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# **Lessons Unlearned: How Biotechnology is Changing Society**

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Agricultural biotechnology has come a long way over the past two decades. While talk of 10-foot-high cows, 2-foot-long ears of corn, and nitrogen-fixing cereals has all but disappeared, crops that are herbicide tolerant and insect resistant are now a common feature of the landscape in several nations. Nevertheless, when one compares agricultural biotechnology with pharmaceutical biotechnology, the differences in the public perception and reception of new technologies are painfully apparent. Pharmaceutical products are embraced worldwide, while resistance to agricultural biotechnology can be found everywhere, not least in the United States. This is unfortunate, as agricultural biotechnologies have the potential to be quite beneficial in a number of ways.

In a recent article in *Technology Review*, Daniel Charles (2003) noted the potential for biotechnology to produce apomicts, *i.e.* crops that would breed true, generation after generation, thereby providing farmers in developing nations with easily reproducible high-yielding varieties. But Charles also noted that it is highly unlikely that this will come to pass. The recently restructured agricultural biotechnology industry would find such varieties threatening rather than desirable, and would be unlikely to invest in them.

Let me make clear the central thesis that I will pursue here: agricultural biotechnology, despite a few successes here and there, has thus far been a failure. It has failed to live up to the hyperbole, of course, but—more importantly—its proponents have failed to enroll citizens and consumers, and even the food processing and retailing industries around the world. Indeed, it is fair to say that probably no group of technologies has produced the rancor, the protests, the opposition, that agricultural biotechnologies have. Moreover, it need not have been this way. The phenomenal successes of pharmaceutical

biotechnologies, of personal computers, of consumer electronics, stand in clear relief to the resistance generated with respect to biotechnology for agriculture and food.

I will begin by discussing the nature of innovations. Then, I will discuss specifically the cases of Roundup Ready® and *Bt* seeds, and will suggest that the purveyors of agricultural biotechnologies are on a path that is quite likely to lead to their demise. I will conclude by noting some lessons that, if learned, might yet turn the industry around.

## THINKING ABOUT INNOVATIONS

There is a school of thought that argues that innovations simply diffuse through society much like objects in a vacuum (Latour, 1987; Rogers, 1995). Once released, according to the diffusion theory, such innovations encounter no friction, no resistance, no stumbling blocks. The British biologist, Hugh Bunting (*passim*), described this approach as the researcher shooting an arrow through the extension agent into the farmer.

In contrast, I would like to suggest another metaphor. Put simply, like stones in curling, innovations require sweepers; but the work of the sweepers is usually invisible. What this means is that upstream innovations need to satisfy everyone in the complex network of relationships between production of the innovation and the acceptance and use of that innovation among final consumers. Those along the trajectory that the innovation follows have to be willing to engage in the invisible work of sweeping—eliminating the friction that can slow or stop an innovation in its tracks.

If one looks at the pharmaceutical industry, it is clear that all products have to satisfy

- the companies producing them (with respect to cost of production, efficiency and consistency of production, demand for the product, *etc.*),
- the government regulators (who must find credible the claims of efficacy and lack of side effects of the drug in question),
- pharmacies responsible for selling the drug,
- physicians who will prescribe the drug,
- insurance companies that will pay for (at least a part of the cost of) the drug, and
- patients who will purchase the drug using prescriptions provided by their physicians.

If any of these actors in the supply chain fails to support the production, regulation, distribution, sales, or consumption of the drug, the product will not reach its final consumer. Similarly, agricultural biotechnology innovations have to satisfy all the actors in the supply chain. To date, this has been only partially the case. Let us examine the cases of Roundup Ready® and *Bt* crops as examples.

## THE CASES OF RR AND BT SEEDS

Plant biotechnology got its start during the Reagan administration, in the early years of deregulation. From the vantage point of Reaganites, regulation stifled innovation, slowed business, and otherwise restricted growth of the market. In 1986, Monsanto executives visited with Vice President Bush with the unusual request that the government regulate the new agricultural biotechnologies (Eichenwald, 2001). While the administration was reluctant at first, it soon began to understand Monsanto's position: without regulation, public opposition was sure to mount. Regulation would enhance public confidence in the new products. And, not incidentally, it would reduce biotechnology companies' liability were adverse effects to arise, and it would weed out the weaker companies, who would be unable to afford the costs of the regulatory process.

Furthermore, it was agreed by all, that executive decisions were far better than the possibility of Congressional hearings. The existing laws enabling regulation by the Environmental Protection Agency, the United States Department of Agriculture (USDA), and the Food and Drug Administration (FDA), would be cobbled together to create a so-called "coordinated framework."

As Kurt Eichenwald (2001) put it:

*It was an outcome that would be repeated, again and again, through three administrations. What Monsanto wished for from Washington, Monsanto—and, by extension, the biotechnology industry—got. If the company's strategy demanded regulations, rules favored by the industry were adopted. And when the company abruptly decided that it needed to throw off the regulations and speed its foods to market, the White House quickly ushered through an unusually generous policy of self-policing.*

Among the first products to emerge from the company's efforts was bovine somatotropin (BST). A public furor soon occurred; company officials were apparently unaware of the importance of enrolling the general public in their projects. As Monsanto CEO, Richard Mahoney, noted (Charles, 2001):

*We got into BST like we got into a lot of things. We'd been making agricultural chemicals for years. You increase the productivity of the farmer; you keep half (of the profits) and give him half. So what's the big deal? There wasn't even one discussion of the social implications. I never thought of it.*

A year later, another company engaged in field trials of an engineered bacterium named "ice-minus," designed to increase frost tolerance in plants. The media quickly broadcast photos of researchers in space suits tending the field. Not surprisingly, these images did not inspire confidence.

While, prior to 1990, Monsanto attempted to engage the critics, things changed when Robert Shapiro was appointed CEO. With missionary zeal, he

pulled out all the stops. Monsanto would change the world for the better, and make a fortune doing it. By 1992, Monsanto had successfully lobbied the Bush administration to speed up the regulatory process. Like most of the biotechnology-industry leaders, the administration echoed the belief that science demonstrated that bioengineered products were safe. Some FDA scientists raised concerns not unlike those noted earlier by industry scientists, but they were now ignored both by the government and by industry. Moreover, labeling was ruled unnecessary. It was argued that labeling would raise unnecessary concerns among the general public.<sup>1</sup>

As former CEO of Pioneer Seeds, Thomas Urban, argued (Eichenwald, 2001):

*Monsanto forgot who their client was...If they had realized their client was the final consumer they should have embraced labeling. They should have said, "We're for it." They should have said, "We insist that food be labeled." They should have said, "I'm the consumer's friend here." There was some risk. But the risk was a hell of a lot less.*

Not surprisingly, the lack of labeling created widespread opposition by small farmer, animal welfare, consumer, and environmental groups. By the late 1990s, these groups had begun to receive both membership dues and foundation funds to challenge the biotechnology regulatory regime, if not the technologies themselves.

Moreover, industry pressure hardly let up. With industry backing, the Clinton administration pressured Europe during trade negotiations, arguing that European concerns were unfounded and based on outdated traditions. Protests erupted in Europe.

### *Farmers*

But if Monsanto was paying relatively little attention to final consumers, it was beginning to woo farmers. This was particularly the case in the development of two types of genetically modified (GM) crops—those tolerant to Monsanto's herbicide Roundup® (glyphosate), and those modified to enhance insect resistance through the addition of genes from *Bacillus thuringiensis*, a common bacterium often used as a spray by organic farmers and in forestry. While farmers did not see significant yield increases<sup>2</sup> (and in some instances they experienced yield decreases), Roundup Ready® and *Bt* crops demanded far less

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<sup>1</sup>Current FDA regulations have the effect of making labeling of non-GM foods nearly impossible. But a recent USDA publication, reporting experimental economic research on consumers' willingness to pay, suggests that when independent scientific information about GM products is presented, differences in willingness to pay between GM and non-GM foods is negligible (Tegene et al., 2003).

<sup>2</sup>Ervin et al. (2000) suggested that when examined worldwide, transgenic crops account for a mean yield increase of no more than two percent.

management. Roundup Ready® plants offered the ability to spray for weeds nearly throughout the crop cycle, while *Bt* crops offered reductions in insecticide use. Given the press of time in contemporary farming, it is of little surprise that farmers embraced these technologies. As countless articles have noted, farmers rapidly adopted both types of genetic modifications.

At the same time, Monsanto's carrots were backed up with several sticks. Toll-free hotlines were established so that farmers suspected of violating the licensing agreements could be reported to the company. State legislatures were lobbied (without success) to require licensing of seed cleaners (Charles, 2001).

While most farmers were, and remain, optimistic about GM crops, organic farmers have shown far less enthusiasm. Given that the USDA-prescribed<sup>3</sup> organic standards prohibit genetic modification, organic farmers have been understandably concerned that GM crops would restrict and even eventually eliminate their markets. And, given the propensity of pollen to drift, GM crops pit organic farmers against conventional farmers as never before.

### *Seed Companies*

Somewhat less obvious is why seed companies were so keen to join the biotechnology bandwagon. After all, seed companies wishing to sell GM crops had to deal with farmers on a daily basis—farmers who were likely also their neighbors—and tell them that they had to sign a complex contract with lots of fine print in order to grow these crops, and that they would no longer be able to save seed as many had done in the past. One need not look too far to find the answer.

It should be remembered that the seed industry in the United States was, until very recently, made up largely of small, mom-and-pop businesses. Moreover, the seed market was stagnant. With little variation, farmers purchased about the same amount of seed every year. Of course, one could build market share at the expense of other companies, but only the larger companies had the capital to expand in that manner. What GM crops offered seed companies was an opportunity to expand their businesses by as much as 20 to 30% as a result of the “no-replant” clause in farmer contracts.

Consider the case of soybean. The seeds are relatively easy to save, as they are large in size and easily cleaned. Throughout much of the latter half of the twentieth century, farmers saved 63% (1960) to 33% (1991) of their seed (USDA, 1963; Doane Agricultural Service, unpublished data). Moreover, large-holding farmers were most likely to save seed. After all, those with larger farms had more capital, were likely to be more educated, have greater skill in seed-saving, and have the most to gain financially by successfully saving seed for planting the following season. Based on unpublished data from Doane

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<sup>3</sup>In response to requests from the organic industry.

Agricultural Services, we estimate that seed-saving declined from 33% in 1991 to 10% in 2001, largely as a result of the “no-replant” clause. This translates into \$391,770,000 in additional gross profits in 2001 for seed companies and their biotechnology partners—a huge windfall, to be sure. Moreover, the seed companies could shrug off farmer complaints by noting that it was the biotechnology companies, not they, who demanded that seed-saving be halted. Separate pricing for the seed and the “technology fee” aided seed companies in that argument (Charles, 2001).

In short, the agricultural biotechnology industry did an excellent job of enrolling (most) farmers and seed companies in their projects, and was, and continues to be, highly successful in getting the US government to do their bidding in a variety of ways.<sup>4</sup> But, further downstream in the supply chain, trouble has been brewing for some time.

### *Manufacturers*

Manufacturers have been wary of GM-food products. They have had little to gain by accepting GM raw materials and potentially a lot to lose. To date, perhaps the most visible fiasco surrounding GM food has been the *Bt* potato. Developed by Monsanto through its NewLeaf division, it was designed to be resistant to the Colorado potato beetle, a major pest. But, not long after it was released, Frito-Lay decided that it did not want the NewLeaf™ potato for its chips, while McDonalds determined that it preferred to avoid them for its fries (Nation’s Restaurant News, 2001; Pollack, 2001). With the two largest buyers of potatoes rejecting the new product, it was not long before Monsanto was forced to withdraw NewLeaf™ from the market. To my knowledge, there are no plans to reintroduce it.

Similarly, GM flax—with the unlikely name of Triffid<sup>5</sup>—was withdrawn from the Canadian market when it was discovered that European buyers, who purchase 60% of the crop, did not want to buy it. The same story applies to the sugar-beet industry, where, despite US government approval, refiners have advised farmers to avoid the GM crop. Hershey and Mars, major customers for the refiners, both expressed serious reservations about using it (Kilman, 2001).

The StarLink™ fiasco of 2000 (Lin *et al.*, 2001–2002) and the more recent Prodigene affair (Gillis, 2002) have upset the relatively pro-biotechnology food-processing industry as well. After the Prodigene incident, both the Grocery Manufacturers of America and the National Food Processors Association issued

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<sup>4</sup>In contrast, the agbiotech companies have had mixed success in Canada—although herbicide-tolerant canola has been well received, BST is still prohibited—and they have largely failed in Europe where popular opposition has trumped company lobbying.

<sup>5</sup>In John Wyndham’s book *The Day of the Triffids* (Doubleday & Colliers, 1951), dangerous carnivorous plants wander the earth!

press releases indicating their desire for a go-slow policy with pharmaceutical crops (Simon, 2002). Surprisingly, several months later, a Monsanto representative presented a paid seminar at the 2002 annual meetings of the American Association for the Advancement of Science in which the company unveiled its proposal to develop pharmaceuticals in corn. Particularly ironic about the proposal are the heroic lengths to which the company proposes to go in order to ensure that the pharmaceutical corn is segregated from food and feed corn. The electric fences, security guards, video cameras, global positioning systems, dedicated planting, harvesting, and transportation equipment that are to be used to ensure segregation appear more suitable for a nuclear power plant than for a field of corn.

### *Consumers*

With respect to consumers, considerable unease still exists. On the one hand, consumers are still frustrated by the lack of labeling. Biotechnology companies spent at least \$5.2 million to successfully defeat a 2002 Oregon ballot initiative that proposed that GM foods be labeled. As Business Week columnist, Julie Forster (2002), argued:

*That's shortsighted. The food industry would be better off educating the public about the safety and benefits of genetic modification. Their fear of a labeling law only means they have done a lousy job so far.*

In contrast, industry spokespersons have argued that labeling would be seen by consumers as a warning about dangerous substances. Economists at the USDA noted that economic theory also argues against food labeling of this sort (Golan *et al.*, 2000). But evidence from numerous surveys shows that US consumers overwhelmingly want GM-food products labeled as such. Indeed, in one recent national study, an astonishing 92% of respondents were in favor of such labeling (Wimberley *et al.*, 2003). Rarely is such a level of consensus found on any issue. Mounting campaigns to avoid labeling make it appear that the industry has something to hide. And, appeals to economic theory ignore the fact that labeling is as much about politics and public relations as it is about economics.

On the other hand, to date, no whole foods have been genetically modified. Genetically modified soybeans are largely used as ingredients in other food products, and are often unrecognizable to consumers. Most GM corn is used for animal feed, the rest for food ingredients. But, already, considerable concern is building around GM wheat, the release date for which has been delayed several times.

### *Finance*

The banking, finance, and investor communities have not been silent about GM foods. Not too long ago, when the future looked quite bright for agricultural

biotechnology, most of the major chemical/pharmaceutical companies had agbiotech units. In 2001, most of those units were spun off. Pharmacia jettisoned Monsanto. Novartis dropped Syngenta. These decisions were made in large part based on profitability. Compared to the bright future in pharmaceuticals, agricultural biotechnology looked rather unimpressive. Since then, Monsanto has stumbled with losses large enough to force the resignation of CEO Hendrik A. Verfaillie. Syngenta recently closed its Torrey Mesa Research Institute in San Diego, largely due to poor sales of its products. Several years ago, Deutsche Bank downgraded its ratings for agricultural biotechnology (Deutsche Bank, 1999). And, recently, the Innovest Strategic Value Advisors, an investment firm, issued a report suggesting that Monsanto was a risky investment (Brammer *et al.*, 2003).

### *Recent Developments*

Of late, the biotechnology industry has been leaning heavily on the US government to get European nations to stop their virtual ban on GM foods. In a rather bizarre turn of events, President Bush made the indefensible argument that there is a direct connection between the use of GM food and the elimination of hunger in Africa (Becker and Barboza, 2003). In point of fact, to date, no significant yield increases have been associated with GM crops. Moreover, the food crops that have been successful—maize, soybean, canola—are not widely grown in most developing countries. In addition, in many African nations, productivity is low because farmers have nowhere to sell surplus production, and United States and European Union subsidies keep world market prices depressed. Furthermore, hunger is largely dependent on lack of access to food, not on overall production figures. Indeed, as countless persons have pointed out, there is already more than enough food in the world presently to feed the entire population.

In addition to possibly leading to the collapse of the entire global trade edifice constructed painstakingly over the last decade, the effort is largely futile. In Europe, consumers have virtually no interest in buying GM foods, as food retailers there know that all too well. Indeed, one retailer, Iceland Foods, has developed an advertising campaign around the fact that its private label products are not GM (Iceland Foods, 2003). Other EU supermarkets, such as Carrefour (Carrefour, 2002) have banned GM foods from their shelves. The French chain Monoprix (2003) has a policy of replacing “products likely to contain GM organisms with existing substitutable products.” Still other firms, such as Royal Ahold (2003), insist on labeling. And, food processors are also sensitive about GM foods. For example, Heinz UK prohibits use of GM raw materials in their processed foods (Heinz, 2003). Thus, even if the United States wins at the Dispute Settlement Process of the World Trade Organization, the biotechnology industry will ultimately fail in its efforts to get Europeans to eat GM foods. The situation in Japan is hardly much different.



Moreover, US farmers have borne the brunt of the effects of consumer rejection of GM foods. The US share of the world soybean market continues to fall, in part due to consumer preferences in the European Union and Japan for non-GM varieties. One recent estimate puts yearly losses at \$300 million (Wolfson, 2003). Yet, most large farm organizations fail to recognize the first rule of marketing: give the customer what he or she wants.

Genetically modified wheat is nearing release in the United States and Canada, although its acceptance is far from certain. On the one hand, it is more than conceivable that domestic millers and bakers may reject it. After all, it poses new logistical problems for them. Some might argue that those who wish to pay a premium for non-GM wheat will compensate the millers and bakers for the extra costs of segregation (although it remains unclear whether adequate segregation is practical). This is certainly possible, but the magnitude of rejection of GM wheat is a large unknown. That means that, at least in the short term, millers and bakers might well be hit by heavy losses.

On the other hand, foreign buyers of US wheat appear far more skeptical. In February, in testimony to the Montana state legislature, Iowa State University agricultural economist Robert Wisner noted that thirty-six nations currently require labeling of GM products and that without some beneficial health implication, prices received for exported wheat are likely to decline to feed levels (Montana House of Representatives, 2003). In a related paper, Wisner (2003) noted that importers will be able to get non-GM wheat at much lower cost from other supplying nations, where expensive segregation is unnecessary.

Moreover, we would do well to remember that Eastern Europe was the center of world wheat production a century ago (Buller, 1919). That position ended as, first, Russia, and then most of the rest of Eastern Europe, were removed from the world market. Today, with re-entry into the world market, Eastern Europe once again has the potential to become a major competitor for the United States. Genetically modified wheat might be just the impetus necessary to bring capital investment to Eastern Europe to reestablish it as a major wheat-exporting region. This would cause wheat prices to fall by as much as one-third (Wisner, 2003). A Canadian research group has reached similar conclusions (Furtan *et al.*, 2002).

At the same time as the biotechnology industry has been struggling, the organic food industry has been growing by leaps and bounds. Organic food sales continue to increase rapidly. In the United States, they have doubled since 1997 to reach \$7.1 billion in 2001 and are expected to double again to \$14 billion by 2005 (Nutrition Business Journal, 2003). Although only a small percentage of total food sales, virtually every supermarket chain now has space dedicated to sale of organic products. In Europe the situation is even brighter.

Supermarkets specializing in organic foods, such as the Whole Foods chain, are doing very well, and many, if not, most major US food processors, including Heinz, Coca-Cola, Kraft, and Mars, now have an organic line. Gerber's, a wholly

owned subsidiary of Novartis, advertizes that its products are organic. The irony, of course, is that the biotechnology industry has been the subject of enormous government largesse and correspondingly high corporate research expenditures, while the organic industry has been, and remains, the stepchild of government- and industry-supported research.

## CONCLUSIONS: LESSONS UNLEARNED

So what lessons can be drawn for the agricultural biotechnology industry and for other industries desirous of public acceptance of their products?

- *Enroll all actors in the supply chain.* The secret of success in innovation lies not merely in getting the next actor in the supply chain to adopt your product, but developing a product that is viewed positively by all actors in the supply chain. This means that the product must, at the very least, not increase the costs—economic and otherwise—of downstream actors. Ideally, it should increase the benefits for every actor in the chain. Remember all those invisible sweepers out there!
- *Compete and cooperate.* While economic textbooks dwell on the virtues of competition, good management and marketing textbooks give equal weight to competition and cooperation. Adam Smith (1994 [1776]) might not have liked this as he was convinced that associations of all sorts were the enemy of the market. But history has proven him wrong. One only need glance at the *Encyclopedia of Associations* to realize that cooperation has a major role in organizing both our economy and society. Moreover, the encyclopedia does not even include the myriad strategic alliances, cross-licenses, and contractual arrangements that are a central feature of the modern business landscape. Competition without cooperation is usually a dead end.
- *Gain by sharing.* Trying too hard to capture all or the lion's share of the market is often a recipe for failure. At the very least, it creates enemies—enemies with political clout, deep pockets, a great desire to invent around whomever has control of the market, and lots of lawyers.
- *Regulate through the entire supply chain.* The current regulatory system is clearly a piecemeal affair. By avoiding public hearings and debate, by patching together a system using existing law, we have created a system that appears to constantly break down. In particular, it fails to recognize that GM organisms wind up where they should not be, either as a result of the normal processes of nature or through the all-too-human processes of production, processing, transportation, warehousing, retailing, and consumption. An effective regulatory system must take the entire supply chain into account.
- *One needs to line up all the ducks in order to effectively sell products.* All actors in the supply chain must both compete and cooperate. If any one

actor engages in behavior that inflicts damage on another actor, the aggrieved actor will surely attempt to block that behavior. Marketing of agricultural biotechnology products without considering this crucial point will continue to be an uphill battle.

Finally, I should note that holding innumerable debates about the pros and cons of agricultural biotechnology will not resolve the issues raised here, as long as the problem is framed as a lack of knowledge. As Les Levidow noted recently, “‘Public debate’ and ‘input from society’ are sought mainly as a means to restore the legitimacy of science and technology, not as a means to reconsider innovation processes” (Levidow and Marris, 2001). The future of agriculture cannot and should not be limited to a simplistic debate in which (1) one is either for or against what are in fact a wide range of new technologies, not all of which are necessarily desirable, and (2) other technoscientific trajectories are ignored, written off, or bypassed in a mistaken effort to find the one “true” solution to the problems of food and agriculture.

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