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THE COMPLEX NATURE OF GMOS CALLS FOR A NEW CONVERSATION

An honest discussion of genetically modified organisms must move beyond narrow concepts of human health to the wider social and environmental impacts of engineered crops.

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BY MAYWA MONTENEGRO

THE GMO DEBATE is one from which I've kept a purposeful distance.

For one thing, it's an issue that has already garnered more than its fair share of attention. For another, when you consider that many domesticated crops resulted from seed irradiation, chromosome doubling and plant tissue culture — none of which are genetically engineered — the boundaries of "natural" are more porous than they initially appear.

But I study seed science and policy, in which genetically engineered organisms — more often referred to as genetically modified organisms, aka GMOs — are pervasive, so it's an issue I cannot ignore. Most recently, the director of a science communications program asked if I could engage her students on a few topics: Is there a scientific consensus on GMOs? How is the media doing when it comes to covering biotech in the food system? Where are the biases and blind spots in reporting?

Swapping emails, we discussed the retraction of a study on "golden rice,"[1] a Slate feature calling the war against GMOs "full of fearmongering, errors, and fraud,"[2] and the infamous tangle among Vandana Shiva, David Remnick and Michael Specter in the aftermath of "Seeds of Doubt,"[3] a critical *New Yorker* profile of Shiva's crusade against genetically modified crops. (Read Shiva's response[4] to the profile, and Remnick's counter response.[5]) Anyone who examines these stories will appreciate the thicket

of fact, interpretation and framing that makes the GMO terrain explosive.

Let me begin with a frank admission: I am a proponent of agroecology[6], food sovereignty, and the rights of farmers to save and reproduce their seed. But I am not anti-GMO. In agreement with my colleagues at various universities and non-governmental organizations, I believe that some GM crops could have some benefits. What I object to is a lack of complex evaluations of the technology, the overzealous selling of its benefits and the framing of cautionary skeptics as anti-science scaremongers. The tendency to treat GMOs in isolation from their historical, social and political contexts is also of no help: The technology was developed as a tool to enhance the scope and scale of industrial agriculture. I don't argue that GMOs cannot be — and never will be — extricated from that context, but that discussion is very different from the more common debate about health benefits or risks.

Why do the merits or demerits of GMOs grab more headline space than systemic food and agriculture concerns? Can we get past what Jonathan Foley calls the "silver bullet" and reductionist thinking[7] on this issue? As a molecular biologist turned science journalist turned social scientist, I've been puzzling over these questions for some 15 years. What I've come to realize is that GMO stories point to deeper struggles over how science is conducted, interpreted and deployed in the arena of "sustainable food."

The New Yorker, Slate, *National Geographic*[8] and numerous other media outlets have been part of an unfortunate trend in which GMO skeptics are framed as anti-science wing nuts. If scientists happen to work at an NGO, the credibility of the organization is frequently assailed — as if researchers outside the academy cannot provide intelligent critiques. To the contrary, organizations such as the Union of Concerned Scientists, Center for Food Safety and Pesticide Action Network support scientists whose research offers an invaluable supplement to academic work. In fact, they often are more willing to pursue "politicized" issues than university researchers who feel to do so would threaten their credibility or "impartiality." There are benefits to this precaution (we want to be as objective as we can be) but also considerable drawbacks, because it tends to deter scientists from considering the larger societal contexts of their research. That food and agriculture researchers are expected to wear the veil of value-free science is especially unfortunate now, when agribusiness is proving phenomenally successful at marginalizing its critics.

Though there are many angles from which to look at this issue, I think three are particularly important to help us get past less consequential aspects of this technology and on to things that are having a greater impact. The first is the construction of scientific consensus around GMO safety. The second is the framing of biotech benefits, which are often exaggerated. Finally, I think it's important to discuss the increasingly murky waters of scientist-industry-media relations.

What Is Safe?

"Good science" is often said to be based on strong scientific consensus, which, in turn, is a powerful statement about the use of rigorous methods and knowledge of science. Therefore, industry has a strong stake in demonstrating the existence of scientific consensus. Most people think of such consensus as emerging purely from objective studies of the natural world. But scholars of science and society argue that consensus is also negotiated and constructed through mechanisms such as conferences, expert panels, assessments of science and policy statements by scientific societies. When expert panels are assembled, for example, who is included — and excluded — can go a long way toward shaping what consensus emerges.

One needn't search far to find media narratives suggesting that the verdict is in: The vast majority[9] of scientists have forged robust agreement around GMO safety; there is no evidence that engineered foods are unsafe to eat. These tactics are reminiscent of those of Big Tobacco and Big Oil, but with an interesting twist. Whereas those groups primarily sought to inflate scientific doubt, in the case of GMOs we are told that the science is settled.

Yet no good scientist would be content with the "epidemiologically shabby construct that if there's no evidence something isn't safe, it must be safe," Tim Wise, director of the Research and Policy Program at the Global Development and Environment Institute at Tufts University, points out[10]. Scientific consensus on GMO safety simply doesn't exist.

The most up-to-date analysis I know of is a 2011 peer-reviewed report[11] that attempted to survey all studies available in international scientific journals on human safety impacts of GMOs. The researchers found that about half of animal-feeding studies conducted in recent years found cause for concern. The other half didn't, and as the researchers noted, "most of these studies have been conducted by biotechnology companies responsible for commercializing these GM plants."

> *"Safety," in sum, has been narrowly defined as human nutritional health, excluding many important safety dimensions and ignoring impacts on the larger agricultural, social and ecological systems.*

Importantly, this assessment — comprehensive as it was — only recognized the toxicological health risks to humans of ingesting GM foods. It did not analyze broader environmental and social impacts, which is where my primary concerns lie. These include overusing GMO-compatible herbicides, promoting the development of herbicide resistant weeds[12] and degrading habitats for biodiversity such as monarch butterflies[13]. Monoculture cropping frequently associated with GMOs brings a host of other concerns: loss of biological pest control (requiring more pesticides), reduced soil fertility (requiring more fertilizer), and strain on nutrition and food security when traditional crop varieties are displaced by GM varieties or contaminated by their pollen. And the combination of GM crops with patent protection has resulted in concentrated seed industry control[14] that has not only diminished public breeders' and farmers' access to germplasm, but also reduced crop genetic diversity, boosting vulnerability to environmental change.

Opportunity costs of pursuing GMOs should be a concern, too. Biotech tends to be expensive, and money spent there is not spent on research and development elsewhere. According to a University of California, Berkeley, review[15], over the past century, the U.S. Department of Agriculture has devoted less than 2 percent of its budget to agroecological and organic agriculture.

"Safety," in sum, has been narrowly defined as human nutritional health, excluding many important safety dimensions and ignoring impacts on the larger agricultural, social and ecological systems. These, to me, are far more frightening than any "frankenfood."

Lately, a few studies have begun to consider these broader dimensions, with troubling results. In March 2015, the World Health Organization reviewed the health effects of the herbicide glyphosate (aka Roundup) — designed to kill weeds without harming GM glyphosate-resistant crops — and decided it should be classified as "probably carcinogenic," meaning animal studies have demonstrated a definite link between cancer and exposure to glyphosate. There is limited but growing evidence of harm to humans — mostly in the form of studies of farm workers who are more highly exposed to the pesticide. (But, as a growing range of toxicological studies are demonstrating[16], exposure levels may not be as important as once thought, as low doses of chemicals, including pesticides, are being demonstrated as harmful to humans — not to mention the potential effects of compounding exposure to multiple chemicals.) In August 2015, the Guardian reported on a possible link between human birth defects and pesticides[17] applied to GM crops in Hawaii. The Fund for Investigative Journalism–sponsored article underscored that scientists don't yet have epidemiological data, but connecting the dots between incidence and exposure, researchers indicated ample cause for concern.

In the words of 300 scientists in a joint statement[18] published in the journal *Environmental Sciences* Europe last January,

> "…the totality of scientific research outcomes in the field of GM crop safety is nuanced; complex; often contradictory or inconclusive; confounded by researchers' choices, assumptions, and funding sources; and, in general, has raised more questions than it has currently answered."

Exaggerated Benefits

A second issue is hyperbole. Despite the fact that over the past 25 years, classical plant breeding in both the U.K. and the U.S. has generally been subordinated to molecular biological methods in terms of resources and attention, biotech advances have not materialized as initially prophesied.[19]

Take yield, for example. Testifying before the National Academies of Sciences[20] in September 2014, North Carolina State crop scientist Major Goodman observed that it's actually classical crossbreeding that continues to set the yield bar. In corn, he said, transgenics have made a roughly 5 percent gain in yields over the past 18 years, while standard breeding produces an estimated 1 percent yield gain annually.

Conventional breeding also appears to be outperforming genetic engineering in the race to develop crops that can maintain productivity in the midst of drought, extreme temperatures, salty soils and shifting pest regimes. A September 2014 *Nature News* article[21] describes the work of researchers from the International Maize and Wheat Improvement Center, or CIMMYT, in Mexico City and the International Institute for Tropical Agriculture in Ibadan, Nigeria, around the use of non-GMO methods to develop drought-resistant corn varieties in 13 African countries. In field trials, these varieties are matching or exceeding yields from nonresistant crops under good rainfall — and yielding up to 30 percent more under drought conditions. The project already has 153 varieties in trial stages, and other seeds are already well beyond trial stage,[22] enabling some 3 million smallholder farmers in Africa to increase yields by an average of 20 to 30 percent.

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Meanwhile, Monsanto, CIMMYT and other researchers are still hoping to get a transgenic drought-tolerant seed trait to Africa "by 2016 at the earliest." Even then, Monsanto's drought-tolerant seeds have been shown to increase yield only about 6 percent in the U.S.,[23] and only under moderate drought conditions. Direct comparisons are always tricky, of course, but as the Nature article put it: "Old-fashioned breeding techniques seem to be leading genetic modification in a race to develop crops that can withstand drought and poor soils."

I don't doubt that next-generation biotech methods — such as genomic editing[24]— will slowly make inroads where current biotechnologies come up short. But complex gene-environment interactions and traits defined by multiple genes — including yield and drought resistance — are reminding scientists that living systems are tough nuts to crack. The major successes of GM to date have all been single-gene tweaks, sometimes called low-hanging fruit. However, as Goodman told the academy, "They're not low-hanging fruit. They were things that were picked up off the ground."

The media often makes GM skeptics sound as though they are ignoring a gold mine of benefits — or worse, depriving Africans,[25] Latin Americans and Southeast Asians of biotech solutions to hunger. But to date, roughly 99 percent of GM acreage has gone to industrial soy, canola, cotton and corn for which the principal end-uses are biofuels, industrial animal feed, oils and ingredients for processed foods. In Foley's words,[7] "While the technology itself might 'work,' it has so far been applied to the wrong parts of the food system to truly make a dent in global food security." (For more on this topic, see anthropologist Glenn Davis Stone's "Golden Rice: Bringing a Superfood Down to Earth."[26])

Of course, there are exceptions: virus-resistant papaya and summer squash have had local benefits, and cassava has been engineered for resistance to brown-streak disease, answering to many critics' concerns that biotech will ignore regionally important,

smallholder crops. Yet even examples that are laudable in one sense (bye-bye, streak disease) require a hard look at ecological factors (why is streak a problem in the first place?) and the political and socioeconomic implications of an engineered solution. For example, as several west African countries prepare to allow GM cowpea to enter their markets, scientists are raising concerns[27] over effects on the informal seed sector, traditional barter and gift practices, and local economies. What is at stake is only partly about GMOs per se, since modified seeds might cross-pollinate with traditional cowpea. It is also about using engineered seeds, alongside favorable marketing, intellectual property and biosafety laws, to open food systems to private sector development without participation or consent from local people.[28]

Muddied Waters for the Media

So where does the media come in? To me, the Guardian's Hawaii story and others like it (e.g., Michael Moss's expose[29] of the U.S. Meat Animal Research Center) illustrate the importance of in-depth reporting. The agri-food space is not an easy beat, with the waters muddied by industry public relations campaigns, conflicting studies and heightened intermingling of science with corporate interests. Witness Eric Lipton's recent *New York Times* investigative report[30] detailing efforts by Monsanto, Dow and other companies to enroll scientists as spokespersons for GMOs to achieve "the gloss of impartiality and weight of authority that come with a professor's pedigree." The organic industry was also implicated, and a finger pointed to Charles Benbrook for receiving support from companies like Stonyfield Organic. However, *Times* readers (in the comment section) and academics (on email listservs) immediately bristled. It was an attempt, they said, to create a balanced profile without discussing the disproportionate nature of the practice: The biotech industry side has invested vastly more resources than the alternative side in corralling scientific support. In addition, Benbrook has consistently disclosed his backing publicly, whereas many of the industry affiliations are only coming to light because NGOs and journalists are requesting records via the Freedom of Information Act.

Scientists aren't the only ones being enlisted in the GMO wars.

While the *Times* story helpfully ignited a conversation over FOIA and transparency, it left underexplored the extent of industry-research relations. The few scientists named in the piece only hint to a larger network[31] of economists, consultants, lobbyists, industry executives and prestigious academics[32] with a deep history of producing peer-reviewed publications, influencing U.S. Department of Agriculture regulatory policy and working to defuse public concern over GMOs. Hardly a better example can be found than the Cornell Alliance for Science, formed in 2014 with a US$5.6 million grant[33] from the Bill & Melinda Gates Foundation to Cornell University to "depolarize" the debate over GM foods. Soon after, I saw an alliance job posting indicating the work would entail outreach to groups that "may not be well informed about the potential biotechnology has for solving major agricultural challenges." A colleague of mine joked that this sort of depolarization amounts to loading up one side with more ammunition.

Scientists aren't the only ones being enlisted in the GMO wars. Another strategy, according to a report[34] recently published by U.S. Right to Know, Friends of the Earth and author Anna Lappé, is the grooming of front groups that appear to be independent media sources and are frequently quoted in the press without reference to their industry ties. These groups include the Alliance to Feed the Future (which produces Common Core–compliant curricula on healthy food for public schools) and the U.S. Farmers & Ranchers Alliance (whose stated goal is "to enhance U.S. consumer trust in modern food production to ensure the abundance of affordable, safe food," and whose partners include the animal pharmaceutical company Elanco, biotech giant Monsanto, and chemical companies DuPont, Dow and Syngenta). Lappé estimates[35] that such third-party coalitions spent US$126 million from 2009 to 2013 "to shape the story of food while presenting the veneer of independence."

Such PR strategies are not new, but it's notable that they've surged at precisely the time when chemical-intensive farming, antibiotic use in livestock and genetic engineering are under intense public scrutiny. Journalists now need to critically evaluate not only the claims of bona fide scientists, farmer coalitions and hunger organizations, but also those made by deceptively named front groups. Some researchers may not even recognize the powerful sway of funding and sponsorships at institutional levels, or the politics of persuasion in elite inner circles. As New York University molecular biologist Marion Nestle argues,[36] a substantial body of literature exists on industry-funded science — much of it looking at the effects of pharmaceutical industry funding of medical professionals. This literature suggests that industry-sponsored research tends to produce findings favoring the sponsor's interests. Such conflicts are "generally unconscious, unintentional, and unrecognized by participants," but they are nonetheless there.

What I would like to pull out from this picture is something more subtle than corporate money corrupting impartial science. The key is learning to recognize that no science exists in a cultural vacuum. The very fact that certain scientific fields (such as molecular biology) are seen as more legitimate than others (such as organic farming and agroecology) grows out of longer-running social and political histories, institution-building and internal struggles for validation. "Fact" is far more densely layered than meets the eye.

What we do know is that since the 1940s, when World War II pesticide, herbicide and fertilizer technologies dovetailed with revolutions in hybrid seed and patenting, agriculture has increasingly moved toward simplified, intensive monoculture to supply multinational food companies with a steady supply of interchangeable ingredients. Surplus production has fended off the Communist Menace, underwritten the expansion of military-strategic interests under the guise of food aid, and extended the market reach of input suppliers, commodity traders, food processors and retail giants to economies from Papua to Plano.

It should come as no surprise, then, that science and technology conducive to these developments has gained clout among certain governments, industry leaders and funding agencies. When

those actors have the power to invest in particular research directions, build educational programs and forge science policy advisory networks, one paradigm — e.g., simplified farming systems + biotechnologies = feed the world — can easily gain traction over another. What comes to appear "normal" papers over what scholars Sheila Jasanoff and Brian Wynne call the co-production of science and political order that shores up the legitimacy of each.

This phenomenon is extraordinarily important for journalists to appreciate because it helps us see how reporting on food means not just weighing objective science against crank science, but teasing through science's sociopolitical contexts. Unless journalists are willing to tread into this space, polarization of the GMO debate will continue, and journalists will be helping ascribe wing nut status to anyone who challenges the status quo.

Building a Better GMO

What are the conditions under which GMOs might work more effectively? Can they be compatible with the needs of farmers, eaters and their communities, not only with the aims of corporations and biotech scientists?

We can start by broadening the conversation around human health to include social science and natural science perspectives, and encompassing the ripple effects of technologies packaged with GMOs. Farmworker health, rural indebtedness and ramifications for aquatic invertebrates, soils and the warming climate must be part of the picture.

Second, we can open the floor to engaged citizens and laborers across the food system. We can consider how GMOs affect not just yields, but also farmers' margins of return, food cultures and communities. We should listen to experiences of Bt cotton growers in India, Roundup Ready farmers in Iowa and academics who remind us[37] that many things once considered safe — DDT, PCBs, BPA and thalidomide, to name a few — later showed "scientific consensus" to be more fragile than popularly perceived.

We also need better regulatory oversight. Many (probably most) GMO crops will be safe to eat, but some could be harmful. What should we do about those without a robust regulatory system? Labeling is one important prong of such a system; not surprisingly, it's being fought tooth and nail[38] by industry. Other regulatory pegs include putting the burden of proving safety onto GMO developers, supporting long-term epidemiological studies and removing the bullying tactics of international trade regimes that pressure countries to deregulate their markets in favor of GM production and imports.

GMOs, in sum, point us to deeper issues that underlie the entire food system.

Finally, I would like to see GM research and development moved into the public sphere. Decoupling profit interests from R&D could open up a realm of possibilities: GMOs adapted for agroecological systems instead of monocultures, GMOs developed through participatory plant breeding,[39] GMOs available to all under open-source seed[40] licenses. As a concrete start, we can re-evaluate the 1980 Bayh-Dole Act,[41] which allows universities to own and commercialize inventions made with federal funding — including granting exclusive licensing of GMO innovations to the private sector. While Bayh-Dole was intended to speed the flow of science into the marketplace "for the public good," backward pressure from industry onto university administrators and faculty has come to profoundly shape the direction of crop and agricultural science. Land-grant universities, strapped by shrinking state budgets, are increasingly pushed to conduct research that leads to patentable outcomes of resale value to industry. Private funding of land-grant schools has been outpacing federal funding[42] for decades.

GMOs, in sum, point us to deeper issues that underlie the entire food system. A nonreductionist evaluation of GMOs can push us toward thinking about effects at multiple scales and time spans. Such an evaluation can get us to think deeply about who benefits from technologies, who controls their availability and access, and who makes such decisions. We get to think about the entanglements of politics, the media and public interest in shaping scientific validity and "consensus." In short, we are invited to think socially and ecologically — indeed agroecologically — about the utility and value of engineered seeds.

If GMOs can survive such scrutiny and emerge as a beneficial tool, I'm certainly not anti-GMO. Let's hope I won't be labeled a wing nut.

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Citations

[1] Nestle, Marion. 2015. "Retraction of the Golden Rice Paper: An Issue of Ethics." Food Politics Blog, August 3. http://www.foodpolitics.com/2015/08/retraction-of-the-golden-rice-paper-an-issue-of-ethics/

[2] Saletan, William. 2015. "Unhealthy Fixation." Slate, July 15. http://www.slate.com/articles/health_and_science/science/2015/07/are_gmos_safe_yes_the_case_against_them_is_full_of_fraud_lies_and_errors.html

[3] Specter, Michael. 2014. "Seeds of Doubt." The New Yorker, August 15. http://www.newyorker.com/magazine/2014/08/25/seeds-of-doubt

[4] Shiva, Vandana. 2014. "Seeds of Truth: Vandana Shiva and the New Yorker." Independent Science News, December 15. http://www.independentsciencenews.org/un-sustainable-farming/seeds-of-truth-vandana-shiva-new-yorker/

[5] Remnick, David. 2014. "New Yorker Editor David Remnick Responds to Vandana Shiva Criticism of Michael Specter's Profile." Genetic Literacy Project Blog, September 2. http://www.geneticliteracyproject.org/2014/09/02/new-yorker-editor-david-remnick-responds-to-vandana-shiva-criticism-of-michael-specters-profile/

[6] Montenegro, Maywa. 2015. "Agroecology Can Help Fix the Broken Food System. Here's How." Ensia, June 17. http://ensia.com/voices/agroecology-can-help-fix-our-broken-food-system-heres-how/

[7] Foley, Jonathan. 2014. "GMOs, Silver Bullets and the Trap of Reductionist Thinking." Ensia, Februrary 25. http://ensia.com/voices/gmos-silver-bullets-and-the-trap-of-reductionist-thinking/

[8] Achenbach, Joel. 2015. "Why Do Many Reasonable People Doubt Science?" National Geographic, March. http://ngm.nationalgeographic.com/2015/03/science-doubters/achenbach-text

[9] Freedman, David H. 2013. "The Truth About Genetically Modified Food." Scientific American, September 1.

[10] Wise, Timothy. 2015. "The War on Genetically-Modified-Food Critics: Et tu, National Geographic?" Food Tank Blog, February 27.

[11] Domingo, José L., and Jordi Giné Bordonaba. 2011. "A literature review on the safety assessment of genetically modified plants." Environment International 37(4): 734-742.

[12] Fraser, Kent. 2013. "Glyphosate Resistant Weeds – Intensifying." Stratus Ag Research Blog, January 25. http://stratusresearch.com/blog/glyphosate-resistant-weeds-intensifying/

[13] University of Minnesota. 2014. "Number of Monarch Butterflies Hibernating in Mexico Reaches an All-time Low." January 29. http://discover.umn.edu/news/environment/number-monarch-butterflies-hibernating-mexico-reaches-all-time-low

[14] Howard, Philip. Seed Industry Structure: 1996-2013. [Information Graphic.] https://msu.edu/~howardp/seedindustry.html

[15] Carlisle, Liz and Albie Miles. 2013. "Closing the Knowledge Gap: How the USDA Could Tap the Potential of Biologically Diversified Farming Systems." Journal of Agriculture, Food Systems, and Community Development 3: 219-225.

[16] Vandenberg, Laura N., Theo Colborn, Tyrone B. Hayes, Jerrold J. Heindel, David R. Jacobs Jr, Duk-Hee Lee, Toshi Shioda et al. 2012 "Hormones and Endocrine-disrupting Chemicals: Low-dose Effects and Nonmonotonic Dose Responses." Endocrine Reviews 33(3):378-455.

[17] Pala, Christopher. 2015. "Pesticides in Paradise: Hawaii's Spike in Birth Defects Puts Focus on GM Crops." The Guardian, August 23. http://www.theguardian.com/us-news/2015/aug/23/hawaii-birth-defects-pesticides-gmo

[18] Hilbeck, Angelika, Rosa Binimelis, Nicolas Defarge, Ricarda Steinbrecher, András Székács, Fern Wickson, Michael Antoniou et al. 2015. "No scientific consensus on GMO safety." Environmental Sciences Europe 27(1): 4.

[19] Murphy, Denis. 2007. Plant breeding and biotechnology: societal context and the future of agriculture. Cambridge University Press.

[20] The National Academies of Sciences. 2014. A Science-Based Look at Genetically Engineered Crops. First Public Meeting, September 15-16. http://nas-sites.org/ge-crops/2014/07/16/first-public-meeting-september-15-16-2014/

[21] Gilbert, Natasha. 2014. "Cross-bred Crops Get Fit Faster." Nature 513(7518): 292-292.

[22] CGIAR. 2013. "Partnerships Lead to Measurable Impacts for Drought Tolerant Maize for Africa." CGIAR News, October 21. http://www.cgiar.org/consortium-news/partnerships-lead-to-measurable-impacts-for-drought-tolerant-maize-for-africa/

[23] Gurian-Sherman, Doug. 2012. "High and Dry: Why Genetic Engineering Is Not Solving Agriculture's Drought Problem in a Thirsty World." Cambridge, MA, Union of Concerned Scientists.

[24] Maxmen, Amy. 2015. "Easy DNA Editing Will Remake the World. Buckle Up." Wired, July.

[25] Paarlberg, Robert. 2009. Starved for Science: How biotechnology is being kept out of Africa. Harvard University Press.

[26] Stone, Glenn Davis. 2015. "Golden Rice: Bringing a Superfood Down to Earth." Food, Farming, and Biotechnology Blog, August 18. http://fieldquestions.com/2015/08/28/golden-rice-bringing-a-superfood-down-to-earth/

[27] ISIS. 2015. "GM African Cowpea to Enter African Markets." The Institute of Science in Society Report, July 9. http://www.i-sis.org.uk/GM_African_Cowpea_to_Enter_African_Markets.php

[28] Stone, Glenn Davis. 2014. "Do Farmers Want GM Crops?" Food, Farming, and Biotechnology Blog, November 15. http://fieldquestions.com/2014/11/15/do-farmers-want-gm-crops/

[29] Moss, Michael. 2015. "U.S. Research Lab Lets Livestock Suffer in Quest for Profit." New York Times, January 19. http://www.nytimes.com/2015/01/20/dining/animal-welfare-at-risk-in-experiments-for-meat-industry.html

[30] Lipton, Eric. 2015. "Food Industry Enlisted Academics in G.M.O. Lobbying War, Emails Show." New York Times, September 5. http://www.nytimes.com/2015/09/06/us/food-industry-enlisted-academics-in-gmo-lobbying-war-emails-show.html

[31] Latham, Jonathan. 2015. "The Puppetmasters of Academia (or What the NY Times Left out)." Independent Science News, September 8. http://www.independentsciencenews.org/science-media/the-puppetmasters-of-academia-ny-times-left-out/

[32] Krantz, Laura. 2015. "Harvard Professor Failed to Disclose Connection." Boston Globe, October 1. http://www.bostonglobe.com/metro/2015/10/01/harvard-professor-failed-disclose-monsanto-connection-paper-touting-gmos/lLJipJQmI5WKS6RAgQbnrN/story.html

[33] Shackford, Stacey. 2014. "New Cornell Alliance for Science Gets $5.6 Million Grant." Cornell Chronicle, August 21. http://news.cornell.edu/stories/2014/08/new-cornell-alliance-science-gets-56-million-grant

[34] Lappé, Anna, Kari Hamershlag, and Stacey Malkan. "Spinning Food: How Food Industry Front Groups and Covert Communications are Shaping the Story of Food." Friends of the Earth, Washington D.C., June.

[35] Lappé, Anna. "The Billion-dollar Business to Sell us Crappy Food." Al Jazeera America, June 30. http://america.aljazeera.com/opinions/2015/6/the-billion-dollar-business-to-sell-us-crappy-food.html

[36] Nestle, Marion. 2015. "Should Scientists with Financial Ties to Monsanto be Subject to FOIA Requests?" Food Politics Blog, September 8. http://www.foodpolitics.com/2015/09/should-scientists-with-financial-ties-to-monsanto-be-subject-to-foia-requests/

[37] Stone, Glenn Davis. 2015. "GM Foods: A Moment of Honesty." Food, Farming, and Biotechnology Blog, July 29. http://fieldquestions.com/2015/07/29/gm-foods-a-moment-of-honesty/

[38] Wise, Timothy. 2015. "The GM Labeling Law to End All Labeling Laws." Food Tank Blog, August 17. http://foodtank.com/news/2015/08/the-gm-labeling-law-to-end-all-labeling-laws

[39] Halewood, Michael, Peter Deupmann, Buwon R. Sthapit, Ronnie Vernoy, and Salvatore Ceccarelli. 2007. Participatory Plant Breeding to Promote Farmer's Rights. Bioversity International. http://www.bioversityinternational.org/e-library/publications/detail/participatory-plant-breeding-to-promote-farmers-rights/

[40] Hamilton, Lisa M. "Linux for Lettuce." Virginia Quarterly Review, Summer 2014. http://www.vqronline.org/reporting-articles/2014/05/linux-lettuce

[41] University of California. 1999. "The Bayh-Dole Act A Guide To The Law And Implementing Regulations." Office of Technology Transfer. http://www.ucop.edu/ott/faculty/bayh.html

[42] Food and Water Watch. 2012. "Public Research, Private Gain: Corporate Influence Over University Agricultural Research," April. http://www.foodandwaterwatch.org/reports/public-research-private-gain/