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Review

Epistemic brokerage in the bio-property narrative: contributions to explaining opposition to transgenic technologies in agriculture

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Unlike some global contentions – abolition of slavery, or universal franchise, for example – the rift over rDNA crops is not about ultimate values. Improvement of farmer welfare and enhanced sustainability of agriculture are universally valued goals. However, means to those ends are politically disputed; that dispute depends on alternative empirical stories about biotechnology, sometimes even alternative epistemologies. Opposition revolves around two fundamental dimensions: bio-safety and bio-property. There is convergence of these dimensions around exceptional risk and vulnerability to corporate control of farmers, but these are analytically separable questions of fact. This paper concentrates on bio-property. Epistemic brokers have successfully established knowledge claims that simultaneously undermine the case for rDNA technologies as potential contributors to development and motivate opposition. Epistemic brokers command authority from their positions at junctures of networks, enabling the screening, weighting, theorizing and diffusion of contentious empirical accounts. In contentions of low information, high information costs and diffuse anxiety, these claims provide cognitive support for opposition to 'GMOs'. Specifically, claims of patents, monopoly corporate control and terminator technology have diffused to and from India in global networks. Though effective in transnational advocacy networks, these claims have proved either false or inconsistent with dynamics on the ground.

Contents

Global rifts and rival networks: the 'GMO'

Transgenic cultivars have spread widely, rapidly but unevenly around the globe [1]. Simultaneously, and reciprocally, networks opposing biotechnology have succeeded in much of the world in limiting or blocking transgenic crops. Much of this success has come from diffusion of powerful knowledge claims around bio-safety and bio-property. These two strands are linked in global resistance to a special construction of agricultural biotechnology: the 'GMO'. The GMO is political shorthand for any agricultural product involving recombinant DNA (rDNA) techniques; its success as a cognitive frame is such that even proponents of genetic engineering in agriculture accept this political terminology. The frame does not apply to rDNA techniques in pharmaceuticals,

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medicine or industry, where transgenics have been globally accepted [2]. Unlike control of international air traffic or infectious diseases, no authoritative knowledge provides consensual norms for products of genetic engineering [3], nor is there any consistent property regime across nations. In this unsettled policy space, intermediaries of knowledge or what I will call epistemic brokers, played a significant role in creating, energizing and sustaining opposition to transgenic crops. Within networks and between networks, intermediaries translate information into terms conducive to political action.[1]

A primary function of epistemic brokers in oppositional networks is to find, ratify and diffuse information that evokes anxiety in mass publics and among public authorities. On the bio-safety strand of this construction are issues such as deaths of livestock from consumption of transgenic crop refuse. For example, reports from NGOs in South India indicated that sheep, then cattle, were dying from ingestion of cotton leaves containing the cry1Ac protein [5–7]. Other stories involve allergenicity, sterility, cancer and a wide range of calamities linked causally to transgenic cultivars. On the bio-property strand, a prominent story has been that of mass suicides of farmers growing Bt cotton in India. This widely distributed and credited narrative posits crushing debt incurred by purchase of expensive and dysfunctional transgenic cotton hybrids from a Monsanto monopoly. Such stories understandably evoke outrage from much of the world [8]. The Bt cotton story from India exhibits common features of the global bio-property narrative: patent control of seeds, monopoly pricing, dependency, debt and agrarian crisis exacerbated by agronomic failure of the technology. Claims of 'bio-serfdom' and 'bio-feudalism' mark the subjugation of the peasant to intellectual property regimes. This bio-property narrative is logically separable from but functionally related to critiques invoking bio-safety: if transgenic ss are novel enough to claim patent protection in some countries, are they not novel enough to be especially risky, to require special regulation and segregation? The single most politically efficacious culmination of this merger is the positing of Terminator Technology, or 'Monsanto's Terminator gene,' that renders second-generation transgenic seeds sterile. The terminator in theory would marry commercial control of bio-property by a multi-national corporation profiting from un-natural processes. Anxiety and outrage together drive a politics that has divided the world into GMO-accepting and GMO-free nations, counties, departments and farms.

Rival networks counter the claims of biotech opponents, typically offering science-based, peer-reviewed studies and wide farmer acceptance of transgenics as counter-weights [8]. Each network claims success. Some nations have approved [25 officially][2] or promoted biotech crops through the logic of the developmental state: China first and most vigorously. Many others prohibit these crops or regulate so heavily as to effectively ban agricultural biotechnology [9,10]. From initiatives in civil society, 'GMO-free zones' have been created around the world. Europe after 1998 has been the epicenter of opposition to agricultural biotechnology, but moratoria are contested globally – from India to California, Poland to Japan – often through diffusion of this spatial tactic. Table 1 indicates the growth of 'GMO-free zones' in Europe between 2007 and 2009.

TABLE 1

GMO-Free resolution signed by European Regions[a] by political unit: 2007 and 2009.

	2007	2009	% Change
Region	167	196	14.8
Provinces, Prefectures & Departments	53	93	43.0
Local Governments	4,278	4,567	6.3
Individuals	27,100	30,370	10.8

Source: www.gmo-free-regions.org. Accessed April 2009.
[a] The EU has specific designations of regions defined by the Assembly of European Regions (AER).

The remainder of this paper will seek to understand the contribution of the bio-property narrative to expansion of political forces for GMO-free space, resolutions, moratoria, laws and direct action. The burden of the argument is that the narrative offers empirical support for the notion that many innocent and powerless people are victims of biotechnology; stopping its spread then becomes a moral imperative. Given those facts, opposition follows naturally among other-regarding citizens at great distance from farmers' fields. There is no need to posit Luddism, or anti-science ideology; opponents are typically quite comfortable embracing new technologies and evoking the authority of science.

Market, developmentalist and catastrophic modes of bio-property

Political opposition to the GMO merged threat narratives of bio-property and bio-safety: threats to nature, in the form of 'biological pollution' (gene flow); threats to human health, in the form of allergens; threats to farmers, in the form of bondage to monopoly seed corporations ('bio-serfs', 'bio-feudalism') and threats to national independence, in the form of dominance of agriculture by multi-national corporations [11–17]. Intellectuals in the ex-colonial world made crucial contributions to theorizing genetic engineering as especially catastrophic for the universal valent of development [18]. These anxieties resonated with fears of neo-colonialism. Diffusion of this intellectual work was facilitated by international non-governmental organizations [INGOs] such as Greenpeace International and Friends of the Earth International. These INGOs carry considerable authority; their imprimatur ratifies authoritative knowledge, particularly in fields where complexity and distance from everyday experience limit access to information. They lead networks built on solidarity around widely accepted normative claims such as sustainability or justice.

What do these abstractions have to do with rDNA cultivars? It is the theoretical work of epistemic brokers to link GMOs to these universal values. Their success in making that linkage negative rather than positive was enabled by the high information costs surrounding molecular biology and the existence of an established cognitive path to anxiety. The bio-safety strand of opposition is

[1] See Mosse and Lewis [4] on theoretical origins and usefulness of the concepts 'brokerage' and 'translation.'

[2] The usual authoritative source is James 2008 and his ISAAA updates. James' data are criticized by opponents for reflecting pro-GMO bias. My critique is that the official data seriously understate diffusion of agricultural biotechnology for reasons of evasion – stealth seeds – discussed in the text. The number 25 does not, for example, include several countries where transgenics are known to be in use – Mexico, Vietnam, Thailand, Pakistan, Ukraine for example.

exemplified by evocation of un-natural acts and unknown consequences: 'Frankenfoods' summarize the narrative, but a wide range of risks is posited, from gene flow to allergenicity. Bio-safety brokers have been successful in diffusing alarming empirical accounts of biotechnology as risky business. Many of these accounts claim the authority of science [8,19].

The 'GMO' came to India, as to many countries, as a multi-faceted threat. Reciprocally, international brokers found that reports from the field in India confirmed their larger narrative of threat. A prominent example is biological catastrophe in the form of dead sheep – and then cattle – in Andhra Pradesh [5–7]. In parallel to bio-safety threats, claims about bio-property posed specific threats to an undifferentiated 'peasantry' in the poor world; much of this narrative was theorized to exclude GMOs from the frame of development, particularly for poor farmers. In India, accounts of farmer suicides caused by Bt cotton were presented to brokers in global networks for dissemination in support of international mobilization against agricultural biotechnology.

Bio-property entered the global rift in three modes: market, developmental and catastrophic. The market mode constructed transgenic plants as technological progress that comes with a cost, but a cost that is fundamentally open to free choice. Farmers can and will pay more for seeds if they believe that marginal revenue exceeds marginal cost. The analogy is Microsoft Word: you can choose alternatives, from pencil and paper to open-source processors – but Word costs money if you choose it. That is the normative structure; the reality is more complicated. For many years, enforcement of intellectual property claims in software in the US was lax, and in much of the world remains extremely lax. Few academics of my generation have not had 'pirated' software on their machines. The parallel in agriculture is clear: in market logic, farmers can buy or reject more expensive seeds just as businesses and individuals can buy or reject Microsoft software; their experience will lead to subsequent dis-adoption or re-purchase. And there will be unauthorized usage of the technology. Seed firms believe that enhanced utility will convince farmers to pay extra for transgenic seeds, just as they pay more for hybrid seeds: the financial bottom line will determine farmer choices. The mechanism is farmer experience in the field. Empirically, the market model receives some confirmation: benefits are in fact shared out across firms and farmers [20]. Were this not the case, it would be very hard to explain the diffusion of transgenic plantings in countries with strong property rights such as the US and Canada. The role of the state in this mode is to enforce contracts freely chosen among economic agents.

The developmental mode adopted by international institutions and academics qualifies the market version and assumes a more active state [21]. In the developmentalist understanding, transgenic seeds in poor countries might prove problematic because of unequal access. Poor farmers and nations might need special institutional support and resources to participate in the 'gene revolution'. In this logic, technology fees and intellectual property matter greatly. Moreover, as in all developmentalist logic, intervention might become necessary because market failure is common; market forces are unlikely to drive the kind of research on the kind of crops that are of importance to vulnerable farmers. In the worst-case scenario, poor farmers might be disadvantaged by aggregate market forces generated by new technology, but have no voice in the matter. Poor farmers would lose if technology fees were prohibitive – and enforceable – and costs of production were subsequently reduced for farmers who could afford to pay fees. 'Farmers' as a class could still benefit, but poor farmers would be caught in a backwash of lower output prices because of increased yields on adopter-farms, but with no reduction in input costs or increased yields on their own farms [22]. Enforcement of intellectual property claims of multi-national firms would in this scenario accelerate concentration of land and the decline of small farmers. In the developmentalist version, then, intellectual property that raises costs or restricts access might redound to the disadvantage of the poor, whatever the success of the technology in the aggregate. The normative conclusion is that development policies and institutional change must anticipate these potentially negative outcomes; the public sector is likely to have an important role to play [23–26].

The assumption of both market and developmentalist narratives is that at least some biotechnology is agro-economically favorable for at least some farmers. The catastrophic mode rejects this proposition fundamentally. This logic escalates the cautions posited by developmentalists from inequality to disaster. In this line of reasoning, rDNA seeds are not valuable for agriculturalists of any size class or of any crop, but rather represent a path toward new forms of subjugation and agrarian crisis. There should be no institutional change to facilitate access to biotechnology, nor public investment in the technology. India was cited as powerful confirmation of the catastrophic logic: the 'failure of Bt cotton' on agronomic and economic grounds was widely accepted as established fact and decisive case in networks opposing globalization [7,13]. The primary epistemic broker in this development was Vandana Shiva, whose account illustrates the oppositional property argument in pure – and widely influential – form:

> ***'Pushed into deepening debt and penury by Monsanto-Mahyco and other genetic-engineering multinationals, the introduction of Bt cotton heralds the death of thousands of farmers. High costs of cultivation and low returns have trapped Indian peasants in a debt trap from which they have no other escape but to take their lives. More than 40,000 farmers have committed suicide over the past decade in India—although the more accurate term would be homicide, or genocide.'***

> ***'These seeds kill biodiversity, farmers, and people's freedom—for example, Monsanto's Bt cotton, which has already pushed thousands of Indian farmers into debt, despair, and death. Bt cotton is based on what has been dubbed 'Terminator Technology,' which makes genetically engineered plants produce sterile seeds.' [27, p. 86]***

In this narrative, there are no choices, no experimentation in the fields, no farmer choices, no institutional mediation, only compulsion and traps. Vandana Shiva's Biopiracy: The Plunder of Nature and Knowledge was published in 1997, before there was any legal transgenic in India; its themes provided the main frames for the connection between transgenics and bio-property critiques. Chapter One posits the mechanism: Piracy Through

Patents. Chapter Two throws down the rhetorical ethical gauntlet: Can Life Be Made? Can Life Be Owned? Dr. Shiva's over-riding concern with biotechnology is that it enables 'the control of agriculture by multi-national corporations [18, p. 91].' In the movement against transgenic crops in India, concern with intellectual property rights and corporate power was married to nationalist and cultural themes of self-reliance, nonviolence, local knowledge and biodiversity [28]. This narrative was accepted within a section of the Indian middle classes and intelligentsia; the resonance is powerful. But Dr. Shiva's accounts are important to the argument of this essay because of their empirical claims, which diffused though global networks opposing biotechnology.

The mechanisms in this argument are important. The bio-property catastrophe story – debt-driven pandemic suicides – depends on several strong claims. First, there is the claim that the technology does not work economically (high costs and low returns). Second, dependency is generated by the act of purchasing transgenic seeds (loss of freedom). This dependency is more than financial or contractual; property rights are enforced biologically via terminator technology. This claim is diagnostic: it contradicts two facts that would be largely unknown among citizens supporting anti-biotechnology networks. First, patents on plants are by no means universal; in the Indian case Dr Shiva analyzed, there were no patents on any plants, including Bt cotton. Second, the Indian case illustrated precisely why such property claims, even if they were to exist, would be very hard to enforce. By what mechanism would farmers be prevented from sharing, saving, back-crossing or producing transgenic seeds?

India's first transgenic cultivar: Bt cotton

The Government of India approved three Bt cotton hybrids with one genetic event (cry1Ac (MON 531 Event)), developed by Mahyco-Monsanto Biotech (MMB) for cultivation on March 26, 2002. This was the day after a rally of the Kisan (farmer) Coordinating Committee demanding de-regulation of Bt cotton. National civil disobedience was threatened by affiliated farmer groups if the Government did not approve transgenic cotton hybrids. In reality, approval was largely a fait accompli, as two large state governments with a large percentage of India's cotton area had already agreed to farmer demands and permitted Bt cotton cultivation – Gujarat and Maharashtra [28]. Stealth seeds had been growing for three years by the time of official approval. Bt cotton was not officially for sale until the cropping season of 2002–2003; by 2004 the area under official Bt hybrids came to 1,213,359 acres and increased to 3,212,300 acres by 2005; current [2009] estimates top 19 million acres. The area under illegal 'stealth' seeds was and is unknown precisely, but was in the early years of rapid adoption a high percentage of all transgenic plantings and remains a substantial presence in cotton fields [29].

Illegal variants of cry1Ac hybrids bred by farmers and legal seeds from MMB and its licensees dominated acreage in the early years [30]. By 2007 there were four genetic events[3] approved for insertion into hybrids, from three companies, one of which used the Chinese public-sector genetic material (Nath Biogene), one of which was developed by an indigenous firm in India (J.K. Agri Genetics Pvt. Ltd). This process continued with more firms, more hybrids and stacked-gene implementation. The number of approved hybrids increased to 281 by 2009. Beginning in 2009, a public-sector Bt cotton variety was legally being grown on small areas. This OPV was developed in the public sector precisely because of the interest of some farmers in saving seeds; saving and replanting hybrid Bt cottons was possible, and practiced in early years, but at the loss of hybrid vigor [31]. Estimates of coverage of transgenic cotton are necessarily imprecise because of the stealth-seed phenomenon, but Bt cultivars covered roughly 19 million acres or 80% of the total cotton area in India in 2008–2009. The single-gene [cry1Ac] version from Mahyco-Monsanto, implemented by numerous licensees, accounted for 12.7 million acres; another 4.5 million acres were under the newer stacked-gene technology [cry1Ac and cry2ab genes]. Implementations of Bt technology from JK Agri Genetic Ltd's alternate cry1Ac and Nath Biogene's 'fusion' gene technologies covered under a half million acres together. Harish Damodaran estimates that the remaining area – something like two million acres – was planted to illegal Bt hybrids [29], though no one knows real numbers.

These technological and property dynamics certainly undermine one leg of the bio-property narrative of monopoly and control. Intervention by state governments altered the other – market prices of Bt hybrids. An administered price reduced the cost of first-generation Bt seeds by 40–50% in 2007 [30]. The transgenic seed system has thus been quite dynamic: new genetic events, new firms, new licensees developing new hybrids, public-sector intervention in breeding and public regulation of the 'trait value' portion of seed prices. It is difficult to imagine how this process could be portrayed as one of monopoly and control. Nevertheless, for a time, something like a monopoly was conferred on Mahyco-Monsanto's Bt cotton hybrids, but not by terminators or property law. To the extent a temporary monopoly in transgenic cotton was operative in India, it was a function of the bio-safety regime, not bio-property.

In the early years of diffusion in India, the most successful cultivars were illegal implementations of Monsanto's cry1Ac transgene for insect resistance in cotton [31]. The rapid diffusion of Bt cotton in India began with these stealth seeds that neither the government nor Monsanto – nor the suicide seed coalition that Dr Shiva led rhetorically – discovered until a massive bollworm incursion in 2001 devastated the non-transgenic cotton in Gujarat state. This particular stealth seed – Navbharat 151 – was produced by Dr D.B. Desai's Navbharat Seeds of Ahmedabad. Dr Desai was subsequently dubbed 'Robin Hood' in the press for his act of undetected appropriation of Monsanto technology. The discovery of these stealth seeds was made not by the state, nor civil society in surveillance mode, but by Mahyco-Monsanto (MMB) trying to recoup their investment in cotton seeds and testing procedures. No property rights adhered to the Navbharat Seeds, but Robin Hood could be and was quashed for violation of the bio-safety regime – specifically the Environment (Protection) Act, l986, and Rules (1989) that

[3] The genetic events are (1) cry1Ac gene (MON 531 Event) by Maharashtra Hybrid Seeds Company Ltd; (2) cry1Ab-Ac gene (GFM cry1A Event) by Nath Seeds Ltd; (3) cry1Ac gene (JK Event 1) by J.K. Agri Genetics Pvt. Ltd; (4) cry1Ac genes (MON 15985 Event) by Maharashtra Hybrid Seeds Company Ltd.

regulate transgenic organisms [32]. The only transgenic cotton undergoing bio-safety testing to become legal was that of MMB. Banning NB 151 on bio-safety grounds left the field open to MMB to license their technology to other seed firms at high prices after farmers demanded and several state governments effected de-regulation of the cry1Ac hybrids. MMB was in effect empowered by bio-safety regulatory authority to operate as a monopoly in a nation with no patents on seeds. But the ban on Navbharat 151 simultaneously prompted emergence of a vigorous cottage industry in illegal Bt hybrids using the NB 151 germplasm in new combinations with new names: Agni, Luxmi, Rakshak, 151, Sunny, Kavach, etc. Had bio-safety institutions worked better, this underground market would have been suppressed, farmers would have had fewer and less attractive choices and MMB's de facto monopoly would have been strengthened.

Forcing Navbharat Seeds out of the cotton business for failing to comply with bio-safety regulations eliminated one (very effective) competitor to MMB. A cottage industry of transgenic Bt cotton was born, mostly in Gujarat [33–36], whereas the legal Bt seed market was left to Mahyco-Monsanto and its licensees from 2002 to 2006. The vigorous development of an underground Bt seed industry decisively refuted the terminator-technology narrative in the fields, but not in advocacy networks.

Bio-property in extremis: terminator technology

'Monsanto's terminator gene' provides an archetype of the political deployment of powerful intellectual property claims by epistemic brokers in networks. The claim was that a patented gene incorporated into Bt cotton had been brought into India through collusion of the Indian state (obtained with bribes) with Monsanto specifically and with a global neo-liberal regime more generally [26,32]. The terminator summarized in one construct the multiple threats of GMOs: the bio-cultural abomination of seeds that could not reproduce resonated with a narrative of corporate greed and acts against nature [37]. Though rhetorically robust, the story was untrue. How, then, could it become so widely believed and globally disseminated? I think the answer lies in the authority of epistemic brokers in networks of solidarity on topics with high information costs and potential anxiety. Network solidarity is built not on the truth value of factual claims, but on normative consensus around universal values.

The story of 'Monsanto's terminator gene' came to India through international networks, most proximately a Canadian NGO (Rural Foundation International, now ETC) through web communications. It was promulgated within India by networks centered on Vandana Shiva and the NGO Navdanya [28,38]. The terminator would in theory force farmers to return each season to buy new seeds – generating a biological dependence of farmers on firms unmatched by customary arrangements. More important symbolically, the venerable cycle of 'self-organizing' agriculture would be replaced by dependency and cash nexus dominated by patents. That India had no patents on plants would be largely unknown in networks where the patented terminator gene story about Bt cotton was promulgated. That the concept patent itself had not led to a completion of a biological invention, and is in some sense a public-sector technology – since it is jointly owned by the United States Government – is little known as well.[4] Moreover, few people would have known that the original Bt cotton germplasm had been crossed into Indian cultivars numerous times since the mid-1990s to produce viable seeds for field trials; presumably such crosses were not terminated – otherwise there could have been no field trials to protest. The narrative of Monsanto as alleged creator and owner of terminator technology provided a powerful condensation symbol: multinational, American, wielding an un-natural and exploitative technology. Real attributes of the firm's record were combined with a false attribution of property rights in genetically engineered sterile seeds. Together with Dow Chemicals, which 'brought us Bhopal and Vietnam,' Monsanto was accused of planning to 'unleash genetic catastrophes.'[5] In an arena of low information and high anxiety, symbolic appeals have extra-ordinary power [39].

Monsanto's representative in India rebutted charges of suicide seeds: 'Since the so-called terminator gene does not exist today in any plant in any country in the world, the question of its involvement in the field trials currently on in India does not arise.' Mahyco-Monsanto Seeds chairman BR Barwale noted publically that the seeds being tested had been approved by the Government of India's Department of Biotechnology for field trials and had 'nothing to do with the so-called terminator genes.'[6] Nevertheless, the notion of suicide seeds was deployed politically to link technology to intellectual property and ultimately to neo-colonial threats to the nation. Vandana Shiva and colleagues [16, p. 98] wrote:

> ***'Freedom from the first cotton colonisation was based on liberation through the spinning wheel... Freedom from the second cotton colonisation needs to be based on liberation through the seed... The freedom of the seeds and freedom of organic farming are simultaneously a resistance against monopolies... like Monsanto and a regeneration of agriculture... The seeds of suicide need to be replaced by the seeds of prosperity.'***

Terminator seeds were specifically banned by the Government of India in response to this movement, as announced in assurances in the Lok Sabha and Rajya Sabha, and via Office Memorandum No. 82-1/98 PQD, dated May 25, 1998. None of these assurances stopped the campaign against terminator technology.

The campaign targeting terminator seeds proved cognitively powerful. Even today, people all over the world firmly believe that

[4] The original patent was granted Delta and Pine Land Company, in collaboration with the United States Department of Agriculture's Agricultural Research Service – U.S. Patent 5,723,765 entitled 'Control of Plant Gene Expression,' on March 3, 1998 for a 'Technology Protection System (TPS).' Further USDA collaboration produced two more patents. Monsanto bought Delta and Pine Land in 2007 (United States Securities and Exchange Commission Form 8-K Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934, dated June 1, 2007). Despite its political prominence, terminator technology was not commercialized, due in large part to vigorous international protests. There have to my knowledge been no applications for field testing of this technology, nor has it been deployed it in any crop anywhere in the world.

[5] Press Release, Asian Social Forum [Hyderabad] Seminar, 2003, 'Beyond Bhopal and Bt.: Taking on the Biotech Giants.' Research Foundation for Science, Technology and Ecology. Delhi. January 4.

[6] Quoted in Dow Jones Agnet November 20, 1998; Sharad Mistry, *Indian Express*, 1998, 'Terminator Gene a Figment of Imagination: Monsanto Chief,' December 4.

farmers cannot save and replant 'GMO seeds', despite extensive evidence to the contrary [30]. The original import of Bt cotton seeds into India was one-hundred grams; there were by 2006 millions of acres under dozens of unauthorized transgenic cottons in the field.[7] Fallout from the decidedly unterminated cry1Ac transgene continues to reverberate through India's cotton sector. Though officially approved Bt hybrids increased from 3 in 2002 to 137 in 2007 to 281 in 2009, deshi (indigenous) Bt hybrids or Navbharat variants continued to circulate.[8] The extent of illicit seed diffusion is unknown; as prices of official seeds have come down dramatically, one would expect the stealth-seed market to recede, and anecdotal accounts indicate that this is happening. Underground seeds are less expensive, but entail greater risk, not of prosecution, but of adulteration. Dr K.R. Kranthi, a scientist with India's Central Cotton Research Institute made a hard estimate based on admittedly limited sampling:[9] 'On average, 28% of the illegal seed brands are non-Bt... Among samples collected and tested by CICR, only 26% of the Bt cotton was true first-generation hybrid, while 46% was contaminated with non-Bt cotton.'

These counterfeit seeds might account for some reports of Bt cotton failure: some farmers purchased seeds of dubious parentage labeled as Bt but did not get the insect protection of the transgene [30]. Not surprisingly, among the first demands of farmers is some system of reliable seed certification.

The terminator hoax so decisively disconfirmed on the ground in India continues to circulate in other countries on the authority of reports from India, largely through the international campaigning of Indian opponents of agricultural biotechnology. This persistence is important because the narrative of a global tyranny of monopoly and patent-controlled GMOs has proved inconsistent with facts on the ground, institutional evolution, farmer ingenuity and state institutional capacity.

First, property claims are not self-enforcing; states will be involved, one way or the other, by intervention or failure to intervene. Monsanto has expended great energies trying to collect technology fees from farmers in Latin America, with spotty results, having failed to obtain a patent from Argentina for glyphosate-resistant soy in 1995.[10] High prices of Monsanto's Bt cotton in India, enabled by government regulatory restrictions, spurred development of the stealth alternatives and eventual emergence of legal competition. Globally, some transgenes have spread so widely underground that they resemble open-access or open-source technology, more Linux than Microsoft.[11] Politics also modifies what corporations can do in markets. Collective action in India demanded a ban on Mahyco-Monsanto's three legal hybrids, and succeeded in one state (Andhra Pradesh); compensation for crop failure unrelated to the transgene was paid by MMB at the insistence of the state government. Continuing resistance to high prices in Andhra Pradesh compelled the state government to pursue a case before the Restrictive Practices Commission (MRTPC) in 2006 [30]. The state government eventually won its case and fixed a price ceiling on transgenic cotton seeds (Rs. 750 per 450 g packet) and ordered all seed companies to abide by its administered price for a 'trait value'. Other state governments then fixed prices at the same level, a reduction of some 40–50% of the purchase price at seed shops. Even in strong property regimes such as the United States, Monsanto is forced into admittedly undesirable publicity to collect technology fees.[12] Strong manifestations of intellectual property have not proved practicable in many countries for reasons of transactions costs, politics and law [41]. Global monopoly power of multi-national property in biota is difficult to find on the ground.

Though enforceable bio-property seems elusive, bio-safety regimes have to some extent provided an alternative route to corporate power in agriculture. Strict control and testing regimes raise costs of seed development beyond what is affordable by small firms, enhancing the power of deep-pocket corporations. Indian farmer and seed organizations have charged that bio-safety officials colluded with Monsanto to give its seeds alone the status of approved hybrids, forcing everyone else to license the technology from Monsanto or give up a rapidly expanding transgenic market. There were demands for regularization of illegal transgenics, especially Navbharat 151 – the original stealth seed – and especially in Gujarat state, where it was first produced. Nevertheless, most seed firms with serious cotton markets chose to license technology from Mahyco-Monsanto, even at prices they considered extortionate.[13] Nor is there evidence of a super-profit gold-mine in biotech dominance. Private firms have been decreasing their investments in agricultural biotechnology, whereas public-sector institutions in low-income countries are increasing investment [42]. Pray and Naseem [20] concluded from their analysis that the

[7] No one knows precise numbers. Data from Navbharat Seeds, progenitor of the first and most successful of the underground *Bt* lines, and parent to most, puts sales at 52.45 *lakh* packets of illegal *Bt* cotton for *kharif* 2005, enough seed cotton to plant 5.245 million acres, or roughly 25% of India's cotton acreage (pers. comm.). Legal *Bt* sales were simultaneously increasing rapidly as well. Conversations with seed producers in Gujarat suggest more stealth seeds than figures from Delhi, but the precise acreage remained unknown, since farmers produced *Bt* hybrids on their own farms and some still used transgenic F2 seeds [31,32,34,36,40].

[8] The highest yield report I found – by accident – in Warangal district in 2006 was 15 quintals/acre from an unmarked package of loose seeds known only as 'Gujarat Bt,' almost certainly a descendent of the Navbharat 151 line so popular with farmers [41].

[9] On 'duplicates' and counterfeits, as opposed to genuine Bt stealth seeds, see Herring and Kandlikar [30]. For Kranti's perspective, http://www.scidev.net/en/features/gm-in-india-the-battle-over-bt-cotton retrieved April 3 2008.

[10] I recently received a communication from Argentina stating that 80% of the soy is illegal. This is significant because Argentina denied Monsanto a patent for glyphostate-resistant soy in 1995, resulting in the spread of stealth transgenic soy all over South America, most egregiously Brazil [41].

[11] Pray and Naseem [20] note that descriptions of many proprietary laboratory technologies have been published. Moreover, '[S]ome genes are in commercial use and can be obtained through reverse engineering, and some techniques have made their way to developing countries by way of unauthorised routes'. Patents either cannot or have not been obtained in many – perhaps most – low-income countries, and are unenforceable in others.

[12] Monsanto states: 'Since 1997, we have only filed suit against farmers 138 times in the United States. This may sound like a lot, but when you consider that we sell seed to about 250,000 American farmers a year, it's really a small number. Of these, we've proceeded through trial with only nine farmers. All nine cases were found in Monsanto's favor.' http://www.monsanto.com/monsanto_today/for_the_record/monsanto_farmer_lawsuits_followup.asp accessed 10.26.09.

[13] Interviews with seed company officials in Gujarat in 2005 first laid out this logic for me.

primary beneficiaries of increased farm revenues to date are not multi-nationals, but farmers and consumers, even in countries that enforce strong intellectual property rights.

Monsanto had no patent in India for the Bt seeds but, with its partner Mahyco, it did have the only technology legally approved by the national bio-safety authority, the Genetic Engineering Approval Committee. Approval came only after lengthy and complex testing procedures. These facts are largely unknown outside specialized knowledge communities. Therefore, reports of epistemic brokers in media-connected networks substituted for knowledge that otherwise incurs high information costs. It is difficult, and time-consuming, to track patent law in numerous countries. More difficult is to assess claims about terminator technology without first some reading in molecular biology. Contrary to the easy assumption of monopoly and control, intellectual property in seeds has generally proved difficult to claim or enforce in much of the poor world, for understandable reasons [41]. Farmers seem not to differ fundamentally from other citizens; opportunistic appropriation of technology has been common in films, pharmaceuticals, music and software [43]. Moreover, there are alternatives to private ownership of biotechnologies. In some countries – most notably China – public-sector research and firms have been important [42]. Public-sector universities have produced important breakthroughs – for example, the ring-spot-virus-resistant papaya [44,45]. Humanitarian use transfers offer an institutional alternative to private property, as developed in pro-vitamin A 'golden rice' [9,46]. Epistemic brokerage within networks shields partisans from these contradictions in the narrative of monopoly and control, just as cognitive and physical distance shields them from questioning reports of biological disasters such as dead sheep in remote villages of South India [6,7].

Transnational opponents of genetic engineering built their critique in part on the presumed monopoly power of multinational corporations, with a parallel critique of bio-piracy enabled by the genomics revolution in biology [18]. When the BBC characterized the small Indian firm Navbharat Seeds' appropriation of Monsanto's Bt cotton gene as 'bio-piracy,' the tables were turned. The assumption that genetic flow can move only from South to North proved problematic. Moreover, the episode of Navbharat Seeds and subsequent pocket breeding in Gujarat illustrated concretely that only a deep urban cultural bias can construct farmers as incapable of agency. Why should farmers be incapable of the kind of agency that makes the illicit sector in non-agricultural technologies so pervasive a global phenomenon? Business software and pharmaceuticals are widely appropriated against standing rules, but agricultural biotechnology is presumed to exert power beyond the agency of its users. Terminator technology offered in theory a plausible explanation for this otherwise condescending portrait of rural people: the 'monopoly' and 'patent' construction of corporate power presupposed an esoteric biological mechanism engineered into seeds. Genetic engineering could, in this view, enforce property claims that were politically and legally unavailable in most countries. How else could patents on seeds have power? But the terminator remains curiously on the shelf. Its political framing outran the technology; there is today no parallel in seeds to copyright protection built into DVDs, music and software.

The so-called T-GURT form of what has been called terminator technology would allow farmers to save seeds minus the transgenic trait [48], and would thus incur less opposition, while reducing the risk of gene flow. But the bio-cultural abomination of the terminator remains, evidently, politically untouchable. Though mass publics have (grudgingly) come to accept terminator-like controls in software, videos and music – with much resistance among the young – the biological expression of termination seems to cross some threshold of hubris and abomination. It could be that this evocation of the unacceptably un-natural exhibits decisive threshold effects, defining what Prince Charles called 'realms that belong to God and God alone.' But I doubt it. It might be that the real explanation is less culturally driven and more biological: perhaps the terminator, despite its international notoriety, simply would not work in the field.

Conclusion: why brokers have power

This paper has asked: what makes the threat narrative of GMOs so powerful internationally? It has argued that despite widespread consensus on fundamental values – farmer welfare and sustainable agriculture – knowledge claims in networks built on trust and solidarity have reinforced a global cognitive rift on biotechnology. It is not normative dissensus, as in the historic contentions over abolition of slavery or female suffrage, but rather contention around knowledge claims integral to those normative positions. These knowledge claims in turn fit into receptors in rival networks contesting genetic engineering in agriculture along two global rifts.

The primal global rift around genetic engineering is between agricultural crops and all other uses – such as pharmaceuticals and medicine. Agricultural crops alone have been segregated into an object of politics and governance termed 'GMOs'. This framing is ensconced in contentious politics, law and trade, whether or not the cultivars are used in food. A second, and logically derivative, global rift divides rival advocacy networks supporting and opposing GMOs – that is agricultural biotechnology. This rift is politically charged and administratively consequential; it hinges on two inter-related dimensions: bio-property and bio-safety. Global opposition forms around critiques of genetically engineered crops on both dimensions. New claims of intellectual property in seeds enabled by the genomics revolution in biology created conflicts over what can be owned, by whom, under what conditions, in which nation. Claims of novelty by firms seeking intellectual property reinforce a second dimension of contention: if novel, might products of genetic engineering raise special risks in comparison with cultivars bred by different techniques? Transnational advocacy politics succeeded in framing 'GMOs' as uniquely risky plants, with corresponding global soft law for special regulation. Farmers have responded to restrictions of both regulation and property claims with stealth strategies [41]. The widespread adoption of Bt cotton in India illustrates why and how evasion of both bio-property and bio-safety regimes is pervasive. Such grass-roots challenges to formal institutions embarrass both sides of the global rift; neither bio-property nor bio-regulations prove so robust as antagonists in advocacy networks contend. The Indian experience also uncovers a fundamental contradiction in mobilization to halt diffusion of agricultural biotechnology. Successful demands for stronger regulation of transgenics strengthen property-like rights

of multi-national firms that find it difficult to enforce their property claims in any other way. Bio-safety regulation can function as bio-property.

If this summary is roughly accurate, it identifies hypotheses for the conditions of politically powerful brokerage of knowledge. Testing these hypotheses would require much more than the case-study briefly sketched above. What the Indian experience suggests as conditions are: (1) networks for diffusion of empirical claims, (2) professionalization of cadres speaking on behalf of the silent, (3) spheres of cognitive distance from both participants and consumers, (4) high information costs, (5) solidarity based on normative consensus.

To illustrate these conditions, consider the narrative of livestock deaths in India. Americans found in 2006 an article entitled 'More on Mass Death of Sheep in India After Grazing in Genetically Engineered Cotton Fields' published by the Organic Consumers Association of Finland, Minnesota.[14] This organization campaigns for 'Health, Justice, Sustainability, Peace and Democracy.' Their source was the Centre for Sustainable Agriculture in Andhra Pradesh, as relayed via Mae-Wan Ho – a self-identified scientist – of the Institute of Science in Society in London. In her disclosure of this catastrophe, she linked dead sheep in Andhra Pradesh to allergenicity of Bt cotton in other parts of India and to deaths of humans from Bt maize in the Philippines.[15]

If this grisly account is accurate, remediation has a moral claim. No one can legitimately oppose 'health, justice, sustainability, peace and democracy,' nor can most people countenance the tragedy of poisoned sheep owned by very poor shepherds, much less deaths of humans in the Philippines. That the association is composed of 'organic consumers' conjures a realm of virtue and purity difficult to fault. Nor can one easily oppose the notion of 'science in society' promoted by Mae-Wan Ho's organization. The idea of embedding science in social processes and values of transparency, of commitment to public awareness and public goods, all seem unexceptional goals. The valence issues on which oppositional networks are based are universal; the empirical claims link specific technology to outcomes contrary to those values. This threat to universal values is what makes action against transgenics justifiable, indeed imperative. Moreover, the claims in this specific case have face plausibility. Their claim to authoritative knowledge is derived from two sources: indigeneity (reports of local villagers and civil society organizations) and science. Additionally, the cognitive distance is great: toxic leaves? allergens in Bt cotton? Remote villages of the 'third world'? But more daunting than cognitive distance are the information costs that would be incurred by trying to make a rational assessment: who are these civil society organizations? Who do they represent? Where does one find authoritative knowledge about the Warangal district? Does the cry1Ac protein have mammalian activity or not? The normative solidarity – being associated with like-minded people – around 'health, justice, sustainability, peace and democracy' is unexceptional; it forms the basis for trust. The empirical claims are contrary to these values, but cognitively inaccessible. As a consequence, trust selects for belief to maintain cognitive consonance: one seeks to keep values and knowledge compatible.

Granted, all citizens are aware of political interests in promulgation of propaganda. But GMO brokerage does differ from that in other advocacy networks. Human Rights Watch and Amnesty International, for example, rest their credibility on factual accounts that face intense scrutiny and refutation by interested authoritative sources: national governments. INGOs in this sphere strongly resist diffusion of erroneous claims, even to the distress of their supporters. INGOs involved with biotechnology work in a field in which cognitive distance of supporters from science and from agriculture is significant, and the possibility of decisive refutation of claims is remote. New technologies are especially susceptible to both framing and epistemic brokerage for valence and evaluation. Torture is inter-subjectively understood; how insecticidal proteins kill sheep is not. Because genetic engineering is cognitively distal, it requires interpretation, mediation by expertise: people who understand gene networks, gene flow, gene-use restriction technology (aka the terminator).

What citizens learn from epistemic brokers has political consequences. If local activists stand for poor farmers and sustainable development, and GMOs destroy farmers, their animals and their environment, campaigns against GMOs are imperative. Funders of NGOs likewise find action imperative when faced with compelling reports of livestock deaths, crushing patents, GMO-driven mass suicides. These outcomes violate universal values embedded in numerous global agreements – sustainability, development, equity – and thus motivate global collective action. The urgency generated by adverse reports from the field quite reasonably motivates remedial actions: mandatory labeling, moratoria, GMO-free zones and financial contributions to NGOs furthering these objectives. Contrary reports are treated skeptically as corporate propaganda, regardless of source – a link back to the bio-property dominance of corporations in the threat narrative.

Opposition to transgenic crops on grounds of bio-property thus finds resonance in mass publics, in parallel to opposition on grounds of bio-safety. Together these strands produce a coherent narrative for mobilization. But there is a deep irony in this theorization of GMOs. Intellectual property claims of commercial firms raise prices of official, approved transgenic seeds; costs of testing raise seed prices; bio-safety regulations restrict competition and options, weeding out small firms and less-experienced firms, as well as public-sector scientists with possible applications based on research findings [9]. Strong bio-property rights and demanding bio-safety regimes therefore together drive high prices of official transgenics and thus invigorate underground markets [30,41]. Both regimes drive farmers to seek illicit seeds whenever these provide agronomic advantages but are too expensive to buy or prohibited by law.[16] Bio-safety regulation sought by oppositional movements thus contributes to de facto bio-property monopolies, to which activists are opposed and to evasion of bio-safety rules by farmers, which activists see as imperative.

[14] The opposition 'organic' and 'GMO,' implying radically alternative approaches to valuation and knowledge, is itself useful for political mobilization, but lacking in sound logic; see Ammann [47].

[15] http://www.i-sis.org.uk/MDSGBTC.php accessed November 12, 2009.

[16] In nations where farmers have some political power, access to expensive seeds may eventually produce pressure on governments for administered prices, as in the case of Bt cotton in India.

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