is a more highly charged topic in Europe than it is in the United States (Joly and Lemarie 1998), and critical perspectives on capital, the way technology is used in relation to the environment, and social justice are more widely held there. Reflecting the incorporation of the “Precautionary Principle” into many EU regulatory frameworks, mandatory labeling of foods containing GMO-derived ingredients was put in place in

1997. Although by 1996 several varieties of GM crops had been approved for production and use by the EU, it was the prospect of large quantities of American-grown Roundup Ready corn and soybeans entering the food chain that exercised European activists. The outbreak of Mad Cow Disease in 1996 and the contamination of Belgian animal feed with dioxins also supplied Europe's consumers with timely object lessons in the unanticipated perils associated with the industrialization of the food supply and the willingness of private and public authorities to dissimulate and misinform.

Opposition to "Frankenfoods" blossomed across Europe. Demonstrators destroyed GM crop test plots in Britain. French farmer José Bové became the icon and inspiration of the movement with his trashing of a McDonald's restaurant and his uncompromising call to direct action (Daley 1999; McNeil 2000). A heavy-handed and culturally misplaced publicity campaign by Monsanto only exacerbated the resistance (Charles 2001; Alvarez 2003). With labeling required, it became impossible to sell any food containing GM ingredients in Europe. Further, widespread popular protest led the EU nations to enact, in 1998, a moratorium on approval of new GM crops until such time as a policy could be formulated that would provide not only for labeling but also for a system permitting effective traceability of GM components in food.

The StarLink incident in the U.S. stimulated testing of grain shipments and foods in many countries. "Adventitious" contamination by GMOs unapproved for human consumption was discovered in cornmeal and potatoes in Japan and in tortilla chips in Britain and Denmark (Pollack 2000b). In the wake of these incidents and with the EU's example, many countries – including major importers of U.S. corn and soy such as China and Japan – have imposed a wide variety of labeling and safety verification procedures on GMOs, which have complicated trade and seriously threatened U.S. commodity markets (Kahn 2002).⁷

European governments are not necessarily hostile to genetic engineering, but they would prefer to follow a precautionary approach to introducing GMOs into the food system and to contain popular opposition by clearly addressing food safety and environmental concerns. In June 2002 the EU proposed a new set of rules calling for labeling of any food containing more than 0.5 percent GM per ingredient and imposing strict arrangements to permit the tracing of all GM crops and foods back to sources of production. Distressed by the precipitous decline in exports of corn and soy since promulgation of the 1998 moratorium and frustrated by European commitment to the anathema of labeling, the U.S. is now trying to force open the EU market to its GMOs through a complaint brought under WTO dispute settlement rules. Joined in its suit by fellow GM-exporting nations Canada and Argentina, the U.S. argues that the EU's restrictions constitute an illegal trade barrier. This pressure tactic has met with some success. In 2004 the EU ap-

proved strains of GM corn for both human (a sweet corn containing Bt) and animal consumption (a Bt feed corn). Although they can be imported, neither variety can yet be actually grown in the EU (Becker 2004). These actions have failed to mollify the U.S., which continues to regard strict labeling and traceability requirements as non-tariff barriers to trade.

With nations of the developing world, the U.S. has added another tactic to direct pressure. It has been sending GMO corn varieties as food aid to countries in Asia and southern Africa, using pressing human need as a means of eroding trade barriers and silencing opposition. It appears that the U.S. objective in including GM grain in shipments for famine relief is as much to maintain pressure on the Europeans as it is to persuade reluctant and uncertain nations of the South to accept GMOs. When controversy erupted over the propriety of using food aid in so apparently instrumental a manner, President Bush himself commented in a speech that "European governments should join, not hinder, the great cause of ending hunger in Africa" by themselves acquiescing in the production and consumption of GMOs (Sanger 2003:A3).

If attitudes to GMOs vary widely among consumers and among governments, the same also holds true for farmers. Acceptance of GM crops in the United States has been widespread with 32 percent of corn, 71 percent of soybean, and over 70 percent of cotton acreage being planted to Bt and herbicide resistant varieties in 2002 (Seely 2002:A1). Given the rapid pace of adoption, it is ironic that studies comparing yields and cost of production of GM and non-GM varieties have found no unambiguous advantages for farmers in their use of the biotech seeds. This appears to be because the companies are charging high "technology fees" as a premium above seed costs, because the cost of Roundup and competing herbicides has been falling, because variable pest pressures do not necessarily reach levels where treatment is economically warranted, and because the technology has not always functioned as well as promised or expected (Myerson 1997; Duffy 2001). Bt varieties are used as insurance against the prospect of insect infestations, which do not always become serious. The appeal of Roundup Ready soybean varieties, despite a clear "yield drag" of 6–7 percent compared to conventional varieties, is located in how they simplify management decisions – don't think twice, just spray – for overburdened farmers having to deal with large amounts of land (Benbrook 1999). The technology licensing agreements that must often be signed as a condition of sale for GM varieties can be, as we will see, a source of considerable resentment. Whatever they think of genetic engineering itself, farmers growing crops in which GM varieties are close to commercialization (e.g., wheat) are debating the wisdom of proceeding with the development of varieties that might be excluded from important export markets.

Predisposed to try any technology that promises to lower their average

costs of production, a good many conventional farmers in North America find GM varieties a moderately useful tool in their ongoing struggle to stay in business. In contrast, organic farmers have found Roundup Ready and Bt crops to be direct threats to their livelihoods. One of the most interesting features of the contemporary American food system is the rapid growth over the last decade of organic farming. Though still quite small as a proportion of total production (on the order of 1 percent of sales), it is the most rapidly growing sector of the food industry at around 20 percent per year. This rapid increase is itself a significant indicator of dissatisfaction with the conventional food and fiber system and of the willingness of certain segments of the population to embrace concrete manifestations of more sustainable production. When the USDA moved in 1998 to formally establish a set of rules defining and regulating organic standards, it included GMOs in its definition. The resulting outcry from organic producers and consumers forced the USDA to withdraw its proposal. In the final version of the standards approved in 2003, no product may be certified organic if it contains GM ingredients or was produced using GMOs.

Widespread contamination of organic corn and soybean crops by pollen from neighboring fields of GMO varieties now threatens the ability of organic producers to market their crops as organic (and, for that matter, the ability of conventional producers of non-GM crops to sell to markets where GMOs are banned). Not only are individual producers faced with the loss of premium prices for their products, but the possibility of any organic production at all is called into question. Who is liable for losses to adventitious contamination is not yet clear, though a recent decision in an Illinois class action suit includes provisions for paying farmers whose crops were contaminated by StarLink pollen (Garden City Group 2003). Several additional suits have been filed by organic farmers, and the courts will certainly be some time in working matters out. The prospects and parameters for "coexistence" of GMO and organic crops are now a major topic of discussion and negotiation among producers, industry, and government organizations (Iowa State University 2001; GRAIN 2004).

More than a quarter of the GMO crops now planted around the world are being grown in developing nations of the geopolitical South. Most of this acreage is in soybeans in Argentina, Brazil, and China, though India has a small but significant planting of BollReady Bt cotton. The demand for Roundup Ready soy is even stronger in Argentina than it is in the United States, with adoption rates approaching 100 percent. The biotechnology industry must also have been pleased by the substantial illicit sales of GM varieties from Argentine farmers to those in neighboring Brazil, where GM varieties were yet to be approved. Under pressure from its commercial farmers, the Brazilian government reversed its position and legalized planting of GM

soy in September of 2003 (Smith 2003). Although royalties are not being paid on the portion of the Argentine crop sold as seed in Brazil, the companies can point to the active black market as clear evidence of desire by Third World farmers for GM seed (Barboza 2003).⁸ Unapproved GM corn, soy, and cotton are now reportedly being grown in Thailand and Pakistan, and surely elsewhere.

It is not clear, however, how well such varieties perform or whether they are as useful to small farmers as to large commercial producers. There is considerable disagreement, for example, over whether the adoption of Bt varieties by some small cotton producers in India has been a success or a disaster (compare Satheesh 2003 with Qaim and Zilberman 2003). Throughout Asia, small and subsistence farmers, and indigenous peoples, have been the backbone of scores of movements and initiatives organized not simply to oppose GMOs, but to engage the broader issues of corporate power, social inequity, and sovereignty, with which the question of seed supplies and new agricultural technology is entwined (Food First 2003). Developing nation governments are deeply conflicted. While they are tempted to pursue what is alleged to be the cutting edge of agricultural development and a route to serious participation in world markets, they are also mistrustful of the aggressive tactics with which seed companies and the U.S. government are pushing GMOs and are leery of reprising, in a Gene Revolution, the problems that had accompanied the earlier Green Revolution.

But, at the turn of the millennium, the much-anticipated Gene Revolution had not yet appeared. After more than a decade of racing hard to cash in on the genetic code, the Gene Giants had been able to bring to market only two GMO traits in only four crops. The financial costs had been enormous. Ultimately, the cost in terms of misspent cultural and political capital in fighting regulations and labeling may have been even higher. The haste of the companies in trying to generate revenue had led them to focus their efforts on products with inherent liabilities and to push harder and faster than civil society was prepared to accept them. At the turn of the millennium, they had succeeded in unsettling many Americans and outraging many Europeans, peasant farmers, and indigenous peoples. Through their own actions, the Gene Giants had done much to catalyze the emergence and growth of a global opposition to the technology on which they had bet their corporate futures.⁹

In the wake of the Monarch controversy, activist organizations in the U.S. conceived a bold public relations move that they hoped would arouse, among Americans, the same level of concern for and opposition to biotechnology that Europe was witnessing. Some sixty groups formed the optimistically named Turning Point Project and sponsored a series of five full-page advertisements critical of genetic engineering in prominent newspapers, including *The New York Times*. The companies understood that they would need to launch a

counteroffensive and, in April of 2000, they created the Council for Biotechnology Information (CBI), which promptly launched a \$50 million campaign for the hearts and minds of North Americans (Barboza 2000a). The effort has involved what CBI refers to as "advertorials" on television, in newspapers, and in magazines such as *National Geographic*, *Gourmet*, and *Natural History*.¹⁰

The campaign's inaugural advertisements in *The New York Times* clearly illustrate the themes that CBI intends the public to absorb. The March 16, 2000, issue of the paper carried a photograph of an Asian mother holding a child who is using chopsticks to eat. The headline reads: "Biotechnology researchers call it 'golden' rice. For the color. For the opportunity." A second advertisement, published two months later, featured a North American farmer and the caption: "Biotechnology gives her a better way to protect her crop – and her children's planet." The copy goes on to elaborate: the GM variety she uses "lets her use fewer chemicals" and is kin to other GM crops that are "helping provide ways for developing countries to better feed a growing population." A third and similar advertisement in the series, featuring GM soybeans, makes an additional claim: "Extensive testing by scientists shows foods derived from plant biotechnology are as safe to eat as traditional foods." The messages are very simple: GM crops meet the needs of the poor and hungry, they do not harm the environment, and they are safe for you to eat.

The plausibility of such claims was enhanced by the June 27, 2000, announcement that the human genome had been sequenced and by the global attention that the prospect of developing 'Golden Rice' attracted a few months later. The "successful deciphering" (Wade 2000a:A1) of the genome was celebrated by the press as another critical milestone in "learning the language in which God created life," as President Clinton so sententiously put it. Shortly thereafter, 'Golden Rice' made the July 31, 2000, cover of *Time* with the headline "This rice could save a million kids a year." As has so frequently been the case with biotechnology, these claims were exaggerated. The "deciphering" was really more of a first draft in which even the number of genes – much less their function and operation – remains unknown and is yet to be determined. Similarly, although 'Golden Rice' does indeed use daffodil transgenes to manufacture beta-carotene, it remains a hypothetical technology, the practical efficacy of which is highly debatable, even assuming that a biotechnological solution is preferable to the simple provision of carrots or tomatoes or leafy greens – other sources of beta-carotene – to vitamin A-deficient populations of hungry people.¹¹ For the biotech companies, the chief value of the genome decoding announcement was that it reinforced the faith of investors in the scientific progress of biology. And the virtue of 'Golden Rice' lay in the fact that it was "*not* the moral equivalent of Roundup Ready beans" (Nash 2000:41).

That is, the new genomics and 'Golden Rice' give biotechnology propo-

nents something concrete to point to when an old Green Revolution war-horse, like economist Vernon Ruttan (1999:58), begins to grumble about the "irrational exuberance" of the gene jockeys and asks them to demonstrate "measurable impacts of biotechnology on either human health or agriculture." Of course, the Gene Giants would love to be able to satisfy Ruttan with something more than promises. What they want more than anything else is to actually have on offer of something besides the "first generation" of biotechnology products represented by herbicide resistance and Bt corn. A few "second generation" products such as a high oil corn variety, cereal varieties fortified with various amino acids, and some pest and disease resistant cultivars are close to release. But none of these are qualitatively superior to existing technologies, nor do they have appreciable consumer appeal or the kind of ethical cachet carried by a 'Golden Rice.'

However, the sequencing of the human genome – like those of a variety of bacteria, a roundworm, the mouse, and the plant *Arabidopsis thaliana* in previous years – does indeed represent a critical milestone on the route that must be taken to additional products. Now that the DNA sequences of organisms are being mapped, attention is being turned from the structure of genomes to their *function*. The emerging field of *functional* genomics is uncovering the ways genes work with each other and with their protein products to shape how an organism develops and operates. Researchers anticipate moving beyond the limitations of single gene transformation to the development of generic tools for manipulating cell circuitry and comprehensively redesigning organisms from the inside out (Lander 1996). The tools of proteomics, bioinformatics, combinatorial genetics, and directed molecular evolution are said to promise a "third generation" of agricultural biotechnology products.

This "third generation" will feature multigenic reworking of crops to create "Golden Rice" analogs of interest to the wealthy and, ironically, the often-overfed consumers of the North. Research is under way on "cancer fighting tomatoes" and "oils with reduced levels of saturated fats" to help prevent heart disease (Council for Biotechnology Information 2003). A great effort is being devoted to "pharming," the production of high value pharmaceutical, and biochemical, substances in crop plants.¹² According to a review in *Science* (Enriquez 1998:926), products featuring these "output traits" will blur the distinctions between product sectors:

Soon medical prescriptions may be personalized to our genotype, along with specific nutraceutical foods. Some vaccines will be delivered through foods such as raw potatoes or bananas. . . . These new products may be delivered through your health management organization, a merger of supermarket and pharmacy, or perhaps even through a series of national health club chains.

Enriquez knows readers have heard the hype before, for he adds, "Genomics is not the biotechnology of the 1980s which promised much and delivered little." According to Nobel laureate and DNA elucidator James D. Watson, "The pace of discovery is going unbelievably fast" (Wade 2003b:D6). So the race to cash in continues, with the technical promise of genomics now serving to justify staying the lengthened course.

Slowing down?

Putting brakes on those racing to cash in has been a consistent objective of those troubled by the directions that biotechnology research has taken ever since Herbert Boyer founded Genentech. Currently, the principal goal of the Organic Consumers Association's Food Agenda 2000 campaign is: "A Global Moratorium on all Genetically Engineered Foods and Crops. Because these products have not been proven safe for human health and the environment, they must be taken off the market" (Cummins 2000:4). In many public lectures and workshops and in classes over the last decade, I myself have made similar representations regarding a moratorium (see Massey 2001); though my rationale for such an approach encompasses more than potential hazards to human and environmental health. Such views are in stark contrast to suggestions by corporate executives that "sustainable agriculture is possible only with biotechnology and imaginative chemistry" (Schneiderman and Carpenter 1990:472) and that their participation in the race to cash in is simply an expression of "planetary patriotism."

Since publication of *First the Seed* in 1988, there has been an enormous outpouring of analysis and commentary concerning the development and commercialization of biotechnology. A great number of books treating agricultural biotechnology has been produced, ranging from a paean to genetic engineering in agriculture (e.g., McHughen 2000) to an avowed "self-defense guide for consumers" (Cummins and Lilliston 2000).¹³ Burgeoning interest in the scientific and business potentials of genetics has not only drawn the focused attention of existing organizations, it has also spawned new professional and business associations (e.g., Biotechnology Industry Organization, Council for Biotechnology Information), new journals and newsletters (e.g., *Nature Biotechnology*, *AgBioForum*, *Biotechnology and Development Monitor*), and new NGOs (e.g., Genetic Resources Action International, Indigenous Peoples Council on Biocolonialism).

Simultaneously, the emergence and growth of the internet has revolutionized the provision and retrieval of various biotechnology data. Information pertaining to nearly any facet of biotechnology is quickly and easily accessed in a number of formats from many different web sites hosted by a wide range

of individuals and organizations (from the FDA to the American Seed Trade Association, to Mothers for Natural Law, to the Third World Network, to the National Science Foundation). The sheer quantity of available biotechnology data is impressive, but it also varies widely in quality. Ultimately, despite the huge amount that has been written over the past sixteen years, what I find most striking about biotechnology, and compelling for my own position, is not what we know but *what we do not know*.

In order to allay popular concern and to preclude what they regard as unpleasantly restrictive regulation, the biotechnology industry and its academic allies have consistently claimed that the genetic engineering of crops is not substantially different from conventional plant breeding. This principle of "substantial equivalence" has been widely applied both to the procedures of genetic engineering, and to its products, and it finds wide expression in corporate propaganda and the policies of U.S. regulatory agencies. Of course, it is true enough that humans have been using sexual recombination to manipulate the genomes of other species for millennia. But, in a very concrete biological sense, the incorporation of jellyfish genes into a monkey (Vogel 2001) is qualitatively different from the breeding of corn. In the latter case, sexual recombination entails the movement of "clusters of functionally linked genes, primarily between similar chromosomes, and includes the relevant promoters, regulatory sequences, and associated genes involved in the coordinated expression of the plant" (Altieri 2001:16).

In contrast, University of Wisconsin plant pathologist Robert Goodman (2002) likens the random insertion of transgenes by genetic engineering techniques to "throwing a grenade into the genome." Harvard's eminent geneticist Richard Lewontin (2001) describes the potential consequences: "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 that is no longer under normal control." Lack of normal control could result in the production of new substances or in unexpected changes in the way the organism functions or interacts with other organisms and the environment. Lewontin concludes that "the process of genetic engineering has a unique ability to produce deleterious effects and . . . this justifies the view that all varieties produced by recombinant DNA technology need to be specially scrutinized and tested."

I find this persuasive. If we don't know with considerable confidence where transgenes are going, or what they will do when they arrive, it seems that we ought to make sure that we learn more before proceeding at speed. Advances in genomics are surely exciting, but they also reveal how much we do not yet know, and how we have sometimes been mistaken in what we thought we did know. Recently, geneticists have been surprised by how few genes comprise

the human genome, and now they are having to rethink gene interactions and the functions of RNA and "junk" DNA in accounting for the complexity apparent in the human organism (Wade 2003a; Pollack 2003c). Indeed, the classical concept of the "gene" is itself regarded by some as an outmoded construct whose persistence is a barrier to an effective understanding of the manifold intricacies of the ways components of the genome interact (Gelbart 1998).

Fundamental uncertainties at the procedural root of genetic engineering are reflected in additional uncertainties at other levels. Critics have raised a variety of questions regarding the human health and environmental impacts of the use and consumption of GMOs. Might the bacterial disease vectors used to transfer DNA facilitate unanticipated transfers into additional organisms? Might the instability of transgenes cause plants to produce novel toxic substances? Might widespread use of antibiotic marker genes that are used to monitor transformation events contribute to the existing problem of antibiotic resistance in bacteria? Might novel transgenic proteins in GM foods cause allergies in some people? Might herbicide resistance engineered into crop plants be transferred to weedy relatives, or even unrelated species? Might Bt toxins affect non-target species? Might widespread deployment of Bt and herbicide tolerant varieties accelerate the development of Bt and herbicide resistance in insects and weeds? Such questions have occasioned extensive discussion and debate among scientists, as well as between the biotechnology companies and their activist critics.

I will not recap those debates here.¹⁴ What seems clear to me, however, is that while there is no consensus, a significant number of scientists un beholden to the companies and without close ties to activist groups have found good reason to question the headlong rush to deployment of GM crops (Lewis et al. 1997; Ervin et al. 2000; Benbrook 2003; Kapuscinski et al. 2003; Pollack 2004a). They regard the questions raised by critics as plausible and worthy of response. What they frequently conclude, however, is that, given the current level of knowledge, it is not now possible to adequately answer those concerns. In some cases this is because studies simply have not been done, and in other cases because, given available knowledge and methods, they *cannot* yet be done (Snow and Palma 1997; National Research Council 2000; Wolfenbarger and Phifer 2000; General Accounting Office 2002; Nestle 2003). The capacity to develop appropriate tools for answering outstanding questions is also constrained by asymmetries among disciplines. While the development of a robust and powerful (but largely reductionist) molecular biology has been underwritten by public and private monies, the field of ecology is in its infancy and has been badly undernourished financially.

Given current patterns of resource allocation and the passion for genomics, an understanding of the molecular ecology of the genome is likely to be developed before we have any effective understanding of the higher-level

hierarchical systems (e.g., farm fields, ecosystems, food chains, human stomachs) into which transgenic organisms are deployed. How can the potential impact of Bt crops on the environment be assessed if we don't even know what lives in the soil (99 percent of soil microorganisms are uncharacterized), much less know how to effectively model the interactions that occur there? In a recent assessment of the future of plant breeding, Ronnie Coffman suggests that "Genomics is likely to take plant breeding in directions unforeseen and unfathomable" (1998:3). If that is so, and if we would like to live in a world that is as safe, equitable, and sustainable as we can make it, then surely we ought to proceed judiciously while doing our best to redress our knowledge deficits so as to illuminate the choice of paths we might take.

Moreover, there is emerging a good deal of evidence that there are indeed some real pitfalls on the little known and apparently unstable path of genetic engineering. Cloned animals are exhibiting severe developmental defects that seem to derive from random errors in individual genes (Kolata 2001). A transgenic variety of the *Arabidopsis* plant was found to be some twenty times more likely to outcross to wild-types than conventional plants (Bergelson et al. 1998), and strains of GM crops including sunflower, canola, and sugar beet have been found to exhibit similar characteristics. A variety of Monsanto's GM soy was found to contain extra fragments of DNA that the company's scientists were not aware of transferring. Australian researchers added a mouse gene to a mousepox virus and accidentally created a mouse-killing pathogen (Finkel 2001).¹⁵ Most recently, the FDA suspended twenty-seven gene therapy trials after the therapeutic gene inserted into patients' cells landed randomly on or near oncogenes, inadvertently turning them on and giving three boys leukemia (Pollack 2003b). Both the British Medical Association (1999) and the American Medical Association (2000) have called for an end to the use of antibiotic resistance marker genes in genetic engineering because of the possibility that such genes could be passed on to bacteria affecting humans. The AMA considered a variety of the potential risks associated with genetic engineering, found them to be small but plausible, and called for a broad plan to study the issue.

While it is true, as the Council for Biotechnology Information (n.d.) is at pains to point out, that "there hasn't been a single documented case of an illness cause by biotech foods," the apparent instability of transgenes, the potential for unintended exchange of engineered DNA, and the appearance of unanticipated and inexplicable effects argues for caution. I find compelling Lewontin's (2001) argument that genetic engineering is "unusually likely to produce unpredictable results," and I believe that a moratorium on the further release of GMOs is justified until our understanding of their biological and ecological effects has been substantially improved. We simply need to know more.

That there is an unusual and biologically intrinsic *potential* for problems

associated with genetic engineering does not mean that those problems must necessarily be manifested. The techniques of biotechnology are tools created by human beings who make choices about how the tools are used as well as about how they are designed. Of course, neither scientists nor engineers make technology any way they like, just as people make history, but not in any way they please. Nature presents certain constraints, but which elements of nature are explored, how nature is interpreted, and how nature is shaped to serve human desire are matters of human choice. I believe that biotechnology in general – and genetic engineering in particular – might be used in safe, socially progressive, and sustainable ways, *if* social circumstances allow them to be developed in a manner appropriate to those goals. Ultimately, my own interest in slowing down the “race to cash in on the genetic code” has more to do with the social dimensions and meanings of the “race to cash in” than it does with the technical circumstance in which the genetic code is involved. Ecological and social sustainability will follow principally from the social arrangements we construct, not from the technologies we create. To imagine otherwise is to succumb to a species of technological determinism. A focus on technical questions can be a deflection from the difficult but necessary task of social transformation.

So, while I do not believe that we now possess the scientific knowledge to use the new genetic technologies safely, I am even more concerned that we do not now have social institutions in place to see that they are used properly and well. Henry Miller and Gregory Conko (2002) are quite right: a small, authoritarian minority is now dictating what kinds of research are permissible and which technologies and products should be available in the marketplace. The powerful tools of biotechnology are now being wielded largely by a narrow set of corporations which claim to want to use them to eliminate hunger, protect the environment, and cure disease, but which in fact simply want to use them as quickly as they can to make money just as fast as possible. Achievement of that narrower goal is predicated upon three social processes that have run as themes throughout this book and whose operation are as salient today as they were sixteen years ago: the extension of the commodity form, the shaping of the public/private division of labor, and the securing of access to that essential raw material, DNA.

Commodities and commodification

In *The Communist Manifesto*, Marx and Engels claimed that what they called “the bourgeois epoch” was characterized by “everlasting uncertainty and agitation.” The last sixteen years have witnessed an enormous amount of scientific and social restructuring as the possibilities and limitations of genetics

and genomics and proteomics have unfolded and as companies large and small have merged, and divested, and invested, and struggled with an awakening global civil society. A great deal of analytic effort has been expended in trying to interpret the fluid and often contradictory course of events involving biotechnology. In this book, I have argued that the commodity form is an underlying and constitutive regularity which shapes and limits the particular forms taken by the episodic and often chaotic expressions of a developing capitalism. To extend the reach of the commodity form is to extend the reach of capitalism. No matter how immense it may already be, the very essence of capitalism is the enlargement of the collection of commodities by which we are already surrounded.

The most familiar way in which the self-expansion of capital occurs is through accumulation, the reinvestment of profits in additional rounds of production. But for accumulation to occur there must be commodities to be sold, and the availability of products is precisely what the biotechnology companies have had difficulty achieving. An emphasis on getting something – anything – into the marketplace has led to work on products such as champagne, fish, and grass that glow in the dark (Riordan 1999; Barboza 2000b; Pollack 2004b). Although these are properly regarded as frivolous, they are being seriously explored by certain companies because they are technically feasible and because, while their overall social utility may be virtually nil, some people would be willing to pay for them. The biotechnology companies' need for income – accumulation *now* – has shaped their release of products in ways that have significant consequences for the environment, farmers, and society as a whole.

Bacillus thuringiensis has long been a useful tool for vegetable growers who have not wanted to use synthetic pesticides for the control of certain caterpillars. Insects did not develop resistance to this natural pesticide because it was used sparingly in widely dispersed fields, accounting for a relatively small total acreage. When the Bt toxin gene is incorporated into crop plants, however, the toxin is expressed in every cell of the plant and that plant makes the toxin available throughout an entire growing season. The prospect of planting millions of acres with Bt corn and other Bt crops generated concern among entomologists and ecologists whose experience with the "pesticide treadmill" led them to anticipate widespread development of insect resistance to Bt toxins if they were indiscriminately introduced. Writing in *Science*, McGaughey and Whalon (1992:1455) bluntly declared that what was at stake was preservation of the efficacy of "the most scientifically, environmentally, and sociologically acceptable pest suppression tools of this century and possibly the next."

But the companies' need for revenue confounded efforts to design a considered, socially rational approach to the introduction of Bt corn and cotton.

After extensive negotiations, the EPA was at least able to require that farmers using Bt crops plant a portion of their fields in "refuges" of non-Bt varieties so that resistant insects might mate with susceptible partners surviving among the conventional plants. Refuge requirements are poorly publicized by seed companies, not actively enforced by the EPA, and widely ignored by farmers (Pollack 2003d).¹⁶ If the refuge strategy is a sham, Monsanto is developing its own solution to the anticipated emergence of resistant insects. The company's vice president for regulatory affairs told Michael Pollan (1998:50), "there are a thousand other Bt's out there. . . . We can handle this problem with new products" – that is, more commodities.

If the experience with herbicide resistance is any indication, the appearance of Bt resistant insects should not be too distant. Contrary to corporate claims that adoption of herbicide resistant varieties would reduce the need to spray, it is now clear that farmers growing Roundup Ready soybeans are using two to five times more herbicide (in pounds applied per acre) than those using other weed management systems (Benbrook 1999:2). It is not now unusual to find Roundup Ready corn and Roundup Ready soy being grown in rotation. One result is a doubling of the use of glyphosate since the introduction of GM varieties in 1996, another is the appearance of Roundup resistant weeds (Pollack 2003a). The gene for Roundup resistance now is embedded in some 70 percent of the soybeans, 65 percent of the cotton, 55 percent of the canola, and 10 percent of the corn grown in the United States. It will likely soon be available in wheat, alfalfa, and turf grass. This is an impressive level of genetic uniformity. The short run interests of farmers and biotechnology companies converge to produce a situation in which the new technical possibilities are used not to seek truly innovative and sustainable solutions to production problems, but to patch and reinforce a system whose characteristic attributes – monoculture, chemical intensity, genetic uniformity – are widely regarded as unsustainable.

If current modes of deployment associated with crop genetic engineering reproduce existing problematics, they also introduce the novel dimension of "biopollution." The adequacy of containment of GMOs has been a principal concern of biotech watchdog groups since the 1980s, and it was a coalition of activist organizations acting on its own initiative, not a government regulatory agency or company lab, that uncovered the contamination of foodstuffs by unapproved StarLink corn in September of 2000. The immediate corporate response was to try to discredit the testing facility, Genetic ID, and to attempt to engineer an ex-post approval for Aventis's controversial variety (after all, people were already eating it). These efforts failed.

In the ensuing months, additional testing confirmed what many suspected or covertly knew. Transgenic DNA was all over the place where it wasn't supposed to be and where people didn't want it. Some of the contamination was

the result of physical commingling of grain in harvest, shipping, and processing. But what was most disturbing was evidence that much of the contamination was the result of pollen flows from field to field, that it was occurring in self-pollinated crops like soybeans as well as open-pollinated crops such as corn and canola, and that government recommended buffer zones intended to isolate GM from non-GM crops were grossly inadequate.

By the harvest season of 2000, organic producers realized that they potentially faced the wholesale loss of markets. In a letter to fellow organic certifying agencies, Farm Verified Organic (2000) laid out what was at stake:

We are facing a crisis in organic production, an invasion that threatens the very existence of organic production as we know it. The problem is the contamination of organic products by Genetically Modified Organisms. . . . In fact, the problem of GMO pollution has become so pervasive that, in the major corn producing areas of the United States, it may not be possible to purchase seed or to grow corn that meets current organic standards.

Early in 2001, the *Wall Street Journal* tested twenty foods that were labeled "GM-free." Sixteen were found to contain transgenic DNA. In Europe, despite the moratorium and labeling requirements, ten out of one hundred products supposedly containing no GM ingredients tested positively. The managing director of a leading U.S. natural foods miller said frankly, "There's no such thing as certified GMO-free" (Callahan and Kilman 2001).

In 2002 consumers found that their own health might be threatened by biopollution associated with the development of "third generation" biotechnology products. In two incidents, the Texas company ProdiGene failed to completely destroy plants in test plots containing corn engineered to produce pharmaceutical substances, subsequently contaminating soybean grain and cross-pollinating with corn plants in a nearby field.¹⁷ The contaminated plants did not enter the food supply, but the company was fined \$3 million (Pollack 2002), and the prospect of inadvertent leakage of crops containing vaccines or antibiotics or birth control substances was alarming for many. Calling such research "an unacceptable risk to the integrity of the food supply" (Clapp 2002), the president of the National Food Processors Association joined food manufacturers and grocery organizations in asking that biopharming not be undertaken in food crops. The biotechnology industry refused, since food crops are the ones they are able to engineer most easily and so are the preferred media for biopharming.

If the food manufacturers are uncomfortable with biopharming in food plants, they are ready to embrace the closely related practice of engineering "nutraceutical" or "functional" foods containing enhanced levels of health-promoting substances (e.g., lycopenes, omega-3 fatty acids) or reduced levels

of unhealthy substances (e.g., trans-fats, saturated fats). Nutritionist Marion Nestle prefers the designation of "techno-foods" for these substances, the development of which she regards as a cynical exercise in the creation of "value-added" products through complex and unnecessary reconstitution and repackaging. She observes that

from the standpoint of nutrition, techno-foods simply are not necessary. . . . The food marketplace is already glutted with an enormous overabundance of calories and products, and it is not difficult to select a health-promoting diet from this supply at quite low cost. The techno-food approach misses the point that the best health outcomes are associated with dietary *patterns* that follow recommendations, not just eating or avoiding one or another single food. [Nestle 2002:355–356]

The besetting sin of the biotechnology industry seems to be its lack of interest in solving for pattern as opposed to identifying partial, temporary, and commodifiable solutions to narrowly defined problems.

There are two things going on here, I think. The first order of business for the companies is arranging for accumulation as quickly as possible. They therefore push as hard as they can on the limited number of product options now available to them in spite of the uncertainties associated with genetic engineering and the possibility – or even likelihood – of generating environmental and human health externalities. A second order of business is a moment of what I have characterized as a process of permanent primitive accumulation: the separation of producers from their means of production and the creation in consumers of new needs whose satisfaction entails the production of new sorts of commodities. To the extent that genetically engineered Bt crop varieties create Bt resistant populations of pests, the utility of a tool for producing independently of conventional agriculture is undermined and possibly even eliminated. To the extent that biopollution undermines the possibility of organic production, the deployment of GM crops constitutes an expropriation of organic farmers. To the extent that GM substances appear in the food supply, eaters everywhere have imposed on them a system of production and provisioning which is increasingly defined by the parameters selected by a narrow range of commercial interests. Consumers are separated from the means of independent and healthy provisioning just as producers are separated from the means of independent and healthy production. The appropriation of nature becomes a means for the subjugation of the social world. According to food and biotechnology consultant Don Westfall, "The hope of the industry is that over time the market is so flooded [with GMOs] that there's nothing you can do about it, you just sort of surrender" (Laidlaw 2001).

Of course, none of this would be happening absent the historical elaboration of both the technical and social means of stabilizing seeds and DNA as

commodities. After all, as economist Lester Thurow (1996:281) notes, "Capitalists do not invest in things they cannot own." As we have seen, plant breeders have long pursued hybrids less for their superior agronomic characteristics than for the "biological patent" that they confer. Given the key role that cytoplasmic male sterility had played in the production of hybrids, researchers were, by the early 1980s, already looking to use biotechnology for the induction of sterility in specified generations of seed parents. As understanding of gene structure and operation advanced during the 1990s, both corporate and public labs explored the ways various functions of a plant – including its fertility – could be switched on and off by application of various chemicals.

In March 1998, U.S. Patent No. 5,723,765 was issued to the USDA and to Delta & Pine Land Co., a leading private seed company that had sponsored the USDA research. Among the claims that were made was one for a method for producing seed that is incapable of germination. Seeds had been engineered so that, when drenched with the antibiotic tetracycline, a toxin gene is activated which does not impede the plant's growth, but renders the seeds it produces infertile. Grain harvested from such a variety could not be saved and used as seed the next year because it would be unable to germinate. Since 1998, such companies as Syngenta, Pharmacia, DuPont, and BASF have developed a variety of similar techniques. Collectively known as "Genetic Use Restriction Technologies," or GURTs, the application of these methods has not yet been commercialized. Their clear purpose is to eliminate once and for all the historical ability of farmers to maintain a degree of independence by short-circuiting the reproduction of capital through the reproduction of their own seed.

In a rhetorical coup, the activists at the ETC Group rechristened the USDA/Delta & Pine patented procedure as "Terminator Technology." The term is appropriate. The technology terminates the reproductive viability of seed. It terminates the long-standing relative autonomy of farmers from the commercial seed market. And in the Third World it could very well terminate people's ability to feed themselves by destroying "the 12,000-year tradition of farmers saving, adapting and exchanging seed in order to advance biodiversity and increase food security" (ETC Group 2002:2).

The subsequent interest of Monsanto – prime exemplar of malign corporate biotechnology – in purchasing Delta & Pine focused additional concern on Terminator Technology. The fact that plants were being rendered sterile touched very fundamental sensibilities about the ethics of manipulating the natural world. The possible spread of Terminator genes to other plants reinforced worries about the unintended ecological effects of genetic engineering. The lack of any agronomic utility to Terminator Technology clearly revealed it as a naked attempt by companies to advantage themselves by limiting the opportunities available to farmers and so highlighted the predatory

dimension of concentrating corporate power. The prospect of using Terminator Technology in developing countries seemed especially problematic. While seed companies are anxious to extend their markets in Asia, Africa, and Latin America, the dissemination of varieties incorporating GURTs could have a devastating effect on the food security of the estimated 1.4 billion farmers who depend upon saved seed to grow their own crops for subsistence needs. These factors converged to make Terminator an issue with global visibility and unusual potency, and it has appeared as an iconic referent in anti-GMO and anti-globalization actions and literature worldwide (Kluger 1999; ETC Group 2002).

Opposition to Terminator Technology has not been limited solely to environmental or anti-corporate organizations. In June 1999 Rockefeller Foundation President Gordon Conway delivered a remarkable speech to executives and employees of Monsanto. In it, he exhibited a keen sense of the degree to which the excesses of biotechnology companies, in their rush to market, had created a broad-based backlash against genetic engineering that was threatening to endanger what Conway regards as a useful tool in the effort to develop crop varieties to serve the needs of Third World farmers. He urged Monsanto to consider major changes in its approach, specifically identified Terminator as a strategic point from which a retreat would be useful, and advised disavowal of GURTs as one way to "remove many of the suspicions about abuse of intellectual property to create market domination" (Conway 1999).

Rocked by the inauguration of the European moratorium, the monarch controversy, and intensifying opposition in many quarters, Monsanto CEO Robert Shapiro made a "public commitment not to commercialize sterile seed technologies, such as the one dubbed 'Terminator'" (Shapiro 1999). AstraZeneca made a similar announcement. However, it would be a mistake to think that so fundamental and long-held a structural objective of the seed industry could be so precipitously abandoned. Since 1999, AstraZeneca has been acquired by Syngenta, which along with other companies, has apparently continued Terminator research. The USDA has licensed exclusive rights to its seed sterilization technology to Delta & Pine, which has declared its intention of moving ahead, now with the morphed justification that the technology will be useful as a containment system for transgenes (Rural Advancement Fund International 2001b; Choi 2002).

Moreover, development of Terminator Technology is the mechanism through which valorization of GM seeds can be achieved most effectively in nations in which intellectual property rights are nonexistent or their enforcement is ineffectual. In 2004 Monsanto decided to stop selling its Roundup Ready soybeans in Argentina because half of Argentine GM soy acres were being planted with saved seed for which no royalties or technology fees could

be collected (Smith 2004). This situation will likely be reproduced in many developing nations that permit (or tolerate illicit) production of GM crops. The companies may have no choice but to pursue some form of Terminator Technology in order to maintain a market for their seed.

GURT/Terminator appears to bring biotechnology companies much closer to the culmination of their historical quest to pry farmers loose from their central means of production and achieve full commodification of the seed. But since they are not quite there yet technically, the social route to commodification of the seed remains important. Indeed, over the past sixteen years, the companies have relied increasingly on the coercive mechanisms of intellectual property law to keep farmers in the market and to secure valorization of their products. The PVPA had been passed in 1970 with a clause permitting farmers to save, replant, and even sell PVP seed to other farmers. Continuing its policy of incrementally but persistently pursuing its core objectives, the seed industry successfully shepherded through Congress a 1994 revision of the PVPA which revoked that right of sale. However, violators were not aggressively pursued. After the 1985 *Hibberd* decision permitting patenting of plants, PVPA was not a vehicle the companies felt they needed to ride very hard, or very much further.

Patenting opened much broader opportunities for market expansion than did PVPA, for purchase of a patented product carries the right to use but not to make. Farmers would be able to use patented seeds (i.e., grow them) but would presumably be in violation of the law if they made them (i.e., saved and replanted them). GM varieties are, of course, patented. Having spent so much to produce them, having waited so long to release them, and being under so much pressure to produce revenue from them, the companies intended to recover as much from the sale of their seeds as they could. To do so, they would have to change the practices of farmers who, by both tradition and material incentive, were inclined to continue saving seed when possible. Since GM varieties of corn are also hybrids, the battles would be fought principally in soybean and canola fields where seed saving is still common. Since the key GM trait in those crops is Roundup tolerance, Monsanto would be the farmers' chief antagonist.

Certainly, Monsanto worked hard to disabuse farmers of any notion that saving Roundup Ready seed was permissible. In radio spots across the Midwest and in advertisements in magazines such as *Farm Journal*, Monsanto warns that it is "vigorously pursuing growers who pirate any brand or variety of its genetically enhanced seeds" and asks for compliance with the arrangements specified in the Technology Use Agreement (TUA), which any farmer buying their seed must sign. The TUA not only explicitly prohibits the purchaser from replanting seed, it also limits Monsanto's liability for any loss associated with use of the product, specifies how a farmer pursuing a

claim must proceed, requires that no herbicide but Roundup be used, and allows the company free access to the farmer's fields. In its own version of "heartland security," Monsanto set up a hotline for farmers to report neighbors who they believe are violating the terms of their agreement. In less than two years, the company had more than 250 cases under investigation in twenty states (Wanamaker 1999). Selective vigorous prosecution has resulted in stiff penalties which have served the purpose of discouraging other farmers from engaging in plant-back. Most of those charged settle out of court.

However, a number of farmers – most prominently Canada's Percy Schmeiser – have defended themselves by claiming that they never planted protected varieties and that the presence of Monsanto's genes in their crops was the result of pollen drift. On May 21, 2004, after six years of legal battles, Canada's Supreme Court held Schmeiser liable for infringing on a Monsanto patent by saving and replanting glyphosate-resistant canola seed even after he had noted that some of his plants were resistant to Roundup. In a split five to four decision, the justices held that how the genes had gotten into Schmeiser's field was immaterial. According to the court, Canadian farmers do not have the right to knowingly "use" patented genes even if they are incorporated into a crop through mechanisms over which the farmer has no control. As University of Guelph agronomist Ann Clark (n.d.) observes, Schmeiser is being "held accountable for something which the seed trade itself cannot do," that is, preventing "adventitious" contamination. Incredibly, the decision puts responsibility for monitoring and reporting the flow of transgenes on the farmer rather than on the company. On the other hand, the court awarded Monsanto no damages since Schmeiser never sprayed Roundup and therefore did not benefit from his use of their genes, nor did the justices choose to require Schmeiser to pay Monsanto's court costs (I-SIS 2004). Monsanto's victory may have been Pyrrhic inasmuch as it may not be worth taking farmers to court for inadvertent infringement if the company does not stand to gain materially.

The Canadian decision on Schmeiser raises more questions than it answers, and it will be especially important to see how such circumstances play out in the U.S. legal system (Hamilton 2003). A trio of North Dakota brothers who find themselves in a situation similar to that of Percy Schmeiser will soon be going to court. In a different iteration of the issue of plant-back of patented materials, Missouri and Illinois farmers have fought back by initiating class action suits against Monsanto claiming that they had never signed the TUA and that payment of the technology fee entitled them to save seed for their own use (Schubert 2001b).

The biotechnology companies would like farmers the world over to traverse a legal path toward what the ETC Group has termed "bioserfdom." But the institutionalization of intellectual property rights remains highly un-

even globally. Almost anything is now patentable in the U.S., but this nation is situated at the extreme end of a wide continuum. In 2002, Canada rejected patents on higher forms of life, and in the European Union plants are only patentable under certain conditions. Many nations, especially in the South, do not even have simple Plant Breeders' Rights (PBR) legislation. The creation of the WTO in 1994 marked the coming of age of the project of "globalization," the extension of social rules and arrangements that facilitate the expansion and stability of the commodity form and market-based activity. A key strategy in this process is "harmonization" of regulations, including those encompassed by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS).

Article 27.3(b) of TRIPS requires nations that are members of WTO to offer some form of intellectual property rights in plants through patenting, PBR, or an "effective *sui generis* system."¹⁸ In theory, the *sui generis* option provides countries with an opportunity to shape legislation to meet their own needs and conditions. In practice, some nations with inadequate resources find it convenient simply to adopt UPOV's PBR framework rather than to develop their own approach. A 1991 change to the UPOV Act made the farmers' "privilege" to save protected seed merely an "optional exception" to the "rights" of the breeder. More worrisome, both the U.S. and the EU nations are using negotiations in bilateral trade agreements to lever their partners not just onto the UPOV path, but beyond its requirements into so-called "TRIPs plus" arrangements which incorporate more restrictive patent-like provisions.

As a result, many countries have established PBR laws that attenuate the farmers' exemption in a variety of ways (GRAIN 2003).¹⁹ A surprising number of Southern nations have banned farmers from using any protected seed other than what they themselves grew on their own land. PBR legislation thus is functioning to constrain the traditional modes of farmer-to-farmer germplasm exchange by which crop biodiversity has been so productively maintained for so long. As the historical example of the U.S. illustrates, the enactment of PBR legislation becomes the platform and justification for the deemphasis of public breeding programs as well as the precursor for the eventual introduction of patents. There can be no doubt that there will be a continuing push beyond PBR and toward patents, for PBR protects only whole plants rather than component parts such as genes, proteins, and DNA sequences. Moreover, PBR arrangements such as the UPOV Act and the U.S. PVPA permit the use of a protected variety in research, whereas a utility patent prohibits such work without a license.

Farmers are therefore not the only ones who find choices about how to perform their work being constrained by the growth of intellectual property rights in general and utility patents in particular. Just as important as the

impact on farmers is the impact on plant scientists themselves. Now, in periodicals such as *The Plant Journal* and *The Annual Review of Phytopathology* one finds articles with such titles as "Transgenic crops, biotechnology and ownership rights: what scientists need to know" (Kowalski et al. 2002). And they need to know a great deal. The article by Kowalski et al. advises plant scientists to perform a "product deconstruction" before embarking on a particular line of research. In a social analog of the anticipated biological work in the lab, the organisms and methods to be used in the proposed research are dissected into their component parts, and each one is analyzed for the intellectual property rights that might be attached to it. Only after undertaking this risk assessment for patent infringement can scientists know whether they have sufficient "freedom to operate" (or "FTO" as it is now known) that would justify proceeding with the planned work.

And such freedom to operate has, over the past sixteen years, become increasingly hard to obtain. Absent the development of many products, the way to validate scientific effort in the race to cash in on the genetic code was to obtain patents which functioned as proxies for future valorization of current research and so became markers of "success" for attracting investment. Writing in *Nature*, Bobrow and Thomas (2001:763) observe that patent policy

has more or less evolved through dialogue within a limited circle of participants. Commercial interests, which are well represented to the patent offices, have not been counterbalanced by those who represent the broader public interest. The result has been an innate tendency for the patent system to "creep" in the direction of extending patentability to biotechnology inventions for which the thresholds for novelty, inventiveness and utility have been lowered.

In what is frequently likened to a nineteenth-century style "land grab," vast tracts of the genescape and its products – DNA sequences, exons, introns, individual mutations, expressed sequence tags, single nucleotide polymorphisms, proteins, protein folds, parts of plants, whole organisms, whole classes of organism – are being appropriated via patents. Since the functional premise of biotechnology is the ecological unity of the genome and its component manifestations, it follows that nearly any research or product will draw upon areas covered by multiple patents. This is especially true since not only is genetic material itself being commodified, but the methods and techniques by which it is studied and manipulated are also patentable subject matter, so key enabling technologies such as the "gene gun" are also being subjected to private control.

The result of this proliferation of patenting and subsequent overlapping of property rights in research has been the progressive diminution of "freedom to operate" for both corporate and public scientists. Given the rather

narrow range of technical possibility in GM crops, an enormous amount of litigation has taken place around the commercially critical nodes of Bt expression and herbicide resistance. Seven companies have been involved in multiple suits and countersuits over patent infringements and licensing arrangement on Bt corn, and Monsanto has been continually engaged in cases as it tries to negotiate the tricky terrain between enhancing its competitive position on Roundup resistance technologies while stopping short – not necessarily successfully (see Barboza 2004) – of what the Federal Trade Commission might consider to be unfair trade practices (Hayenga 1998). The desire to avoid costly and time-consuming reciprocal infringement suits is one factor that has driven the consolidation trend among biotechnology firms (Mayer 2003).

While the private sector may see problems with the current system, it is they who have principally shaped it and they are unlikely to work for significant reform. The broad scope of what is now patentable entails risks and transaction costs, but the payoffs can be very large. For example, in 1992 the NBF Agracetus received a U.S. patent that gave it rights over all GM soybean varieties, regardless of the manner of transformation. Monsanto, Novartis, and Pioneer Hi-Bred challenged the European version of that patent. However, once Monsanto acquired Agracetus in 1996, it happily reversed its position and, with the May 2003 decision of the European Patent Office to uphold the patent, now stands to profit mightily from its rights in *every* GM soy plant.

Ironically, the rush to patent genetic materials was accelerated by a public agency, the NIH, which in 1995 filed for patents on several thousand partial human DNA sequences even though their function had not been determined. The move was apparently motivated by a desire to preclude acquisition of patents by the private company Celera Genomics. Human Genome Project director Francis Crick explained, "Every piece we get, it's like saving another block from speculators" (Hayden 2000:51). Whether they like it or not, academic and public researchers find themselves enmeshed in the appropriationist, market-oriented world of corporate biology, and they find they must play by its rules. Increasingly, access to the tools and materials of plant improvement are subject to intellectual property restrictions.

Most critically, patented germplasm – unlike that protected under PVPA – is not available for research purposes and cannot be used in breeding programs except under license. Plant breeding is an additive process in which incremental genetic additions are made to existing cultivars. If such additions – and the techniques to produce them – are patented, there may develop a progressive accumulation of property rights which becomes extremely difficult to manage. Transaction costs balloon. Desirable germplasm may be unavailable or accessible only through acceptance of Materials Transfer

Agreements (MTAs) which specify the conditions under which and for which the material can or cannot be used.²⁰ Permitting public researchers royalty-free access to germplasm may even be in the interest of a private company since it encourages broad use and distribution of the material without relinquishing the power to set the terms of commercialization (Coffman 1998). Reach Through Licensing Agreements (RTLAs), which involve conferral of rights in future discoveries made with licensed research techniques and tools, are also coming into use (Heller and Eisenberg 1998). According to University of Wisconsin corn breeder William Tracy, "Improvements will slow with the loss of free exchange. That's just basically inevitable" (Pollack 2001:D2).

The prospect of such slowing is beginning to generate broad concern (Dickson 2003). One worry is that the sheer number of patents in functionally related areas will lead to a "tragedy of the anticommons" (Heller and Eisenberg 1998), in which scientific progress is retarded by the legal and managerial difficulties of reconciling and coordinating different owners' property rights. If the "Balkanization" (Byron 2001) of patents in biotechnology is actually impeding the development and application of knowledge, then the fundamental premise for granting them – their ultimate contribution to overall social welfare through technical progress – is called into question. The scope of many biotechnology patents is troubling as well, and one cotton breeder has suggested that Agracetus's claim to all GM cotton plants is like Henry Ford filing for patent protection on all automobiles (van Wijk 1995:15). The declining standard of inventiveness for patents also appears to be permitting the wholesale appropriation of DNA sequences for effort that can be described as "intellectually trivial" (Bobrow and Thomas 2001:764). According to an editorial in the influential journal *The Lancet* (2002), "the current patent system appears to add the fuel of greed and monopoly to a flicker of discovery." The article questions whether DNA sequences ought to be patented at all and calls for a formal rethinking of the relationship between intellectual property rights and the public good.

Equity issues surrounding the patenting of plant genetic material of special importance to poor people and developing nations were highlighted by the sequencing of the rice genome by Syngenta in 2001 and the company's assertion of its intent to withhold some information from the public domain and to patent genes of importance (Pollack and Yoon 2001). If it is increasingly difficult and costly for the public sector in countries such as Britain and the United States to gain access to desired materials, it is even more difficult for the CG system centers to do so, and almost completely prohibitive for national programs of poorer or developing countries. In 2002, the British government's Commission on Intellectual Property Rights released a report which concluded that the global extension of IPRs under the TRIPS frame-

work would generate few benefits for developing nations and would likely impose significant costs, and they specifically warned developing countries against providing patent protection for plants and animals (Commission on Intellectual Property Rights 2002). In a report released the following year and titled *Keeping Science Open*, Britain's Royal Society (2003) echoed that advice and expressed further concern over the increasing commodification of scientific information generally.

A measure of how deep the discomfort over current patenting practice runs, and how critical the situation has become in regard to crop improvement, is reflected in a recent announcement made in the July 11, 2003, issue of *Science*. The presidents of nine prominent public universities joined with the presidents of three leading foundations to announce the establishment of the Public-Sector Intellectual Property Resource for Agriculture (PIPRA). The authors state that "limited or conditional access to a wide range of patented technologies has been identified as a significant barrier to the applications of biotechnology in the development of new crops" (Atkinson et al. 2003:174). The PIPRA consortium proposes to recover their institutions' freedom to operate (FTO) through a collective patent management regime that would retain the right to use licensed technology for specified purposes (such as improvement of subsistence and minor crops) and allow the sharing of new technologies with other public research institutions.

Such arrangements could "begin to overcome the fragmentation of public-sector IP rights and re-establish the necessary FTO in agricultural biotechnology for the public good, while at the same time improving private-sector interactions by more efficiently identifying collective commercial licensing opportunities" (Atkinson et al. 2003:175). This is hardly the uncompromising "no patents on life" position taken by many NGOs. Though it is not without contradictions, the PIPRA initiative is a serious and concrete effort to reclaim at least part of the principle of free exchange and to operationalize collective action among public institutions for the public good. That it has been proposed by organizations with considerable stature and cultural capital is an indicator of the degree to which conditions conducive to the possible reform and restructuring of intellectual property rights are emerging.

Divisions of labor: biotechnologization and freedom to operate

The extension of intellectual property rights has historically been, and continues to be, a powerful tool for private industry to shape the social division of labor in plant improvement. Inasmuch as IPRs facilitate and protect private investment in agricultural research, economists and seed company executives have long suggested that with their implementation public sector

scientists ought to be reoriented to work that does not compete with capital. The argument has not changed since the 1950s and is still oft repeated, for example: "Where more effective protection exists for intellectual property rights, the public sector has reallocated public funds away from variety development toward fundamental or pre-technology research" (Fuglie et al. 1996:2). What has changed, however, are the means of enacting that reallocation. Up until recently, its achievement depended largely on the rhetorical and ideological potency of the argument in persuading legislators and deans and research administrators of the propriety of limiting public activity to certain tasks. Now, with expansive private patenting, public breeders are finding that the nature and content of their work are being constrained by the sheer number and scope of the germplasm and techniques that can be – and sometimes are – placed off-limits to them (Coffman 1998; Sears 1998).

There is no question that private industry has increased its commitment to agricultural research in general and that it has moved into a dominant role in plant breeding in particular. While private sector outlays for plant breeding have increased about 7 percent per year since the 1980s, support for similar public sector activity remained flat and has even begun to decline. In the mid-1990s, Iowa State's Kenneth Frey directed a National Plant Breeding Study which surveyed the status of the field. Among his principal findings were that as of 1994 industry accounted for 61 percent of plant breeding expenditures, a similar proportion of scientific person-years, and that while the companies were increasing the number of breeders they employed the number in the public sector was declining (Frey 1996). In a division of labor that he describes as "changing daily," Frey (1998:6) also noted the movement of public sector activity out of cultivar development and into "genepool enrichment," development of methodologies, and the application of basic biology to crop improvement. That, of course, is the established historical dynamic. What is novel, however, is that private industry in effect had also become deeply involved in germplasm enhancement through its pursuit of genetic engineering. In the 1980s, biotechnology dissolved the boundary between basic and applied work and sent industry into the university in pursuit of the expertise it lacked. Having developed that in-house biotechnological capacity, the companies now find themselves once again working on the same terrain as their public counterparts, and Frey (1998:6) sees the need to develop "new formats of cooperation."

Given its early and heavy involvement with biotechnology, industry has certain structural advantages in this current working out of the division of labor. Its principal advantage is its dominant position in regard to intellectual property. In the area of agricultural biotechnology 76 percent of patents have been issued to the private sector (Atkinson et al. 2003:175), and of those privately held patents about three quarters are owned by only five companies:

Pharmacia, DuPont, Syngenta, Dow, and Bayer (Pollack 2001). Control over key enabling technologies is even more tightly concentrated. For example, the gene constructs patented by just four firms are in 96 percent of herbicide tolerant corn varieties, 86 percent of herbicide tolerant soybeans, and 81 percent of herbicide tolerant cotton (Oehmke and Wolf 2002).

In an assessment of the future of public plant breeding, Cornell University's Ronnie Coffman (1998:5, 6) sums up the implications for him and his colleagues:

With most important enabling technologies controlled by large-scale companies in the private sector, it is difficult to see how public sector programs can continue to be relevant in the production of advanced breeding material unless strong partnerships exist between public sector programs and those holding the enabling technologies in the private sector. Research exemptions are generally available but leave the public sector breeder in the very difficult position of developing technology that s/he may not be able to distribute. . . . More and more of the best science is patented.

To the extent that industry data or technology is nonfungible – e.g., key DNA sequences of a crop plant, or a uniquely powerful technique – public plant scientists may be unable to pursue certain lines of inquiry or may be forced to fit their research to a company's terms simply to gain access to critical means of production.

Industry is still keenly interested in maintaining the sorts of partnerships with public sector researchers referred to by Coffman. Exploring genomics promises to be a complicated and expensive undertaking, and the opportunity to gain preferential access to the insights of university scientists is welcomed. In 1998, Novartis concluded an arrangement with UC-Berkeley's Department of Plant and Microbial Biology that gave Berkeley \$25 million and access to Novartis' genomic database in return for a seat on departmental committees and first right to negotiate a license to patents from selected discoveries (Rausser 1999).²¹ Although reminiscent of the blockbuster university/industry agreements of the 1980s, such large-scale deals are now uncommon. That scarcity is not a reflection of a lack of interest in university/industry ties, but is indicative of their very ubiquity. The proliferation of such relationships over the last sixteen years has resulted in a routinization of academic/industrial cooperation, and it is the unusual size, rather than the content, of the Berkeley/Novartis partnership that makes it noteworthy. All Land Grant Universities now manage many hundreds of gifts and contracts that are the vehicles for the flow of information and ideas and expertise and property between their researchers and the companies with the financial resources to purchase access to them.

These enhanced ties between universities and corporations are most striking in the life sciences, but are characteristic of developments within the academy as a whole. The emergence of the "entrepreneurial university" (Slaughter and Leslie 1997) and the "commercialization of higher education" (Bok 2003) have occasioned much comment. A major stimulus to the capitalization of academic knowledge was the passage in 1980 of the Bayh-Dole Act allowing universities to retain patents on discoveries made with federal funds and to license them to industry. Over the last decade, universities have rapidly increased the number of patents they hold, and royalties accruing to them more than doubled between 1992 and 1997 to \$617 million per year. UC-Berkeley College of Natural Resources dean Gordon Rausser (1999:5) admits that universities are becoming "more like private companies."

With intensified academic/commercial collaboration comes a transfer not only of technology but also of codes and norms that subtly but effectively induce "the university to become isomorphic with its corporate environment" in both attitude and practice (Kleinman and Vallas 2001:466.) Harvard's ex-President Derek Bok concurs: "Certainly many more people in academic life think that you can have all the virtues of that life and be rich at the same time – in fact they think that you ought to" (quoted in Rimer 2003:A16). Most importantly, ideas generated by public funds that would otherwise have remained in the public domain are now privatized.

If the principal normative effect on the university of intensifying cooperation with industry has been an increasingly proprietary approach to the development of knowledge, the principal material effect – in the life sciences generally and in the agricultural sector in particular – has been a profound commitment to the rapid development of biotechnology. During the 1980s, federal funding agencies, state governments, and universities bought into the promised brave new world of biology in a manner that was not much less enthusiastic than Calgene or Monsanto. There is now no LGU without its own biotechnology center. Even in the midst of fiscal straitening, my own state of Wisconsin still found the resources to implement a \$317 million BioStar program to construct four state-of-the-art biotechnology research buildings for the University of Wisconsin. Hiring patterns in agronomy and crop science and horticulture and plant pathology departments made complementary shifts.

An associate dean at the University of Wisconsin's College of Agricultural and Life Sciences explained the new dispensation that has been operative since the mid-1980s (Freistadt 1988:10, 29c):

The plant breeders and plant physiologists, those kinds of applied research programs are being redirected into molecular biology and biotechnology programs. The reason is that there are monies available from both federal and private sources to sponsor molecular research ac-

tivities. . . . We don't have a hell of a lot of choice. We have to go where the money is.

Where the money has been is evident in what Buttel (1999:1) has described as the "biotechnologization of agricultural R&D."

With reference to the division of labor between public and private plant breeding, biotechnologization has had two principal meanings. First, it has resulted in the continued ebbing of cultivar release by public institutions. This is problematic since the maintenance of public cultivar development is an effective way to provide alternatives to the varieties offered by the seed companies and to supply quality cultivars for minor crops in which markets are too small to elicit investment from private breeders. Industry has unambiguously demonstrated how it intends to develop the crops of the future, and it has been very aggressive in pressuring the public breeders who are still involved in finished variety development to incorporate proprietary genes – for example, Roundup Ready genes in wheat – into their programs. To lose independent public cultivar development is to lose our best vehicle for ensuring that there will be alternatives to the chemically dependent suicide seeds that are the products of corporate laboratories. For example, a soybean breeder at the University of Minnesota has explored making the plants more competitive with weeds, an approach diametrically opposed to herbicide tolerance. Further, the Gene Giants have shown no more willingness to engage in varietal development for "orphan" crops any more than they have been willing to put research into orphan drugs. Despite hand-wringing in the plant science community over the lack of breeders for minor crops (see Frey 1997), the University of Wisconsin is presently allowing its oat breeding program – one of the last of its kind – to slip quietly away as faculty shift to genomics in the lab rather than cultivars in the field.

Second, the growing emphasis of public plant scientists on biotechnology and genomics brings them into a production location similar to corporate knowledge workers. Having successfully levered breeders away from finished cultivars, the companies now confront the need to readjust the division of labor with a new set of public researchers. The marketization of the university, which has proceeded in parallel with the development of biotechnology, for some time obscured this dynamic. With Bayh-Dole providing a novel opportunity to profit from the labor of its biological professoriate, university IPR managers were anxious to license biotechnology inventions to the highest bidder, often not even preserving their own institutions' rights to use the technologies. For instance, although the widely used "gene gun" was developed at Cornell University, that critical enabling technology was licensed to Agracetus and subsequently acquired by Monsanto when it bought Agracetus.

Hence, it was largely their own inexperience and cupidity that brought

universities to the point at which the PIPRA institution presidents can complain "Our institutions have found that the public research sector finds itself increasingly restricted when wishing to develop new crops with the technologies it has itself invented, including so-called 'enabling technologies' – the research tools necessary for further experimentation and innovation" (Atkinson et al. 2003:174). The inauguration of PIPRA is a response to the recognition of the difficulties into which universities placed themselves through their embrace of an atomized, market-based approach to knowledge production. Further, it must be understood as a response to the recognition that – as PIPRA points out on its web site (though not in the *Science* article) – "There are only a small number of large multi-national firms that control a large proportion of cutting edge agricultural IP" (PIPRA 2003). Public sector germplasm enhancement and genomics are in danger of being subordinated to industry, as was cultivar development before them. PIPRA is fundamentally an attempt to build a platform from which the public sector can defend and reassert its freedom to operate not just in technological practice but in the social division of labor with a narrow set of Gene Giants.

How that division of labor will be worked out on the terrain of genomics is uncertain. On the one hand, PIPRA participants recognize that serving the "public good" requires them to preserve a sufficient amount of FTO to use the technology they develop "for furthering their goals of achieving food security for the poor and excluded of the world" (Atkinson et al. 2003:175). This appears to mean providing technology preferentially to public breeding programs and small farmers in the developing world, and possibly even to small seed companies in the North. On the other hand, PIPRA's founders simultaneously envision creating "additional opportunities to generate royalty income to support public-sector research by providing convenient one-stop shopping for commercial licensing" (Atkinson et al. 2003:175). As we have seen throughout this book, a balance between the competing goals of public service and institutional profitability is a precarious equilibrium to maintain, especially given industry's constant pressure to shift their pursuits in the direction of commodification. Still, it is significant that a commitment to the public good is being made so explicitly, and that a concrete challenge is being mounted by the public sector to the hegemony of the genomic oligopoly.

Note, however, that the issue of the division of labor that engages PIPRA is couched largely in terms of the use and control of the tools of biotechnology. By "biotechnologization" what is most centrally meant is a general commitment to advanced genetic technologies as the core paradigm for plant improvement. Among public plant scientists, as well as among their private counterparts, there is near universal excitement over the potential of the new knowledge and techniques being developed and deployed. While in the public sector there is frequent criticism of the way biotechnology and genetic

engineering are being *used* by companies, condemnation of the technologies themselves is rare. Given the "enormous path dependence" (Buttel 1999:1) that investment in biotechnology has already established, these techniques are going to remain at the core of agricultural research for a long time to come. Happily, there is much interest among public scientists in how biotechnology might be used to achieve a truly sustainable agriculture (e.g., Coffman 1998; Manning 2000).

To the extent that public plant scientists have adopted a corporate understanding of agricultural problematics, that goal will be difficult to achieve.²² The development of Terminator Technology by the USDA's Agricultural Research Service is a prime example of the ways in which the goals of corporate and public scientists can become isomorphic. Bt corn and Roundup Ready soybeans represent a change in the form of industrial monoculture rather than a shift to a fundamentally new approach. New approaches are available, however. The emergent set of conceptual, technical, and methodological resources known as "agroecology" (see, e.g., Altieri 1996; Giampietro 2004) appears to be particularly promising in that regard. Genomics, with its emphasis on apprehending the interaction of genome and environment from a systems point of view, seems compatible with an agroecological outlook. It is to be hoped that a division of labor between public and private plant science can be maintained that creates for the public sector not only a broad freedom to operate but also encompasses the motivations and objectives for the use of biotechnology that are very different from those of private industry.

How the contest over the shape of the division of labor in the North proceeds will have major ramifications for the scientists, farmers, and eaters of the South. The CGIAR centers and the national agricultural research programs of developing nations have long looked to the public sector plant breeding institutions of the industrialized countries as a source of technology and expertise. If the patent-driven tying up of germplasm and enabling technologies is problematic for the public sector in the North, lack of access to these resources is even more acute in the South. CG system budgets are as flat as those of public sector institutions in the North. With a reduced flow of new knowledge from their accustomed source, the CGIAR has begun to look to the private sector for strategic alliances that will give its research centers access to the information it believes it needs to serve the interests of the world's resource-poor farmers and the hungry.

The CG system leadership and its advisors feel a special urgency since there is among them a widely shared perception that biotechnology is the key to achievement of what Rockefeller Foundation President Gordon Conway has proposed as a "doubly green revolution." CGIAR system chair Ismail Serageldin has similarly called for embracing "Promethean science"

(Serageldin and Persley 2000), by which he means an integration of agroecology, biotechnology, and precision farming. Certainly, genetic engineering as it has been developed by the private sector now has little to offer poor farmers and, indeed, is in many ways a direct threat to their livelihood and well-being. The Gene Giants have developed GM cultivars for the farmers who can pay for the seed, and that means corn and soybean varieties to be fed to animals in Iowa feedlots rather than the development of disease resistant varieties of cassava that might actually be of use to subsistence farmers in Zambia. Still, many in the international agricultural research community are convinced that biotechnology *could* make a critical contribution to overcoming the constraints on agricultural production in the Third World if it were applied in response to human needs rather than market signals (Jefferson 1993; Conway and Toenniessen 1999; Victor and Runge 2002).

The problem with such a strategy, just as it is for the public sector in the North, is attaining sufficient freedom to operate in social and technical spaces that are increasingly dominated by capital. The CGIAR and its LDC partners actually face far fewer constraints than does the public sector in the North. Because the countries in which CG centers are located do not now recognize patents on living organisms, germplasm and many enabling technologies patented in the U.S., Europe, or Australia can now be freely used by CG institutions (Nottenburg et al. 2002). Such an approach, however, is being actively discouraged by donor governments who would certainly apply powerful political pressures and might retaliate by restricting funding or information flows. Bilateral trade pacts may already be restricting this option. And the capacity to benefit from access to germplasm or techniques depends critically on the capacity to use them, not simply to possess them. The CGIAR, if not many developing nations, will likely choose cooperation rather than confrontation with those who hold the purse strings and the passwords to the databases. The CGIAR system now feels it has no option but to access the privately held enabling technologies it needs by establishing strategic alliances with industry (Serageldin and Persley 2000). Since the late 1990s, the CG centers have concluded a wide variety of exchanges, contracts, joint ventures, and licensing arrangements with companies such as Pioneer, Monsanto, and Novartis (Manicad 1999). In October 2002, the CGIAR took the unprecedented step of adding the Syngenta Foundation for Sustainable Agriculture as a member. Syngenta now joins the Ford, Kellogg, and Rockefeller Foundations in CG governance and policy activities.

Closer relations between the public and private sectors – in the North and the South – are, unfortunately, founded on fundamental asymmetries of need, resources, and power. The companies are now spending far more money on research than the public sector. When Hoechst and Rhone-Poulenc merged to become Aventis the annual research budget of that company alone was about \$3 billion, ten times that of the entire CG system. The private sector

has a considerable lead in the number of patents it has acquired and the enabling technologies that it consequently controls. The companies also have substantially more experience in structuring business arrangements than do public sector institutions.

Drawing on his experience from concluding the deal between his own institution and Novartis, UC-Berkeley dean Gordon Rausser suggests that however difficult such alliances are to construct, public institutions in the developing world have no choice but to proceed with them. He advises a "focus on leveraging the complementarities and potential synergies between their knowledge assets and those of the private sector" (Rausser et al. 2000). Berkeley, like many universities in the North, had a considerable stock of intellectual labor power with which to bargain. What do the CG centers and the national research programs of the LDCs have to offer? They cannot offer much intellectual labor power (though what they do have is comparatively inexpensive). What they do have is access to the 80 percent of the world's farmers who do not yet buy seed. And, as Rausser notes, they have something else that is appealing: "germplasm" (Rausser et al. 2000).

Genetic resources and ecoliberalization

My history of plant breeding and improvement is largely the story of how germplasm has been gradually but steadily integrated into the generalized commodity system, which is the defining feature of capitalism. I have argued that the rough border which has marked the division of labor between public and private plant breeding has followed the shifting contours of the commodity form. With their recent foray into patenting, public plant scientists are trying to balance their responsibility for the development of public goods for the public domain with the mandate to make money through the production of commodities for the benefit of the entrepreneurial university.

This is a fundamentally contradictory process, and I fear the tendency over time will be to honor the market rather than the commons. Farmers and indigenous peoples find themselves in an analogous situation with regard to genetic resources. It is thought that elements of the commons can be preserved even as a means of capturing revenue once the provision of access to genetic resources is established. As Camila Montecinos (1996) has pointed out, this has led to a contradictory conjuncture in which western IPRs are rejected, but "different" forms of IPRs are embraced. But the market, in all its forms, carries a profoundly incorporative tendency. In Erna Bennet's (2002:5) memorable phrasing, such quasi-property rights may in fact be the "weapons of the enemy" inasmuch as they may ultimately erode the non-market attitudes and practices they are intended to protect.

I myself was insufficiently sensitive to this point sixteen years ago. At that

time, I felt that, for reasons of *realpolitik*, the impasse over the FAO Undertaking could not be resolved in favor of "common heritage." As a pragmatic matter, I thought that recognition of genetic resources as national property would be acceptable to the advanced capitalist nations and would elicit among them a willingness to pay for access to genetic information. I hoped that the solidary front that had characterized the countries of the South in regard to the Undertaking could be extended into cooperation on a new, multilateral regime for the equitable management of genetic resources. As it happened, the 1992 Convention on Biological Diversity affirmed the principle of national sovereignty over genetic resources. I was proven correct in my estimation of the outlook of the North. I was shown, however, to be overly sanguine in my anticipation of collective action on the part of the South. What resulted was the emergence of a wide range of bilateral, market-oriented arrangements, while the multilateral FAO Undertaking was relegated to jurisdiction over a narrow range of materials. Although so-called "Farmers' Rights" were recognized, they remain rhetorical constructs, and peasant farmers and indigenous peoples have been subjected to a new round of appropriationist initiatives.

Through most of the 1980s, seed companies were still resisting the prospect of paying for their raw materials. However, given the scientific and commercial excitement over biotechnology, the fiction that genetic resources are the common heritage of mankind proved impossible to maintain. With biotechnology companies selling many millions of dollars worth of stock on the strength of their manipulation and ownership of genes it became unambiguously clear to the states, bureaucrats, scientists, farmers, and indigenous peoples of the South that genetic resources were valuable. This rapid conscientization was accelerated by the growing interest of biotechnology companies in medicinal as well as crop plants. Nations of the South were asked to open their fields and forests to chemical as well as agricultural prospectors (Eisner 1989). Companies came under increasing pressure as activist groups levied charges of "biopiracy." Northern environmental organizations began to lobby for compensation as well, seeing such payments as a means of funding conservation efforts. In his book *The Diversity of Life*, E. O. Wilson (1992:283) described the "unmined riches" available in tropical regions and called for a New Environmentalism that would use bioprospecting to "draw more income from the wildlands without killing them, and so to give the invisible hand of free-market economics a green thumb."

Out of the 1989 FAO Conference came Resolution 4/89, an "agreed interpretation of the Undertaking." This agreed interpretation explicitly recognized the legitimacy of "Plant Breeders' Rights" and the expression of those rights in the legal protection of varieties. Balancing this concession to the developed nations was language specifying that "Farmers' Rights" will also be recognized. Just as plant scientists are entitled to a reward for their labor in

creating breeding lines and elite varieties, so farmers have a right to a reward for creating and maintaining landraces and other forms of plant genetic resources. Further, just as the reward for plant breeders is not moral but material, so should farmers be entitled to material reward for use of the fruits of their labor. This *quid pro quo* appeared to offer a way out of the Seed Wars impasse. But Farmers' Rights had no legally binding meaning, and although the FAO created an International Fund for Plant Genetic Resources contributions were voluntary and, consequently, were negligible.

Then, in 1992, the drug company Merck concluded an agreement with Costa Rica's National Biodiversity Institute (INBio) which gave Merck exclusive access to biological materials collected by INBio in return for a lump sum payment of \$1 million (Kloppenburger 1992). Two models for managing genetic resources on a compensatory basis were being established. The FAO approach was multilateral and embedded in institutions of international governance. The Merck/INBio approach was a bilateral market transaction between autonomous parties. The FAO and Merck/INBio arrangements marked the end of the discourse of common heritage and represented two alternative paths for shaping a legitimized framework for the collection of genetic resources. If there were to be a new exchange regime, business interests and their political allies preferred that it be based on the familiar foundation of the market. Since then, a process of "ecoliberalization"²³ has been under way in which conventional market mechanisms have increasingly been applied to the acquisition of genetic material.

This emergent neoliberal, market-oriented regime for genetic resources was given sanction by the Convention on Biological Diversity (CBD) which was passed in 1992. In its Preamble, the Convention explicitly affirms the "sovereign rights of nations" over biodiversity. Second, in Article 15 the Convention provides for access to genetic resources "on mutually agreed terms" (as does the FAO Undertaking), but fails to specify a particular framework for determining those terms. Article 15 itself contains only the vaguest of language regarding "sharing in a fair and equitable way the results of research and development." Article 16 specifies "access to and transfer of technology . . . under fair and most favorable terms" but immediately removes all the teeth from this provision by qualifying it with unambiguous subordination to "effective protection of intellectual property rights." In effect, Articles 15 and 16 of the CBD do little more than affirm that genetic resources may be bought and sold subject to current intellectual property law. And since the Convention is not explicit about the nature of the parties who should come to mutual agreement, the Convention implicitly encompasses transactions made by virtually anyone or any institution.

The indeterminacy of "mutually agreed terms" is further compounded by paragraph 3 of Article 15. The language of that paragraph excludes from the

Convention all *ex situ* collections of genetic resources outside the country of origin and which were acquired prior to the adoption of the Convention. Most notably, this left uncertain the status of the critically important CGIAR gene banks whose holdings were collected originally under the regime of "common heritage." Not only does the Convention not mention Farmers' Rights, it makes only the vaguest noises in the direction of the rights of "indigenous and local communities." Though recognizing the utility of the knowledge and activities of farmers and indigenous peoples, the Convention does no more than "encourage the equitable sharing of the benefits arising from the utilization of such knowledge" (Article 8,j; emphasis added). The Convention thus affirms the force of current intellectual property arrangements but fails to seize the opportunity to move effectively toward provision of a symmetrical set of rights for informal or community knowledge production.

As a result of these deficiencies, the Convention did not so much provide for the conservation of PGRFAs as it established the conditions for their commercialization (Athanasίου 1992). And it did so in a way that allowed more or less free play of market forces. Any parties (states, research agencies, companies, communities, individuals) may enter into agreements for the sale of genetic resources on mutually agreed terms as long as they adhere to existing intellectual property arrangements (which do not include Farmers' Rights). The Convention thus gave an official global imprimatur to the commercialization of biodiversity. In doing so, it simply affirmed the commercial status quo, for the Convention countenanced no more than what was already being done (viz. the INBio-Merck deal).

A principal consequence of the generality of the CBD's language is a tendency for the commercialization of genetic resources to be manifested in bilateral rather than multilateral arrangements. And the past decade has seen an enormous proliferation of such arrangements. The government of the United States gave its imprimatur to bilateralism by requiring the bioprospecting initiatives it underwrites through its International Cooperative Biodiversity Grants (ICBG) program to provide compensation for the peoples and communities who host the bioprospectors (NIH 1993). Many scientists and some conservation groups – Conservation International and the New York Botanical Garden, for example – have become directly involved in the search for green gold (e.g., Balick et al. 1994). Lacking the ethnographic skills and sensitivities to efficiently extract culturally embedded information, companies such as Merck, Monsanto, and Eli Lilly have entered into alliances with a variety of universities and conservation organizations whose ethnobiologists provide the interpersonal solvents needed to make the data flow freely (NIH 1993). Scores of companies and many hundreds of academic scientists are now scouring the lands and bodies of farmers and indigenous peoples for commercially or scientifically useful genetic materials and

components. While well-known transnational corporations like Monsanto, Pfizer, and Merck focus on the collection of plants and animals, the Human Genome Diversity Project extended bioprospecting to the blood and tissues of indigenous peoples themselves (Harry 1994).

For farmers and indigenous peoples, however, there are a variety of drawbacks to the bilateral, market-oriented approach. The most obvious of these is the difficulty in establishing a price for genetic materials. The utility of any particular accession cannot be determined at the point of collection. It is only after evaluation and extensive research and development that the rare "hit" results in a new drug or an improved plant variety. Moreover, some genetic traits which are apparently useless now may become important only at some time in the future when their latent utility is revealed by changing social or ecological conditions. As a result of this indeterminacy, the "up front" payments that bioprospectors can be expected to offer for access to genetic resources have been quite small. Recourse to royalties or other forms of time-lagged payments linked to future values provides farmers and indigenous peoples with a way to capture financial benefits in such a situation. But playing the royalty game with transnational corporations that possess large stables of accountants and lawyers, who are expert in writing and interpreting contracts in a way that favors their employers, is no simple matter. As Martínez-Alier (1994:81) notes, the poor tend to sell what they have at a low price simply because they are poor, and "If Costa Rica cannot get a good price for bananas, how can it get a good price for biological diversity?"

Perhaps, most fundamentally, western property arrangements were not designed for collective/community innovation and are simply not well suited to the needs of indigenous peoples and farmers or to their landraces. Over the decade of the 1990s there was a flood of literature from progressives and well-meaning ecoliberals (e.g., Hamilton 1993; Kadidal 1993; Reid et al. 1993; Greaves 1994; Brush and Stabinsky 1996) and from organizations representing or allied with farmers and indigenous peoples (e.g., Gupta 1993; Posey and Dutfield 1996; Rothschild 1997) trying their best to figure out how existing IPR and market arrangements might be twisted and stretched and transmogrified to operate so as to protect the rights and reward the inventive activities of community and informal innovation. The provision for *sui generis* arrangements under TRIPS appeared to offer a real opportunity for the design of "traditional resource rights" that might be articulated to existing property rights law in ways that would actually benefit those who produce and reproduce crop landraces and other forms of embodied indigenous knowledge. It may be that when a clear and unambiguous association of crop genetic material with a people or community is possible, bilateral arrangements between a community or a people and an outside entity may be useful and equitable if intelligently crafted.

Certainly the obstacles to be overcome in concluding such agreements are substantial. Indigenous and peasant communities are rarely the homogeneous, solidary, stable entities that some analysts imagine, and different factions may have very different positions on the propriety or conditions of any particular bioprospecting agreement. While the principle of prior informed consent might provide some operational guidance, the farmers and indigenous peoples who are being targeted by the bioprospectors typically do not have very extensive knowledge of what the bioprospectors will do with the information and organisms they collect, or of the legal, scientific, and commercial frameworks into which they are being inserted. Absent such understanding, it is difficult to see how farmers and indigenous peoples can provide informed consent to bioprospecting activities and construct exchange agreements that are adequately sensitive to their own interests. While the literature is replete with examples of abuses (for summaries see especially Rural Advancement Fund International 1995, 2000a), there are few extant models for how hybridization of indigenous and industrial arrangements for intellectual property rights might be successfully accomplished (see especially Cleveland and Murray 1997 and King and Eyzaguirre 1999 for a review of efforts).

This disjuncture between the models and their application seems to point to a fundamental contradiction between the collective, cooperative, multi-generational modes of knowledge production that are frequently characteristic of indigenous and local farm communities and the capitalist property and market institutions with which they are confronted. Over the last two decades, corporate interests have worked very hard indeed to put in place a legal framework of global reach which is designed to allow anything and everything to be privately and individually owned and therefore privately and individually sold. Since all production is social (no Robinson Crusoes on this planet), it ought to be clear that IPRs are actually an attempt to circumvent and obscure the very reality of social production and to subsume the products of social production under private, individual (either literally "individual" or corporate) ownership.

It follows that existing IPRs can be nothing but antagonistic toward social relations founded on collective responsibility and communal or community ownership. Peoples and communities who do choose to engage in bilateral agreements may find themselves drawn inexorably into the web of values, ethics, and activities characteristic of the market in contemporary capitalism (Agrawal 1995; Argumedo 1995). Indeed, it is this tendency that is of particular concern to Camila Montecinos and Erna Bennet (2002). "Regrettably," writes Montecinos (1996:27), "the gradual deviation of the discussion toward alternatives or exceptions inside the existing system has lost us precious time in determining what is really needed, regardless of whether or not it fits into a predetermined definition or regulation. This is especially serious when for

various reasons we are being confronted with absolute demands to 'finally' define Farmers' Rights."

Farmers Rights' have indeed recently been given a more determinate form than in the past. In 1994, negotiations were initiated to revise the FAO's International Undertaking on Plant Genetic Resources in order to harmonize it with the Convention on Biodiversity. This revision of the Undertaking was to address significant weaknesses in the CBD. The Convention had failed to deal with plant germplasm already appropriated and stored in gene banks and, even more critically, had also neglected to concretely engage the question of "Farmers Rights." In 1994, an agreement was reached which brought much of the germplasm held in CGIAR gene banks (some 500,000 accessions) under the trusteeship of the FAO, by whom the materials would be held in the public domain – and unpatentable – for the benefit of humanity. Access to that "in trust" germplasm would be on the basis of "facilitated access" rather than "free access." That is, materials would be available to countries adhering to the Undertaking and also agreeing to provide the "benefits sharing" envisioned by the CBD. Further progress was stymied by continued disagreement over what constituted benefits sharing and its relation to Farmers' Rights. Over the next nine years, although it was a signatory neither of the CBD nor of the Undertaking, the United States took the lead in precluding any material expression of Farmers' Rights, which it insisted was merely a concept rather than an actionable mandate requiring financial commitment.

Nevertheless, pressures for some kind of accommodation continued to grow. In the absence of an agreed upon multilateral framework for exchange, breeders the world over complained of the imposition of increasingly onerous restrictions placed on the availability of germplasm by national governments. The sequencing of the rice genome highlighted the potentials that might go unrealized if the flow of plant genetic information were to be subject to continued constraints. Instances of biopiracy in crop plants – patenting of ICRISAT chickpea and lentil varieties in Australia, appropriation of the Indian descriptor "Basmati rice" by the Texas company RiceTec, the patenting of a Mexican bean landrace by an American breeder – underlined the latitude for abuses under existing arrangements.

In November 2001, a revised FAO Undertaking was approved as a legally binding International Treaty on Plant Genetic Resources for Food and Agriculture (FAO 2001). The Treaty created a "Multilateral System of Access and Benefit Sharing" and passed with only two nations abstaining: Japan and the United States.²⁴ In 2003, the U.S. became a signatory to the Treaty, if for no other reason than to be able to shape how its provisions are implemented. Although the ambivalence of the U.S. is only apparent, it is authentic among those NGOs that have over the last decade worked hardest to encourage the birthing of a truly new international genetic order. For those progressives, the

Treaty can be seen as a glass half empty, or a glass half full, a "trick or treaty," as the ETC Group (2001b) appropriately phrases it. There are five principal "tricks," yet they are hardly covert and will be familiar to anyone who has followed the Seed Wars.

First, the content of Farmers' Rights is still under-determined. While Article 9 of the Treaty accords farmers three important categories of rights, those perquisites are not specified as clearly as might be preferred. Second, most of the important provisions of the Treaty – including Farmers' Rights – incorporate the proviso, "subject to national legislation." Indeed, the Treaty makes it explicit that "responsibility for realizing Farmers' Rights . . . rests with national governments," so there is no multilateral instrument for enforcement.²⁵ Even more critically, the right to "save, use, exchange, and sell farm saved seed" is also made subject to national law, which is to say, to PBR legislation. Farmers' Rights are effectively made subordinate to plant breeders' rights. Third, although there is a mechanism for sharing the benefits of commercialization of germplasm, the level, form, and manner of payment are yet to be determined, which may well lead to the kind of negotiating that has already resulted in decades of empty coffers for the FAO Gene Fund. Fourth, materials collected from farmers and stored under the auspices of the Multilateral System may have only the thinnest veneer of protection from patenting. The Material Transfer Agreement (MTA) mandated by the Treaty for the exchange of germplasm requires only that intellectual property rights not be claimed on germplasm "*in the form received* from the Multilateral System" (FAO 2001:7, emphasis added). This has been taken by the private sector to mean that any subsequent transformation of the material renders it patentable. Finally, although Article 13.3 suggests that "benefits . . . should flow primarily, directly and indirectly, to farmers," one suspects that "indirectly" through the scientific community will be the dominant route since the Treaty envisions exchange of information, transfer of technology, and capacity building as the main mechanisms for benefits sharing.

Under the Treaty, both public and private plant breeders have free access to the germplasm they want and can formally acquire intellectual property rights to the cultivars they produce. Farmers must respect PBRs and patents and might, some time in the future, be recipients of benefits as they filter down through plant scientists' research programs. In sum, it can be argued that the Treaty has not actually moved the international genetic resources regime much beyond where the Undertaking had it twenty years ago.

While the Treaty is clearly not a qualitative advance over past arrangements, it can be seen to represent meaningful progress toward a more equitable global framework for crop germplasm exchange. There is now a legitimate, formal Multilateral System to manage access to most of the world's most important food crops and to provide a counterbalance to market-based

bilateral arrangements. Critically, the rich and invaluable materials stored in CGIAR center gene banks are placed unambiguously in the public domain under the control of an intergovernmental body. Plant genetic materials are available on a "facilitated" (i.e., free but regulated) basis to those nations ratifying the Treaty. Any party requesting germplasm is required to accept a Materials Transfer Agreement that mandates payment of "an equitable share of the benefits" arising from development of any commercial cultivar or product that incorporates material accessed from the Multilateral System.

The wording of the MTA ban on patenting of materials as received from the system *could* be read as disallowing patenting on *any* part of the material. Even if a pro-business reading is ultimately upheld, the provision will at least slow the process of commodification and act to prevent patent claims on existing varieties. Most importantly, though their articulation leaves much room for equivocation, Farmers' Rights appear in the Treaty in a much stronger form than they have in previous agreements. Farmers' Rights are declared to include (FAO 2001:5):

- (a) protection of indigenous knowledge relevant to plant genetic resources for food and agriculture;
- (b) the right to equitably participate in sharing benefits arising from the utilization of plant genetic resources; and
- (c) the right to participate in making decisions, at the national level, on matters related to the conservation and sustainable use of plant genetic resources for food and agriculture.

Operationalizing what are more statements of principle than concrete commitments to specific actions or policies will not be easy, but those provisions are quite solid platforms from which to work.

And work there will be, for even as the Treaty was ratified by the requisite forty nations on June 29, 2004, and became a legally binding document, it is still substantially a work in progress. Genetic Resources Action International (GRAIN), which had lobbied hard for a strong statement of Farmers' Rights and a strict ban on incorporating materials covered by the Multilateral System into any patented cultivar, finds the Treaty a "disappointing compromise" inasmuch as "many of the central issues remain unresolved and open to interpretation" (GRAIN 2001:2). Erna Bennet (2001:7) joins Camila Montecinos in deploring the way Farmers' Rights have taken on some of the institutional and epistemological trappings of intellectual property rights. Of the Treaty, she asks, "What's new about all of this? Nothing. The International Treaty . . . concedes nothing but a few fragments of bracketed text and some '*room for re-opening discussion*' on the '*key issue*' of Farmers' Rights." But it is the very indeterminacy of the treaty – an unstable combination of promise and danger – that provides a continuing opportunity. The seed

industry, the U.S. State Department, and the CGIAR system are all as ambivalent about the Treaty as GRAIN and Erna Bennet. How will the phrase "in the form received" be interpreted? Will the CGIAR centers agree to participate? How will benefits sharing be arranged? The very fact that, as GRAIN (2001:3) puts it, "a lot is left up to consensus interpretation and future debate" means that options are still in play and that progressive outcomes are still realizable.

Pat Roy Mooney, Executive Director of the ETC Group, understands the weaknesses of the Treaty as clearly as anyone, but he embraces its indeterminacy as an opportunity: "It will become what we make of it. It is the white elephant turned into the mouse that could roar. We believe it signals a very important breakthrough" (ETC Group 2001b). I agree with the ETC Group, for I believe that a set of social and political and scientific circumstances is now coalescing that makes the achievement of progressive outcomes at least plausible.

Conclusion: revitalizing public plant science

This book has traced the story of how plant breeding and seed production became a means of capital accumulation. A corollary to the rise of private industry and the commodification of the seed has been the relegation of public plant science to areas complementary to rather than competitive with corporate plant science. When I completed *First the Seed* in 1988, the development and deployment of the new biotechnologies was proceeding along these established historical trajectories. Even now, the objectives of the seed industry – transformed into the life industry – remain constant. The Gene Giants want to ensure the continuous circulation and expansion of their capital by encoding in seed the shape and content of agricultural production processes. They want to ensure enlargement of their markets by forcing the farmer to buy seed (and inputs required by the seed) every growing season. They want the assistance of public science in achieving these ends. Moreover, their ambitions have grown. They are seeking now to extend their reach beyond the farm gate and into the supermarket in order to impose a particular mode of consumption on the world's eaters in the same way they have imposed a pattern of production on the farm sector. The influence of industry over the conduct and direction of public science has the effect of foreclosing alternatives even as the need for alternatives has become increasingly urgent.

Happily, one of the most salient features of the story over the last sixteen years has been the emergence and growth of opposition to the manner in which the companies have developed and deployed biotechnology. This opposition has had multiple sources that are widely diffused in both space and in orientation to issues of concern. The environmental community has the

deepest roots in resistance. Today, it is a rare environmental organization – local or global, radical or mainstream – that is not critical of the effect of GM crops on the biosphere. Consumers' and food organizations' concerns over biotechnology have grown in proportion to the GM food products available. The initial, narrow pulse of distress that attended the introduction of rBGH in the U.S. in 1993 was revived in America and ballooned in Europe with the widespread planting of GM crops after 1996. As more organisms became candidates for transgene incorporation, religious groups came to question the ethics of such recombination. Animal rights groups similarly balked at the prospect of treating the beings with which we share this earth as objects to be dissected and reconstituted. Farmers' organizations in the North and South objected to the erosion of their ability to save seeds and the possible damage to their ability to sell their crops if consumers rejected GM foods. Groups opposed to corporate globalization found consolidation in the life sciences to be a paradigmatic expression of what they most feared and regarded TRIPS as a prime vehicle for facilitating the imposition of global market structures. Indigenous peoples confronted bioprospecting as a new form of colonization.

Because the issues it touches upon are so wide-ranging and because it manifests itself in different forms in multiple locations over the globe, opposition to the corporate development of biotechnology has taken some time to gain coherence and momentum. But as the underlying connections between apparently disparate issues and locations are revealed and articulated, opposition to genetic engineering in agriculture takes on a unique and unifying global potency. A remarkable range of organizations around the world finds some facet of biotechnology problematic.²⁶ Concern is not limited to militant organizations such as Greenpeace, but also extends to mainstream organizations such as the Sierra Club and even the relatively staid Audubon Society.

Globally, a steadily growing number of actions have been undertaken by numerous groups at many different scales with the objective of constraining and restraining the activities of the biotechnology industry. Direct action can be fragmentary and covert, as with the destruction of GMO test plots in the United States, Europe, and India. More commonly, it takes the form of demonstrations at points of sale such as supermarkets. In India, the Seed Satyagraha²⁷ and the Monsanto Quit India! movements have mobilized hundreds of thousands of people (Shiva 2001). Especially, activists have made an effort to organize parallel and alternative conferences wherever biotechnology trade groups hold their annual meetings or wherever CBD or WTO deliberations take place (Tokar 2001).

The opposition looks to find expression in the mechanisms of governance as well in symbolic forms. A variety of municipalities in the U.S. have attempted to declare themselves "GMO-free zones." In March of 2004 Mendocino County, California, became the first locality in the U.S. to succeed in

doing so when its residents passed Measure H prohibiting the raising of genetically modified organisms. A principle motivation for the ban is to ensure that crops can continue to be grown organically (Pogash 2004). In Vermont, where seventy-nine towns have passed resolutions opposing the use of GM crops, bills requiring the labeling of GM seed and protecting farmers from liability for the adventitious patent infringement that landed Percy Schmeiser in court were introduced into the state legislature during its 2003–4 session. The “Farmers’ Right to Know Act” was passed into law and any GM seed sold in the state must be labeled as such. However, the “Farmer Protection Act” faced stiff opposition from the biotechnology industry because it would require seed manufacturers themselves to indemnify farmers against any liabilities resulting from actual use of GM seed *and* against patent infringement liabilities resulting from inadvertent contamination of crops by GM varieties. In Vermont, it would be the seed companies, not farmers, who are on the hook for any damages resulting from intentional *or* adventitious “use” of GM genes.

Action has been effective on national and international scales as well. When the USDA decided to permit the use of GMOs under its organic rules over 275,000 people responded – more comment than the USDA had ever received on an issue – and forced the Secretary of Agriculture to rescind the proposal. Consumers in the EU collectively refuse to purchase GM foods and popular pressure is the principal reason that the *de facto* moratorium has been maintained. With the leadership of some politically sophisticated and deeply committed NGOs, a signal victory was achieved on the international level with incorporation of the “precautionary principle” into the Cartagena Protocol on Biosafety that was developed as an outcome of the CBD. By allowing the regulation of imports of GMOs even in the absence of scientific certainty about their potential harms, the Protocol gives nations an important measure of control in dealing with WTO-based pressures to open their markets (Egziabher 2003).

Sensitive to growing opposition to its activities, industry has fought back with the considerable political, economic, and cultural resources at its disposal. A principal theme in its discursive efforts to smooth the way for GM varieties has been the benefits such crops would allegedly have for the world’s poor and hungry. In addition to its own advertisements and outreach materials (e.g., CBI 2000), the Council for Biotechnology Information recruited ex-President Jimmy Carter as a spokesman. In a *New York Times* op-ed piece titled “Who’s Afraid of Genetic Engineering,” Carter (1998:A23) criticizes such precautionary latitude as threatening to “leave food rotting on the dock” while people go hungry. He concludes that

If [GMO] imports like these are regulated unnecessarily, the real losers will be the developing nations. Instead of reaping the benefits of decades of discovery and research, people from Africa and Southeast Asia will

remain prisoners of outdated technology. Their countries could suffer for years to come. It is crucial that they reject the propaganda of extremist groups before it is too late.

More recently, U.S. trade representative Robert Zoellick criticized the EU moratorium on GMOs as "immoral" inasmuch as it encouraged developing nations to take a similar stance and therefore deprived the hungry of needed – albeit GM – food (Becker 2003:A6). Activists countered that the U.S. had no real interest in feeding hungry people – witness its world-leading stinginess in foreign aid²⁸ – and that what it was really worried about was making sure the biotech companies were well fed.

Important actors in the international public agricultural research community agree that the hunger card is a red herring and that the biotechnology industry is not motivated by meeting human needs (Conway 1999; Herdt 1999; Paarlberg 2000; Victor and Runge 2002). But where activist critics of the companies see the problem as too much biotechnology, prominent Green Revolutionaries see the problem as too *little* biotechnology. That is, the companies are pushing Bt and herbicide resistant corn and Roundup Ready soybeans when what hungry people in Africa and Asia and Latin America need are disease resistant and insect resistant and locally adapted varieties of corn, chickpeas, cassava, lentils, rice, sorghum millet, and bananas. Though biotechnology could be applied to those crops, it has not been because private industry does not develop seeds for people who cannot pay for them. That responsibility has been assumed by the CGIAR centers and national agricultural research programs. But access by those public institutions to the necessary tools is now being constrained by the narrow range of private interests who own them.

This situation is understood with great clarity within the Rockefeller Foundation. The Foundation's Director for Agricultural Science observes that

The business plans of the mega-seed companies seem straightforward: control everything from genetic engineering of seed to the selling of seeds to farmers, to marketing plant-grown drugs, modified foods, and industrial products. They aggressively employ patents to claim intellectual property. . . . They can be expected to seek profits from new high-quality seeds for farmers who are capable of paying a premium price. But they have little incentive for producing crops that are important to the poor and disadvantaged farmers who primarily save their own seed. [Herdt 1999:9]

Rockefeller President Gordon Conway summarizes the implications for the public sector:

Developing-country crop variety development systems are poorly equipped to deal with the rapid changes that are occurring. They have

depended extensively on international free exchange of germplasm. . . . As plant research in the industrialized world has come to be dominated by private companies who closely guard their proprietary technologies, the process of innovation in the developing countries has slowed. Public-sector plant breeders don't know how to respond, and when they try, they are handicapped by the huge disparity in resources and negotiating power between themselves and the companies. [Conway 1999:2]

Remarkably, there is a growing sense in the international agricultural research community that corporate concentration and the private appropriation of the natural world through intellectual property rights has become *the* major obstacle to equitable agricultural development.

The practical implications of this insight were not lost on Conway. In his extraordinary 1999 speech to the staff of Monsanto, he issued a call to quite radical reform. Voicing his confidence that application of biotechnology holds enormous promise for the "poor and excluded," he proceeded to indict Monsanto, in particular, and the biotechnology industry, in general, for a host of failings including inattention to outcomes in the rush to market, inappropriate patenting of gene sequences, engaging in biopiracy, and abusing market power. He advised Monsanto (and, by implication, the industry generally) to embrace the precautionary principle, abandon utility patents on plants in favor of PVP exclusively, accept labeling of GMOs, phase out the use of antibiotic resistance markers, disavow Terminator Technology, establish a fellowship program for developing country scientists, and agree to license patented enabling technologies in developing nations at no cost. He concluded by calling for development of an agricultural science that employs both "ecological approaches" and "participatory approaches that strengthen farmers' own experimentation and decision-making" (Conway 1999:4).

Note that Conway's position is actually not very far from that of Greenpeace or the ETC Group or the Organic Consumers Association! However, he is speaking not to Greenpeace, but to Monsanto. Although his program is quite radical, his political frame of reference has not kept pace with his structural analysis. His instinct is to reform Monsanto rather than join with unaccustomed allies to change the structures within which industry operates. When he imagines the revitalization of public agricultural science, he anticipates "new forms of public-private collaboration" (Conway and Toennessen 1999:C56) rather than a public sector emancipated from corporate hegemony. So while the Rockefeller Foundation funds a multi-year initiative to support the emergence of fairer intellectual property policies that "defend the sharing of knowledge, information, and research among scientists, inventors, farmers, and creators" (Rockefeller Foundation 2002), it is also creating the African Agricultural Technology Foundation in cooperation with Monsanto, Syngenta, DuPont, and Dow (Gillis 2003).

One promising development is a proposal originating at Cornell University and involving three CGIAR centers and the public plant science programs of China, Brazil, France, Japan, the UK, and the Netherlands. The "Challenge Program: 'Unlocking Genetic Diversity in Crops for the Resource Poor,'" would fund a "unique *public platform*" for using molecular and traditional means to develop enabling technologies for the breeding of varieties suited to the needs of the poor. A central feature of the program would be a PIPRA-like approach to acquiring intellectual property rights in order to "ensure that research outcomes remain accessible in the public domain" (International Maize and Wheat Improvement Center 2003). Can such initiatives be platforms for the formation of connections with novel partners in civil society? Or will the public sector be drawn back within the orbit of capital?

Parallel developments are occurring in public sector plant science in the United States. A paper presented by Cornell University plant breeder Ronnie Coffman at the 1998 annual meeting of the American Seed Trade Association demonstrates that, like Conway, he is acutely aware of the challenges facing public plant scientists. And like Conway, he clearly locates the source of those challenges in the concentration of corporate power and the expansion of intellectual property rights. Citing a paper by his Kansas State wheat breeder colleague, Rollin Sears (1998), Coffman comments:

If words were copyrighted, only the few who owned them could communicate and our society would be harmed. Genes are analogous to words in that they allow the creation of new plant cultivars just as words allow the creation of a book. Everyone in society should have the right to use genes. Cultivars (novel genotypes or combinations of genes), not genes should be eligible for patenting. It is now clear that the patenting of genes will result in only two or three companies having a major influence on the food system. [Coffman 1998:8]

Exploring the implications of this tendency, he cites the comments of his Cornell colleague Charles Arntzen:

With the dramatic shift to proprietary protection for crops, and a massive consolidation of the seed supply industry into vertically integrated food/feed life sciences companies, the future employers of crop breeders are rapidly changing. If the history of corporations involved in this consolidation is any indicator, crop breeders run the risk of becoming "hired hands" working for MBAs and corporate attorneys. [quoted in Coffman 1998:7]

Coffman finds this restrictive division of labor unpalatable and, no less than Conway, is prepared to interrogate the basic assumptions of property

and power that have for so long defined the political economy of plant improvement.

For at least some plant scientists, and especially those still involved in cultivar development, questioning has matured into a willingness to directly challenge prevailing patterns. In the summer of 2000, five public plant breeders, one sociologist, and the director of an activist NGO met to explore the prospects for revitalizing public plant science. One of the participants, Washington State University wheat breeder Stephen Jones, was embroiled in controversy over his refusal to incorporate Monsanto and BASF herbicide resistance genes into his wheat cultivars (Schubert 2001b). Jones's stance resonated powerfully with his colleagues, who formed a Caucus on the Future of Public Plant Breeding. The Caucus's vision of that future included opposition to the patenting of naturally occurring genes and cooperation with farmers as central components of "vigorous, creative plant breeding programs, supported by public funds." With the facilitation of the Rural Advancement Fund International-USA, the Caucus initiative took on a more expansive form: in September 2003, some twenty-five public plant scientists met in Washington, D.C., with representatives of selected NGOs and farmers' organizations at a "Summit on Seeds and Breeds for the 21st Century."

Recognizing that public breeders now operate in an environment "where control of elite germplasm has increasingly become proprietary," the goal of the Summit was to "Develop a blueprint or road map for re-invigorating public domain land and animal breeding to meet the needs of a more sustainable agriculture" (Sligh and Lauffer 2004). There are several features of this initiative that closely parallel the concerns outlined by Gordon Conway in his Monsanto address. First, there is a clear and explicit recognition that growing corporate power is the chief force shaping and conditioning the context within which public plant science operates. Any effort at change must necessarily engage the exigencies of political economy, and especially the role of intellectual property rights. Second, there is an explicit commitment to service of the "public interest," which is defined both as the enhancement of "farmer and consumer choice" and as work that is "targeted to support . . . sustainable systems." Third, there is also an explicit commitment to research approaches that incorporate "tie ins with farmers (participatory programs)" and "cooperative problem solving." At both international and domestic levels, there is within the public plant science sector an emergent sense that revitalization of its activities will require confronting corporate dominance, a reorientation of research objectives to sustainability, and inclusion of clients in research processes.

Where this Summit initiative represented a critical and material advance over the Rockefeller Foundation model is in its effort to connect to a different set of social actors in pursuit of solutions to key problematics. Land grant sci-

entists at the Summit were talking not to Monsanto or Syngenta or Dow or DuPont, but to representatives of the Rural Advancement Fund International-USA, the Union of Concerned Scientists, the Organic Farming Research Foundation, the Northern Plains Sustainable Agriculture Society, and the Land Institute. It is in this reworking of the *social* landscape that the Summit broke new ground. The Summit was an opportunity for public sector plant science to withdraw from its accustomed role as a supplicant to private industry and to embrace an alliance with civil society organizations willing to confront the Gene Giants and demand that resources be provided for alternative paths.

Rural Advancement Fund International (2001a) has made the argument that the CGIAR's international research centers should adopt such a strategy:

The arguments for common cause seem strong. We are both dedicated to ending hunger and achieving food security. We also share a common enemy – the corporate/country driven demand for privatization and the diminution of public research in deference to corporate solutions. We share – to a degree that would shock many – a common vision of “sustainable agriculture” and a mutual antipathy for intellectual property monopoly. All this should be a basis for alliance.

Could it be that this alliance will emerge first in the United States?

The conclusions and policy recommendations that emerged from the summit (see Sligh and Lauffer 2004:171–175) are not themselves particularly remarkable or original. Nor do they adequately reflect the oppositional energy that was so apparent in the meeting's presentations and discussions. What is significant, however, is that public plant scientists found common ground with some quite radical advocacy organizations and established an institutional vehicle for strengthening and reinforcing that relationship. As this book goes to press a follow-up conference is scheduled for September 2004 in order to engage a larger set of stakeholders and to begin mapping concrete strategies for the reinvigoration of public plant and animal breeding.

An obstacle to cooperation among civil society organizations and public plant science may be their differing attitudes to biotechnology. Although there are exceptions (see Altieri 2001; Cox 2002), most public plant scientists anticipate that the new genetic technologies will be useful and even vital adjuncts to conventional breeding. All too often, however, activist and advocacy groups working to oppose the activities of the Gene Giant multinationals have tended to fall into a conceptual shorthand in which “biotechnology” (and especially the subsets “genetic engineering” and “GMOs”) is almost completely identified with the companies that are using it. The result is a species of technological determinism in which opposition to “biotechnology” is insufficiently distinguished from opposition to “*corporate* biotechnology.”

Failure to make that distinction alienates many scientists – themselves often users of particular biotechnologies – who are otherwise sympathetic to criticisms directed at the manner in which those biotechnologies are being used by commercial interests. It has also led to impoverishment of debate and a discursive climate in which the narrow and dystopian construct of “Frankenfood” confronts the similarly narrow but utopian construct of “Golden Rice.” This simplistic dualism obscures important differences not only among technologies and their likely impacts, but between the character of corporate and public research as well (Stone 2002; Ruivenkamp 2003).

A conjoining of activist groups and scientists interested in reclaiming a truly public science would be a very good thing. Achieving such an alliance will likely mean untangling biotechnology from the corporation and developing a more nuanced approach both to the technologies themselves and to distinguishing “between the practice and the practitioner,” as wheat breeder Stephen Jones puts it. This should be possible, for the focus of concern and opposition from civil society tends to be on genetic engineering (the transfer of genes from one species to another) and GMOs, rather than on the many other methods and techniques which do not involve transgenes. Moreover, with the cutting edge of research moving to genomics, plant scientists may soon have available information and tools that will allow them to explore the deep reservoirs of diversity that are available within organisms’ own genomes (Tanksley and McCouch 1997; Nielsen 2003). Genetic engineering would become “intragenic” rather than “transgenic,” and many of the objections to current practice might be obviated.

But to focus too much on the tools rather than on who is using the tools and for what the tools are being used is to misapprehend the problem. What is really needed is not so much the banning of one tool or the approval of another, but a revision of the way in which we develop tools and for what we imagine we are using them. The real problem, as Henry Miller and Gregory Conko (2001:303) point out in the quote that opened this chapter, is that a small authoritarian minority dictates “what kinds of research are permissible and which technologies and products should be available in the marketplace.” This is nowhere clearer in the world today than in plant improvement, where a set of five companies dominates the science and commerce of seed production.

That domination has been achieved through the progressive commodification of the seed by legal and technical means, through the relegation of public sector science to complementary activities, and through free access to genetic raw materials. Industry’s capacity to maintain those conditions of its hegemony is now in question. The Gene Giants’ pursuit of profits led them to press the commercialization of biotechnology more quickly than was socially acceptable. The contradictions embedded in the appropriation of

public resources and the erosion of public protections were made palpable to people around the world. Farmers, indigenous peoples, consumers, and scientists all found their choices diminished, their "freedom to operate" – to use the scientific neologism – restricted as a result of corporate activity associated with biotechnology.

Opposition from civil society has accordingly increased substantially over the past decade, especially outside the U.S., and now threatens the commercial viability of GM seeds and foods. In the scientific community, there is a growing perception that the permitted scope of patenting has been stretched beyond its social utility. Public sector plant scientists find themselves uncomfortably confined by corporate property rights even as the field of genomics opens before them. And access to genetic resources is now subject to compensation. A great many circumstances are in flux and, while capital is mobilizing to respond to these challenges, there appears to be considerable opportunity to create space for progressive change.

In particular, public plant scientists are poised to essay a reassertion of their formerly central role in crop improvement. An active and influential core is disturbed by the way industry has used the new biotechnologies, dissatisfied with their appointed role in the sectoral division of labor, frustrated by the difficulties in accessing key means of production, and anxious to fulfill their mandate to serve the public interest by contributing to the development of a sustainable agriculture. Most importantly, the consequences of the massive consolidation of capital that have occurred over the last decade has fostered the maturation of political-economic sensibility that is more accurately attuned to the realities of late capitalism. Some, at least, are ready to seek an alternative future that is relatively autonomous from industry and its straitened objectives

The emerging interest in sustainability and in participatory approaches to plant breeding is especially encouraging. Decades of gradual subordination to industry and the emergence of increasingly marketized research institutions have established powerful scientific and social path dependencies that will not be easily renounced. Organic/sustainable research programs are uncommon, agroecological/alternative method and theory is underdeveloped, and there is little experience with participatory endeavors. But if public scientists are committed to treading some new paths, the time may never be better. Participation can usefully be implemented through connection to some of the many civil society organizations that are working for a just and sustainable food system and through enhanced contacts with farmers. Moreover, plant scientists in public institutions may well find themselves in a position of surprising strength in the near future. Genomics is complicated and expensive and universities could well regain the preeminent standing they had before industry made its massive, and perhaps misplaced, investments in

research and patents. Judicious use of patenting may be a useful tactic for the public sector to preclude private appropriation of research results and to preserve free exchange among public entities (i.e., through PIPRA-like arrangements).

If crop production is to be shaped to meet human needs rather than to make profits in the twenty-first century, then public agricultural research institutions must find a way to play a key role in that endeavor. The four principal reasons for maintaining a robust public presence in plant improvement are the same as they were sixteen years ago. First, the public sector can produce public goods that are socially valuable but do not attract private investment because they are not profitable: cultivars for subsistence farmers, varieties in minor crops, cultivars for alternative (e.g., organic) production systems, management oriented input-displacing technologies and practices. Second, by developing and releasing finished cultivars, the public sector can provide a countervailing force to the market power of large companies as well as maintain standards of quality. Third, the public sector can explore options and alternatives and innovations that are not pursued by private industry. Given the many uncertainties associated with global warming and the cumulative and unanticipated effects of human action on the biosphere, it is irresponsible to commit the future to a single path defined by profitability. Fourth, we need the public sector to supply independent and reliable information if we are to have an informed populace capable of making informed decisions in a complex and uncertain world.

In 1988, I concluded this book with a challenge to plant scientists to consider Henry Wallace's call to political duty. I will end this edition with a similar passage from Erna Bennet (2002:10):

The day is coming when scientists and intellectuals will accept the need to take social action and accept social responsibility as an integral, and not a supplementary part of their scientific responsibility, adding their voice and their actions to those of millions of others. That will be a day of great hope for a direly threatened world.

That day may be near.

Engineering News for several articles describing private collection activities in tropical plants, algae, fungi, and marine organisms.

10. Conclusion

- 1 The argument summarized here is drawn from Kloppenburg and Kleinman (1986); see also Kloppenburg and Kleinman (1987a, 1987b, 1987c).
- 2 Occidental Petroleum has recently purchased a collection of rice lines from China, and Zoecon Corporation also bought a set of soybean land races from the Chinese.

11. Still the seed

- 1 The terms “Terminator Technology” and “Gene Giants” were coined by the exceptionally creative and media-savvy people at the ETC Group (Action Group on Erosion, Technology and Concentration). Previously known as RAFI (Rural Advancement Fund International), the ETC Group has been involved in the issues surrounding plant breeding, biotechnology, and genetic resources since the 1970s. The Group maintains constant and comprehensive oversight of scientific, economic, commercial, and political activity in the broad area of biotechnology and the life sciences. It is a prolific production of position papers, updates, analyses, and commentary that is invaluable for anyone working in this area. Readers are urged to visit the organization’s web site www.etcgroup.org.
- 2 For use of the term “means of reproduction” I am indebted to Dr. Wendy Russell, Department of Biological Sciences, University of Wollagong.
- 3 “FDA considers a GE [genetically engineered, that is, GM] crop safe if it is substantially the same as its non-GE version and the genetic modification does not cause the crop to produce a substance that is new or used in a new way or that is present in much larger amounts than in currently safe food. If the genetic modification produces a new substance that is not an approved food additive, the safety of the new substance as a food must be proven” (Shoemaker 2001:31).
- 4 For extensive treatment of corporate resistance to regulation and the politicking that entailed, see especially Marion Nestle’s excellent *Safe Food: Bacteria, Biotechnology, and Bioterrorism* (2003).
- 5 An excellent example is the *Safe Food News* published and distributed by Mothers for Natural Law of the Natural Law Party (2000).
- 6 See the list at www.truefoodnow.org/home_polls.html. The proportion of respondents to various polls taken between 1997 and 2003 who say they want labeling of GM foods ranges from 68 percent to 94 percent.
- 7 See *The Non-GMO Source* (Writing Solutions 2003) for a summary of regulations by nation.
- 8 Says Clive James, head of the International Service for the Acquisition of Agri-biotech Applications, “There’s piracy going on. These farmers think so much of this technology, they will steal it” (Barboza 2003).

- 9 Executives recognize this only too well. According to Gene Grabowski of the Grocery Manufacturers of America, "For the price of what it would have cost to market a new breakfast cereal, the biotech industry probably could have saved itself a lot of the struggle that it is going through today" (Eichenwald et al. 2001:C6).
- 10 Reprints of the advertisements and a list of the groups that are part of the Turning Point Project are available at www.turnpoint.org. Founding members of the CBI were Aventis, BASF, Dow Chemical, DuPont, Monsanto, Novartis, Zeneca, the American Crop Protection Association, and the Biotechnology Industry Organization. Many materials produced by the CBI are available at www.whybiotech.com.
- 11 See especially Nestle (2003), pages 153–166, for an effective review of the issue.
- 12 For an exceptionally informative and thought provoking analysis of such "third generation" products and initiatives, see "Biotech's 'generation 3'" (Rural Advancement Fund International 2000b).
- 13 For example, Sheldon Krimsky, *Biotechnics and Society: The Rise of Industrial Genetics* (1991); Paul Raeburn, *The Last Harvest: The Genetic Gamble that Threatens to Destroy American Agriculture* (1995); Sheldon Krimsky and Roger Wrubel, *Agricultural Biotechnology and the Environment: Science, Policy, and Social Issues* (1996); Vanadana Shiva, *Biopiracy: The Plunder of Nature and Knowledge* (1997); Luke Anderson *Genetic Engineering, Food, and Our Environment* (1999); Martin Teitel and Kimberly A. Wilson, *Genetically Engineered Food: Changing the Nature of Nature* (1999); Richard Manning, *Food's Frontier: The Next Green Revolution* (2000); Daniel Charles, *Lords of the Harvest: Biotech, Big Money, and the Future of Food* (2001); Brian Tokai, *Redesigning Life? The Worldwide Challenge to Genetic Engineering* (2001); Marion Nestle, *Safe Food: Bacteria, Biotechnology, and Bioterrorism* (2003).
- 14 But see, for example, National Research Council, *Genetically Modified Pest-Protected Plants: Science and Regulation* (2000) and Rissler and Mellon, *The Ecological Risks of Engineered Crops* (1996).
- 15 According to Annabelle Duncan, chief of molecular science at Australia's Commonwealth Scientific and Industrial Research Organization, "This shows that something we thought was hard – increasing the pathogenicity of a virus – is easy" (Finkel 2001:585).
- 16 Says one entomologist, "The problem is, we're asking cotton growers to produce insects. They are not interested in growing insects. They want to destroy insects" (Charles 2001:184).
- 17 The USDA has refused to reveal the pharmaceutical substances the corn was engineered to produce, saying it is confidential business information. "Biopharming" initiatives undertaken by companies such as ProdiGene and Epicyte Pharmaceutical are known to involve research designed to produce vaccines for HIV, cholera, and hepatitis-B, growth hormones, clotting agents, industrial enzymes, human antibodies, contraceptives, spermatocides, immunosuppressant cytokines, and abortion-inducing drugs. The host plant of choice is corn, but possibilities are also being explored using tomato, potato, and banana.
- 18 *Sui generis* is a "Latin phrase meaning 'of its own kind of class.'" This is the sys-

tem for WTO member states that do not allow patents on plants/plant varieties, to provide an effective alternative means of protection. Although not specifically defined in the TRIPs agreement, minimum requirements are indicated” (Kowalski et al. 2002:409).

- 19 See GRAIN (2003) for a country by country listing of the restrictions.
- 20 Public breeders report that they regularly receive letters from industry lawyers listing the varieties that cannot be used for anything except testing and mandating that plants be destroyed when testing is completed.
- 21 An interesting aspect of the Berkeley/Novartis strategic alliance was the manner in which the two parties got together. The agreement was not the result of a one-on-one courtship, but the end result of an auction process in which Novartis was selected from among five different corporate suitors (see Rausser 1999).
- 22 The degree to which this can occur is illustrated by the comments of public scientists themselves. British breeder Lindsay Innes (n.d.) describes himself as “a so-called public sector plant breeder, though these days I seem to be more of a hybrid between public and private, and at time shave to adopt chameleon-like characteristics.” Dan Charles (2001:37) records the acclimatization of Roger Beachy, then-assistant professor at Washington University, to corporate culture. Offended at first by Monsanto’s appropriation of his work, Beachy recalls that “after a while I realized this is just the way it is. They are good collaborators. They had to feel that they were owners of it in order to promote the company. And then you say, ‘That’s what companies do!’ You forgive and you go on.”
- 23 The phrase “ecoliberal” is Hammond’s (1993).
- 24 In the throes of security madness, the United States wanted a clause allowing it to refuse to freely exchange germplasm with any nation it considered to be a security threat.
- 25 Not only is there no mechanism for enforcement, there is not even any mechanism for monitoring. In a clarification of FAO/CGIAR trust arrangement, the CG states that in sending germplasm to those requesting accessions or engaged in regeneration, “in neither case will the source Centre be under an obligation to monitor the compliance of the recipient with these undertakings.” The slippage possible in this arrangement is already apparent. In 2001, Jasmine rice from IRRI was shipped to a researcher in the United States without a Materials Transfer Agreement. The situation only came to light through the vigilance of a local Philippine NGO.
- 26 For example, among the sixty organizations supporting the Turning Point Project’s advertisements in *The New York Times* were: the Foundation on Economic Trends, the International Center for Technology Assessment, Greenpeace USA, the Council for Responsible Genetics, Food First/Institute for Food & Development Policy, Friends of the Earth, Humane Society USA, Institute for Agriculture and Trade policy, Organic Consumers association, Pesticide Action Network, Sierra Club, Center for Food Safety, Mothers & Others for a Livable Planet, Earth Island Institute, and the Native Forest Council.
- 27 *Satyagraha* is the Ghandian term for nonviolent resistance.
- 28 The United States ranks twenty-second in the percentage of its gross national product devoted to foreign aid, the lowest among the advanced industrial nations.