CORN CULTURE AND DANGEROUS DNA:
Real and Imagined Consequences of Maize Transgene Flow in Oaxaca*

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Abstract: "Genetic pollution" in Oaxaca has become Exhibit A for critics of crop genetic engineering and the focus of angry charges and counterclaims by biotechnology researchers. Like many disputes about science and technology, this one is linked to economic and resource-control conflicts. To understand why this controversy is so intense, we need to locate the scientific findings and claims about crop gene flow within the broader frame of international agro-food restructuring and its consequences for agrarian communities. The dispute over maize transgene flow in Mexico has unfolded in the context of U.S. and "life industry" agendas for trade liberalization and worldwide expansion of intellectual property rights. Equally germane is the cultural and economic significance of corn and of small-scale farming in Mexico, where rural livelihoods have been hard hid by neoliberal reforms. Whether or not the contested report in *Nature* (November 2001) stands up to scientific scrutiny, it is probable that the introgression into Mexican local maize varieties of *Bt* transgene constructs from genetically engineered U.S. corn has occurred, despite Mexico's ban on GE grain planting. The possible risks posed by traveling transgenes are not well understood, but there are plausible scientific reasons for concern about possible hazards to agricultural biodiversity and agro-ecosystems. More troubling, however, are the likely consequences –for local food security, cultural survival, and national economic sovereignty– of the private ownership of staple-crop genetic resources and of the influence on trade policy, agricultural research, seed and food markets, and farming-system options of a small number of powerful states and transnational firms. Processes at the global level (e.g., in the WTO), regional level (e.g., trade pacts in the Americas) and local level (farmers' successes in agroecology and organizing) suggest that the political space for alternative agendas may be opening. Despite the privatization and narrowed focus of much research funding, genetics, ecology, crop science, and participatory research have much to contribute to widening this space by evaluating sustainable-farming options as well as biotechnology applications.

Keywords: Biotechnology, gene flow, agriculture, globalization, intellectual property, food trade

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I Introduction: The maize gene flow controversy and its context

In November 2001, the journal *Nature* published evidence that genetically engineered DNA, probably from U.S.-grown transgenic corn, had somehow found its way into the genomes of local maize varieties in the Sierra Juarez of Oaxaca, Mexico, a part of the region where maize was first domesticated. (Quist and Chapela 2001). The report, by two researchers from the University of California at Berkeley, was echoed in the international press, challenged by other researchers, and sparked an uproar that pitted ardent advocates of crop genetic engineering (GE) against their equally fervent opponents. The controversy soon involved the Mexican government, international genetic and crop scientists, transnational biotechnology corporations, indigenous villagers, Latin American critics of neoliberalism, environmental organizations, and "anti-globalization" and food-sovereignty activists from dozens of countries. The apparent detection of a few invisible, sub-molecular genetic constructs in corn collected from mountain farmers' fields quickly became a *cause celèbre* for agro-biotechnology defenders and detractors alike.

Most genetic scientists claiming authority in the matter have treated it as a scientific methodological problem resolvable by more accurate testing. However, it has proved impossible to fix the maize gene-flow dispute within the confines of techno-scientific discourse. Like other technologies, plant breeding and crop genetic engineering are both produced by, and further constitute, particular social relations and patterns of resource control; conflicts over technologies may signal contestations of those patterns of control. Disputes about crop biotechnology today reflect struggles over agricultural markets and over land, labor, genes, and other food-producing resources.

These struggles have deep roots in Mexico. Embodied within a single kernel of suspect Mexican maize is a turbulent history of crop domestication and original civilization, conquest and expropriation, industrialization and new empires nourished by this versatile grain, and rural restructuring and mass migration linked to Mexico's green revolution and to trade liberalization. Now, there is a very real possibility that rural communities and Mexican agriculture more broadly are about to be hit by another crippling blow. (1) In this context, *campesino* activists and their allies see the upholding of Mexico's current ban on the planting of transgenic corn as critical to their livelihoods and their survival as cultural communities.

It is easy to discount the alarmist assertion by some anti-GE activists—or mass-media caricatures of their positions—that the "genetic pollution" of ancient maize landraces threatens the very soul of Mexico. By some of these accounts, laboratory-made transgenes will produce dangerous food and will trigger the rapid depletion of maize biodiversity, the loss of ecologically and culturally vital crop varieties, and the consequent, final demise of autonomous Indian communities. Reality, as usual, is more complex. Consumption of transgenic *Bt* corn (2), if it is at all hazardous, is probably less so than the myriad health risks from contaminated water, pesticide exposure, and malnutrition already endured by many Mexican campesinos. Moreover, Mexican maize landraces in even the most isolated mountain plots are far from "pure": maize genetic erosion long predates genetic engineering, and most Mexican *ejidos* and indigenous communes are already drawn into transnational circuits of exchange and accumulation and of cultural transformation, not all of it unchosen or unwelcome.

Despite this complexity, the argument of the GE critics has a great deal of truth at its core. I will defend this claim on two main bases. The first is techno-scientific, to wit: transgene introgression it is very likely to have occurred in Oaxaca and elsewhere in Mexican centers of maize genetic diversity, whether or not the *Nature* submission demonstrated this. It is even likely that some farmers are intentionally introducing transgenes into their creolized corn landraces. It is possible that today's relatively simple, single-trait transgenes such as *Bt*-toxin constructs may not contribute to the loss of valuable maize traits, but the risk cannot yet be ruled out. The ecological effects of *Bt* toxins are not well understood, and future, more complex traits may have more damaging effects. Meanwhile, until much more is known about the consequences of transgene flow, the massive importing and sale of U.S. genetically engineered corn in Mexico constitutes a large-scale experiment with results that are unpredictable, possibly dangerous ecologically, and certainly irreversible. This experiment is being carried out without the knowledge or consent of most of those likely to be affected.

The second reason why the GE critics have a case is political-economic. Whether or not transgenic maize turns out to endanger biological diversity, the widespread planting of transgenic crops in the remaining "GMO-free" countries of Latin America—still most of the region as of this writing—would help to bring about significant changes in agricultural production systems and in hemispheric and international trade. Confirmation of the presence of transgenes in territories where transgenic crops may not now legally be planted will make it all the more difficult for those states to produce certifiably "non-GMO" corn and to retain the option of a precautionary policy position on genetically engineered crops. (3)

In addition, the full-scale adoption of GE crops in Latin America would accelerate current trends toward greater industrialization and external-input dependency in farming. It would strengthen the competitive advantage of the United States in Latin American and world food and fiber markets and would speed the incorporation of Latin American food systems into a global agro-food complex dominated by a small number of powerful conglomerates. Even if transgene flow in Oaxaca turns out to pose little *direct* danger to maize gene pools, as most crop-GE proponents and some GE critics contend, these political-economic trends are likely to undermine further what remains of Mexico's self-provisioning, corn-growing communities, and with them, the repositories of maize germplasm that those communities have created and conserved.

II Traveling transgenes: the techno-scientific controversy

The troubling implications of reported transgene flow in Mexican maize

The debate among scientists and activists that followed the publication of the Quist and Chapela report in *Nature* was highly politicized from the start. For critics of crop genetic engineering, Quist and Chapela's apparent discovery was important for at least four reasons. First, in their view it confirmed the vulnerability of genetically diverse local maize landraces to "genetic pollution" by transgenic plants (ETC Group 2002).(4) GE critics and some genetic and crop scientists are concerned that the transfer of powerful genetic capacities from such bio-engineered crops—in this case, the ability to produce toxins lethal to corn ear worms and other lepidopteran pests—may confer a survival advantage to the recipient plants (Regal 1994; Ellstrand 2001; Lutman 1999; Stewart et. al. 1997; cf. Louwarrs et al. 2002). If so, they might out-compete and displace other crop varieties or their wild relatives and ancestors, such as teosinte in the case of maize. Were this to occur in a region of great crop genetic diversity such as Southern and Central Mexico, it could further endanger the diminishing gene pools of maize and the wild plant species from which maize was derived. Particular maize and maize-relative genes might become extinct, and with their disappearance, unique traits might be lost. A tremendous variety of maize traits are valued by Mexican and other American peasant agriculturalists who have selected them over centuries to suit local growing and food preferences (Brush 1998; Bellon 2001). Some of this endangered genetic information may even prove vital in the future to the continued productivity of corn farming worldwide, given that new traits must be continuously added to maize and other crops as crop pests evolve and climatic conditions change (Thrupp 2000).

Second, the *Nature* report seemed to provide evidence that possibly-dangerous transgenes can travel farther and faster than biotechnology advocates had been willing to admit.(5) The phenomenon of gene flow from transgenic or conventional crops, while not controversial in principle, was little noted or studied until recently, as new biotechnological tools have made genes easier to trace and since the controversies surrounding transgenic crops have raised questions about its consequences (Ohio State University 2002). Regulatory policies for GE crops in the United States have generally not taken gene flow into account, but rather have been based on the premise that human-made gene constructs will remain confined to the crop and the harvest cycle into which the were intentionally placed.(6) Especially in the case of corn and other partially or fully out-crossing, wind-pollinated crops, this is clearly not the case. Transgenes can travel in pollen and become incorporated into the genomes of pollinated plants miles away through the process of normal plant sexual reproduction, as some would-be producers of "GMO-free" corn and canola (rapeseed) oil in the United States and Canada have learned to their dismay. Cross-pollination can occur between crop plants and wild plants of related but distinct species (Radosevich et. al. 1996; Darmency et. al. 1998). A related concern is that pollen or root exudates from corn and other plants with genetically engineered toxic properties may harm soil biota, useful pest predators, or wild species such as swallowtail and possibly monarch butterflies (Donnegan and Seidler 1999, Hilbeck et. al. 1998, Sears et. al. 2001).

Third, GE skeptics used the occasion of the Oaxaca maize report to draw attention to the little-understood problems of another kind of gene flow, horizontal gene transfer. Horizontal gene transfer is the movement of genetic material from one organism to another by means other than sexual reproduction. It is now known that microorganisms such as bacteria are capable of exchanging genetic material directly from one species to another, and that this occurs commonly (Tapperser et al. 1998).DNA from genetically modified food can be transferred to bacteria in the human gut (UKFSA 2003). Gene transfer has been observed between distantly related species: a parasitic bacterium and the adzuki bean beetle (Kondo et. al. 2002), and probably occurs frequently among microorganisms and plant tissues in soil. The consequences are unknown but it is plausible that they may enable the development of new or more virulent pathogens. One need not postulate horizontal gene transfer in Oaxaca or in the U.S. Midwest to explain the unexpected presence of transgenes in non-GE fields: pollination by nearby plants grown from a few transgenic seeds offers a sufficient explanation. However, the flurry of speculation about the source and the consequences of transgenes in Oaxacan maize has highlighted just how little is known about the myriad ways in which genes interact and move within and between organisms, and what the effects of such phenomena may be. Growing recognition of the scope of this uncertainty is challenging the biotechnology industry's portrayal of genetic engineering techno-science as entirely safe, predictable, and precise.

A related issue highlighted by advocates of tighter GE regulation is the pleiotropic effects of genetic engineering (Benbrook 2000). Pleiotropic effects are multiple, unintended traits and behaviors that have resulted from the laboratory manipulation of genomes, for example, greater fragility of plant tissues and increased vulnerability of some crops to fungal disease (Coghlan 1999; Saxena and Stotzky 2001) The standard methods of genetic engineering —introduction of synthesized genes, powerful gene-expression promoters derived from viruses, and vectors designed to break through evolved barriers to inter-species gene transfer— sometimes have unpredicted consequences that are not related to the traits that the GE plants were designed to exhibit. The activities of natural genes are sometimes "silenced" as a result of genetic manipulation directed at different genes. These and other interactions among transgenes and other elements of natural genomes are poorly understood. Some worry that such unanticipated effects genetic engineering may result in damage to soil microbes and other agronomically important organisms and ecosystems in farm ecosystems (Donnegan et al. 1999; Altieri 2000; Obrycki et al. 2001; See McAfee 2003a for further discussion).

Some advocates of crop genetic engineering recognize these uncertainties but are confident that their effects can be controlled for compensated for. Whether or not this is possible in large-scale, monocrop fields typical of U.S. agriculture remains to be seen. In smaller-scale, more diversity-based farming systems in developing countries, unintended consequences may be more common as well as harder to detect and control. The *milpas* cultivated by Mesoamerican smallholders are typically support a variety of crop rotations and/or intercropped plantings of maize, various legumes, and forage crops, as well as squash and other vegetables. Such farming systems may be more vulnerable to "non-target" effects of *Bt* toxins on pollinators or nitrogen-fixing microbes or other accidental damage to intercropped plants or soil biota.

Finally, even if the *Bt* gene flow in the Sierra Juarez in not confirmed, the *Nature* report brought into sharp relief the problem of presuming —as U.S. government negotiators and biotechnology firms have generally done— that the same agricultural goals, management models, and biotechnology regulations are applicable in the United States and in the global South. Pending further study of the benefits and risks of GE crops, the Mexican government banned the planting of transgenic corn in 1998. However, the importing of U.S. transgenic corn for human and animal consumption is legal and is itself a source of controversy, as I will explain below. Most of the scientists who have commented on the Oaxaca case suspect that the probable origin in Oaxacan fields of the transgenic promoter constructs identified by Quist and Chapela, if indeed they are present, would have been U.S. *Bt* corn that was sold either as grain for tortillas or as animal feed, or possibly corn seeds brought home by seasonal migrants to the United States.

In either case, the presence of transgenes in Oaxaca would expose the inefficacy of Mexican state policy intended to restrict the country's grain production, at least for the present, to conventional crops. More than that, it points to the inappropriateness of any developing-country policy for the management of GE crops that is modeled after U.S. regulations. U.S. rules presume a system of fully commercialized agriculture, in which varieties are uniform, seeds are purchased, and harvests are sold: a system in which seeds are one sort of commodity and food is a different commodity entirely. In Mexican and other partially self-provisioning peasant economies, the cycle of agricultural life is both more local and more closed. The same seed may be the source of life both in the sense of the next day's meal and the next season's planting material.

Retraction, rebuttals, and counterattacks: The GE industry on the defensive

As soon as the Quist and Chapela findings became known, the Mexico-based International Maize and Wheat Research Center temporarily ceased collecting and distributing samples from the region. (CIMMYT 2001) (7) CIMMYT is the World-Bank affiliated primary international research center and seed bank for maize. Although no evidence of transgenes in the CIMMYT corn germplasm collections has been found to date, or at least, none has been announced, CIMMYT scientists have acknowledged that if *Bt* corn has been inadvertently or deliberated planted nearby, the introgression of transgenic constructs into varieties in farmers' field varieties is virtually inevitable. In a statement issued in May 2002, CIMMYT maintained that while much remains unknown about the effects of transgene introgression and of environmental and farmer selection pressures on genetic diversity, it is unlikely that a single-gene trait such as *Bt* toxicity would it itself result in a loss of maize genetic resources (CIMMYT 2002).

However, CIMMYT also noted the need for more research on ways to limit the diffusion of "genes that should not be openly and freely distributed… into the environment", such as genes for the production of pharmaceutical substances or future, more complex multi-gene constructs (ibid., p. 4). In the meantime, CIMMYT stated, it was taking extra care to ensure the integrity of the maize seeds in its collection. CIMMYT collections are shared widely with companies and researchers worldwide: the center provided 25,086 corn seed samples in 1999 alone (Koo et al. 2003: 2). In light of the uncertainty surrounding the effects of errant transgenes and given the volatility of scientific debates and international negotiations over biotechnology policy, CIMMYT could not afford to be suspected of supplying seeds with synthetic genes or proprietary components to plant breeders or farmers. NGO critics accused CIMMYT of placing its own interests above those of Mexican campesinos by failing to prioritize the testing of farmers' varieties *in situ* for transgenic contamination and the study of its consequences (ETC Group 2002b).

Mexico's National Institute of Ecology (INE), a branch of the Department of the Environment and Natural Resources, initiated its own investigation as soon as the *Nature* report came to light.(8) A research team headed by Jorge Soberon, secretary of the country's National Commission on Biodiversity (CONABIO) and ecologist and INE president and ecologist Ezeqiel Ezcurra reported at a number of international meetings and to the Mexican press that their tests of corn kernels collected in Oaxaca and in neighboring Guerrero state had produced evidence of the widespread presence of the same CaMV35S promoter sequence reported by Quist and Chapela (Mantell 2002). However, a scientific paper describing their findings was rejected by *Nature* in 2002 (Science 2002).

By this time, nearly a year after the Quist and Chapela report was published, a highly polarized debate had already been running through the pages of *Nature* and other journals. It began in April 2002, when *Nature* published a communication from two genetic researchers who accused Quist and Chapela of sloppy science. They acknowledged that "transgenic corn may or may not be hybridizing to traditional maize cultivars in Mexico" but maintained that Quist and Chapela's apparent discovery of introgressed transgenic sequences was probably an artefactual result of a flawed testing procedure. The researchers also held that Quist and Chapela's second claim—that the transgenes had become fragmented and redistributed in the maize genomes—was unprecedented and improbable (Metz and Futterer 2002: 600-601).

In the same issue, *Nature's* editor took the unusual step of backing off from the journal's initial, implied endorsement of the peer-reviewed Quist and Chapela report. Citing "inconclusive" discussions among Quist and Chapela and additional reviewers and "diverse advice received", *Nature* concluded that "the evidence available is not sufficient to justify the publication of the original paper." (Nature 2002: 602) Nature's tepid statement was less than a "retraction", although it was thus characterized in press and biotechnology industry accounts, but it was certainly out of the ordinary for a scientific journal to publish editorial doubts about its own peer-reviewed publication. Many research reports that pass peer muster and are published are later found to be incomplete, inaccurate, or subject to contrasting interpretations; this is how the practice of normal scientific inquiry in the Kuhnian sense proceeds (Kuhn 1962). But the debate about transgenic maize was about much more than "normal" science: all participants are involved in one way or another in a high-stakes struggle over the future of the agrobiotechnology industry and the related restructuring of transnational agro-food systems.

Nature's prevaricating statement was accompanied by a published communication by six of Quist and Chapela's own colleagues from the Department of Plant and Microbial Biology of the University of California, Berkeley, who also argued that the original findings had to have been false, and a reply by Quist and Chapela offering further evidence in defense of their study (Kaplinski et al. 2002: 601-602; Quist and Chapela 2002: 602). The subsequent *Nature* issue carried a letter from Andrew Suarez, also a U.C. Berkeley colleague, and 11 other ecologists and plant scientists from major U.S. research universities (Suarez et al. 2002). They accused *Nature* of compromising its objectivity by overruling the results of its own peer-review process and by making a special, suspect case of a particular report, a practice they found "particularly troubling when articles are related to economic or political interests". An accompanying letter by three other U.C. Berkeley and San Francisco researchers was explicit about what they called "webs of political and financial influence that compromise the objectivity of [Quist and Chapela's] critics" (Worthy et al.: 897). The writers stated that Quist and Chapela's critics in *Nature* all had "competing financial interest in their published contributions" which they had failed to disclose.(9) In a reply published in *Nature*, two of those accused of conflicts of interest avowed that their concern "was exclusively over the quality of the scientific data and conclusions" and that the implication that their past private-sector funding had compromised their science was itself "a threat to academic freedom" (Metz and Futterer 2002b). An additional letter from a U.C. Berkeley researcher charged Chapela himself with a conflict of interest because Chapela was an outspoken critic of the Berkeley-Novartis arrangement (note 9) and because he serves on the board of Pesticide Action Network, "an advocacy group opposing genetically modified organisms" (Kaplinsky 2002b).

Whatever the motives of these individual authors, there is no doubt that the *Nature* controversy has been influenced by very active "political and economic interests", including private-sector biotechnology firms as well as non-government organizations (NGOs) critical of crop genetic engineering. Immediately after the Quist and Chapela report was published, a series of internet postings by scientists and others active in promoting crop GE —including electronic messages from apparently fictitious authors traced to affiliates of a public-relations firm used by the Monsanto corporation— condemned the report as incompetent and as evidence of irrational fear of genetic technologies. (Pearce 2002) In February 2002, 144 civil-society groups issued a statement accusing the biotechnology industry of using "intimidatory" techniques to "silence" dissident scientists (Mann 2002). In response, the AgBioWorld Foundation, headed by the plant molecular geneticist and pro-GE campaigner

Dr. C.S. Prakash, issued its own statement “In Support of Scientific Discourse in Mexican GM Maize Scandal" (AgBioWorld 2002).

Crop genetic engineering on the defensive

The embattled and, in some cases, compromised positions in which genetic and crop scientists with close industry links were finding themselves may have made some of these criticisms more strident. Since at least 1980, molecular biology and other areas of high-technology research in universities and their spin-off enterprises have become increasingly oriented toward profitable applications, restricted by patents, and funded by corporate grants, contracts, and public-private partnerships. By the late 1990s, a growing number of public-sector scientists, and even Berkeley Chancellor Robert Berdahl, were expressing concern that corporate priorities were shaping basic research agendas and that intellectual-property restrictions were inhibiting access to research tools and materials and blocking the exchange of scientific knowledge, even among colleagues and students (Eyal and Press 2000).

In addition, biotechnology firms are facing the consequences of hyperbolic predictions of molecular-genetic miracles. In medical biotechnology, hopes for effective, clinically-approvable “gene therapies” have not yet been fulfilled. In agriculture, the performance of transgenic crops has been, for the most part, mediocre (McAfee 2003a). The GE crop varieties that have been planted commercially are not generally higher-yielding: they were designed to respond to proprietary herbicides (mainly Monsanto’s Roundup and other brands of glyphosate) or to produce their own insecticides (*Bt* toxins), not to produce more food. Although glyphosate-tolerant (“Roundup-Ready”) and *Bt* crops can reduce labor and machinery needs, they cost more than conventional seeds and have been much more profitable for agrochemical/seed firms than for farmers (Boyd 2003). In most cases, transgenics have not enabled farmers to reduce their use of pesticides. In some places, they have already begun to stimulate the evolution of glyphosate-tolerant weeds, and the evolution of *Bt*-resistant insects appears inevitable (Benbrook 2001; McAfee 2003a; Pollack 2003). Meanwhile, crop genetic engineers have yet to develop profitable new products to follow the relatively simple, first-generation transgenic applications. Predicted vitamin-A rich and drought-resistant or salt-tolerant crops are still in the development stages. “Life-industry” firms are struggling to cope with low profit margins in their agricultural divisions, investor apprehension, farmer skepticism, and consumer mistrust that has spread from Europe to the United States and many countries in the global South.

It was in this context that GE advocates responded to the *Nature* report. Under other circumstances, the disputed interpretation of a small set of laboratory results might have remained an obscure technical discussion of interest only to specialists. After all, the Quist and Chapela findings have not been disproved, and even their most vehement critics acknowledge that gene flow from transgenic maize will occur. Nevertheless, many biotechnology advocates treated *Nature's* editorial retreat as if it somehow had laid to rest all reasonable doubts about the environmental safety of crop genetic engineering. For their part, anti-GE campaigners highlighted the original *Nature* report as damning evidence of the immediate danger from promiscuous transgenic crops to agricultural and other biodiversity and to the survival of indigenous and agrarian societies, and as further grounds for opposition to the U.S. government agenda for the promotion of biotechnology in global environmental and trade negotiations.

III The international politics of transgene flow

Trade wars and transgenic crops

The intensity of reactions on both sides of the Oaxaca gene-flow controversy must be seen in the context of the conflict over biotechnology policy that has been gaining momentum in international trade talks and environmental treaties during the past 15 years. These tensions rose on January 9, 2002, when U.S. Trade Representative Robert Zoellick denounced what he called Europe's "Luddite" and "immoral" moratorium on transgenic grains and food products. "European antiscientific policies are spreading to other corners of the globe", he told reporters. (Becker 2003). In May, the U.S. asked the World Trade Organization to declare the European Union moratorium on genetically modified (GM) agricultural products illegal.

To understand U.S. motives and the E.U.'s defiant response, it is useful to look first at the economic geography of genetically engineered crops. The world's main GE-crop producers are the United States (66 %), Argentina (22%), Canada (6%), and China (4%) (James 2002).(10) The two biggest players—and competitors—in global food trade, both imports and exports, are the United States and the European Union, which have had nearly opposite policies on the commercial planting and consumer labeling of genetically engineered crops. Most European countries and New Zealand do not presently permit the commercial planting of transgenic crops. Japan and Australia have approved a few crops for limited commercialization, but both countries are attempting to keep their food imports and exports "GMO-free". South Korea and Taiwan allow limited GE-food imports but require them to be labeled.

The majority of states in the global South have not approved commercial planting of GE crops, although many have not explicitly banned transgenics and some are permitting GE-crop field trails (Nap et al. 2003).(11) As in the case of Mexico, some governments may not be aware —at least officially— of the deliberate or inadvertent planting of transgenic seeds in their territories. When they have bargained as a bloc in international treaty negotiations, as they often do, developing countries have generally stood for stricter biotechnology regulation, for the labeling of GE organisms and products, and against the global standardization of patents and other intellectual property rules for organisms, genes, and biotechnology products and raw materials ("genetic resources") (McAfee 2003b). However, developing-country policies are varied and in flux, under considerable and conflicting pressures from their trade partners or hoped-for buyers of their exports, international agencies, industry lobbyists, and foreign and domestic NGOs.

The government of India, in the face of vigorous domestic dissent, approved the commercial planting of *Bt* cotton in 2002, but its regulators have not yet permitted planting or importing of GE grains or other food crops and products. China has invested substantially in GE tobacco, encouraged farmers to plant Bt cotton, and promoted research on dozens of other GE crop applications, but backed off in 2002 from its endorsement of transgenic food imports. South Africa allows some GE crops and hosts its own biotechnology research, but other Southern African governments made world headlines in 2002 when they rejected unlabeled shipments food aid in the form of U.S. yellow corn.(12) Biotechnology proponents depicted African governments as irrational, heedless of their peoples' hunger, and pawns in the protectionist trade machinations of the E.U. (Paarlberg 2002). Most of the affected Southern African states, except Zambia, later agreed to accept grain shipments even if they were likely to contain transgenics, but preferably if the grain were milled so that it could not be planted.

In Latin America, as noted above, Argentina is already heavily involved in GE crop production: mainly of soy, but also some maize and cotton. It is the world's third largest soy exporter. About 80% of Argentine soy fields are planted in herbicide-tolerant varieties marketed by the Monsanto corporation.(13) But even Argentina is leery of allowing transgenic varieties of those crops that are exported to "GMO-sensitive" markets. (Burachick and Traynor 2002) Chile allows the importing and multiplication of transgenic seeds for export but not for planting. Paraguay and Bolivia have had temporary bans on GE crops. Mexico, Uruguay, Bolivia, and Colombia have approved field testing of a variety of GE grains and horticultural crops. At the same time, legal battles and policy debates on GE crops and foods are underway in dozens of countries, including Mexico, Brazil, Colombia, and other Latin American states. Policy on intellectual property rights (IPR), especially provisions that would affect the development and export of patented crops, drugs, and genetic-engineering methods, is also being contested in negotiations over regional trade accords, particularly the U.S.-proposed Free Trade Area of the Americas (FTAA).

The position of Brazil, as the region's largest economy and one of the major global agro-exporters, will be critical to the future of GE crops in Latin America. Brazil sponsors its own national research in agro-biotechnology, and the government of Enrique Cardoso approved commercial planting of herbicide-tolerant soy. However, legal planting of GE soy has been blocked by Brazilian courts in response to case brought by nongovernmental organizations.[14] There is considerable public opposition to GE products; environmental activists and members of the militant rural settlers organization *Movimento Sem Terra* have occupied government offices to demand fuller debate on the consequences of transgenics. "Brazil's stubborn resistance to GM crops took the bio-tech companies by surprise," the U.K. Guardian reported (Branford 2002).

> As part of its global strategy, Monsanto had bought up seed companies in Brazil and was poised to dominate bio-tech farming. The Brazilian government had expressed its support for GM crops and was helping to fund a pounds 250m factory that Monsanto was building in the north-east of the country to supply the whole of South America with the raw

> materials for Round-Up. In early 2000, Monsanto even imported GM seeds to sell to farmers in the following planting season, after the anticipated authorisation. (ibid.)

Brazil is the world's second-largest soy exporter after the United States. If Brazil either legalizes GE soy, or if the spread of GE crops and transgenes "contaminates" too much of the country's soy crop, the country could lose its present trade advantage in exporting soy to European and Asian countries. A spokesman for the American Soybean Association told the New York Times, "We are very hopeful that last domino will fall. That's why the environmentalists are putting up a stink down there in Brazil. They know if that goes, it's all gone" (Barboza 2001). As of August 2003, the agriculture minister under the new administration of Luiz Ignácio Lula da Silva was keeping policy options open.

Biotechnology policy and the control of national food production

Many governments have cited health concerns and the unknown ecological effects of transgenics, such as the transgene introgression reported by Quist and Chapela, as reasons for their no-GE policies. But more than this is at stake, as the Brazilian case illustrates. For Latin America, the breaching of the present "no-GMO" border between the United States and most its Southern neighbors would further strengthen the competitive advantages of the heavily-subsidized U.S. agro-food/biotechnology complex in Latin American and global markets for seeds, grains, and food products. Transnational agribusiness firms which have invested deeply in crop GE are well aware of this, as are anti-GE activists and the U.S. government officials who defend corporate agrobiotechnology interests in international fora. As their concerns have grown about U.S. export losses resulting from biotechnology regulations, U.S.-based agribusiness and biotechnology firms have assisted in and lobbied for government activities in support of crop genetic engineering (Vaughan 2002).

If Latin American governments and agro-producers adopt GE crops, or if "genetic pollution" prevents them from segregating transgenic from conventional products, this will foreclose their option of maintaining non-GMO markets in Europe and Asia. It is likely to accelerate the acquisition of domestic seed and farm-input enterprises by transnational firms, with the consequent narrowing of crop-variety and farm-management options for commercial farmers. Embrace of crop genetic engineering by Latin American states would also be accompanied by increased pressure for the adoption and enforcement of U.S.-style patents on crop varieties, genetic information, and genetic engineering technologies, and for the privatization, or partial privatization through private-sector partnerships, of national agricultural research and development activities. These changes would further constrain the ability of public-sector science to serve national and, especially, small-farmer needs. Most significantly for Latin American domestic politics, maintaining a "no GMO" policy is one of the few means by which Latin American countries can preserve a degree of control over the structure of their agro-food systems and the source of their food supply. The ending of resistance to GE crops and products, in combination with other trade liberalization measures, would facilitate increased imports of U.S. and Canadian grain and horticultural crops, further imperiling the economic survival of small and medium-scale farmers and agricultural enterprises across the region.

The fate of Mexico's corn economy as a consequence of trade liberalization, accelerated by the North American Free Trade Agreement (NAFTA), illustrates just what many developing-country farmers and agricultural entrepreneurs fear will be the consequence of more "free-trade" provisions, such as those proposed in the draft of the FTAA pact. Mexican corn imports, mainly from the United States, surged 12-fold from 1995 to 2001, from 396,000 metric tons in the last pre-NAFTA year to an annual average of 4,854,000 metric tons (USDA, cited in Vaughan 2002), as the Mexican government has implemented NAFTA provisions, some of them ahead of schedule, and as it has phased out supports for maize and other staples and cash crops. Imports of U.S. grain were expected to soar further in 2003 as a result of NAFTA requirements for further tariff reduction. Both U.S. and Mexican tariffs were eliminated for many crops in 2003, although limited maize tariffs may remain until 2008 (Skorburg 2002b). In December 2002, *campesinos* and small entrepreneurs, NGOs, and political opponents of the Vicente Fox, protested these changes; farmers rode on horseback into the hall of Congress. Preparations for blockades along the U.S.-Mexico border in January led the government to postpone some of its planned actions. Dialogue between the Fox government and NAFTA opponents, including 12 organizations in coalition under the slogan "El Campo No Aguanta Mas" (The Countryside Can't Stand Any More) reached an impasse.

Feelings run high because the effect on Mexico's maize-producing small-farm sector has already been severe. An estimated 15 million Mexicans depend directly on corn from plots of five acres or less for income and sustenance. While many continue to produce maize, an unknown but clearly substantial number of these small-scale producers are no longer able to sell the portion of their crops they had relied on for cash income (Weiner 2002). Farmers I interviewed in July 2003 around Nochixtlan, Oaxaca, reported recent 30 – 40 percent declines in the prices they are now offered for their maize, to the point where sales no longer cover their costs of production. Adding to the crisis, they said, grain dealers now will buy only one color of maize, which they mix with imported U.S. corn and then sell the product with a deceptive "local" label. The farmers face similar problems with their sales of beans and livestock, both of are now under-priced by U.S. imports. These indigenous Mixtec growers name 10 different groups of maize landraces and many more individual strains maintained by family networks, as well as 12 types of wheat, 22 varieties of pulses and beans, and about 200 types of horticultural of medicinal plants that they cultivate or collect. Much of this agricultural biodiversity may be lost if more of them are forced by economic pressure to abandon their lands.

Fox's agriculture minister, Javier Usabiaga, an agribusiness magnate from Guanajuato, has said that farmers who cannot survive the changes must simply find other work. For many, this can only mean migration to the United States. The importing of U.S. corn has not led to compensation in the form of lower staple food prices: the price of tortillas rose 483 between 1994 and 1999 (Nadal 2002).In addition, concerns about food and farm safety have led to the introduction of at least six congressional resolutions related to GE crops, and Mexico's own commercial farm sector fears inundation by foreign firms According to a member of the governments Biosafety Council, "There is concern over increasing economic control by the multinationals. The idea that biotechnology only benefits big multinational corporations has very deep roots in Mexico" (Pegg 2002).

Implementation of the Free Trade Agreement of the Americas (FTAA) as currently proposed would open markets in the Americas to U.S. exporters of bulk agricultural commodities: maize and other coarse grains, soy, cotton, and rice (Skorburg 2002a). Such U.S. agribusiness gains might put farmers in South America, where the U.S. now sells few of these commodities, in a predicament similar to that of Mexican corn farmers. The FTAA would also bring about intensified competition with Latin American producers of fruits and vegetables, sugar, poultry, meats, and dairy products (ibid.).

Farmers and agro-enterprises in other world regions are facing similar competitive pressures. In African and many Asian countries, too, trade accords, structural adjustment conditionalities, WTO requirements, and the conversion of government agencies to the gospel of competitive efficiency have brought an end, for better or worse, to many forms of state support for agriculture, intensifying rural crises in many regions. Meanwhile the "free trade" double standard under which Europe and the U.S. continue to subsidize their vast farm exports generates deepening anger in countries that have been told to liberalize to compete.(15) It is in this context that we can understand why the "Oaxaca maize scandal" has been the focus of such heated debates in international aid agencies and in the corridors of trade, environmental, and intellectual property negotiations.

Mexican maize in global bio-diplomacy

The *Nature* report added fuel to fires of controversy that were already ablaze in multilateral negotiations over food trade, food safety, genetic engineering, and intellectual property, and led Mexican farmers' organizations to add their voices to these disputes. In April 2002, Miguel Ramírez Domínguez, President of the Communal Property Commissariat of Capulalpan de Méndez, Ixtlán, Oaxaca, cited the *Nature* report and linked the local gene-flow problem to the fate of farming worldwide. He told delegates to Biosafety Protocol talks in the Hague that transgenic "pollution…puts the world's food security at risk since farmers around the world rely on these genetic resources to create new varieties which adapt to changing environmental conditions." Ramirez called upon the Commission for Environmental Cooperation (CEC) of NAFTA to undertake "a thorough investigation about the consequences of the presence of genetic contamination in the indigenous maize varieties and effective remedial measures." (Greenpeace 2002). In June 2002, the CEC Secretariat announced its intention to prepare a special report upon the potential effects of transgenic corn on traditional varieties of maize in Mexico, citing an earlier CEC finding that ""“insufficient knowledge on the impact of emerging technologies, such as the use of transgenics, [is] one of North America's most important concerns to biodiversity" (CEC 2002). (16)

At the second World Food Summit in Rome in June, 2002, I listened to Mexican farmer representatives telling delegates that synthetic genes in local corn plots are a danger not only to local and global food supplies but to the cultural life of indigenous Mexicans.(17) Alberto

Gomez of the Mexican national Union of Regional Peasant Organizations (UNORCA) and Aldo Gonzales Rojo of the Union de Organizaciones de la Sierra Juarez de Oaxaca and the international peasant confederation Via Campesina pointed out that American indigenous farmers have developed and conserved maize genetic diversity for millennia. "Look at a map: you'll see that the areas of diversity and the territories of our peoples coincide", Gonzales said. Local maize culture is under siege just at the time when crop germplasm and other genetic resources have suddenly been recognized as valuable by outsiders and are being taken for biotechnology research with little or no compensation to local communities, he added. All this is happening at the same time that economic liberalization is threatening farmers' land rights and undermining indigenous corn economies: the campesinos he represented, Gonzalez said, object both to maize transgenes and to the equally unwanted presence of cheap, subsidized U.S. corn in Mexican rural markets

Not only rural Mexican NGOs have raised alarms about the Oaxaca case. At the Johannesburg Earth Summit (Rio+10) in August, South Africa's BioWatch and other African NGOs cited the Oaxaca study as further reason to resist the "dumping" of cheap U.S. corn in national markets or as food aid. In addition to driving down local farmers' prices, they argued, it might endanger locally-adapted maize landraces in Southern Africa's own, secondary centers of maize diversity. In October 2002, peasant and environmentalist organizations in the Philippines demonstrated at the annual meeting of the Consultative Group for International Agricultural Research, the main global network of green-revolution agricultural research centers and seed banks. They charged the CGIAR and its member center, CIMMYT, with failing to undertake proactive investigation of the extent and possible effects of transgene flow in Mexico. These and other transnational NGOs have called for a worldwide moratorium on the release of transgenic crops in centers of agricultural biodiversity, which are primarily in the global South.(18)

International NGO coalitions and some European and developing-country governments have been raising concerns about GMOs in international negotiations since at least the early 1990s, when the issue emerged during the drafting of the Convention on Biological Diversity. In recent years, in the context of the rapid expansion of GE-crop acreage and exports and the proliferation of private, intellectual property rights (IPR) claims on genetic information and biotechnology tools, GE critics have found a more receptive audience among delegates to international economic and environmental treaty talks (McAfee 2003b). During this time, however, the international acceptance of biotechnology products and the recognition of intellectual property has become a diplomatic priority for the United States in these same fora.

Thus, when the Oaxaca gene-flow issue came to a head, disputes over biotechnology and IPR were already underway in the World Trade Organization (WTO) and its sub-agreements on Agriculture (AoA), Technical Barriers to Trade (TBT), Sanitary and Phytosanitary (SPS) measures, and Trade-Related Intellectual Property Rights (TRIPs), as well as the *Codex Alimentarius* food-safety talks. Biotechnology, particularly genetic engineering designed to prevent crops from making viable seeds ("Terminator" technologies), remains controversial in conferences of the parties to the Convention on Biological Diversity conferences. Access to crop genetic resources and the patenting of genes and genetically altered crop varieties are the key points of contention in finalization of the International Treaty on Plant Genetic Resources for Food and Agriculture, negotiated in November 2001.

The global accord most likely to affect the ability of countries to adopt or reject GE crops and products is the Cartagena Protocol on Biosafety. The Protocol, a sub-agreement of the CBD, was finally hammered out in January 2000, despite 11 years of unflagging opposition by the United States. It was pushed through by an alliance of the European Union and the Southern-country negotiating bloc of Like-Mind Countries under the able leadership of Ethiopia's Tewolde Berhan Gebre Egziabher. Latin America delegations to the Protocol talks split into two camps: the majority backed the Southern-bloc position in favor of a strong accord, but three grain-exporting states—Argentina, Chile, and Uruguay—allied with Australia and the United States in opposing the accord until the 11th hour. The United States is not expected to ratify and has discouraged countries from doing so.

When Protocol took effect on September 11, 2003, it had been ratified by 60 countries. It provides countries with a basis in international law for choosing to reject or postpone the import of transgenic planting or breeding materials. It thus could be a counterweight to WTO provisions which might make countries liable to sanctions for "unfair trade practices" if they decline imports on the grounds that they are genetically engineered. The accord requires that shipments of genetically engineered seeds, planting materials, and animals meant to be released into the environment must be labeled and accompanied by detailed information regarding their transgenic composition and any available information about their likely environmental effects. In a concession to the United States, treaty negotiators agreed that GE exports meant for processing, food, or animal feed would not have to be labeled as transgenic.

The Protocol also cites the "precautionary principle" and states that countries may adopt a "precautionary approach" to decisions about biotechnology-product imports. Importantly, it specifies that they may take "socioeconomic considerations", in additional to potential adverse effects on conservation and sustainable use of biological diversity, into account in their decisions about which categories of imports they will accept. Thus, the Protocol will enable countries and communities to retain the option of declining imports of living transgenic materials. However, countries that decline transgenic imports can be required to specify the scientific grounds for any such decisions. Conflicts over the Protocol may soon take the form of disputes over what constitutes "sound science" in evaluating "potential adverse effects" of "living modified organisms", although the Protocol text states clearly that "Lack of scientific certainty due to insufficient relevant scientific information and knowledge…" shall not prevent a country from rejecting transgenic imports.(19)

This is the context in which the *Nature* submission debate became so inflamed. These international disputes over biotechnology and science policy are so hard-fought, I submit, because they are an expression of a deeper, underlying struggle over the global politics of food security and food trade and over the trajectory, pace, and terms of economic globalization.

Rewriting global trade rules to promote biotechnology

Agricultural and biotechnology policies have been central to efforts by the United States to reconstruct the rules of international trade to advance U.S. economic interests. Objections to U.S. biotechnology policies have also been a prominent aspect of resistance by other countries to those U.S. efforts. Even while the United States was losing ground in traditional industrial sectors such as steel, successive Washington administrations have worked to maintain the large volume of agricultural exports that have long been critical to U.S. economic growth (Busch et al. 1991; McAfee 2003a). They have also, increasingly, sought to advance the U.S. competitive advantage in newer, high-technology exports, including the products of medical and agricultural biotechnology. The GATT IV trade talks, which began in 1986 and culminated in the launching of the WTO in 1994, reflected these two goals most clearly in two of the sub-agreements that distinguish the WTO from previous trade regimes, the Agreement on Agriculture (AoA) and the Trade-Related Intellectual Property Rights Agreement (TRIPs).

The WTO Agreement on Agriculture Introduced at the insistence of the U.S., the AoA brought food trade and farm policy into the realm of global economic governance for the first time. In the name of "free trade" in agriculture, it requires countries to phase out quotas and other means by which many have tried to limit their agricultural imports in order to protect domestic producers. The United States and its main agro-export competitor, the European Union, continue to argue over which of their respective programs of state support for farmers and land management are really "subsidies" that constitute discriminatory trade practices prohibited under the WTO. Neither has eliminated the government assistance to agriculture that pumps their agro-export volumes by keeping world food prices near or below the costs of production. Instead, the 2002 U.S. farm-policy law increased subsidies to politically influential agribusiness constituencies, and the E.U. Common Agricultural Policy, revised the same year, left the annual level European spending for farm-sector support nearly unchanged. Meanwhile, a variety of protectionist measures by the E.U. and, especially, the U.S. still limit their imports of agricultural and other products from would-be developing nations. In contrast, a combination of WTO rules, conditionalities attached to development-agency loans, requirements of bilateral trade and aid pacts, and threats of trade sanctions have forced many Southern governments to reduce food-import restrictions such as import licenses and to decrease or end farmer- and food-price supports and agricultural-input subsidies (Murphy 1999; Madeley 2000).

WTO Trade-Related Intellectual Property Agreement: TRIPs was initiated and promoted by an international business coalition of European, Japanese, and U.S.-based multinational corporations, with U.S. government encouragement (Drahos 1999). The United States, the main force in the WTO, wanted member governments to open their markets to foreign exports and investments, especially in industries where the U.S. is relatively strong, such as agriculture, financial services, computer electronics, entertainment media, and biotechnology. TRIPs stipulates that WTO parties must recognize patent claims "in all fields of technology" (TRIPs Article 27.1,WTO 1996). (20) By requiring countries to recognize and enforce property rights to crop varieties and the chemicals they depend upon, as well as biotechnology tools, techniques, and expertise, these trade rules foster the expansion of established biotechnology industries, which are strongest in the United States, and raise barriers to entry against newer private or public biotechnology enterprises (Kenney 1998; Boyd 2002).

Outside of the WTO, the United States Departments of State, Commerce, and Agriculture are working in a variety of ways, often in cooperation with private companies and organizations such as the U.S. Chamber of Commerce, to promote international acceptance of genetically engineered crops and related technology and inputs exports by U.S.-based firms. Among these are capacity-building programs, bilateral trade talks and behind-the-scenes arm twisting, and regional pacts such as the FTAA.

US "Capacity Building" for agro-biotechnology: The U.S. Agency for International Development and other federal agencies are working actively in Latin America and other developing and "transitional" countries to build a constituency of professional agro-biotechnology experts and official supporters of genetic engineering and related intellectual property laws. In 2001 and 2002, the Foreign Agricultural Service of the U.S. Department of Agriculture sponsored seminars in Ecuador, Chile, Peru, Argentina, Uruguay, and Paraguay to fill "the information gap that widely exists in these markets" (U.S. FAS 2002) . The U.S. spent more than $90 million in trade capacity-building assistance to the Americas in 2002 alone (U.S. Trade Representative 2003).(21) These activities included biotechnology "orientation" visits for Chilean officials to U.S. government agencies and private corporations involved in GE agriculture and a seminar in Mexico to "dispel the myths and misconceptions" surrounding biotechnology (Ibid.). Commerce Secretary Donald Evans told the U.S. House of representatives that the Department's Market Access and Compliance Unit conducts international outreach around the world to promote biotechnology Evans explained that "MAC's role lies in ensuring that member countries abide by their commitments under the WTO…to govern biotechnology through science-based, nondiscriminatory and transparent measures" and that the agency seeks to ensure that other countries do not use biotechnology regulatory policies such as requirements for biotechnology product labeling, traceability, and precaution "as disguised barriers to trade." (Evans 2001).

The Free Trade Agreement of the Americas: The FTAA, proposed by George Herbert Bush in 1990, would create a hemispheric "free trade" zone in 34 American countries, excluding only Cuba. The "free trade" term is deceptive in that the draft FTAA provisions would bring about restructuring of trade regulations and restrictions, not their elimination. The pact as proposed would reduce controls on the movement of capital across borders and the ability of governments to favor domestic enterprises or particular uses of national resources (FTAA 2002:Chapter on Agriculture, Article 18). Some Latin American governments fear that this would favor the economic success of the region's more powerful nations and firms, including agrochemical/seed conglomerates such as Monsanto, without compensatory guarantees of access for their exports to U.S. markets, particularly since Commerce Secretary Evans has said that U.S. farm subsidies and market access could be addressed at the global level, not in the FTAA talks (Katz 2002). The opportunity to increase its exports to Latin America would be particularly welcome in the wake of U.S. losses of agro-export markets in Europe, Korea, and other countries that are not accepting GE-crop products.

U.S. negotiators hope to use the FTAA to stiffen hemispheric standards for IPR enforcement, for example, by requiring damage payments for IPR violations. "Because the United States maintains a decisive competitive advantage in high-technology, knowledge-based industries that are dependent on IPR, this is one of the most important topics for U.S. negotiators" (U.S. GAO 2001). But while the U.S. has proposed IPR rules that would go beyond those of TRIPs, other FTAA delegations want to retain the right to not allow patents on living organisms, or even to prohibit such patents (Ibid.). Another proposal that would favor U.S. exporters in biotechnology, agriculture, and food processing calls for "harmonization" of FTAA countries' safety standards and certification procedures in line with the SPS section of the WTO (FTAA 2002 V2:14). Those rules stipulate that decisions to import or reject products must be "science based". A coalition of 33 agribusiness and biotechnology trade organizations told U.S. Trade representative Zoellick in April, 2002, that

> [I]t is critical that the US government maintain and strengthen its long-held strategy of promoting science-based labeling polices that are consistent with US domestic regulation. Any shift away from defending science-based policies could have a damaging effect on exports of agricultural commodities by accelerating a growing trend

away from the use of biotech ingredients in exported food products (Vaughan 2002: 16). Latin American critics contend that this would make it harder for their countries to reject possibly-hazardous GE products, while giving the U.S. more basis for rejecting Latin American products, because the interpretation of what is "safe" and "scientific" has been modeled on processes used in the United States.

Conclusion

The Western Hemisphere is the forefront of globalization and has been so for more than 500 years. But the region has now experienced two decades of trade liberalization and other policy reforms intended to foster its further integration into global circuits of production and exchange. For most countries and most sectors of the population, globalization in the form of increased imports, exports, and foreign investment has done nothing to diminish the damages of structural inequality, oppressive debt, and the continuing, net outflow of the regions' human, natural, and financial resources. For the majority of people, even in the few countries such as Chile which have seen relatively steady GDP growth, another decade of development has been lost. Disillusion with the promise of globalization is deepening.

Scientific and political controversy over crop genetic engineering has escalated in the context of deepening economic crisis in both American continents. The United States proposes to manage that crises by means of hemispheric economic integration under a program of intensified neoliberalism, with few concessions to the social and ecological traumas that such a program entails and with no reform of existing institutions that reinforce the dominance of the dollar. Argentina, the country in most acute economic crisis at the start of the new century, has perhaps followed the Washington neoliberal prescription most faithfully. Argentina also happens to be the world's second-largest producer, after the United States, of genetically engineered crops. While Argentina's current tribulation cannot be blamed on genetic engineering, it has become poignantly clear that the combination of economic liberalization, close linkage to the dollar, and large-scale, export-oriented agriculture has not saved the country from hunger and fiscal disaster.

The stalemated FTAA talks suggest that the U.S. "free trade" program for the hemisphere is generating anxiety, resentment, and resistance, even as it is endorsed rhetorically by some Latin American states. The current efforts by some Latin American governments to assert their sovereignty over genetic resources and their autonomy in food trade, farm policy, and biotechnology regulation are among the signals of a Latin American counter-trend to U.S.-led hemispheric integration. The hostility to genetic-resources bioprospecting by many indigenous peoples' organizations and the opposition to transgenic crops by some farmers' and environmentalist NGOs are certainly expressions of resistance to globalization on neoliberal terms under the U.S. umbrella.(22)

Provisions in the emerging regimes of global environmental governance provide some bases for policies that —if governments make good use of them— could help to counteract incorporation into globally-consolidated, industrial agro-food systems dominated by a few transnational giants. These provisions include commitments under the Convention on Biological Diversity to the traditions of "local and indigenous communities" relevant to biodiversity, to the conservation of agricultural biodiversity *in situ* (in the communities and ecosystems where it has been developed), and to the fair sharing of the benefits of biodiversity. Other potentially useful tools are the recognition by the Cartagena Protocol on Biosafety of the validity of the "precautionary principle" and the relevance of "socio-economic" considerations" to biotechnology regulation and trade. Another is the language in the WTO TRIPs Agreement that allows countries to limit patents on living things for the sake of the environment or public health and order. Most important may be the general principle in these and other global institutions that countries of the global South require "special and differential treatment" under the rules of aid and trade.

Is it possible that there is a double "paradigm crisis" in Latin America: an incipient challenge to the Washington consensus and a questioning of the benefits of industrialized export-oriented agriculture, and that there is a linkage between the two? This is the view of adherents of "food sovereignty", the goal of a growing movement of rural-based organizations and their professional allies in environmental NGOs, academic centers, and public-sector agricultural agencies. The international food sovereignty movement comprises organizations of peasants and farm laborers, herders and fishers,, and international NGOs, such as Genetic Resources Action International, that coordinate exchanges among them. Most of its members oppose genetic engineering as a strategy for agriculture, but not because it affronts an idealized "harmony with Nature" or the "purity" of traditional crop landraces.

Rather, they are wary of what they perceive as its ecological unsoundness and negative socioeconomic consequences.

Food sovereignty as these groups define it requires broad access to land and other food-producing resources, as well as laborers' rights. "Sovereignty" is less an attribute of traditional polities than a political-economic space for multiple, alternative developments, locally imagined but internationally networked. Rather than eschewing national states, these organizations want to see state regulatory and rural development agencies strengthened and held accountable. Through farmer-to-farmer exchanges, they develop and apply principles of agroecology, using traditional and new methods, low inputs of external energy and chemicals, and intensive reliance on site-specific farmer intelligence. For them, agroecology is more than a technological means of conserving biodiversity and increasing productivity, although some have done so with impressive success (Uphoff 2002). It is a also means toward greater social equity and local control over food sources and supplies, and the core of a social and environmental alternative to neoliberalism. It remains to be seem whether the goals and ethos of food sovereignty will resonate with growing desire among some Latin American governments for greater autonomy in trade, food, and development policy.(23)

Genetic engineering alters the fundamental cellular processes of living, reproducing organisms. In the words of biotechnology enthusiasts, it "creates new forms of life". To anti-GE activists, it "gives pollution a life of its own". Because of this, genetic engineering is a particularly powerful technology. Some of its effects are latent and nearly impossible to predict; therefore it is especially difficult to evaluate in terms of conventional, short-term, risk-benefit analysis. But beyond these problems, and more frequently overlooked, is the fact that assessing the likely biophysical and social impacts of errant genes and of crop biotechnology more generally requires a more multifaceted conceptualization of "sound science" and analysis of more than the technology *per se*.

Farmers in the Oaxaca's Sierra do have reason to be concerned about the introgression of manufactured DNA into their corn plants, but probably not because eating the harvest of those plants will damage their families' health. It may turn out that they have little reason to fear that their transgenic visitants will crowd out valued local maize traits or damage soil organisms and surrounding ecosystems. At this point, there is no way of knowing for sure. But there are other, more likely causal pathways through which the undetected travels of transgenes may represent a threat to Mexican indigenous and campesino livelihoods and cultural survival. Too narrow a focus on the techno-scientific achievements or the biological hazards of genetic engineering risks losing sight of the greater dangers to agricultural sustainability and rural well-being posed by the global restructuring of agro-food systems and the growing dominance of the industrial paradigm in agriculture. The terms of the debate over "genetic pollution", which has focused mainly on the reliability of laboratory data, have diverted needed attention from the particular ways in which the proliferation of transgenes contributes to this aspect of globalization.

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[1] If remaining Mexican tariffs on corn imports are phased out by 2008, according to the schedule set by the North American Free Trade Agreement, and especially if Mexico drops its policy against planting transgenic grain, even more US corn will enter Mexican markets and a larger portion of it will be transgenic. Markets for local corn and options for obtaining non-GM seed will shrink further in Mexico.

[2] *Bt* corn carries genetic instructions, originally obtained from *Bacillus thuringiensis* bacteria, for the production in all of the corn plants' tissues of one of several crystalline proteins that are toxic to certain plant-eating insects. It is meant to reduce the need to spray insecticidal chemicals.

[3] For example, soy plantations now expanding into Brazilian Amazonia aim for markets where certification requirements (China) and GMO bans or future labeling requirements (Europe) favor non-GMO soy, which the U.S. is unable or unwilling to provide. Some of Brazil's soybean, further south are grown from illegal, herbicide-tolerant seeds obtained via Argentina. Whether Brazil makes GM soy legal, and how "non-GMO" labeling and certification rules will be interpreted under evolving E.U. and Chinese regulations, will affect and will be influenced by WTO and regional trade negotiations, political developments within Brazil, and pressures form the U.S. and the Monsanto corporation.

[4] Transgenic organisms are those that contain genetic material synthesized from DNA obtained from other species. An organism can also be engineered to alter the location, number, or expression of its own genetic material. It would then be genetically engineered, but not transgenic in the strict sense.

[5] Some advocates of crop genetic engineering now argue that potentially hazardous gene flow can be contained by the use of genetic-use restriction technologies, or GURTs, which will be designed to prevent plants from producing fertile seeds or to switch other gene functions on or off. NGO critics have dubbed them "terminator" or "traitor" technologies. Such genetic-engineering applications are still in the early development stage, and it is not at all clear whether they might be used reliably and safely to restrict gene flow or for other purposes.

[6] A recent U.S. National Academy of Sciences evaluation of the scope and adequacy of current regulation found it to be improved but still inadequate and in some respects, superficial. The 2002 NAS study of the U.S. Animal and Plant Health Inspection Service's (APHIS) regulation of transgenic plants recommends longer-term, post-commercialization monitoring, evaluation of environmental changes at larger spatial scales in both agricultural and in adjacent, unmanaged ecosystems, and greater scientific and public input (NAS 2002).

[7] The new of transgene flow in Mexico was reported in a September 27 news story in *Nature* before the Quist and Chapela evidence was published (Dalton 2001).

[8] In January, researchers at the National Autonomous University of Mexico and the Center for Investigation and Advanced Studies (CINVESTAV) at the National Polytechnic Institute announced

that their own preliminary studies confirmed the presence in Oaxacan maize samples of the same CaMV promoter sequence that Quist and Chapela reported; further tests were planned (Mann 2002).

[9] Some of these reputed conflicts of interests stemmed from the controversial alliance at the time between the U.C. Berkeley Department of Plant and Microbial Biology and the major agrobiotechnology firm Syngenta (formerly Novartis). In an arrangement brokered by Gordon Rauser, then head of Berkeley's College of Natural Resources, a research wing of Novartis was allowed a degree of input into college research-funding decisions. The corporation also obtained option rights to patents on discoveries by the Plant and Microbial Biology department, potentially including findings resulting from research funded by public sources. In exchange, the department received a $25-million dollar grant and access to some of the company's plant-genetic databases.

[10] In 2002, the Chinese government announced a policy shift away from transgenic crops. Its crop biotechnology research continues, but China began requiring that soybean importers obtain certificates stating that their goods have no adverse effects on humans, animals and the environment.

[11] According to a September 2003 report by the International Food Policy Research Institute, " In the developing world the approval and cultivation of genetically modified (GM) crops is largely limited to the commercial production of insect-resistant cotton in Argentina, China, India, Mexico, and South Africa. Approvals of GM crops used for food or feed lag far behind cotton: a single transgenic maize event (an instance of genetic modification) has been approved in the Philippines and South Africa, and a single transgenic soybean event has been approved in Argentina, Mexico, South Africa, and Uruguay. Argentina has also approved six GM corn events for cultivation. In contrast, 11 food and feed crops representing over 47 transgenic events have been approved for cultivation in the developed world." (Cohen et al. 2003)

[12] U.S. aid and trade officials, who apparently saw the famine crises as a public relations opportunity, were at first unwilling to provide grain from non-GE sources or cash to purchase surplus grain from other countries in Africa and elsewhere. In September 2002, USAID chief Andrew Natsios asked U.S. food-aid organizations to distribute grain shipments containing GE maize in drought-stricken Southern African countries, *and* to offer public statements endorsing the safety and suitability of GE grain and food. Most of theme declined to do the latter.

[13] This transgenic soy can withstand spraying with glyphosate, a herbicide made by Monsanto and other firms that have licensed the right to use Monsanto's patented glyphosate-tolerance technology. Glyphosate can be used on fields after crop seedlings have emerged in order to kill all other vegetation. This reduces labor and machinery costs, although not seed costs nor total amounts of pesticide sprayed (Benbrook 2001). Herbicide tolerance, mainly to glyphosate, has been the main application of crop genetic engineering —about 76% of GE crops contain the trait— and glyphosate sales account for the greater portion of agrobiotechnology profits. (Boyd 2003) However, strains of weeds that can withstand glyphosate can evolve where the chemical is sprayed, as in the case of most pesticides. Resistant weeds are already a problem in many places where Roundup-Ready crops have been planted (Pollack 2003).

[14] Meanwhile, it is widely acknowledged that some Brazilian farmers have planted smuggled transgenic soy beans, especially in regions near the borders with Argentina and Paraguay, while farmers in other parts of Brazil are trying to maintain the "GMO-free" status of their crops.

[15] According to the International Food Policy Research Institute (IFPRI), protectionism and subsidies by industrialized nations cost developing countries about US$24 billion annually in lost agricultural and agro-industrial income (IFPRI 2003).

[16] Topics of concern identified by the CEC "include, *inter alia*, the relationship between the production of traditional maize varieties and the conservation and sustainable use of megadiversity in Mexico; the effects of trade liberalization in the farm sector, effects of nontraditional corn imports on the conservation of traditional maize varieties; and the effectiveness of domestic policy measures in place

in Mexico, including the moratorium on planting transgenic corn varieties, and on protecting traditional maize varieties."

[17] Gonzales stated: "The contamination of our traditional maize undermines the fundamental autonomy of our indigenous and farming communities because we are not merely talking about our food supply; maize is a vital part of our cultural heritage. The statements made by some officials that contamination is not serious because it will not spread rapidly, or because it will 'increase our maize biodiversity,' are completely disrespectful and cynical." En defensa del maíz y contra la contaminación transgénica," news release issued by civil society organizations (CASIFOP, CECCAM, ETC Group, ANEC, CENAMI, COMPITCH, FDCCH, FZLN, Greenpeace, Instituto Maya, SER Mixe, UNORCA, UNOSJO, and RMALC) in Mexico City on World Food Day, October 16, 2001.

[18] Among the most active of these NGOs are the fast-growing farmers' federation, Via Campesina, with affiliates on five continents, the Malaysia-based Third World Network, Genetic Resources Action International with headquarters in Barcelona, Greenpeace International, Pesticide Action International, the Minnesota-based Institute for Agriculture and Trade Policy, the Canada-based ETC Group, the Intermediate Technology Development Group, several international coalitions of indigenous peoples' organizations, and numerous regional and national farmers', tribal, and environmentalist groups, especially in South America and South and Southeast Asia.

[19] Article 10 paragraph 6 states that "Lack of scientific certainty due to insufficient relevant scientific information and knowledge regarding the extent of the potential adverse effects of a living modified organism on the conservation and sustainable use of biological diversity in the Party of import, taking also into account risks to human health, shall not prevent that Party from taking a decision, as appropriate, with regard to the import of the living modified organism in question as referred to in paragraph 3 above, in order to avoid or minimize such potential adverse effects."

[20] Defenders of TRIPs maintain that biotechnology enterprises require globalized intellectual property regimes, without which investments in the next generation of miracle crops (and drugs) will not be forthcoming. The TRIPs agreement is said to be necessary because it requires WTO members to recognize the proprietary claims of local or foreign citizens or enterprises to brand-name crop varieties and biotechnological "inventions". Under these circumstances, we are told, biotechnological innovation will flourish and its benefits will be distributed through the global market. (Mossinghoff, 1998)

[21] "The U.S. government is committed to providing trade-related technical assistance to developing countries in the Americas so that these countries participate fully in important trade negotiations, such as the Free Trade Area of the Americas (FTAA) and the World Trade Organization's (WTO) Doha Development Agenda, and trade effectively in a global environment." http://www.revistainterforum.com/english/articles/110302eco_trade_capacity.html accessed January 25, 2003.

[22] Governments of some Latin American and other tropical countries have paid little heed local-level values of biodiversity. Instead, they have interpreted CDB sovereignty provisions that recognize their sovereignty over biodiversity as a sort of national-level property right. Biotechnology enthusiasts, and the overemphasis in the CBD text on biotechnology, have contributed to their unrealistic hopes for income from sales of genetic-resources access to biotechnology industries. The result of conceptualizing the values of genetic resources in terms of their international commercial-sale prices has undermined the interests of local communities that make use of and conserve genetic resources, while inhibiting biological research in some regions.

[23] The decision by Brazil's president to put aside the planned purchase of military jets to save resources to fighting hunger through his new Ministry of Food Security is a symbolic but positive sign. Brazilian state support for the expansion of soy plantations in Amazonia at the expense forests and of small cultivators there is not. Undoubtedly the Movimento Sem Terra, which advocates government aid for local food self-reliance, will press Lula to fulfill his promises.

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