Understanding the Social Controversies over Agricultural Biotechnology

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Introduction

In sociology *social problems* are a subject of inquiry and teaching. That subject is a central aspect of any sociology curriculum at a higher education institution (Best, 2011). However, there is not a single definition of what constitutes a social problem. And, what is perceived as a social problem or not is highly subjective; that is, one person's social problem can be another person's solution to a social problem.

However, Dr. J.S. Mahoney of Virginia Commonwealth University (http://www.people.vcu.edu/~jmahoney/define.htm) argues that there are widely agreed upon criteria for whether a social problem can be said to exist. These are:

1. The objective condition must be perceived to be a social problem publicly. That is, there must be some public outcry. People must become actively involved in discussing the problem. Public attention becomes directed toward that social condition.
2. The condition must involve a gap between social ideals and social reality.
3. A significant proportion of the population must be involved in defining the problem. A large proportion of the population must be concerned about the condition—it must have national attention.
4. The condition must be capable of solution through collective action by people. If no solution is perceived to be possible, people will resign themselves to their fate.

From this perspective, the development and commercialization of agricultural biotechnologies (GM crops), or more specifically transgenic crops with herbicide tolerance or insect resistance traits, can be viewed as a social problem. I am not arguing these technologies are the cause of problems in society; rather, my point is that the intense debates

and campaigns in favor of or in opposition to these technologies rise to the definition of social problem a la Mahoney above.

It is inarguable that there is a lot of public attention on GM crops, whether the attention is favorable or not. Ballot initiatives to label GM crops have taken place in several states, including Hawaii, California, Oregon, Colorado, Vermont, and other northeastern states ((http://www.centerforfoodsafety.org/issues/976/ge-food-labeling/state-labeling-initiatives#). In addition, the geographic spread and numbers of people and amounts of money being spent on the initiatives, for and against, mean that conditions 3 and 4 are satisfied: the scope is national, and collective action is seen as a solution one way or another. Condition 2 is met because GM crop proponents see the technologies as largely beneficial to society, and opposition to them baffling or based in scientific illiteracy (Evenson, 2006; Faivre, 2015). Opponents, on the other hand, view the advent and deployment of the technologies as a highly controversial scheme to restructure the food supply for profit with dubious benefits, or even dangers, for society (e.g., Smith, 2003).

For these reasons, in this paper I will argue that GM crops can be viewed as presenting a potentially intractable social problem. Specifically, I hypothesize that

> *The development path of the agricultural biotechnology industry, including the novelty of the technologies, has resulted in rapid deployment and adoption, while at the same time created a strong resistance movement.*

That is, the very crop traits, industry structure, and regulatory approval process that have facilitated extremely rapid and extensive adoption have also created social and economic conditions and product characteristics that have engendered unease among consumers and others. This unease has proven to be exploitable by anti-GM groups attempting to develop negative images of the industry and the technologies.

To support this hypothesis, I first review the relevant court decisions that allowed and encouraged the use of utility patents in agriculture—an economic sector in which they had not been used extensively. Then I discuss the ramifications of the resulting structure of the life science industry, wherein the seed sector was integrated with the agricultural chemical sector. After this I argue that it might have been a strategic error on the part of the biotechnology industry to initiate commercialization with transgenic crops in which novel genes are introduced across species lines. This is followed by a review of the regulatory theories or frameworks of "Substantial Equivalence" and "Generally Recognized as Safe" (G.R.A.S.) that have governed the federal government approval process. Finally, a discussion of how opponents and proponents frame debates over GM crops and a discussion of several possible outcomes are presented.

Court Decisions and Intellectual Property Regimes

Ananda Mohan Chakrabarty, a molecular scientist working for General Electric, requested a patent on a bacterium that was designed using molecular techniques to dissolve crude oil and was intended to treat oil spills. His request was rejected by a patent

examiner, because living organisms were not legally defined as patentable materials. Chakrabarty appealed to the Board of Patent Appeals and Interferences, but it agreed with the original decision.

Chakrabarty then appealed to the United States Court of Customs and Patent Appeals, and it ruled in favor of his position. The appeals court held that living organisms were like any other invention. Sidney A. Diamond, Commissioner of Patents and Trademarks, appealed to the Supreme Court. The Supreme Court case was argued on March 17, 1980, and decided on June 16, 1980. In a 5-4 ruling, the court ruled in favor of Chakrabarty and upheld the patent, holding that:

> A live, human-made micro-organism is patentable subject matter under [Title 35 U.S.C.] 101. Respondent's micro-organism constitutes a "manufacture" or "composition of matter" within that statute.

The majority focused on language in the original patent act that seemed to provide extremely wide coverage. In addition, as late as 1952 Congress had confirmed this interpretation by decreeing that patents could be granted for "anything under the sun" (Jasanoff, 2008; Welsh, 2009a).

The minority argued in its dissent that Congress had specifically taken up this issue through the establishment of the Plant Patent Act of 1930 and the Plant Variety Protection Act of 1970. If the original patent act had covered living organisms, then Congress would not have been required to enact separate legislation for agricultural innovations such as improved crop varieties. Critics of the majority's opinion argued that the court would have been on firmer legal ground if it had decided that the human invention had changed in such a way that Thomas Jefferson's original notion of intellectual property and patentable matter was out of date (Jasanoff, 2008; Welsh, 2009a).

In any case, the decision held that a genetically altered microorganism can be patented. Though there was relevant earlier case law regarding plants, bacteria, etc., prior to Diamond, the general interpretation was that altered natural organisms that were no longer living could be patented (Pease, 2004 [1989]). This decision, and the subsequent J.E.M. Ag Supply versus Pioneer HI-Bred, gave plant patent applicants the option of seeking utility patents under 35 U.S.C. § 101 to protect a novel variety. J.E.M. Ag Supply versus Pioneer HI-Bred clarified things by holding that the earlier Plant Patent Act of 1930 and the Plant Variety Protection Act of 1970 did not preclude patenting of seeds and plants (Pease, 2004).

The decisions increased the incentive to research, develop, and commercialize biotechnologies, including agricultural ones. They provided a huge boost to the agricultural biotechnology industry, as firms could protect their inventions or intellectual property with patents. This is because utility patents offer broader protection than the Plant Patent Act of 1930 and the Plant Variety Protection Act of 1970. The Plant Patent Act applies only to asexually reproduced and non-tuber-propagated plants; and the Plant Variety Protection Act allows a farmer privilege (farmers can save and replant seeds) and a broader research exemption than exists currently (Glenna et al., 2015; Pease, 2004).

Commercial Impacts and Industry Structure

The court decisions noted above were extremely critical building blocks for the biotechnology or life science industry. I argue they made possible the current development trajectory of the biotechnology industry and its tremendous impacts in the agricultural sector. Specifically, patenting provided sufficient protection for agricultural chemical firms to finance a shift to a life science orientation—essentially, a shift to an integrated pesticide and seed sector. Chemical firms purchased seed companies to use seed intellectual property as the vehicle for delivering transgenic technology in agriculture (Ervin et al., 2000). This shifted the seed industry from dispersed ownership, with lots of small firms, to more concentrated ownership, with a few firms controlling the industry.

Indeed, St. Louis–based Monsanto Co. was not a seed firm until after the Supreme Court decision and now is the world's largest seed firm. And the chemical firm DuPont purchased the largest seed firm Pioneer HI-Bred. The concentration ratio of the top four firms in the newly formed seed industry is over 60%, with Monsanto controlling over 25% (http://www.etcgroup.org/putting_the_cartel_before_the_horse_2013; see Table 1). A top-four ratio of 40% and one firm controlling 25% are generally considered to define a concentrated sector. The concentration in the biotechnology industry, combined with the seed and pesticide industries merging to a large extent, has had a number of important ramifications. It has made the biotech industry a target for critics such as the ETC Group, which points out its cartel-like nature. Farmers are said to be at a disadvantage, especially given the use of utility patents in place of the less restrictive intellectual property regimes used historically in agriculture (http://www.etcgroup.org/putting_the_cartel_before_the_horse_2013).

Others have pointed to the potential to increase herbicide (especially glyphosate) use in agriculture through the commercialization of herbicide-tolerant crops. And concerns have been raised regarding environmental risks from development of resistance to glyphosate and the soil bacterium *Bacillus thuringiensis*, engineered into corn, soybean, and cotton, because of the very large acreages on which the new technologies have been planted (Ervin & Welsh, 2006).

TABLE 1: Concentration in the Seed Industry, 2013

Rank	Company	Seed Sales ($US mil)	% Market Share
1	Monsanto	8,953	26.0
2	DuPont Pioneer	6,261	18.2
3	Syngenta (Switzerland)	3,185	9.2
4	Vilmorin (France) (Groupe Limagrain)	1,670	4.8
	Total (CR4)		60.2

Source: ETC Group.

Novel Technologies and Permissive Biosafety Regulation

In addition to industry structural arrangements, the nature of the technologies themselves combined with the regulatory theories employed to review them prior to commercialization have created opportunities for critics of GM crops.

A transgene is genetic material (DNA) that is inserted via gene splicing techniques *across species lines* into the genome of a host organism's cell. And a transgenic agronomic crop is one containing novel DNA derived from an organism other than the parental seeds or in addition to the parental genetic material. The foreign DNA is incorporated early in development and is inherited by offspring in Mendelian fashion (Ervin et al., 2000; Kindt et al., 2015). Conventional breeding methods did not attempt to move genetic material across species lines. For example, using conventional plant breeding methods it is not possible to insert a soil bacterium into a crop plant such that it is manifest through the plant parts. Therefore, transgenic crops are novel technologies and likely to be of interest to consumers and others. This remains true for now at least, despite the recent finding by Kindt and colleagues (2015) that horizontal gene transfer of agrobacterium DNA has occurred without direct human intervention in sweet potatoes and probably other agronomically important crops. However, we were familiar with this mechanism previously, since we used it to deliver insect resistance and/or herbicide tolerance traits to soybean, corn, cotton, and canola.

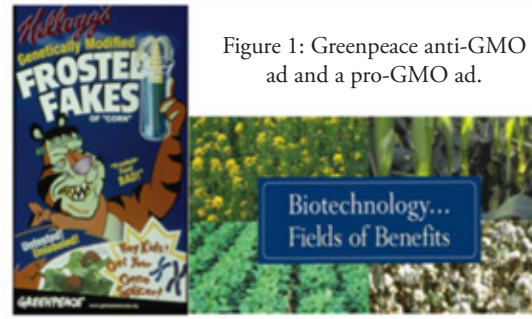

Figure 1: Greenpeace anti-GMO ad and a pro-GMO ad.

Indeed, there are other techniques to engineer crop varieties to manifest novel and potentially useful traits that are closer to conventional methods (Ervin & Welsh, 2006; Nielsen, 2003). For example, cisgenic (also intragenic) techniques might have been a more strategic approach. Cisgenesis refers to organisms that have been engineered using a process in which genes are artificially transferred between organisms that could otherwise be conventionally bred. Unlike in transgenesis, genes are only transferred between closely related organisms. A few food products engineered through cisgenic techniques are in the early stages of commercialization. And some preliminary studies look at consumer attitudes toward cisgenic crop products (Delwaide et al., 2015; also see Nielsen, 2003, for a discussion of types of transformations).

The reaction of consumers and groups that have been active in opposition to GM/transgenic crops to cisgenic crops will be interesting to see. It may be more difficult to mount campaigns based on the strangeness and novelty of the technology if it involves closely related organisms. In addition, if the findings by Kindt and colleagues (2015) are replicated widely and gain traction, it may become more difficult to campaign against transgenic crops.

However, it is clear that opposition groups have been very successful to date in exploiting the novelty of transgenic techniques to push consumers away from GM crop products (www.greenpeaceusa.org/; see Figure 1).

One reason is that critics see the US principles of substantial equivalence and generally recognized as safe as inadequate to regulate the novel technologies. Substantial equivalence means that if GE food is characterized as substantially equivalent to its "natural" antecedent, it can be assumed to pose no new health risk; GM crops are mostly the same as conventional crops, so they are treated this way by the regulatory process (Welsh, 2009b). In addition, under G.R.A.S. protocols, if a substance is generally recognized as safe under conditions of its intended use among qualified experts, it is not subject to premarket review as a food additive by the FDA, which would trigger more exacting safety testing (see http://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/default.htm). So for example, since *Bt* is used as a foliar spray in organic agriculture and is considered to have low mammalian toxicity, it is considered safe if engineered into corn and manifested through parts of the plant. That is, *Bt* is generally recognized as safe whether a foliar spray or a transgene. I argue that the perceived novelty of the GM/transgenic crops to date, combined with the use of non-novel regulatory regimes, provide rhetorical raw material to anti-GM groups.

Rapid Adoption and Resulting Push-Back

The commercialization of transgenic crops has resulted in rapid adoption globally (http://www.isaaa.org/). This is a result of the resources concentrated in the life science sector and the global reach of the firms in it as well as the popularity of transgenically derived traits among farmers. In addition, the restrictive patent protections and permissive regulatory environment have incentivized firms to move the required technologies forward and invest heavily in their success. However, I argue that these same conditions and circumstances have also created an increasingly successful backlash and resistance movement against the technologies. This is due in part to the ability of anti-GMO groups to cast in a negative light both the new technologies and IP regimes and the transformed seed industry's resulting concentration and integration with the pesticide industry. In addition, these same groups have been somewhat successful in painting the regulatory regimes employed as ineffective and as catering to the life science firms (e.g., Smith, 2003).

However, I also argue that the development path and commercialization strategy of the firms in the life science sector prevent meaningful and rigorous public debate and input. Environmental and other groups and individuals believe themselves to be frozen out of the process and do not trust the major players in the life science sector because, at least in part, of their involvement in the pesticide industry—a frequent target of environmental groups. For example, in the Chakrabarty v Diamond decision the dissent focused on the lack of provision for Congress to weigh in on such an important policy decision with far-reaching economic and social implications (Jasanoff, 2008; Welsh, 2009a).

Faced with these circumstances, groups suspicious of the new technologies began campaigns against them. Anti-biotech groups employed provocative symbols to turn

consumers away from the technologies (see Figure 1). Such campaigns are not peculiar to anti-GMO groups. In fact, they have become a common method of influencing policy when access to formal institutions such as Congress, the executive branch, and the courts are not available or have proven ineffective (Rosenbaum, 2013).

As discussed earlier, the campaigns have been successful in creating support among the general public for labeling GMO ingredients and have resulted in some state-level policies supported by anti-GMO groups and opposed by industry (http://www.centerforfoodsafety.org/issues/976/ge-food-labeling/state-labeling-initiatives#). In addition, industry has responded with its own public relations campaigns and attempts to pass legislation at the federal level to undercut state labeling laws (http://coalitionforsafeaffordablefood.org/). Each side in the debate attempts to convince policy makers and, especially, food consumers of the legitimacy of their arguments and the poverty of the opponents' arguments. In sociology, this type of social action is called "framing."

Framing is an action-oriented set of beliefs and meanings that inspire and legitimize activities and campaigns (Clapp & Fuchs, 2009). Anti-biotech groups have a shared frame. Their frame emphasizes lack of data on the safety of consuming GM foods, lack of sufficient regulations from the EPA, FDA, and USDA, and biodiversity loss due to negative impacts on non-target plants and animals (Welsh & Ervin, 2006).

Life science firms and most scientists and policy makers also have a shared frame for agricultural biotechnology. This frame emphasizes increased food security and environmental sustainability, less pesticide use, higher yields, and increased nutritional intake (http://coalitionforsafeaffordablefood.org/; and see Figure 1).

The result is a polarized dialogue, especially in the United States. What is needed is greater social consensus around technological change in the food and agricultural sector (Welsh & Ervin, 2006). This consensus will probably not be obtained through the current conflicting strategies of industry and anti-GMO groups.

Discussion and Conclusions

The development path and commercialization strategy followed by the life science industry was economically rational and very effective, resulting in rapid commercialization and adoption by farmers in the US and elsewhere (isaaa.org/). At the same time, the structure of the emergent life science industry and the perceived novelty of its technologies and IP regimes, coupled with a permissive regulatory theory, created the conditions for an effective anti-GM food campaign. At this point the outcome is unclear. If GM foods are labeled, will consumers listen to anti-GM rhetoric and turn away from them? If this occurs, GM technology might become largely irrelevant. However, it is also possible that that most consumers will focus on price and product quality and not on traits such as genetic modification. If this is the case, then consumers wary of GM foods will drive the demand for organic and other non-GM food, and the dominant issue will become coexistence. Can we develop policies and a reliable infrastructure whereby GM foods and non-GM foods can serve their respective constituencies?

Another approach would be to engage in meaningful dialogue around the salient issues. For example, industry might consider acquiescing and reverting to more traditional forms

of IP protection, such as Plant Variety Protection Certificates (see Ervin et al., 2000). In addition, to bolster public confidence and allay concerns, GM crops, at least in the short term, could be regulated under a food additive regime (http://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/default.htm). This would trigger additional food safety testing, which would raise costs but might produce longer-term sustainable economic and social benefits. These types of suggestions may appear to be far-fetched or nonstarters. However, given the effectiveness to date of anti-GM food groups in influencing public opinion, it could be time for industry to try a different strategy than PR campaigns and flexing its legislative and policy muscles.

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Figure 1: Greenpeace anti-GM food cartoon and pro GM food advertisement.

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