Food for the Few: The Biotechnology Revolution in Latin America*

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ABSTRACT – *This article introduces the main issues raised in biotechnology in Latin American agriculture in the era of neoliberal globalism. We begin by discussing the theoretical concerns regarding biotechnology's "revolutionary" potential, and identify where empirical work could respond to these concerns. A historical overview of modern agriculture in the United States provides a means to highlight a number of problems that have arisen as a result of this technological paradigm and its transfer to the developing world. These theoretical and historical concerns are then empirically assessed with the help of case studies drawn from the forthcoming book* Food for the Few. *Most of these cases provide support that the technology is becoming revolutionary in its detrimental social and environmental impacts.*

RÉSUMÉ — *L'article présente les principaux enjeux que soulève l'utilisation de la biotechnologie dans l'agriculture en Amérique latine durant la période actuelle de mondialisation néolibérale. Les auteurs discutent d'abord des préoccupations théoriques quant au potentiel « révolutionnaire » de la biotechnologie et précisent quels aspects du travail empirique pourraient répondre à ces préoccupations. Un survol historique de l'agriculture moderne aux États-Unis leur permet de signaler plusieurs problèmes causés par ce paradigme technologique et son transfert au monde en développement. Les auteurs évaluent ensuite de manière empirique ces préoccupations théoriques et historiques à l'aide d'études de cas tirées d'un livre à paraître,* Food for the Few. *La plupart des cas examinés appuient l'idée selon laquelle la technologie est en train de devenir révolutionnaire à cause de ses impacts nuisibles aux plans social et environnemental.*

Introduction

During the 1980s and early 1990s, when agricultural biotechnology was still in the laboratory or field trial stage of its development, most observers considered that it would have a revolutionary effect on agricultural production and therefore a profound impact on agrarian social structures and the environment. The question remained whether such an impact would be positive or negative. Critical observers tended to make rather apocalyptic predictions in this regard: social structures were predicted to further polarize as fewer and larger farmers overwhelmingly dominated the scene while others bankrupted; negative environmental repercussions would overwhelm from such causes as rising use of agrichemicals; and biodiversity losses and increased crop vulnerability, prompted by increased crop homogeneity, raised food security concerns (Goodman, Sorj, and Wilkinson 1987).

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In sharp contrast with this view, industry proponents, economists, and others deployed similar arguments to those touted for the previous agricultural revolution, the Green Revolution of the 1970s: biotechnology would solve the world's food production problems and end world hunger. Some, such as D. Gale Johnson (2002), editor of *Economic Development and Cultural Change*, continue to argue that the greatest problem with biotechnology is the political forces preventing its faster diffusion and hence its ability to benefit the "millions of small and poor farmers who could gain if GMO [transgenic crop] varieties were available" (4).

While still in its early years, one of the most prominent pioneers in the analysis of biotechnology's socio-economic impact, Frederick Buttel, switched away from his original position regarding its revolutionary potential. Impatient with the fact that by the late 1980s biotechnology had still not effected a major change in either the agrarian social structure or on productivity, Buttel (1989a, 1989b) changed his estimation of its future trajectory. He later argued that biotechnology should no longer be considered an "epoch-making" technology the way electronics and informatics are. By the end of his life, however, Buttel was writing about the environmentalization of anti-GMO struggles and suggesting ways of framing them so as to incorporate plant scientists into the movement (Buttel 2005).

These debates about the technology have continued into the 21st century: some scholars argue that biotechnology can be the solution to feed the poor (Johnson 2002), while others point out that genetically engineered (GE) or genetically modified organisms (GMOs) focus on a small number of countries, affect a small number of crops, and are suitable primarily for large-scale farms (Buckland 2004). Given these polarized stances on biotechnology's potential, it is extremely important to offer an empirically based assessment now that several transgenic crops and other GE or GMOs have actually been implemented. We no longer need to rely on prospective research about possible impacts, as we increasingly have the capability to ascertain the actual impact of biotechnology on the basis of field data.

This article will first outline the theoretical premise for assessments of the social impact on agricultural biotechnologies by drawing on this earlier debate with Buttel to provide an analytical framework (Otero 1991, 1995). Buttel was not the only scholar to turn against an earlier position heralding biotechnology's revolutionary impacts, but he went beyond a call for toning down predictions and exaggerated in the opposite direction, almost in a "devil's advocate" manner. As such, he provides a framework with which to structure our investigation. The next section details the emergence of modern agriculture in the United States — the technological paradigm that has come to dominate capitalist agriculture throughout the world — and highlights some of its problems. The third section draws on the findings of a number of case studies in the forthcoming *Food for the Few* to show the Latin American experience of agricultural biotechnology. Most of these cases provide support that the technology is becoming revolutionary in its detrimental social and environmental impacts. The last section will use these case studies to draw conclusions.

I. Is Biotechnology Revolutionary?

Although the very definition of "biotechnology" has been the subject of controversy, the meaning we intend refers to the "new biotechnologies." We use the definition provided by the General Accounting Office (GAO) of the US Congress.

> Today, biotechnology is generally considered to be a component of high technology, and the "new biotechnologies" are those resulting from recently developed, sophisticated research

techniques, including plant cell and protoplast culture, plant regeneration, somatic hybridization, embryo transfer, and recombinant DNA methods (GAO 1986, 10).

A most basic concern with the debate over biotechnology's revolutionary status lies in the false dilemma presented by asking the question at all. More importantly, we must ask first whether there is a "third technological revolution" within a long wave of capitalist development in effect (Mandel 1978, 1980) or indeed an "information age" of capitalism (Castells 2000a, 2000b, 2004; Pérez 2002). Does this new technological revolution or era — based on electronics, informatics, new materials, and biotechnology — actually represent a new phase of capitalism? If we can answer this affirmatively, then we can ask what the place of biotechnology is in the information age, as Manuel Castells has attempted. While acknowledging that each technology has its own rhythm of development, in the context of these dynamics we need to keep the question of the "third technological revolution" or the "information age" a conceptually unified phenomenon, not one made up of several juxtaposed revolutions based on each of the new technologies.

As a world economy, capitalism entered a period of profound crisis in the early 1970s (Aglietta 1979; Mandel 1978) as its heavy-industry-based development began to decline (Piore and Sabel 1984). The restructuring of the world economy, which started in the 1980s, was predicated on productivity increases, which in turn depend on new technologies (Hastopoulos, Krugman, and Summers 1988; Young 1988; Thurow 1987). Now that most state socialist societies have been drawn back into capitalism, largely due to their productivity problems and lack of technological innovation, the conditions have been in place since the early 1990s for a new phase of capitalist development. Therefore, rather than engaging in a partial analysis of whether any given technology is revolutionary or not, the task at hand, for economic sociology at least, is to decode the implications of the "reformation of capitalism" (Sklair 1989, 2002) for the new international division of labour and the new information age (Castells 2000a).

Even accepting Buttel's formulation of the research problem, there remain concerns with his evaluation of the technology. Buttel proposed three criteria that have to be fulfilled for a technology to be labelled "revolutionary." (1) The technology must have a wide applicability; (2) it should be cost reducing for production as well as create large new categories of consumer and producer goods; and (3) it should be applied to leading or ascendant sectors of the economy. Out of these criteria, Buttel (1989a) argues that the last is least fulfilled by the technology for three reasons: (1) It is a "substitutionist" technology, so it will only "patch up" the problems of Western agriculture and medicine; (2) while early research may have been oriented toward revolutionary goals, these have been abandoned for short-term commercial and profit interests; and (3) the technology is only applicable to declining sectors (agriculture and manufacture), rather than to leading ones (services), making it a "subsidiary technical form." Further, he argues that the industry itself is in decline. We address each of these points in turn.

First, Buttel tends to minimize the importance of biotechnology on the grounds that it is a "substitutionist" technology, one that facilitates the replacement of some long-established crop or product by a new one. However, there is little justification for why substitutionism by itself cannot create major change. On the contrary, even if the technology were limited to substitutionism, it remains capable of facilitating profound changes in productivity, the international division of labour, and even the environment, all of which can generate major social changes. A classic example of this was the introduction of high fructose corn syrup in the United States. From 1978 to 1987 this corn-based sweetener, produced with new enzymatic techniques, replaced 42% of the sugar used in the United States. Slightly more than 40% of caloric sweeteners continue to come from this source

(Otero and Flora, forthcoming). The switch was profoundly damaging for several Caribbean countries and the Philippines, whose foreign exchange largely came from these sugar exports (Ahmed 1988; Otero 1992). Consequently, mere "substitutionism" can have profoundly damaging effects on countries exporting primary goods, where, in many, a majority continues to live off agriculture.

Thus, even if limited to substitutionism, the technology retains a tremendous potential for promoting major changes. However, given that the technology is more advanced than the science (with respect to knowledge and understanding of processes and outcomes), the potential for a revolutionary research agenda — for example, one that goes beyond substitutionism to include the development of new categories of goods and processes — cannot be discounted. Buttel argues that such agendas have been abandoned, at least in the industry labs. However, there still remain many university labs whose very significant "basic" research may sooner or later become "applied," as has happened in the past. Further, such questions of research agendas could be subjected to rapid changes. For example, during the Reagan administration, legislation was passed that enhanced the commodification of science by enabling universities to patent federally funded research results (P.L 96-517), and permitting the patenting of plants, micro-organisms, and animals. Such goal-oriented changes strongly depend on the direction dictated by the state's interests.

With respect to the question of whether agriculture is a declining sector, the answer depends on whether one measures decline by production and productivity or by proportion of the labour force absorbed by the sector. Despite a constantly reducing labour force, agriculture's productivity has been historically dynamic, indeed surpassing the rest of the US economy during the 1980s in its productivity rate of growth (National Research Council 1989, 33), and producing enough food for an exportable surplus (Orden, Paarlberg, and Roe 1999). On the other hand, if labour force participation were the measure of dynamism, then the tertiary or "services" sector (with over 70% of the US labour force) would indeed surpass agriculture. We can turn to insights from the Green Revolution for the revolutionary potential of changes to the sector.

The Green Revolution was the name given to US-style modern agriculture when it was exported to Third World countries in the 1960s and 1970s. Such modernization began in the United States in the 1860s with the widespread introduction of mechanical horse-drawn harvesting and threshing equipment, new ploughs and disc harrows, and so on. Our focus, however, is on technological developments around the biological components of agriculture, primarily seeds. In this regard, modern agriculture is best dated to the 1930s with the introduction of hybrid corn. It was further enhanced with other improved crop varieties, chemical fertilizers, pesticides, insecticides, herbicides, and increasingly sophisticated agricultural machinery. As a package, these technological innovations gave a tremendous boost to productivity, although many farmers were displaced from their occupations and had to look for other employment (Cochrane 1979; Kloppenburg 1988).

Without the robust process of industrialization that the United States experienced after the 1930s, the resulting negative socio-economic consequences for Third World countries were much graver. Massive migrations to the cities occurred, but little employment could be found. The "tertiary" sector in the cities swelled rapidly, very often outside the formal economy (Portes, Castells, and Benton 1989), thus absorbing people below their working capacities and diminishing their living standards. This was certainly not a sign of "dynamism," but masked severe under and unemployment of people who had been displaced from agriculture (Bartra 2004). Latin American agriculture therefore became more productively dynamic, but it absorbed fewer people, causing a social decline that was arguably "revolutionary" in impact.

Lastly, it has been suggested that the biotechnology industry itself is declining. Certainly industry fluctuations have been dramatic. However, while many biotech firms did suffer disproportionately in the Wall Street crash of 1987 (when biotech stock prices declined 44%), these early difficulties accelerated concentration trends in the industry and, by the turn of the century, three firms concentrated the production of 70% of genetically improved seeds. Similarly, reduced "in-house" efforts by biotechnology companies signal a new emphasis on university–industry linkages rather than a decline. Such increased university–industry commercial links are a well-documented trend in the biological sciences (Otero 1992; Stein 2004; Busch 2000; Kleinman 2003).

In sum, biotechnology potential is best viewed within the context of a "third technological revolution," and there is significant evidence to refute calls to diminish its revolutionary potential.

II. The Rise of Modern Agriculture in the United States

Given that the United States remains the leading country in technological innovation in agriculture, new developments emerging in the country both directly and indirectly affect other nations. Consequently, any analysis of biotechnology must be set in a world perspective that considers the impact of US developments in agriculture on other countries.

In the 1930s, the main problem of agriculture in the United States was a relative scarcity of food in the context of strong population growth. Given this problem, the achievements of modern agriculture were spectacular. The shift from horses to tractors, which started as early as the 1920s, signalled the advent of the "power age" of agricultural production and initiated modern agriculture. Prior to the power age, agricultural production had many similarities with peasant production. It required minimal inputs and cash incomes were low. The power age shifted production from this technically sophisticated system — requiring careful management to meet the needs of both current production and required inputs for the following year — to a technologically sophisticated system requiring capital (Berlan 1991, 121).

Through such modernization, the necessary inputs increased exponentially: artificial fertilizer replaced animal fertilizer, and tractors were joined by threshers, sprayers, pesticides, hybrid plants, and the like. These inputs represented an acute substitution of labour-power for capital: between 1920 and 1970, "the use of purchased inputs nearly doubled" while the "quantity of labor declined by nearly three-fourths" (Knutson, Penn, and Flinchbaugh 1998, 215). As already noted, the robust industrialization process taking place in the United States before and after the depression of the 1930s absorbed most of those displaced in agriculture. Today less than 2% of the workforce in the United States is dedicated to farming; the total number of farms declined from its peak of almost 7 million in 1935 to about 2 million in 1997 (United States Department of Agriculture [USDA] 2003, chap. 3).

Social polarization or social differentiation of the US agrarian structure accompanied this shift. The decline in farms was accompanied by an increase in their size: the almost 7 million farms in 1935 had an average size of 155 acres; by 1964 the number was less than half that, averaging 352 acres; by 1997 there were 1.91 million farms with an average of 487 acres (USDA 2003, 5). These averages represent a decline in mid-size farms, while both small and large farms have increased in numbers. Social polarization is further supported by farm sales data. By 1997, farms with sales of US$ 500,000 or more represented only 3% of farms and accounted for 52% of agricultural production. Between 1982 and 1997 (when constant dollar data were available), this is the only sales class that showed consistent increases.[1] In contrast, small-family farms with sales of less than US$ 250,000 accounted

1. See <http://www.ers.usda.gov/Briefing/FarmStructure/>.

for only 2% of agricultural production but represented 91% of US farms (Hoppe and MacDonald 2001, 3). Most of these farms reported inadequate income to cover expenses (4).

While these small-family farms include retirement and residential/lifestyle farms, they also represent those farmers who have been rendered "inefficient" by the technological paradigm of modern agriculture, which contains an unequivocal bias in favour of large-scale production. In sum, only early adopters of technological innovations, who must be financially well endowed and have superior managerial skills, have been able to stay afloat in US agriculture (Cochrane 1979).

This new capital-intensive structure of agriculture contained a profound change in the agrarian social agents and set the stage for the new agro-industrial complex and the two main sectors that would escort the activity of farming into the modern age: the inputs-producing component (heavily oligopolistic: suppliers substantially control *selling* prices of inputs), and the processing and distributing component (oligopsonistic: few purchasers of farm products controlling *buying* prices). Concentration of these market participants has long been the norm and is deepening. The most important subsectors in inputs and processing display such high "concentration indexes" that only four or fewer giant firms control 50% of sales or purchases. For example, the four largest firms in flour milling increased their processing share from 33% in 1977 to 62% in 1997 (MacDonald and Denbaly n.d., 6). This agribusiness concentration is even more prominent in meat-packing: for example, the share of the slaughter of the four largest firms in steer and heifer meat-packing increased from 36% in 1980 to 78% in 1998 (6).

"Modern agriculture" ultimately brought such unprecedented productivity increases that eventually supply outstripped domestic demand, and the exportation of surpluses became the dominant US agricultural strategy (Berlan 1991). However, this did not occur without any repercussions, including the five main problems facing US agriculture today, most of them interrelated.

First, as indicated, farming has ceased to be profitable for most producers. Excepting those few farms that became very large, farming has ceased to be profitable for those squeezed between oligopolistic input markets and oligopsonistic processors and purchasers. The high degree of concentration of both these sectors is exacerbated by the fact that many of the same firms are leaders in different industries and related businesses, forcing farmers to deal with a limited number of large agribusinesses in a range of different contexts (MacDonald and Denbaly n.d., 2). Therefore, direct producers confront increasing production costs at the same time that an oligopsonistic processing structure makes it hard to retain any benefits of productivity increases. While some of these benefits are transferred to consumers via lower prices, the greatest portion is accrued by the processing firms (Goldburg et al. 1990).

Second, modern agriculture has been accompanied by a shift toward agribusiness as the producers, promoters, and disseminators of agricultural technologies. In the beginning of the agricultural revolution of the 1930s, the creators and disseminators of farm technologies were the agricultural universities of the United States (the land-grant colleges) and the international agricultural research centers (Kloppenburg and Kenney 1983). These institutions had a public or semi-public character and mandates that had a social orientation. In contrast, the new producers of technology — especially with respect to biotechnology — are large transnational corporations (TNCs), whose mandate is to maximize profits, not attend to social priorities. The potential for detrimental social repercussions increases considerably with profit-directed technological development.

Third, the American model of modern agriculture has resulted in such severe environmental problems that it calls its sustainability into question. While traditional plant breeding techniques produced improved plant varieties, it also created two mutually reinforcing complications: plant genetic diversity declined as local varieties were left behind in favour of improved ones, and the resulting increased homogeneity rendered new varieties more vulnerable to pests. The corn blight of the 1970s, when a disease organism attacked a "cytoplasmic character carried by over 90 percent of American corn varieties" (Kloppenburg 1988, 163), is a case in point.

Further, the intensive use of machinery and petrochemicals has resulted in severe problems of soil degradation, underground water contamination, and the appearance of chemical residues in food. While soil erosion has declined in the United States due to conservation efforts, it is still widespread: depending on region, soil type, and crop, production losses are estimated to range from 3 to 31% for a 100-year period, and annual economic losses are estimated at US$ 56 million.[2] Contamination from the requisites of agricultural production further challenge the sustainability of US-style agriculture. In the northern Gulf of Mexico, it is believed that fertilizer and manure runoff from agricultural lands have been the cause of a $7000m^2$ hypoxic "dead zone," killing fish, crabs, and other marine life (Ribaudo et al. 2001).

Fourth, the food consumption pattern promoted by US agriculture is heavily inclined to animal protein. The social problems associated with this dietary shift have three aspects: food security, environmental effects, and health impacts. It can take up to 10kg of grain to produce 1kg of meat. Therefore, a dietary emphasis on meat involves dedicating enormous quantities of grain to produce livestock feed. The irrationality of this form of production is evident with respect to food security. Despite the fact that malnutrition and starvation remain persistent and severe, the global cereal production dedicated to animal feed has more than doubled from 273 million metric tonnes in 1961 to 685 million metric tonnes in 2001. By 2001, the cereal supply dedicated to feed in developed countries was over 50% of the amount of grain consumed for food in developing countries, where 78% of the world's population lives (FAOSTAT 2005).

The environmental costs of the high meat diet exacerbate sustainability problems as more land and water resources are needed to produce less food. Soil erosion and manure and urine disposal are persistent problems of livestock production. Further, a greenhouse gas produced in the digestive process of ruminants, methane, is estimated to account for 15% of the world's production. For human health, alarm bells have also rung loudly regarding the high-fat, high-cholesterol, high-protein, low-fibre, meat- and dairy-based American diet. Currently, the United States faces a growing epidemic of overweight and obese people: an estimated 61% of US adults and 13% of children and adolescents were overweight in 1999 (United States Department of Health and Human Services 2001).

Fifth, agricultural products are increasingly being replaced by processed "food" in consumption patterns. The American diet has not only come to emphasize meat and dairy but it is characterized by a high degree of prepared and processed foods. This consumption shift from raw agricultural products to processed foods exacerbates many of the social, health, and environmental concerns already noted. Furthermore, processors — increasingly global in reach and production methods — now mediate the relationship between consumer and agricultural product. Therefore, not only has such food manufacturing facilitated the growth of the agri-food complex (Friedmann 1995) — as the high profits attached to value added processing are a key factor for capital accumulation — but also the media-mediated consumption choices further entrench dominance by a limited number of corporations and reduce the potential for alternatives.

2. See <http://www.ers.usda.gov/Briefing/GlobalResources/>.

A. Biotechnology and International Relations: US State Support and Evolving Patent Laws

The preceding section of this paper highlighted significant problems emerging from the evolution of modern agriculture. The addition of biotechnology to this model raises further issues, particularly with respect to international economic relations and patent rights.

In spite of free trade rhetoric, the US government has worked hard to facilitate the development of its biotechnology industry. While transnational corporations have become the crucial agents in producing and disseminating modern agricultural technologies, this process of technological innovation took place in close association with the US government and the US land-grant colleges. The latter produced the science with government funding, and firms developed the new inputs for modern agriculture. Public-private research relationships remain complex and interrelated to the extent that resources developed or preserved by public or semi-public institutions may be monopolized by large TNCs. Consequently, state-facilitated TNC concentration appears to be the norm in biotechnology, as developed countries, consistently led by the United States, vie for technological hegemony. As most developing nations do not have the resources available to create appropriate technologies (Otero 1989), they will very likely be locked in as technology consumers — "reduced to importing expensive high-tech packages created for developed-nation purposes" (Peritore 1995, 15).

Control over genetic resources is a key method by which TNCs based in developed nations attempt biotechnological dominance. Gene banks have become a priority in developed nations, and the frequent refusal of these banks to grant germplasm to other nations is promoting a system where the monopoly of genetic resources will become a form of power (Kloppenburg 1988). Ironically, as modern agriculture compromises their genetic heritage, developing countries will become increasingly beholden to developed nations, and their "genetic-environmental erosion could actually enhance corporate profitability and control" (Peritore 1995, 17). Furthermore, unlikely alliances among TNCs and conservationist organizations are fixing their sights on the remaining forests and "biological hotspots." The goal is to "preserve areas of biodiversity in the third world while guaranteeing access to foreign investment" (Carlsen 2004, 52). In order to create the Mesoamerican Biological Corridor, for instance, many subsistence peasant communities have not even been consulted (65–66) and many could face eviction from their ancestral lands.

Biotechnology adds another feature to international economic relations. As discussed, the agro-food complex is now an internationally structured food production complex. Technological advances that assist in the isolation of "generic ingredients" increasingly allow for the substitution of agricultural products in profit-determined global sourcing strategies (Friedmann 1991, 67). Biotechnological research that might substitute key crops from developing nations, such as cocoa, coffee, vanilla, and rubber is already underway (Peritore 1995, 22). The resulting fluidity of the international division of labour has considerable implications for national economic strategies and trade stability. Furthermore, it increases the capability of TNCs to source their ingredients in such a way as to externalize environmental costs to regions outside the view of their target market, thus maintaining consumer support for their products.

State support of the biotechnology industry is not limited to economic and research support, however, but is also expressed in policy and law, most notably through patent rights. In the United States a patent grants the monopoly over the use of protected inventions — which may be either products or industrial processes — for 20 years, with some exceptions. A most defining characteristic of the biotechnology industry is its frenzy for patents; the rise in applications is so rapid that the US Patent and Trademark Office suffers an enormous backlog in processing them. The backlog of applications, including appeals and amendments, climbed to 6907 in 1987, up from 5837 a year earlier (Crawford 1988). By 2003, the backlog had reached 500,000, and is expected to reach 1 million by 2008 (Reichardt 2003). In part, this accumulation has doubtlessly resulted from the supportive context for biotechnology development the US government has effectively created.

One of the multiple problems posited by the proliferation of patents is the tremendous inequality of conditions among nation-states to produce inventions. Another is the introduction of an additional mechanism of national economic differentiation, as developed countries are prepared to internationally protect the industrial property of their firms through the promotion of homogeneous patent legislation across the globe, such as through the Uruguay Round of the General Agreement on Tariffs and Trade and the subsequent Trade Related Intellectual Property Agreements of the World Trade Organization (WTO). Critics such as Vandana Shiva (2000) claim that such laws are guilty of the "myth of ignorance as innovation," whereby innovations unknown in the United States but practised elsewhere can be patented, allowing US corporations to patent gains made by centuries of indigenous cultivation (502). Attempts by developing countries to reform the agreements are defeated on the basis that "the WTO cannot be subordinated to other international agreements" (507). In sum, there are strong suggestions that the increasing commodification and monopolization of knowledge will have further polarizing effects not only within but also among countries.

B. Bringing in the Majority of the People

The forgoing analysis argues that we gain more by considering biotechnology as part of the "third technological revolution" (Mandel 1978) or the "information age" (Castells 2000a). To the extent that new technologies have been at the core of neoliberal economic restructuring since the 1980s, biotechnology has played a major role in transforming agriculture. While this transformation is by no means universal, it is increasingly widening, both through impacts resulting from direct adoption of biotech products and through indirect impacts of substitutionism. Moreover, the biotechnology industry is healthy rather than declining, but due to cyclical short-term financial problems it has undergone a major process of concentration in the hands of the chemical and pharmaceutical giants.

In fact, this emerging market structure does question whether there will be an independent biotechnology industry per se. Rather, biotechnology has already proven itself as an enabling technology to expand the profitability of the existing pharmaceutical and petrochemical industries.[3] This new industry structure is undoubtedly having a major bearing on the ways biotechnology products are disseminated in the world. The contrasts in this regard with the Green Revolution, which was promoted by public and semi-public institutions, are profound. In addition, biotechnology has caused or facilitated ascending rates of productivity growth. The obvious consequence is that large proportions of the labour force will become redundant. Whether resulting unemployment will be mitigated by economic expansion in other sectors is indeed an important question, for the shape of the new distribution of income and standards of living of people in the midst of neoliberal economic restructuring depends largely on such changes.

Although the bulk of biotechnology research and development is taking place in advanced societies, deployment of its fruits will have implications for the world economy as a whole. As Iftikhar Ahmed (1989) suggested early on in the debate, the "application of biotechnologies to agriculture would automatically affect 60% of the Third World population who depend on agriculture alone for their livelihood" (553). Given the vast heterogeneity existing among them, Third World societies will be affected differentially by the information age, depending on the profile of their socio-economic

3. Thanks to Martin Kenney for this insight.

structures. Some have recently become industrialized, precisely on the basis of new technologies, and larger countries have a certain potential to jump on the bandwagon of the technological revolution; others might be integrated to the world economy simply as producers of cheap labour-power, while still others could be marginalized from the main economic trends. Thus, one thing that should be looked at more closely is the new stratification of underdeveloped societies that is bound to emerge. An initial formulation has been provided by Manuel Castells (1986, 2000a, 2000b, 2004).

The main question regarding this world stratification is whether nations will be linked to the new phase of capitalism in the information age, and in what role: will they become marginalized from the world economy, linked primarily to provide cheap labour, or develop the ability to jump on the bandwagon of new technologies? Castells sees the majority of Third World countries as being condemned to economic obsolescence, unemployment, misery, hunger, illness, and violence in their large urban centres. Countries in the latter stratum would be either marginalized from the world economy or would experience a "perverse integration" (Castells and Laserna 1989; Castells 2004) through the production and export of illegal crops. Therefore, a pressing question regards what happens to countries that adopt these foreign-developed biotechnologies, and to those whose crops are directly or indirectly affected by the new transgenic varieties produced in advanced countries?

III. Global Technological Diffusion and Stratification: Latin American Case Studies

This section will now draw on the conclusions of a number of case studies of experiences with agricultural biotechnology in Latin America, forthcoming in *Food for the Few*.[4] Far from the idyllic image created by its proponents, early indications are that biotechnology's introduction, coinciding with the advancement of neoliberal globalism, is wreaking havoc on Latin America's agriculture and its capacity to feed its own people.

This early scholarly research on the social impacts of agricultural biotechnology clearly demonstrates some very particular effects the export of the American model of modern agriculture has had on the region. A number of social problems with the exporting of the American agricultural model to developing countries had already become apparent with the introduction of Green Revolution technologies in the postwar period. The case studies conducted in *Food for the Few* provide support for many of these concerns and draw further attention to three issue areas of particular salience in the Latin American agricultural biotechnology experience: social polarization within nations, environmental impacts, and international inequity.

The conceptual overview provided by the *Food for the Few* case studies gives clear indication that from adoption to impact, there are definite differences between advanced industrial countries and developing ones with respect to their relationship with agricultural biotechnologies. Such differences can be seen in the differential power involved in the negotiation and implementation of regulatory frameworks around biotechnology, which determine its role in any given country (Jansen and Roquas, forthcoming, chap. 3), and in the impacts on the specific issues of hunger and biodiversity (Fitting, forthcoming, chap. 5; Poitras, forthcoming, chap. 4; Teubal, forthcoming, chap. 7). These patterns will be elaborated on below. Furthermore, binding all these experiences is a seemingly irrevocable connection among neoliberal economic reforms, modern agriculture, and GM technologies. The technological package of modern agriculture, now extended by the addition of biotechnology, is

4. Author and chapter number will reference all case studies cited from this book.

inevitably associated with economic (free market) policies. While this is not necessary for the technology itself, it is the current policy context for its dissemination.

No better example of the link between these features can be made than that evidenced by Argentina's dramatic transition to GM soybean production. Argentina has fully embraced the biotechnology/free market agricultural program. It has undertaken radical structural adjustments toward neoliberal reformation, including the rapid deregulation and dismantling of agricultural boards and supports (Teubal, forthcoming, chap. 7). In about a decade, the country's agriculture has been reoriented away from production for the domestic market and toward the production of GM soy for the export market. Other countries responding to the call of the export market and pressures to open their markets undergo similar reorientations, though few to the extent of Argentina.

Mexico provides another example of such restructuring. According to Elizabeth Fitting (forthcoming, chap. 5), the 1980s ushered in a series of agricultural restructuring policies in Mexico, what she terms the "neoliberal corn regime." This regime shifted emphasis away from self-sufficiency in corn to cheap food policies and corn imports. By 2000, Mexico was the second largest importer of corn from the United States, a good percentage of which was GM.

However, not all connections to neoliberal restructuring and biotechnologies occur at the national, or even the officially sanctioned, level. In some cases the connection is made through the cobbled together responses of subsistence producers under stress. Hisano and Altoe (forthcoming, chap. 10), for example, argue that despite an official national prohibition against GM crops in Brazil, many small soybean farmers turned to the use of GM soybeans when faced with rapid economic restructuring, in the hopes that these crops would circumvent their economic imperilment.

The social impacts of the above dynamics will be investigated in the next section. However, first it must be noted that while there are a number of similarities among the impacts evidenced in these countries, there is also a sufficient amount of differences in their adoption and incorporation into the new agricultural paradigm. Consequently, a high potential for regional stratification exists: the neoliberal paradigm, specifically manifested here in deregulated agriculture and a transition to GM technologies, is prompting different regional incorporation into the global economy. For example, Argentina's profound neoliberal restructuring and full-scale transition to GM soybean production for export has transformed it into a major player in the global soybean market (Teubal, forthcoming, chap. 7). The international role to be played by many other Latin American countries is not yet as clear as Argentina's. The role of Brazil, for example, another major soybean producer, will highly depend on the resolution of massive internal struggles over the regulation of biotechnology (Jepson, Brannstrom, and Stancato de Souza, forthcoming, chap. 9). Similarly, Mexico currently addresses its GM adoption somewhat inconsistently, on a case-by-case assessment (Poitras, forthcoming, chap. 4), and its relationship with GM crops takes place in a context of high peasant and environmental opposition, especially with respect to corn (Poitras, forthcoming, chap. 11).

The outcome of many of these national dynamics remains to be seen. Our current data are still insufficient to predict the result of specific regional stratification patterns. Yet the cases presented here do provide enough evidence to flag a clear shifting of the international division of labour in agricultural production.

A. Emerging Patterns of Impact: Food for the Few

In our assessment of this collection of case studies we found overwhelming evidence that the adoption of the technological paradigm of modern agriculture in general, and the addition of biotechnology to that model in particular, are having profound effects on agrarian social organization in many developing countries. Increasing social polarization, the growing dissimilarity and differential viability between commercial and subsistence production, the consequent uprooting of peasants, the replacement of traditional staples production with production for export, and increased dependency on food imports are all evident changes.

Once again, we turn to Argentina as a prime example of the contradictions inherent in such modernization of agriculture. As Miguel Teubal (forthcoming, chap. 7) clearly illustrates in his case study of the country, in many situations hunger is less about food production capacity than about a lack of food "entitlements," the ability to obtain the food that is available. Argentina's dramatic transition from one of the few developing countries self-sufficient in food to a country in crisis — where half the population is below the official poverty line and one-quarter is so impoverished as to be unable to cover basic food needs — occurred in the context of increasing agricultural production and exports.

According to Teubal's (forthcoming, chap. 7) data, soy production in Argentina has boomed since the 1980s, as production rose from 3.7 million tonnes in 1980–81 to 35 million tonnes by 2002–03. Between the last two agricultural censuses (1988–2002), the area sowed with oilseeds increased 66%, mainly due to soybeans. Within these increases there is significant regional variation: the northeast region has increased oilseed cultivation by 86.5% while the northwest region increased cultivation by 138%. Since its introduction in 1997, this production is virtually 100% GM. The data provided by Teubal irrefutably outline a shift to the monocultivation of GM soybeans.

This production shift necessarily comes at a cost to other types of production. While the proportion of grain and oilseed production accounted for by soybeans rose from 10.6% in 1980–81 to about 50% in 2002–03, the proportion accounted for by wheat, corn, and other crops has dropped 6.2%, 7.5%, and 25.1% respectively (calculated from Teubal, forthcoming, chap. 7). The area dedicated to the production of rice, a crop important in the national diet, dropped 47%. In 30 years, 3.5 million ha of meat and milk production shifted to crop production. While the production shifts differed by region, the "soybeanization" of Argentinian agriculture has lead to general losses of traditional farming activities and of the production of non-soybean farm products: "sweet potatoes and sugar cane in Tucuman, dairy farms in Santa Fe and Cordoba, cotton in Chaco, fruit in the pampas ... [as well as] a notable decline in livestock production nation-wide. . . ." (chap. 7).

Concurrent with this shift, deregulation policies facilitated the concentration and centralization of food processing and distribution, and led to the loss of many agricultural supports that could otherwise mitigate impacts on food supplies and on agricultural workers, 90% of whom are small- and medium-sized farmers, peasants, and rural labourers (Teubal, forthcoming, chap. 7). The impacts have been varied but overall negative: increased unemployment, increased farm size, and decreased farm numbers (a full 24.5% between 1988 and 2002); food prices increasing faster than the relative price index, and some basic foodstuffs, such as milk, experiencing scarcities. Such food access affects consumers and the increasing ex-farmers and labourers now confronting agriculture as consumers. Farmer responses to the crisis range from attempts to "flee toward the future" (accessing credit in attempts to adapt to new conditions) to multi-occupational approaches to staying afloat.

In sum, Argentina's wholehearted embracing of neoliberal restructuring and reorienting its agricultural production toward GM soybean production for export have come at the cost of national food entitlements and rising social unrest.

Although Mexico is not subject to the same wholesale transformation of its agricultural production as is Argentina, the neoliberal corn regime policies in Mexico effected a similarly negative impact on its agricultural producers. Although corn production by small producers in Mexico did not decline, cheap food policies and the importation of GM corn nonetheless profoundly affected them. Elizabeth Fitting's (forthcoming, chap. 5) case study of Tehuacan Valley in Mexico reveals that the new agricultural policies erroneously assumed that cheap corn imports would not affect subsistence producers. However, this assumption neglected the fact that subsistence producers were very often also petty corn sellers, who operated counter-cyclically to the cheap corn imports, as they sold when prices were low and replenished their supplies when prices were high.

Fitting's extensive fieldwork and interviews with small producers in the area revealed that in response to the economic crisis brought by agricultural restructuring, undocumented labour migration became a key survival strategy. With little or no alternative employment options, remittances sent back home from this illegal labour abroad provided significant support for the local community. From a population of 7000, 500–1000 residents were estimated to be working in the United States (chap. 5). Out of Fitting's 60 interviewees, two-thirds either had participated in such labour strategies or had household members who had done so.

Similar to the experiences in Argentina and Mexico, Brazil faced neoliberal pressure to open its markets in the 1980s. Restructuring and transnational investment in agriculture subjected farmers to pressures to grow competitive commodities, such as soybeans, and resulted in social polarization as commercially oriented farmers became larger and small farmers were marginalized (Hisano and Altoe, forthcoming, chap. 10). A volatile export market and insufficient profits are significant barriers to small farmers entering the competitive market; many of these farmers abandon their farms and migrate to urban slums.

In sum, the question of hunger and whether biotechnology will, in fact, become the saviour of the poor appears to be answered in these few cases in the clear negative, at least in the current context. While the technology is purportedly pro-poor, there is ample evidence that numerous factors preclude the poor from accessing its intended benefits. Seemingly replicating the experiences of the Green Revolution, increased food production does not necessarily lead to decreased hunger. Despite the Green Revolution's theoretical "scale neutrality" and its phenomenal success with respect to increasing cereal yields, hunger and poverty increased in many regions as a result of it (Otero and Pechlaner, forthcoming, chap. 2). Similarly, the social and economic context of biotechnology, not just its ability to increase food production, is again revealed to be central to food security.

Consequently, the prospects for those agricultural producers outside of the increasingly globally integrated food system are consistently bleak. This may be due to partial technology diffusion, technology inapplicability, or international inequality (as will be discussed). Repeatedly, these case studies tell a story of declining subsistence and small-commodity producers with limited or no alternative means of support. In this respect, the addition of biotechnology to the technological package of modern agriculture has not changed the anti-poor technological dynamics of modern agricultural development in any way, other than to exacerbate its concomitant negative effects of capital concentration and centralization that the technology facilitates. A specific investigation of the pro-poor potential of biotechnology in Mexico found that the modification of patent laws, the style of regulation, and the shifting away from publicly funded research all precluded the possibility of the technology benefiting small producers in the current context (Poitras, forthcoming, chap. 4). Even the development of specific pro-poor applications, such as golden rice, a GM rice engineered to produce pro-vitamin A, does little to assuage this concern when the dynamics over patent prohibitions on commercialization and subsequent ownership transfer are more closely examined (ETC Group 2005).

Not to overstate the case, the impact of biotechnology is not uniform, and in the growing body of empirical evidence there are some examples of positive economic impacts. There is limited evidence of pro-poor benefits, such as from Bt cotton production in the Makhathini Flats of South Africa, where a definite economic benefit for adopters of Bt cotton over non-adopters was found (Thirtle, Beyers, Ismael, and Piesse 2003). It is notable, however, that many of those who support the dissemination of the technology from a poverty alleviation perspective emphasize the importance of supports necessary to capture these benefits. For example, even the evidence of the Makhathini Flats study was presented in the context of the unusual systems of support available in the area. Equally significant, the findings noted that one of the main constraints on the technology's adoption even in that region was access to credit or supplementary non-farm income, which was necessary to purchase the higher-priced seed. Supports appear key to capturing pro-poor benefits.

A special issue of the *Journal of International Development* (2005, Vol. 17) investigates the contextual factors that can facilitate biotechnology's diffusion in a pro-poor manner, and there is no doubt that capacity building around technology development and dissemination can affect its pro-poor capabilities (see for example, Byerlee and Fischer 2002; Chataway 2005; Cohen and Paarlberg 2004). However, while inroads have been made with particular GM technological applications or specific industry–NGO partnerships, the broader evidence seems to indicate that, in the current socio-political context, the concerns raised by the technology far outweigh the benefits with respect to the fate of poor and small producers.

B. Biotechnology in the Latin American Environment

Our selection of case studies also provided some insight into some of the environmental concerns around the technology. The environmental concerns raised by biotechnology are diverse, potentially highly significant, and frequently lacking a sufficient degree of scientific knowledge and certainty. Two considerable environmental problems that are supported by a fair amount of scientific knowledge are biotechnology-specific exacerbations of problems initiated by the Green Revolution: petrochemical reliance and threats to biodiversity. The position of herbicide tolerance as the most prevalent GM trait furthers the entrenchment of petrochemical reliance in agricultural production (Otero and Pechlaner, forthcoming, chap. 2). This petrochemical dependency has arguably already reached unsustainable levels in the American agricultural system, and diffusion to a broader area only increases the damage. The threat to biodiversity is much more multi-causal.

Genetic contamination, for example, greatly expands on the threats to biodiversity that were already raised by the Green Revolution's transition to industrial mono-cropping. Weaknesses in many Latin American state structures can mean that even when regulations are put in place — such as those prohibiting the cultivation of GM corn in Mexico — negative environmental repercussions still occur. Recent scares over the contamination of the Mexican Landraces are likely a direct result of weak regulation and monitoring of GM corn imported only for food and feed purposes. The social control over biodiversity does not begin and end with regulation, however. Case studies in Latin America also reveal a proliferation of connections between the social and the environmental.

At a most basic level, agricultural producers pushed to the edge of economic viability are going to engage in their practice in the most profitable way they can; environmental considerations are necessarily pushed to lower priorities. Sometimes the very adoption of the technology, with all its attendant environmental issues, is directly geared toward staying economically afloat in the face of restructuring. This was noted already with respect to Brazil where, despite prohibitions on GM crop production (until recently), the smuggling of GM seeds became the strategy of many Brazilian farmers faced with economic crisis (Hisano and Altoe, forthcoming, chap. 10). Once again, control over the technology, and consequently over its environmental impacts, is absent.

The links between social and environmental effects can also be less direct, however. Elizabeth

Fitting's (forthcoming, chap. 5) case study demonstrates that even those actions seemingly not directly affecting a negative environmental response can result in long-term compromises to something as significant as in situ maize biodiversity. The adaptation strategies of rural households struggling under neoliberal reforms that Fitting outlined (i.e., out-migration and increased corn production) resulted in generational divisions: the young migrated and the older generation remained to farm. These youths lost their agricultural knowledge. Consequently. long-term corn production, and, hence, the maintenance of Landraces, are called into question. Fitting calls these adaptation strategies the social aspect of biodiversity.

Consequently the social context of biotechnology's diffusion can be seen to exacerbate undesirable environmental impacts at the very same time that its social reorganization decreases the capacity for debate over these impacts. Armando Bartra (2004) argues that Mexican food production (and we could extend beyond Mexico) has social, cultural, and environmental aspects that are not recognized by the "absolute mercantilism" of our production system. While these other aspects go beyond the scope of our investigation here, it is important to note the lack of recognition of many functions of the peasant economy, from the maintenance of natural resources to the restoration, preservation, and development of Mexican culture (Bartra 2004). Were these functions to be included in the economic sustainability calculation, the "inefficient" peasant producer would be seen as efficient in a way that "agribusiness clearly flunks the test of sustainability" (36).

C. Global Governance and International Equity

Regionally our case studies hint at the internal differentiation that Latin America is undergoing with respect to national responses to the new technological paradigm and subsequent adoption into the global food market. Yet there still remain significant commonalities among developing countries negotiating at the global policy table. Jansen and Roquas (forthcoming, chap. 3) provide insight into the ways that Latin American countries attempt to meet the need for biotechnology regulations. While some countries were stimulated to respond by their early involvement with the industry, others were only prompted by becoming signatories to the Cartagena Protocol on Biosafety. The protocol aims to harmonize biosafety regulations; however, there is room for country-specific approaches to creating these regulations, and each country was found to arrive at their particular regulatory response through a number of different internal and external factors. The high cost and necessary expertise required for developing such a system, however, lead many developing countries to rely on international expertise, models, and standards, rather than engaging in internal processes of law-making.

There are a number of consequences to this international modelling that Jansen and Roquas (forthcoming, chap. 3) argue tends to "forget" the weak state character of many Latin American governments. The frequent "inadequacy of state performance" and the "inability to enforce laws" is readily apparent in the long use of GM soy prior to approval in Brazil (Jepson, Brannstrom, and Stancato de Souza, forthcoming, chap. 9) and in the introduction of GM contamination in Mexico's Landraces, likely through poor regulation and monitoring of food and feed imports (Fitting, forthcoming, chap. 5). Regulations and the enforcement of regulations are demonstrated to be two very separate things.

Two other consequences of this international support speak more directly to the global power imbalance around such technologies: an emphasis on "sound science," which supplants the precautionary approach; and a silencing of public debate over the technology as a result of this emphasis. Consequently, the selection of regulations with social criteria in mind does not usually occur, and the most powerful lobby groups push for regulations that favour their economic interests. This disadvantage of developing countries to address their societal needs is exacerbated by a reliance on expert systems detached from local concerns and contexts. In many cases the complications and irregularities around biotech crop approval in developing countries are viewed with the assumption that the goal is to overcome obstacles to approval rather than to assess the advantages versus disadvantages of approval (see, for example, Cohen and Paarlberg 2004).

The "developing country disadvantage" regarding regulation further manifests itself in the economic disadvantage these countries face with respect to conducting the necessary assessments on the extent to which technologies are in their best interests. In some cases, the profitability and national benefit of the technology is itself in question. For example, preliminary quantitative assessments of recombinant bovine somatotropin (rBST) use in Mexico, supplemented with interviews and data from the US experience, raise significant doubt about the profitability of the milk productivity-enhancing hormone (Otero, Poitras, and Pechlaner, forthcoming, chap. 6). However, a number of negative impacts are also raised by the use of rBST, such as compromises of the underground water supplies from the high intensity production and the alienation of dual purpose and small-farm operations, which lack the capital for such intensification of their milk production but still face reduced profits. In such cases, the economic benefits of the technology appear to be transferred almost wholly to the technology's producers, while there are negative social and environmental effects on the region of adoption. Stronger state involvement in assessment and regulation would be required to assess and prevent such cost/benefit imbalances.

Recent revisions to seed laws introduced in many Latin American countries are not indicative of such strengthening of assessment procedures, however; rather, they emphasize policies likely to intensify the negative social impacts outlined in our case studies. Despite continued declines overall in government intervention in market processes, the seed law revisions in Latin America counter this trend in a manner supportive of further privatization of genetic resources (GRAIN 2005). These new laws vary by country; however, significant commonalities exist around the theme of increasing protection for private seed, such as through compulsory registration and certification. In many cases, this prohibits the production and marketing of non-registered seed, and can even prohibit "the donation … or even the non-monetary exchange of seeds among farmers" (3).

In a context of strong international support, solutions could eventually be found to the "developing country disadvantage." More ominously for the question of international equity, however, a significant part of international negotiations involves the betterment of the interests of industrialized countries. The neoliberal restructuring embraced in some of the developing countries discussed here is dubiously matched by a similar ideology in industrialized countries. Trade liberalization for developing countries in the context of hefty US, Japanese, and EU agricultural subsidies — whether direct subsidies or indirectly through non-agricultural subsidies such as on environmental grounds — subject developing countries to cheap imports against which local producers cannot compete. Similarly, changes in the international legal context of biotechnology, specifically the intellectual property rights component of the WTO, are leading to numerous inequalities and opening the door to biopiracy (Poitras, forthcoming, chap. 4).

In sum, even the limited treatment provided here seems to provide strong indication that the international legal context emerging around biotechnology is balanced against the benefit of developing countries in general and of its middle and poor farmers in particular.

Conclusion

Returning to the introductory discussion of biotechnology's revolutionary potential for a moment, a number of conclusions can be drawn from our case studies. First, while agriculture may be a declining sector, particularly in developed countries, all indications so far are that changes to this sector in developing countries are likely to be profound. The increasingly universal model of a globally marketed, industrial "farming without farmers" (Teubal, forthcoming, chap. 7) is not without deep social consequences in countries where this renders vast masses of people without an adequate livelihood in agriculture, or alternatives for gainful employment in other sectors of the national economies. Therefore, while this technology is indeed "substitutionist" in its current agricultural application, this has not minimized its impact on these countries. The increasing concentration of control over the food supply by a handful of TNCs, the imbalanced international context for trade and for intellectual property rights, the emphasis on production for export in a context where new biotechnologies could dramatically change the international division of labour: these all speak to the relative national weakness of developing countries. Locally, the case studies here provide full testament to the technology's negative social and environmental impacts.

Even where the experience of biotechnology may not be direct, the integration of technology and policy in the context of neoliberal restructuring ensures that no producers are immune from its effects. Hisano and Altoe (forthcoming, chap. 10) assess a number of responses to the agricultural restructuring in Brazil — attempts to integrate into the mainstream technological paradigm, differentiating into niche market production, re-emphasizing production for local markets, and extension programs — to conclude that small-family farmers are engaged in a "relentless survival game", which requires significant financial and human resources to mitigate.

Given the repository of negative consequences, seemingly most prevalent in developing countries, it seems fair to question whether agricultural biotechnologies should be allowed at all. It is not the intention of the authors to make claims for the inherent good or evil of biotechnology as a technology in itself, however. Nor were these intentions indicated in the case studies cited here. These case studies merely document the impacts of the technology in its current social, political, and economic context. In this context, the dissemination of the technology in Latin American countries has been highly problematic.

Contrasting Buttel, the argument presented here is that biotechnology could be the most important technical force to shape world agriculture over the coming decades. However, the technology is a double-edged sword: which way it cuts will depend largely upon who wields it and how (Kloppenburg 1988; Kloppenburg, Kleinman, and Otero 1988). Concerns regarding the potentially negative social impacts arising from a profit-oriented, transnational biotechnology industry found little counterbalance in our case studies. Broadly speaking, with respect to these Latin American case studies, it is difficult to find social positives in the restructuring that the technology has facilitated thus far.

Some might argue that social reorganization is a necessary component of technological change, and to avoid any change that has negative impacts would be to exclude any potential benefits. However, the changes brought about by agricultural technologies in an industrialized country, where only 3% of the economically active population engages in agriculture, are going to be drastically different than the experience of that change in a developing country, where sometimes 25–60% of the economically active population is engaged. The difference of these percentages needs to be placed at the forefront when considering the "necessary" proletarianization of subsistence peasants who are no longer viable in the transition to commercial agriculture and neoliberal economic restructuring. In the developing country experiences represented here, poverty and hunger for many appear to be the most consistent companions of the technology's impact on social organization.

A key issue that remains unresolved with respect to the future of GE technology is its hegemonic status. As several of these case studies have pointed out, there is high contestation around GE technology, and a broad resistance to it both for its environmental and its social implications. As Poitras (forthcoming, chap. 11) conveys, GMOs entered the scene in Mexico just as rural producers felt they were being "set aside" for neoliberal competitiveness. In consequence, resistance to the technology was incorporated into the broader struggles of peasant social movements. Social disruption around the technology was also evidenced in Brazil and Argentina. In this light, the biggest impetus for biotechnology's adoption — sweeping neoliberal economic reforms and deregulation — may also be the biggest factor behind its inability to gain hegemonic status as the number and diversity of groups negatively affected breed significant resistance.

While the potential for a GMO retraction or for the emergence of an alternative development structure are far from assured, it is clear that GE technology is not undergoing a seamless adoption into the neoliberal project. This high level of contestation around the implementation of GE technology and neoliberal restructuring adds a wild card to considerations of future possibilities. In addition to a general need for more case studies on the social impact of agricultural biotechnologies, this is certainly one area that particularly warrants future research.

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