BEYOND THE SCIENCE II

BIOTECHNOLOGY

BEYOND THE SCIENCE

Genetic Literacy Project Special Report

BEYOND THE SCIENCE

BIOTECHNOLOGY

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WILL BIOTECHNOLOGY REGULATIONS SQUELCH NEXT FOOD AND FARMING INNOVATION?

Jon Entine, executive director of the Genetic Literacy Project, oversaw the assignments and the editing of the GMO Beyond the Science series.

Genetically engineered crops and animals (GMOs) have been a controversial public issue since the first products were introduced in the 1990s. They have posed unique challenges for governments to regulate. Although most working scientists in the field hold the opinion that genetic engineering, for the most part, is part of a continuum of the human manipulation of our food supply that's gone on for thousands of years, critics contend differently.

Many crop biotechnology skeptics frame their concerns in quasi-religious terms, as a violation of "nature" or fears that the increased use of GE foods will lead to a 'corporate takeover' of our seed and food systems, and the adoption of an ecologically destructive 'industrialized' agriculture system. GMOs have become a symbol of the battle over what our global, regional and local food systems should look like going forward.

The clout of the food movement that vocally rejects many aspects of conventional farming has exponentially increased since then, promoted by mainstream journalists, scientists and non-profit groups from Michael Pollan to Consumers Union to the Environmental Working Group. Organic leaders and lobbyists, such as Gary Hirshberg, founder of Stonyfield Organics and Just Label It, openly demonize conventional food and farming in defiance of their commitments agreed to in the 1990s that organic food would not be promoted at the expense of conventional agriculture. Attempts to reign in the unchecked influence of the conventional food critics have repeatedly failed; over much of the past decade, they've had a sympathetic ear in Washington. Partly in response to the prevailing winds, the USDA has evolved increasingly byzantine regulatory structures when it comes to new GE products.

GENETIC LITERACY PROJECT: GMO BEYOND THE SCIENCE

The Genetic Literacy Project 10-part series Beyond the Science II (Beyond the Science I can be viewed here) commences with this introductory article. Leading scientists, journalists and social scientists explore the ramifications of genetic engineering and so-called new breeding technologies (NBTs), specifically gene-editing technologies such as CRISPR. We will post two articles each week, on Tuesday and Wednesday, over the next 5 weeks.

Regulation is at the heart of this ongoing debate. Many scientists and entrepreneurs have come to view the two key agencies regulating GE in the United States—the Food and Drug Administration and Department of Agriculture—as places where 'innovation goes to die.' That's an exaggeration, but not without some truth; regulations are inherently political, and the winds have been blowing against technological breakthroughs in agriculture for much of the last decade. On average, it takes upwards of $125 million and 7-10 years for the Agriculture Department to approve a trait, exhausting almost half of a new products 20-year patent protection. No wonder the agricultural sector is consolidating, and most new products are innovated by larger corporations.

The regulatory climate may be changing, perhaps radically, in the United States and possibly in the United Kingdom, as the result of recent elections.

Many of the old rules and regulations regulating GE crops were set up in the 1980s and early 1990s. They are arguably creaky, overly-restrictive and do not account for dramatic increases in our understanding of how genetic engineering works and the now clear consensus on their safety.

Now with NBTs, which are largely unregulated since the techniques were not foreseen 30 years ago when regulations were first formulated, agricultural genetic research is at an inflection point: Will governments make the same mistake that they did previously and regulate innovation almost out of existence, or will they incorporate reasonable risk-risk and risk-benefit calculations in evaluating which technological advances should proceed with limited regulations?

Decisions on these issues will shape not only food and farming in Europe, North America and the industrialized nations, but the food insecure developing world, which looks to the West for regulatory guidance.

GENE EDITING AND ANIMALS

The second article in our series, by University of California animal geneticist Alison Van Eenennaam, addresses the challenges of regulating genetically engineered animals. She focuses on dehorned cows, which have been developed without gene editing over many

years with, at times, less than optimal results. Should gene editing be evaluated on a case-by-case basis triggered by the novelty of the traits, or should the entire process be heavily regulated—the general approach favored by the European Union in regulating more conventional genetic engineering?

PESTICIDE DEBATE: HOW SHOULD AGRICULTURAL CHEMICALS BE REGULATED TO ENCOURAGE SUSTAINABILITY?

Dave Walton, an Iowa farmer, discusses the brouhaha that has erupted in recent years over the use of glyphosate, the active ingredient in the weed killer originally developed under patent by Monsanto. Many GMO critics are now expressing concerns over pesticide use in conventional agriculture, using glyphosate as a proxy for attacking the technology. Are their concerns appropriate? Walton, who grows both GE and non-GE crops and is director of the Iowa Soybean Association, has used glyphosate on his farm since the introduction of herbicide resistant crops in 1996. He uses on average a soda-sized cup of glyphosate per acre, and the use of the herbicide has allowed him to switch from more toxic chemicals. Most strikingly he discusses the sustainability impact if a glyphosate ban is imposed, as many activists are calling for.

In a separate article, plant pathologist Steve Savage challenges us to think in a more nuanced way about a popular belief that organic farming is ecologically superior to conventional agriculture. The Agricultural Department has been a fractious mess in recent years in its efforts to oversee and encourage new breeding technologies. When the Clinton administration oversaw the founding of the National Organics Standards Board in 1995, USDA officials extracted the commitment from organic industry that the alternative farming system would not be promoted at the expense of conventional agriculture. After all, study after study, then and now, has established that organic farming offers no safety nor clear ecological benefits.

"Let me be clear about one thing," said former Secretary of Agriculture Dan Glickman in December 2000. "The organic label is not a statement about food safety, nor is 'organic' a value judgment about nutrition or quality."

But that's not what's happened.

REGULATIONS AND THE 'NGO PROBLEM' IN AFRICA AND ASIA

While GE crops were pioneered in the United States and embraced in other western countries outside of Europe, there has been resistance in regions of the world where these innovations could arguably bring the most impact: Africa and poorer sections of

Asia. Mahaletchumy Arujanan, executive director of Malaysian Biotechnology Information Centre and editor-in-chief of The Petri Dish, the first science newspaper in Malaysia, takes on the emerging Asian food security crisis posed by a parallel rise in population and living (and food consumption) standards. She reviews the successes and failures in various countries, and the effective campaigns by anti-GMO NGOs, mostly European funded, to block further biotech innovation.

Margaret Karembu, director of International Service for the Acquisition of Agri-biotech Applications, Africa regional office (ISSSA) AfriCenter based in Nairobi, has found a similar pattern of mostly European-funded NGOs attempting to sabotage research and spread misinformation about the basic science of crop biotechnology. Africa is the ultimate 'organic experiment', and farmers have failed miserably using family agro-ecology techniques for decades. Cracks are beginning to form in the anti-GMO wall erected across the continent and there are hopes that young people will be attracted to farming, lured by the introduction of GE crops and other innovations.

PUBLIC OPINION AND GMOS

Brandon McFadden, assistant professor in the Food and Resource Economics Department, University of Florida, addresses the complex views of consumers regarding innovation and GE foods. The public has a widely distorted perception of what genetic engineering entails, which helps explain why consumers remain so skeptical about technological innovation in farming.

Julie Kelly, a contributing writer to numerous publications including the Wall Street Journal, National Review and the GLP, takes on Hollywood in her analysis of the celebrity embrace of the anti-GMO movement. Who are the 'movers and shakers' manipulating public opinion in favor of the organic movement and against conventional agriculture? Is the celebrity-backed science misinformation campaign working?

FUTURE OF GM RESEARCH AND HOW THE PUBLIC DEBATE MAY EVOLVE

Paul Vincelli, extension professor and Provost's Distinguished Service Professor at the University of Kentucky, has been perturbed about the attack on independent university researchers for working with the biotechnology industry over the years. By law, land grant university scientists are required to work with all stakeholders, particularly corporations who are developing the products used by farmers, including organic farmers. No, scientists who partner with corporations in research and product development are not 'shills'. He rejects the knee jerk belief, advanced by many activist critics of GE crops, that corporate funding pollutes science and should be banned.

Finally, risk expert David Ropeik has an optimistic take on the future. He believes 2016

may have been a turning point in the debate over GE foods. Technology rejectionists, from Greenpeace to labeling activists, are sounding increasingly shrill and less scientific. Gene editing, he believes, could undercut claims that GE foods are unsafe because they are unnatural. He is convinced, perhaps optimistically, that GE opponents will soon be viewed as 'science denialists.'

We will see.

Anti-GMO critics cite opinion polls and the votes of anti-GMO legislators in Europe and elsewhere as 'proof' that genetic engineering should be curtailed and more heavily regulated. That's a rickety platform if one believes in science, however; science is not a popularity contest.

WILL—AND SHOULD—GENE EDITED ANIMALS BE REGULATED?

Alison Van Eenennaam, PhD., Animal Genomics and Biotechnology, University of California, Davis.

HIGHLIGHTS

- Gene editing method has been developed to dehorn dairy cows
- It is unclear whether gene editing will be formally regarded as animal breeding – which has not been traditionally regulated
- Gene edited animals should be evaluated on a case-by-case basis triggered by the novelty of the resulting attributes
- Regulatory frameworks should consider potential benefits of gene edited animals and the opportunity costs of precluding the use of this technology

Gene editing techniques are now being deployed by agricultural researchers to more precisely modify crops and animals without using “foreign” genes. This approach may quell some of the public skepticism of more classic transgenic products, often called GMOs. But questions remain about how these new products will be regulated.

The most dramatic advances are focused in the animal sector. Dairy cows, like those of the Holstein breed, naturally grow horns. They are often physically dehorned because they can pose a threat to other cows, as well as to farm workers handling the cattle. The team I lead at the University of California-Davis is collaborating with a company called Recombinetics, which has developed a method to produce dairy cattle that are genetically dehorned. The gene edited cattle are getting their new, horn-free alleles from the naturally hornless Angus breed to create hornless Holsteins.

Although this process mimics natural breeding in many key ways, questions remain about how or if the United States and governments around the world will regulate it. At the current time it is unclear whether gene editing of animals will be formally regulated in the same way as animals containing rDNA constructs that are the more traditional products of genetic engineering.

Animal breeding per se is not regulated by the U.S. government, although it is illegal to sell an unsafe food product regardless of the breeding method that was used to produce it. I am unaware of a unique food safety concern that has been associated with traditional animal breeding methods. Gene editing does not necessarily introduce any "foreign" rDNA or "transgenic sequences" into the genome, and many of the changes produced would be indistinguishable from naturally-occurring alleles and variations. As such, many applications will not fit the classical definition of genetic engineering.

For example, many edits are likely to alter alleles of a given gene using a template nucleic acid dictated by the sequence of a naturally-occurring allele from the same species (e.g. the "hornless" Holsteins carry a polled allele from Angus) [1]. As such, there will be no novel rDNA sequence present in the genome of the edited animal, and likewise no novel phenotype associated with that sequence. It is not evident what unique risks might be associated with an animal that is carrying such an allele given the exact same sequence and resulting phenotype would be observed in the closely-related breed from which the allele sequence was derived [2].

U.S. REGULATORS SO FAR HAVE NOT WEIGHED IN

Currently, the Food and Drug Administration (FDA) defines "genetically engineered (GE) animals" as those animals modified by rDNA techniques, including the entire lineage of animals that contain the modification [3]. The rDNA construct in the GE animal is considered a new animal drug and thus is a regulated article under the new animal drug provisions of the Federal Food Drug and Cosmetics Act. These two sentences are potentially contradictory as it is not clear if it is the use of rDNA techniques in the development of a product, or the presence of an rDNA construct (drug) in the product, that is the trigger for regulatory oversight. The use of rDNA techniques does not necessarily result in an rDNA construct in the animal.

It is possible that gene editing nucleases might introduce double stranded breaks at locations other than the target locus, and thereby induce alterations elsewhere in the genome [4]. Such off-target events are analogous to spontaneous mutations that occur in conventional breeding and are specifically induced in unregulated mutagenesis breeding, and can be minimized by careful selection of the guide sequence that targets the specific DNA sequence to be cut as well as the design of the gene editing reagents [5]. There are groups working on ways to rapidly identify and suppress such potential off-target effects [6]. Complete sequencing of polled calves derived from two independent cell lines to 20X coverage did not find any off-target introgression of the polled allele, nor any insertion-deletions (indels) ascribable to off-target DNA cleavage by the TALENs.[1].

Globally, governments and regulators are currently deliberating about how gene-edited animals should be regulated, if at all. It is no coincidence that there have been a slew of recent policy papers from normally unobtrusive public sector breeders and academicians from around the world discussing the need for regulation of genome editing to be science-based, proportional to risk, product focused and fit for purpose [2, 7-11].

CURRENT REGULATIONS OF TRANSGENICS DON'T CLEARLY APPLY

Many agencies around the world are involved with the regulation and governance of genetically engineered animals besides the U.S. FDA, including the European Medicine Agency (EMA), the European Food Safety Authority (EFSA), and the Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO). The definition of a "genetically engineered" animal differs among these different agencies.

The Codex Alimentarius (Codex), or "Food Code", was established by FAO and WHO to develop harmonized international food standards, which protect consumer health and promote fair practices in food trade. In 2008 the Codex developed the science-based "Guideline for the Conduct of Food Safety Assessment of Foods Derived from Recombinant-DNA Animals (GL68-2008)" [12] which provides internationally-recognized recommendations for assessing the nutrition and safety of food from GE animals. In that document, a "Recombinant-DNA Animal" is defined as an animal in which the genetic material has been changed through in vitro nucleic acid techniques, including rDNA and direct injection of nucleic acid into cells or organelles.

The Cartagena Protocol on Biosafety (CPB) is an international agreement which aims to ensure the safe handling, transport and use of any living modified organism. The CPB defines "Living modified organism" to mean any living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology, and specifically excludes techniques used in traditional breeding and selection.

Likewise, the EU definition of a genetically engineered organism included in Directive 2001/18/EC encompasses an "organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination."

Many applications of gene editing would result in products that have modifications that could occur by mating and/or natural recombination, and carry no novel combination of genetic material or rDNA construct. Additionally, many modifications would be indistinguishable from the naturally occurring variation that is the basis of all animal breeding programs and, in fact, evolution. The only way to tell the difference would be for the breeder to state whether the genetic variations in their germplasm was "naturally"

occurring (which could include crossbreeding and mutation breeding induced by human intervention) or obtained via gene editing.

In this way it is somewhat analogous to cloning which makes an identical copy of an organism – a genetic twin. The milk, meat and eggs from cloned animals are indistinguishable from the products produced by conventionally bred animals. In the United States the FDA determined there were no unique risks associated with products derived from clones and this process is allowed to be used in animal breeding programs. Conversely, animal cloning is prohibited in some countries in the EU where the process-based regulatory approach judged the process unacceptable on ethical grounds.

LINES BLURRY AS TO WHAT CONSTITUTES GENETIC ENGINEERING

Most recently the U.S. National Academy of Sciences (NAS) [13] concluded that the distinction between conventional breeding and genetic engineering is becoming less obvious. Some emerging genetic engineering technologies (like gene editing) have the potential to create novel varieties that are hard to distinguish genetically from varieties produced through conventional breeding or processes that occur in nature.

The NAS reasoned that conventionally bred varieties are associated with the same benefits and risks as genetically engineered varieties. They further concluded that a process-based regulatory approach is becoming less and less technically defensible as the old approaches to genetic engineering become less novel and as emerging processes — such as genome editing and synthetic biology — fail to fit current regulatory categories of genetic engineering. They recommended a tiered regulatory approach focused on any intended and unintended novel characteristics of the end product resulting from the breeding methods that may present potential hazards, rather than focusing regulation on the process or breeding method by which that genetic change was achieved.

Ideally gene edited animals will be considered on a case-by-case basis using such a tiered regulatory approach triggered by the novelty of the resulting attributes or phenotypes displayed by the animal. There is a need to ensure that the extent of regulatory oversight is proportional to the unique risks, if any, associated with the novel phenotypes.

> **"Animal breeders are perhaps the group most aware of the chilling impact that regulatory gridlock can have on the deployment of potentially valuable breeding techniques."**

Given there is currently not a single genetically engineered animal being sold for food anywhere in the world despite more than 30 years since the first genetically engineered livestock were produced in 1985, animal breeders are perhaps the group most aware of the chilling impact that regulatory gridlock can have on the deployment of potentially valuable breeding techniques.

> **"Agricultural production systems are complicated and complex and there are no black and white answers – no forbidden or perfect solutions. Every solution has tradeoffs, also known as risk and benefits, as with every other decision we make in life."**

From a personal perspective I am agnostic as to which specific breeding method I use to achieve genetic progress in my research – whichever worksconsistently, and enables the best rate of genetic progress is the one I would prefer to use if the regulations associated with the use of that technique are not prohibitive. Unfortunately, this has not been the case for genetic engineering for the past 20 years of my career. This has effectively precluded the use of this method in my research and by public sector breeders globally.

I have watched with growing frustration as the expensive regulatory system focused on the use of genetic engineering in agricultural breeding programs has wasted millions, if not billions, of dollars evaluating safe products. Those funds could have been better used to research to solve pressing agricultural problems. Agricultural production systems are complicated and complex and there are no black and white answers – no forbidden or perfect solutions. Every solution has tradeoffs, also known as risk and benefits, as with every other decision we make in life.

If regulations around gene editing ultimately work to impede the seamless integration of gene editing methods with conventional animal breeding programs, they will effectively preclude the use of this technique in such programs. Idealistically, the best regulatory approach is one that allows new technologies to be used while preventing unacceptable risks to animal and human health or the environment. Here the definition of unacceptable becomes contentious, with some arguing that any level of risk is unacceptable.

However, in a world facing burgeoning animal protein demands, it important to ensure that regulatory frameworks also appropriately consider and weigh the potential benefits of gene edited animals to global food security. Perhaps as importantly should also be a careful evaluation of the opportunity cost associated with precluding the use of

> "Doing nothing by forestalling progress on potential solutions to global problems is in fact doing something, and opportunity cost should also be part of the evaluation of new plant and animal varieties."

gene editing technology in animal breeding programs, something that has rarely been considered for genetically engineered crops. Doing nothing by forestalling progress on potential solutions to global problems is in fact doing something, and opportunity costs should also be a consideration in the evaluation of new plant and animal varieties.

This piece was adapted by the author and expanded from A. L. Van Eenennaam. 2017. Genetic Modification of Food Animals. Current Opinion in Biotechnology.

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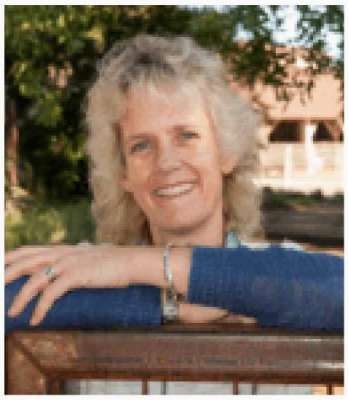

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> "When consumer focus groups were told GMOs have been used for 20 years with no ill health effects, the reaction was not relief. They wanted to know why they didn't know about them sooner."

TRANSPARENCY IS KEY TO CONSUMER ACCEPTANCE OF NEW TECHNOLOGY

Charlie Arnot, CEO, Center for Food Integrity,
April 6, 2016

The benefits of gene-editing technology are far reaching. Pigs that are immune to devastating diseases. Cows that don't grow horns would eliminate the animal welfare controversy associated with removing them. Hens that produce only female offspring would do away with the need to euthanize male chicks. The technology is also being tested for its ability to edit fruits and vegetables to increase their edible flesh, resist browning and slow down ripening.

But, it remains to be seen if gene-editing technology can avoid the stigma many consumers associate with GMOs.

When GMOs were introduced, scientific research and regulatory agencies said conclusively they were safe, so not much consideration was given to providing additional details to consumers. This unintentional lack of transparency eroded consumer trust in the technology and the food system in general.

When consumer focus groups convened by The Center for Food Integrity (CFI) were told GMOs have been used for 20 years with no ill health effects, the reaction was not relief. They wanted to know why they didn't know about them sooner.

"This is beyond scary to me," one woman replied. "I feel like I've been deceived. The fact that we've been eating this stuff [for decades] ... why weren't they providing more information all along about what I'm eating?"

Two decades after they were introduced, GMOs are still under attack in the United States and the technology's adoption around the world is being hampered. Will gene-editing technology experience a similar fate or can it be another step toward the next Green Revolution?

Transparency is essential to building trust. Consumers want all the details so they can decide for themselves. Simply reporting facts and science does not fulfill consumers' definition of transparency. They don't just want to know whether something "can" be done but whether it "should" be done. Is it the right thing to do? Food producers must commit to communicating an ethical foundation for their work.

For a sustainable balance, communication must be grounded in ethics and then supported by science and economics. Information impacts knowledge. Ethics – or values – impact feelings and beliefs and that's what drives consumer decisions.

Authentic transparency can transform a relationship that is tarnished with suspicion by reducing fear of the unknown and creating a platform for building trust. CFI's consumer trust research demonstrates that as those in the food system increase transparency, they will also increase consumer trust.

Since transparency can be an elusive term, CFI first set out to define it -- asking consumers who they hold most responsible for demonstrating transparency. Food companies? Farmers? Grocery stores? Restaurants? Far and away, consumers hold food companies most responsible. And not only for areas we might expect like labor and human rights and business ethics, but also for the impact of food on health and the environment, food safety, and even animal well-being.

The online survey of 2,000 people also asked precisely what consumers want and expect food producers to be transparent about – policies, practices, performance or verification? Consumers responded that transparency in a company's or organization's practices count most toward earning trust. That's because practices are a demonstration of a company's values in action, and CFI's research shows shared values are the foundation for earning trust.

Including information on product labels, offering engagement opportunities through company websites and protecting whistleblowers all ranked as important practices in demonstrating transparency. Those practices reflect an organization's values and become a good predictor of trust.

Food system stakeholders that believe these are not their issues do so at their own risk. CFI's research reflects a new reality in which consumers increasingly expect their favorite brands to assure more than quality and safety. As with consumers who were upset they weren't given more information about GMOs years earlier, consumers today expect the supply chain to be transparent about everything from production practices to ingredients.

As a result, those involved in bringing food to the table must commit to communicating the ethical foundation of their work. They can no longer assume that the public knows they prioritize safety and care about health, animal well-being, and the environment, among other things. They must be willing to engage in a dialogue with consumers and to embrace and answer their questions in an honest, open manner.

CFI's research leaves no doubt that effectively demonstrating transparency will help those in the food system increase public trust in their people, processes and products. Some farms and food companies have embraced this reality and pulled back the curtain. The journey may not be simple, but the reward – earning consumer trust – is priceless.

VIEW FROM A FARM: WITHOUT GLYPHOSATE, WHAT WOULD FARMING LOOK LIKE?

Dave Walton, full-time Iowa farmer growing GM and non-GM corn, soybeans, alfalfa and hay and Director, Iowa Soybean Association.

HIGHLIGHTS

- On our farm we use what amounts to large soda-sized cup of glyphosate per acre
- GE crops and glyphosate allowed us to switch to more sustainable no-till farming
- "Superweed" problem no worse using glyphosate than other pest chemicals
- Our use of most toxic chemicals has gone down, as it has for most conventional farmers
- Banning glyphosate would result in using more toxic chemicals, abandoning no-till

The news earlier this year that the European Union stepped to the brink of banning the herbicide glyphosate got me thinking—what would our farming operation look like if we had this herbicide tolerant crop system taken away? It's a question I've pondered for no other reason than to determine what my alternatives would be if the use of this chemical becomes a political football in the United States as it's become elsewhere.

How would the loss of glyphosate change what we do now? Are the alternatives better or worse than the current production model? To be sure, thinking this through was not a pleasant exercise, but it's a critical one considering how overheated the global discussion has become on this chemical.

Most people reading this are probably familiar with glyphosate. It goes by the trade name Roundup. It does a great job at killing weeds. If you do any gardening, you've probably bought it at your local hardware store and used it on your lawn safely for decades. We use glyphosate with crops, like soybeans, that are herbicide resistant. That means we can spray it after the weeds and/or the crop has emerged and it will kill the weeds but not harm the crops. For farmers and consumers, that's a good thing, I believe.

But if you're an anti-GMO activist, glyphosate is the root of all evil. They say that farmers, like me, drench our crops in this herbicide; turns farmers into chemical junkies; hurts beneficial insects; destroys the vitality of the soil; leads to a massive infestation of monstrous weeds; and worst of all that it will kill me of cancer. Science says none of these are true, and that's confirmed by my personal experience. But advocacy organizations are all over the Internet promoting these scare stories, and many of their claims are circulated by the mainstream news as if they are true. It hurts my brain to read that stuff.

There are people out there who truly believe that we farmers douse, drown, drench or saturate our crops in chemicals. Anti-GMO campaigners, organic activists and irresponsible news reports use those phrases all the time (see here, here, here, here). In graphic form it often looks something like this meme from GMOFreeUSA pictured here:

Really?

Does GMOFreeUSA actually think we load up big tankers of herbicide and drown our crops with the stuff? First, they don't understand the meaning of the word drown; second, to really drench a crop we would have to use one of those big tanker airplanes they use to fight forest fires. The video in this link, for example, would qualify as a drenching, probably not a drowning. Sorry, that simply is not what we do on a modern farm.

Nothing could be further from the truth.

On our farm, we grow both GMO and non-GMO crops. When planting season arrives in Iowa, I begin applying herbicides to prepare for planting. On our no-till ground—the most sustainable form of agriculture, and it's been made possible by the use of GM crops—we use a combination of glyphosate, 2,4-D and metalachlor for corn. Forsoybeans we add a pre-packaged mix of chlorimuron, flumioxazin and thifensulfuron. On our tilled ground, we leave out the glyphosate and 2,4-D, as it's not needed because tillage kills the weeds that are present.

So, what about this drowning of our fields with glyphosate that we've been reading so much about? On our corn ground, before planting we apply 16 ounces of glyphosate along with a small amount of these other chemicals. To put that in perspective, it's a little more than half a gallon of total herbicide spread out over an acre, or roughly the size of a football field.

In other words, per square foot, on the corn ground we apply what amounts to 1/3 of a drop per square foot. On soybean ground it's approximately 1/12 of a drop per square foot. What we do is a misting and not a "dousing." We're not "drowning" plants in pesticides; we're using what amounts to an eyedropper.

That's what we do now. But as a farmer, I have to be sober about this. What happens if the activists scare enough people, or members of Congress, and a ban is put in place, like what may very well happen in Europe after the 18-month temporary renewal ends. What's the worst case scenario?

HERE'S HOW I USED TO FARM

I'm not saying it would be a full-on nuclear winter here, but it would be a regression to an earlier time, and I know a far less sustainable time, before glyphosate came into wider use in the late 1980s. To take a phrase from a show from a while back – "Imagine if you will… a time not long ago…. "

One of the biggest issues for all farmers, conventional and organic, is how to prepare the soil for seeding by clearing away, and preventing weed competition. Let's start at the

beginning of the crop cycle and work through this. As a farmer, the first thing I need to decide before the season even begins, is what type of production model should I use: conventional tillage; conservation tillage; or no-till?

We used to rely a lot on conventional tillage (and many organic farmers still do). Conventional tillage is a system in which the ground is tilled either in the fall after the previous crop is harvested or early in the spring before planting. A plow rolls the ground, which doesn't do much good for the soil structure—it speeds up the decomposition of crop residue and soil organic matter. That leads to increases in carbon release from the soil via CO2. Not good, and a practice that we've eliminated in our operation. In fact, we have not used a moldboard plow (like the one seen below) in probably 25 years.

Next, we used a disk to level the ground and remove any weeds that may have germinated after the primary tillage was complete. The secondary tillage step was always done in the spring, and the timing could be anywhere from a few days to a few weeks prior to planting. If weeds were present, we would perform yet another tillage pass. Then we would plant.

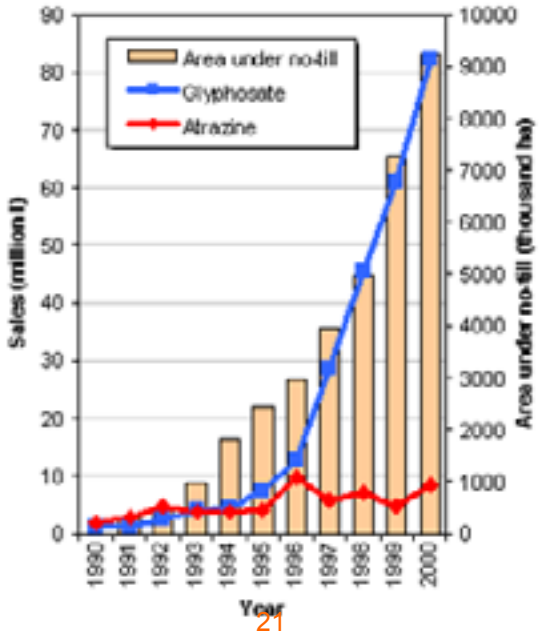
After planting, but before the crop emerged, we would make a herbicide application to prevent weeds from germinating and competing with the crop. Weeds are a bitch. They really are. They steal water and nutrients from the crop, and can out-compete them because of their aggressive growth. Organic farmers say that they are their number one headache; they use a combination of soil management techniques, some of which we use as well, and natural chemicals (some of which are quite toxic, like copper sulfate).

Depending on the crop, we would usually use a wide variety of pre-emergent herbicides. These products were efficient in reducing broadleaf weeds and relatively good at preventing grass type weeds but they weren't 100 percent effective. Yep, it meant that we had to do one or two more tillage passes, this time with what we called a row-crop cultivator. So in total we made at times up to five tillage passes for each crop season. And once weeds emerged, we didn't have many crop-safe herbicide options. Weedy fields were common, and resulted in loss of yield, and another increase in weed pressure the next season.

As we farmers became more aware of the damage tillage could do, we added conservation tillage to the mix, which resulted in less turning of the soil. Herbicides improved but they still weren't 100 percent effective. However, we were able to cut the number of tillage steps down from five to as few as two.

In the late 1970's, the production system called no-till was being developed. It was interesting to me as it solved a few of the soil issues, but as a complete system it didn't seem workable when first introduced. It was heavily dependent on intense management. Even with all its ecological advantages, most conventional (and organic farmers, then and now) did not adopt it because it just didn't control weeds very well—unless you used a lot of chemical applications, and few farmers, organic or conventional, want to do that.

Everything began to change in 1996, when herbicide tolerant (Ht) crops were introduced. The first to market were soybeans tweaked to have a tolerance to glyphosate, known as Roundup Ready. You could spray a field with glyphosate to prevent weeds from growing, and if you had to spray after the soybeans emerged, the crop was unharmed. This started to get interesting. Suddenly, as the chart below makes clear, the various systems started to come together in a great ecological package. I was able to cut down drastically on the use of far more toxic chemicals and substitute glyphosate, which was also more effective, and that enabled us to move to more no-till farming, a huge boost to our commitment to sustainability. Everything was coming together, as you can see here:



HOW HERBICIDE RESISTANT FARMING HAS CHANGED FARMING, AND ME

The older generation of farmers loved to see fields that were flat and free of surface residue prior to planting. They took great pride in the ability to plow and not have a single corn stalk on the surface. I get that, however I'm not as OCD as those old guys were. They liked things neat and orderly. That tendency went back for generations. You see, we have traced our farming lineage back to colonial days, and we've always been farmers in the New World. We worked our way through what is now known as Long Island, through New Jersey, then Ohio and Indiana, landing in East Central Iowa. When I say I had to fight some history, I really had to fight some history. Many farm families in the Midwest followed a similar path, and they equally hated disorder. No-till was first seen by many Midwest farmers as nearly sacrilegious; residue everywhere, and weeds were sometimes allowed to emerge. Scandalous!

I had to fight that perspective in our own operation. I'm not a traditional guy. I love to make hamburger out of sacred cows, and I try to do it nearly every day in my farming operation. Other farmers around us had begun to use no-till for planting soybeans into corn residue, but they still mostly tilled using conservation tillage prior to planting corn. For them, the traditional process was hard to break. But we jumped into the no-till production system with both feet.

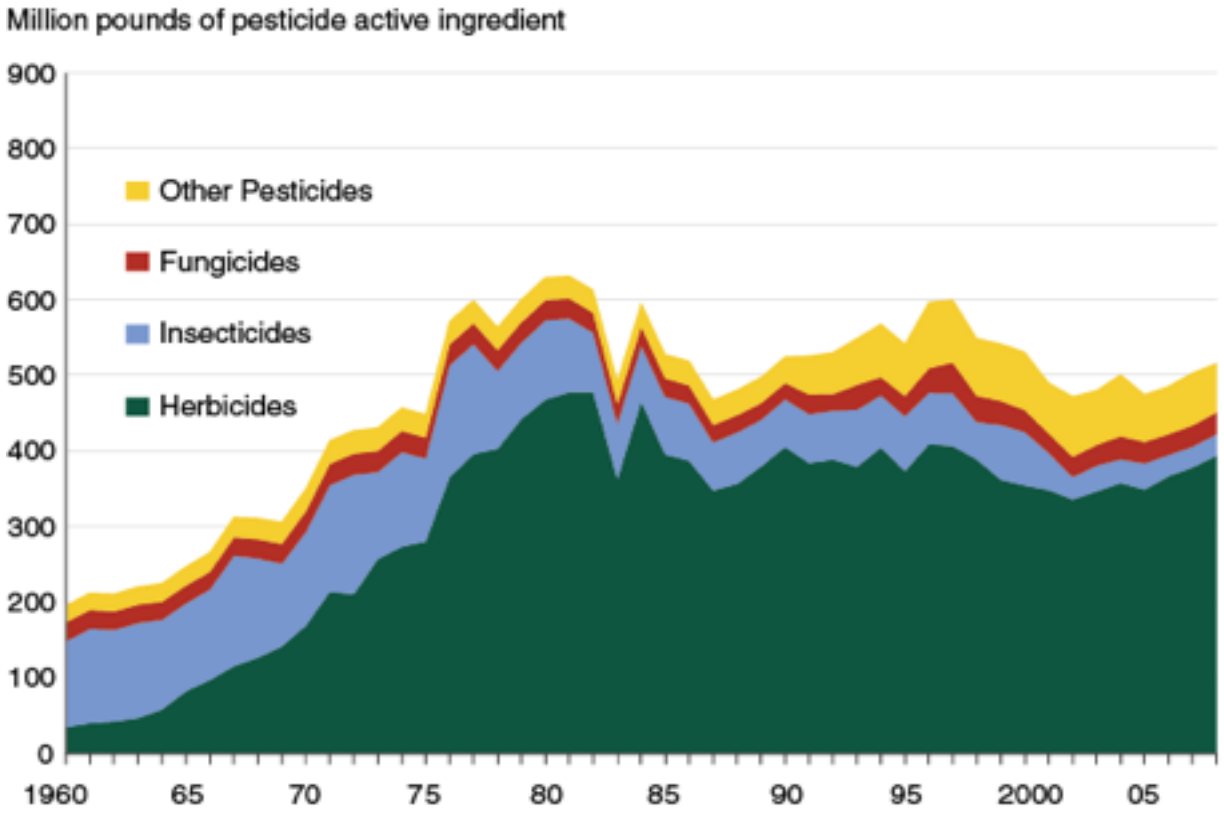
Let's look for a second at the herbicides we used in the past, compared to what we use now—what we would have to go back to if glyphosate were banned. We still use a range of older chemicals, primarily, acetachlor, metalachlor, pendimethalin, atrazine, dicamba, 2,4-D and glyphosate They've all been around since I started farming in the early 1980's, and most were produced much earlier—including glyphosate. No, glyphosate is not new, despite what the activists say and it wasn't invented for use on herbicide tolerant crops. It's been on the market since 1974, and quickly became the best-selling herbicide in the world. Why? Because it is so effective, and allowed us to cut down on the use of far more toxic chemicals. For example, I've reduced my use of paraquat—which, although safe for farming, is 1500 times more toxic than glyphosate—to almost nothing.

What about claims that since the introduction of herbicide resistant GMO crops we use even more chemicals than we did before? That's not my experience, as I will explain, despite what you may read on some websites. Sure, it's use has gone up. How could it not! It's paired with GMO crops whose use has boomed.

But that's kind of a silly statistic. If critics were genuinely interested in sustainability, they'd ask, "Has the overall use of the chemicals and in particular the most toxic chemicals gone up?" Those are questions that really matter to the soil and humans. The answers are clear, according to independent government statistics. According to the USDA, in a **2014 report**, pesticide use in the US peaked in 1981, and has trended downward since then. Here are

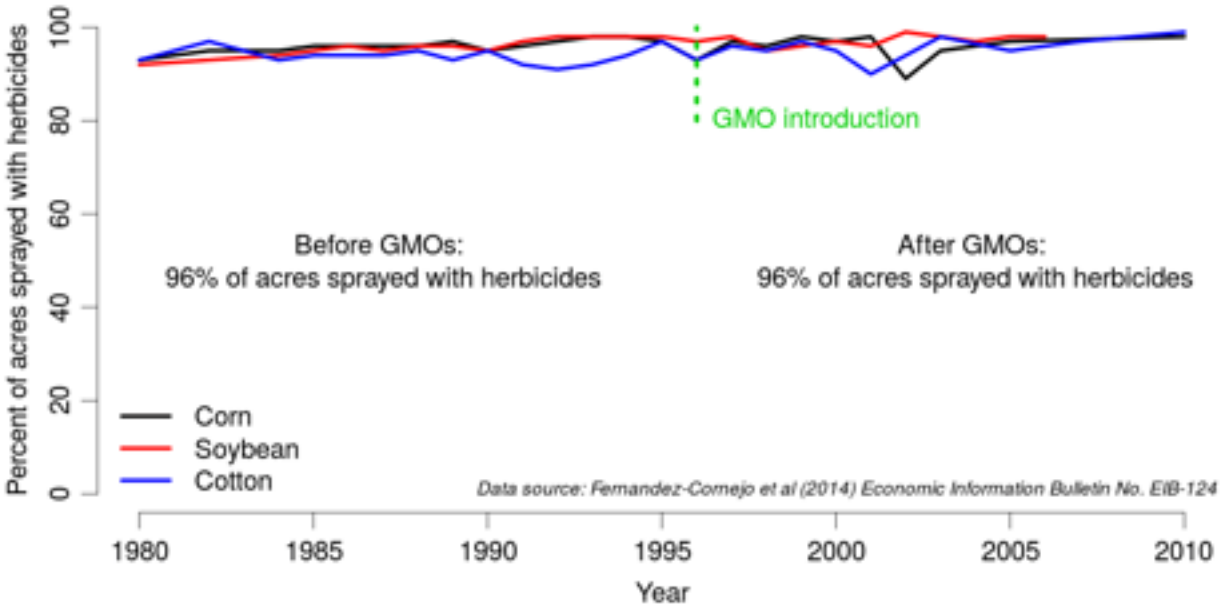
two graphs they used to illustrate the trend. Note the drop off beginning in 1996 when GMO crops were introduced.

Pesticide use in U.S. agriculture peaked in 1981 (21 selected crops, 1960 -2008)

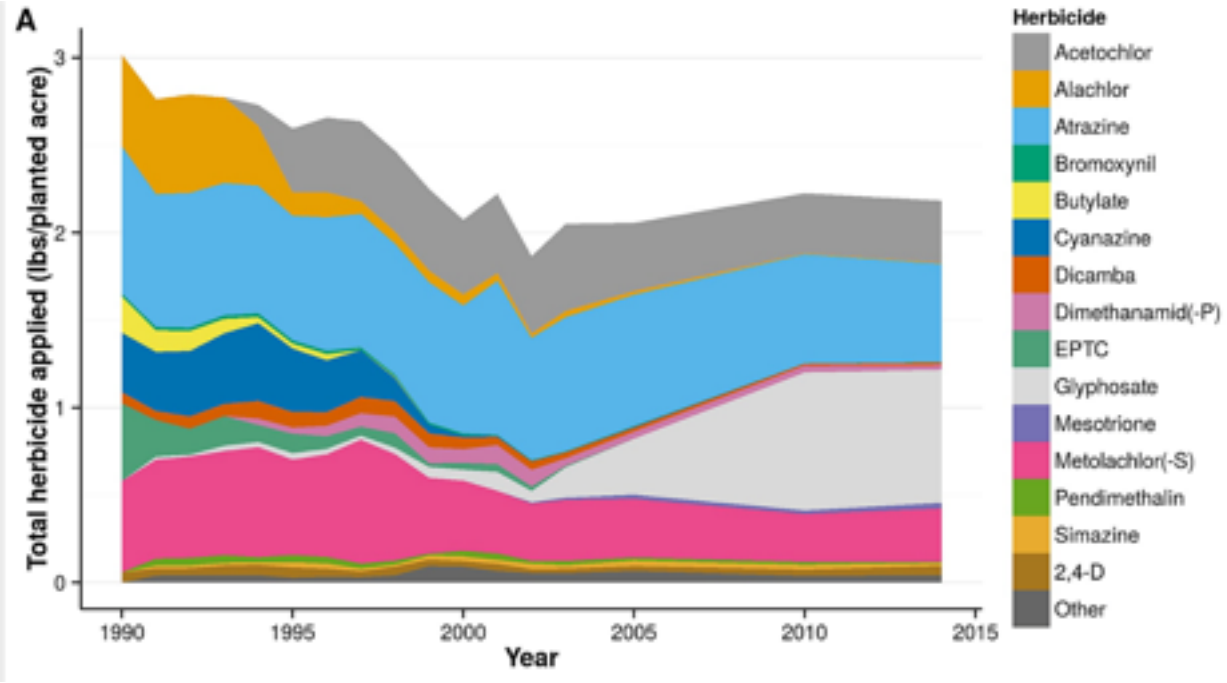


Source: USDA, Economic Research Service using USDA, National Agricultural Statistics Service and proprietary data.

While glyphosate use has, of course, grown, it has not increased the use of chemicals, as some claim.



Glyphosate, a very mild toxicant, has replaced far harsher ones, as this chart of the usage of chemicals on corn in the US, though 2015, illustrates.



Source: Wyoming Weed Sciences

What about the claim, made as an accusation, that glyphosate causes "superweeds"? I hear it mentioned quite a bit. It's a genuine issue for farmers, but the reality is weed resistance is nothing new. Pests, whether they are weeds or insects, evolve. It's what they do. According to the Weed Science Society of America, weed resistance predates herbicide tolerant crops by at least 40 years. Our job as farmers is to be stewards of not only the land, but of the herbicide tolerant technology and herbicides themselves, it is also our responsibility to minimize the chance of resistance. Banning glyphosate won't solve the

superweed problem. Soybean farmers who have switched away from glyphosate to other conventionally bred non-GMO herbicides such as ALS inhibitors have it even worse—their superweed problem is far worse than with glyphosate. Beware of what you wish for.

SUSTAINABILITY

That brings me to my last, and likely most important, point. Let's look forward instead of back. I dislike the term 'sustainability' because it's such an ill-defined buzzword. Sustainable farming is a nebulous term, because everything we do involves environmental tradeoffs. Our operation attempts to embrace the three pillars of ecological farming: It has to be economically stable, environmentally sound and socially acceptable. The concept we've handed down for generations isn't unique to us; it's ingrained in our family to leave the land in a better condition than we found it. That means lots of things. I must take care of the soil so it remains fertile for my lifetime and for my children, and for all generations to come.

So then, what happens if herbicide tolerant crops, or specifically glyphosate, is taken away? Simply said, we can only use what's on the shelf already. We'd have to regress to a prior production model that includes one of several distasteful options. including more tillage and less environmentally smart chemicals.

That's simply not acting as a steward to our land and our children.

Dave Walton is a full-time Farmer in Cedar County Iowa, 6th Generation, growing GM and non-GM corn, soybeans, alfalfa and hay on 500 acres. Iowa State University, studied Animal Science. Director, Iowa Soybean Association and licensed Commercial Pesticide Applicator and former Certified Crop Advisor.

> "CFI's peer-reviewed and published trust model shows that communicating with shared values is three-to-five times more important to building consumer trust than simply providing information."

TECHNOLOGY IN FARMING AND FOOD: FARMERS AND PRODUCERS NEED TO BUILD TRUST

Charlie Arnot, CEO, Center for Food Integrity

The benefits of technology improvements in the food system have been enormous and herbicide tolerant crops are only the tip of the iceberg. Only around one percent of the US population is involved in food and farming, so the confusion and concern about the massive changes that have occurred in food production over the last 60 years is understandable. But, embracing technology in order to improve efficiency, protect and preserve our natural resources, feed a rapidly growing global population and many more positive impacts is ethically and morally appropriate.

In 1950, the US population was 154-million and one farmer produced enough in a year to feed 30 people. We've more than doubled the population and one farmer today produces enough to feed 160 people. Today's farmers produce an amazing 262 percent more food with two percent fewer inputs such as labor, seed, animal feed and fertilizer.

The "Green Revolution" refers to technological advances 50 or 60 years ago that paved the way for global agricultural productivity increases. Things such as high-yielding varieties of seed, chemical fertilizers, irrigation and new methods of cultivation are credited with saving the lives of a billion people. Something similar needs to happen again.

The herbicide-tolerant crops that led to widespread adoption of no-till farming discussed by Mr. Walton is only one of many advances in agriculture that have taken place in the last half-century. Improved animal health products and housing systems help keep animals that produce food healthier and more productive. In addition to herbicide-tolerant crops, genetic engineering has produced non-browning apples that could encourage healthier eating and bruise-resistant potatoes that could lead to reduced food waste. New gene-editing technology holds the potential for life-changing applications in plants, animals, people and essentially any kind of organism.

Global estimates point to the need for 100 percent more food by mid-century. Agriculture must produce more, using less through innovation and the responsible use of technology,

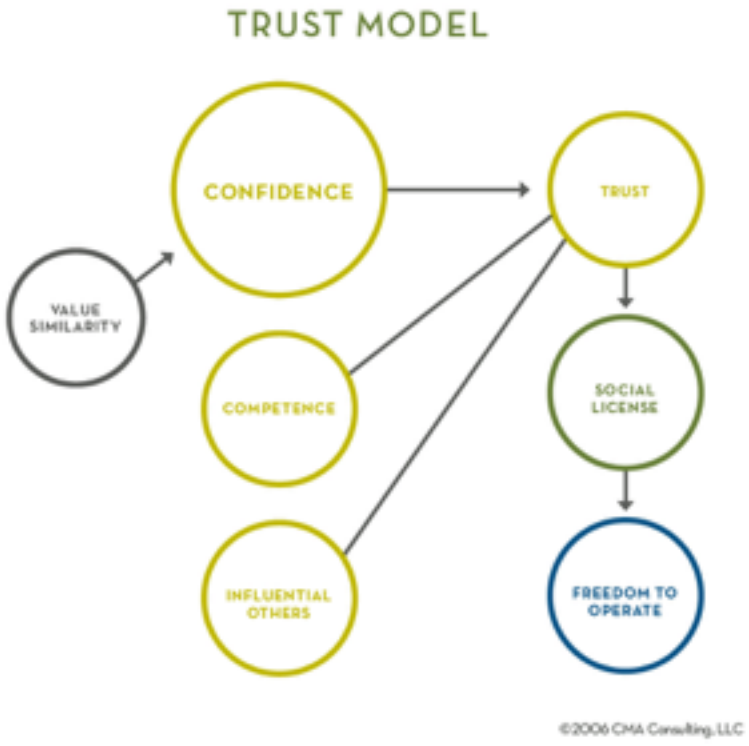
which America's farmers have been doing for decades. It is in humanity's best interest to use technology in food production because it allows us to feed a rapidly growing global population.

But, that message won't generate public support for today's agriculture technology.

Research by the Center for Food Integrity shows only one-fourth of consumers feel the US has a responsibility to provide food for the rest of the world. What consumers care about most, according to CFI's research, is having access to healthy, affordable food. Farmers are more likely to build support for today's farming by talking about what they do on the farm today that helps keep food healthy and affordable.

Many people are uncomfortable with modern food production systems and the size and scale of today's farming operations. That's understandable. With a predominant "big is bad" mindset, many Americans believe today's food producers place profit ahead of public interest.

Building trusting relationships with consumers is about making what farmers are doing relevant to them and helping them understand that farmers share their values when it comes to important issues like protecting soil and water and providing healthy, affordable food. CFI's peer-reviewed and published trust model shows that communicating with shared values is three-to-five times more important to building consumer trust than simply providing information.



Food and agriculture must change the conversation and transparency is the key. CFI's research proves that as those in the food and agriculture increase transparency, they also increase consumer trust. The link between transparency and trust is real, direct and powerful.

The new reality is that consumers expect more than quality and safety. They also expect the supply chain to be transparent. Farmers and food companies who believe these are not their issues do so at their own risk. They can no longer assume that the public knows they care about the food they produce. This makes them susceptible to the belief that they're no longer worthy of public trust. Food recalls, environmental accidents, undercover videos and other incidents further reinforce that distrust.

As a result, those in food production must commit to transparency, be willing to engage in a dialogue with consumers and answer their questions in an honest, open manner. Effectively demonstrating transparency will help increase trust in their processes and products, while supporting consumers in making informed decisions. Some farms and food companies have embraced this reality and pulled back the curtain.

As consumers are bombarded with conflicting information it is understandable that new technology is being met with skepticism and society's increased demand for transparency must be satisfied. While the demand for more information is accompanied by an obligation for consumers to objectively examine the data and to focus on the need for safe, healthy, affordable, responsibly-produced food, it's the food system's responsibility to embrace the skepticism and communicate in a transparent manner.

IS ORGANIC FARMING BETTER FOR THE ENVIRONMENT?

Steve Savage, is trained in biology (B.S. Stanford) and plant pathology (Ph.D. University California, Davis), and has worked for Colorado State University, DuPont, Mycogen and as a consultant for various organizations and NGOs

HIGHLIGHTS

- Conventional farmers free to utilize ecological farming options allowed in organic and those using GMOs, synthetic chemicals
- Organic farmers more dependent on older, 'natural' less targeted chemical pesticides that can be more toxic, harm beneficial insects
- Organic 15-50% yield gap means expansion of organics pressures limited land resources with negative environmental impact
- Organic rules block farmers from using state-of-the-art soil building practices
- GE encouraged wider adoption of ecologically protective no-till farming
- Farm sustainability best promoted by using best practices regardless whether organic or conventional

Many consumers believe that buying organic is "voting with their dollars" for a more environmentally desirable form of farming. That belief is promoted in organic marketing campaigns. Unfortunately, those consumer intentions are not supported by a realistic assessment of state-of-the-art environmentally optimal farming methods.

The standards that govern organic farming, set in agreements between the US Department of Agriculture and organic groups, include some important limitations, which

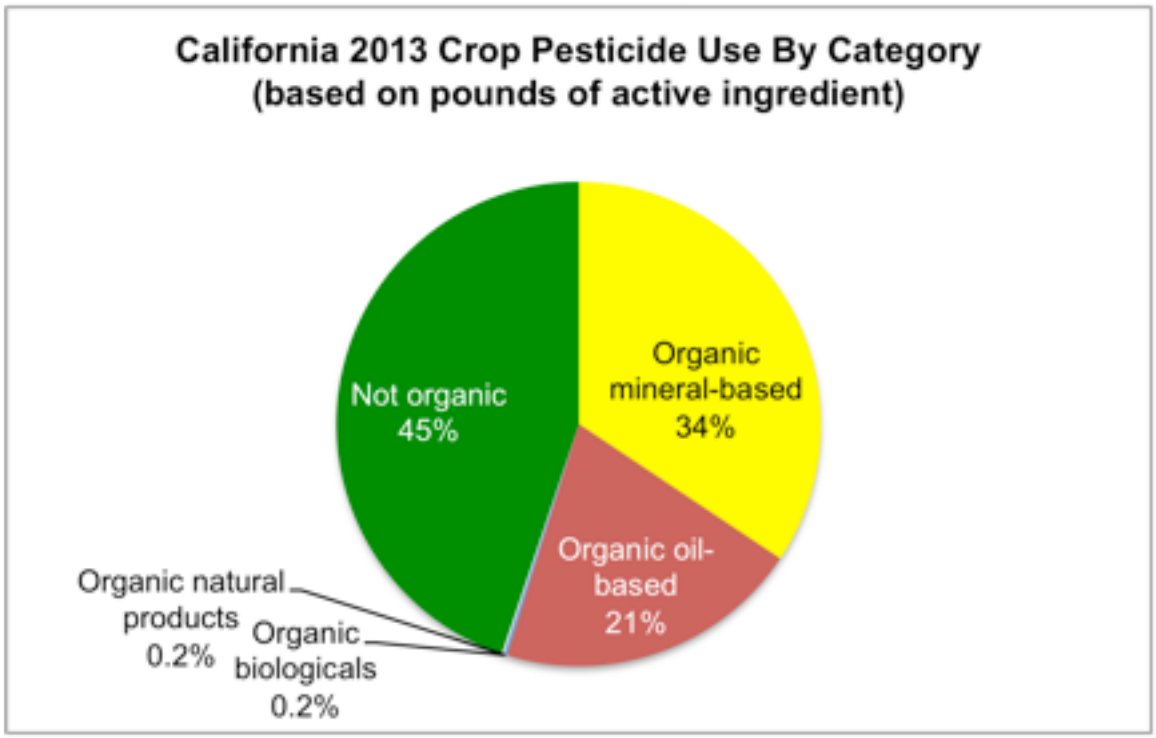
preclude some of the most sustainable and environmentally-friendly farming practices. Neither "organic" nor "conventional" are monolithic categories as both include a range of practices. However conventional farmers are free to utilize all the good farming options allowed in organic, while also having access to some useful ecologically sensitive tools that fall into the "synthetic chemistry" and "GMO" categories, but are not available to organic farmers. In many cases those tools are needed in order to implement the most advanced science-guided strategies for the benefit of the environment.

What are the environmental tradeoffs between organic and conventional/GMO systems in terms of pesticides, land-use efficiency, soil building, water quality and greenhouse gas emissions?

PESTICIDES

Many consumers are convinced that organic means no pesticides. In fact, both organic and conventional farmers use pesticides in order to protect their crops from inordinate damage from insects, nematodes, fungi and other pests. Failing to do so would have the environmental downside of reducing the efficiency with which those farmers use resources like land, water, fuel, labor and fertilizer.

Not only do both organic and conventional farmers use pesticides, in many cases they use the same pesticides. In 2013 in California's diverse agricultural sector, 55% of the total pounds of pesticides applied were made with chemical or biological materials approved for organic, and those pesticides were used by both categories of growers.



Data summarized from CalPIP 1

In the case of GMO insect resistant crops, the modified plant is producing the very same bacterial Bt (Bacillus thuringiensis) protein that is commonly sprayed on organic fields.

For all farmers, the most environmentally sound approach to pest control is to use a wide range of tools including the encouragement of 'natural enemies' of the pests, resistance available from the crop's genetic base and also applied chemical or biological pesticides. This strategy is called Integrated Pest Management or IPM.

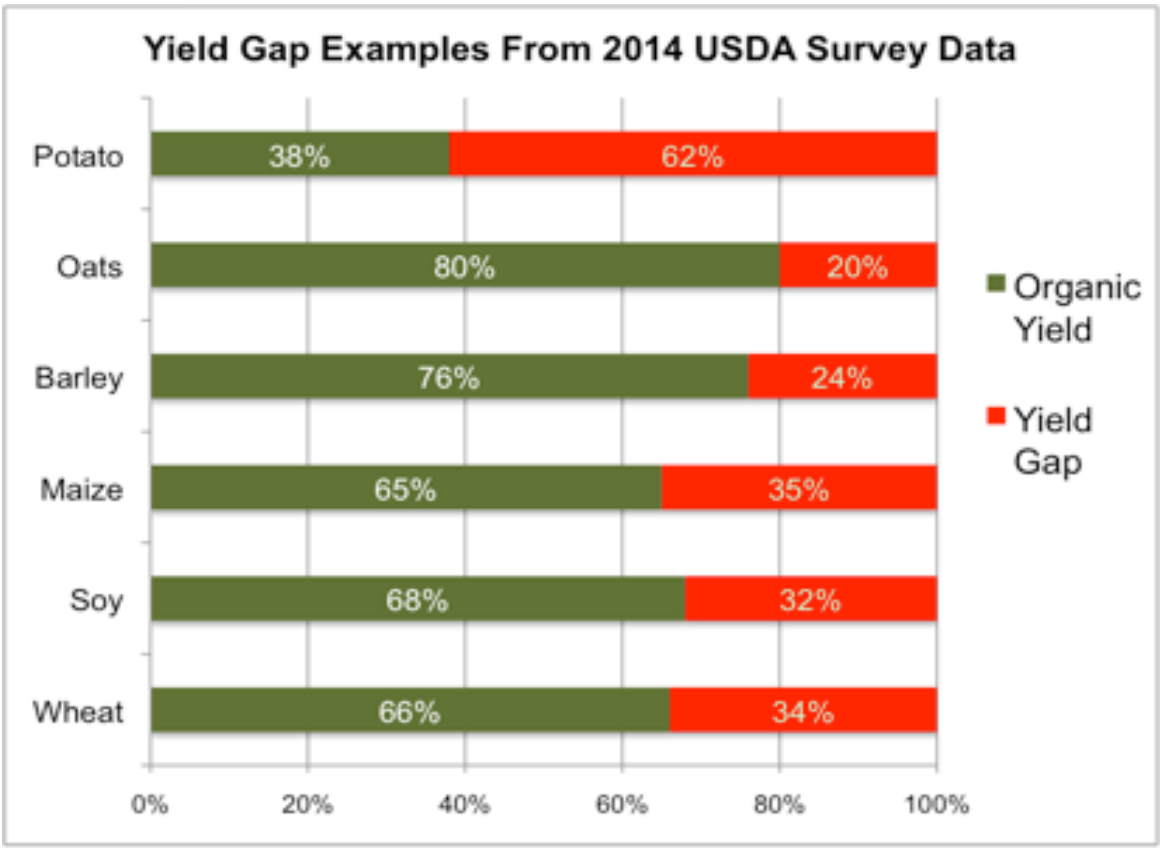
Conventional farmers are able to include "synthetic" pesticides as part of their IPM programs—options that are often more effective, and require lower use rates and fewer spraying applications. That has cost advantages for the farmer, but also environmental benefits in terms of less fuel use and less soil compaction. In a few conventional crops in which Bt versions have been allowed (e.g. cotton, corn, soybeans, brinjal) even fewer spray applications are needed for the IPM program because the pesticide is efficiently delivered in the plant itself.

The synthetic pesticides used by conventional farmers often help to stabilize their IPM programs. For example, there is a current crisis in the California spinach crop in which a sound IPM system is under threat because of the high percentage of organic spinach production (~50%). In organic plantings, farmers are not allowed to use a synthetic seed treatment fungicide to manage downy mildew disease spread through infected seed. The 'natural' substitutes are less effective, and as a result even traditional farmers have witnessed failing resistance genes. More fungicide spray applications have been needed by all spinach growers; organic farmers are using less environmentally friendly options such as 'natural' copper sulfate, which is acutely toxic, mutagenic, and which can bioaccumulate in the ecosystem, threatening aquatic wildlife.

Organic farmers also tend to be more dependent on older, 'natural' chemical pesticides such as sulfur, lime sulfur, various salts of copper and petroleum distillates. These chemicals, which are less targeted and can sometimes harm beneficial insects, can end up requiring far more spray trips, and in the case of copper, put a persistent, toxic load on the environment. Many of these issues could be avoided by substituting various environmentally benign, synthetic fungicides—but synthetics are not permitted under organic regulations. Organic farmers can only use pesticides that are considered natural, and that does not always mean safer from a health or environmental perspective.

EFFICIENT USE OF LAND

There is already a global shortage of arable farm land. Converting forests or grasslands to farming has well documented destructive impacts, including a reduction in biodiversity and the loss of plant and soil carbon sinks to prevent global warming. A switch from conventional to organic farming would exacerbate this problem, and is a major reason why organic farming, if scaled up, would be so fundamentally problematic.



Organic crops are well documented to yield less output for every acre or hectare farmed. The yield gap ranges from approximately 15-50 percent. Some organic proponents have argued that this difference is diminishing or that it can be overcome, but specifics are scanty. Considering global food demands are expected to roughly double by 2050, the gap is too significant to ignore. Indeed, a major conversion of agriculture to organic, as critics of "intensive agriculture" campaign for, could lead to environmentally unacceptable pressure for "land use change"— converting even more of the small remaining reserves of wild lands to farming, threatening habitat and biodiversity, ecosystems services, and soil-stored carbon.

For major row crops, this negative environmental scenario is only hypothetical, but for fruits and vegetables, organic is already compromising the efficient use of the unique and limited land resources best suited to growing those crops.

BUILDING HEALTHY SOILS AND 'NO TILL' FARMING

When the organic movement began around a century ago, its key contribution was a focus on the building of healthy soil. The standard, plow-based agriculture of the pre-industrial era was not the romantic ideal we often imagine.

It was essentially a mining operation that depleted the fertility and tilth of the lands which had been converted from forest and prairie biomes. The founders of the organic movement addressed the problems created by plow-based agriculture: replenishing the "organic matter" in the farmed soils by importing large quantities of manures or composts.

Organic pioneers also championed the on-site production of organic matter using "green manure crops" and "cover crops," which involved raising plants that are not harvested, but "tilled in" for the purpose of building up the soil. However, if a crop production season is substituted with a season of growing a "green manure" crop, the overall land-use-efficiency of organic can be even lower.

From an environmental perspective, there are several downsides to the organic approach. First, the total supply of such organic matter is limited. All the manures produced in US animal agriculture would only be sufficient to fertilize something like five percent of our crops. Even at existing scale, the US organic industry uses manures from conventional operations in order to have enough supply. When manures are processed to make them safer for use on food crops, there are surprisingly large emissions of the potent greenhouse gases methane and nitrous oxide. This "carbon footprint" of composting for organic farms is problematic from an environmental point of view.

Fortunately, over many years of research and innovation, the farming community has developed better ways to build soil health in ways both more scalable and environmentally friendlier than the organic farming approach. Once again, there is an overlap with organic practices, but the cutting edge systems involve elements banned or impractical under the organic rules.

The core of this new approach is a system under development by farmers since the early 1960s called “no-till” agriculture. In 1943, Edward H. Faulkner wrote “The Plowman’s Folly”, which questioned the wisdom and necessity of the mechanical tillage and plowing of soil—practices that had led to environmental disasters like the Dust Bowl of the 1930s.

Plowing farmland is probably the single worst aspect of traditional farming from an environmental perspective. However, it was not until the early 1960s, and the introduction of synthetic herbicides, that other means of weed control became possible.

In a natural ecosystem like the wild prairies of Middle America, plants feed themselves and the soil via photosynthesis during the entire, frost-free growing season. The plants nutrients are naturally recycled. Without mechanical disturbance, the soil builds in quality. No-till based soil building systems today imitate natural ecosystems in that the soil is fed, first through the growth of the crop up until harvest, and then through growth of a cover crop until there is a hard freeze. The soil and the plant residues are left undisturbed by mechanical tillage. The crop for the next season is planted directly through the surface residues, and the growth of weeds is achieved using synthetic herbicides, not mechanical tillage.

These progressive conventional farming methods greatly diminish erosion, sedimentation and fertilizer pollution of streams. Soils farmed this way can sequester significant amounts of carbon in stable forms below ground. No-till farming has been expanding and already represents a far larger fraction (over 35% nationally) of current farming than organic. Cover cropping has not yet been implemented to the same degree, but is steadily increasing. There are some organic, low- and no-till systems, but the greatest potential for expansion of science-driven, environmentally optimal row cropping systems is by farmers who have helpful tools like synthetic herbicides, seed treatment fungicides and insecticides, and herbicide tolerant, GMO crop traits.

WATER QUALITY

Perhaps the most difficult environmental challenge for farming concerns pollution of surface and ground water with fertilizers. When a crop is harvested it takes with it substantial quantities of nitrogen, potassium, phosphorus and other minerals which then serve the nutritional needs of animals and people. Those nutrients need to be re-supplied for subsequent crops. It is a major challenge to supply enough nutrition during peak demand without having the potential for some of those nutrients to move into ground water or surface water. This is particularly challenging for rain-fed crops in which precipitation is unpredictable.

The most water-mobile nutrients are phosphorus and the nitrate form of nitrogen. Organic fertilizers supply the same mineral nutrients as "synthetic" sources, but these tend to be incorporated in the organic matter in forms that are more slowly released as they are "mineralized" by microbial activity. This makes these fertilizers less likely to pollute water during something like a spring rain event, but they can also be limiting for crop growth during high demand periods - one of the reasons for typically lower yields in organic.

Manures also tend to contain excessive amounts of phosphorus, which is why their use on crops is discouraged around bodies of water like the Chesapeake Bay. Organic fertilizers can also mineralize well past the time when the crop is actively taking up fertilizer. A study of the ground water under conventional and organic greenhouses has documented how the less controlled release from organic fertilizers can be problematic.

In irrigated crops, conventional growers have an option called "spoon feeding" of nutrients in which they supply water-soluble fertilizers in the irrigation water on an as-needed basis. To do this with organic-accepted options is much more expensive.

There have been two historic examples of large-scale fraud in the California organic fertilizer business in which purportedly "natural" products were "spiked" with "synthetic nitrogen." Ultimately the plant absorbs the same fertilizer components whether they start as organic or synthetic. Again, fertilization is a challenging trade-off, but conventional growers have more tools at their disposal to practice environmentally friendly fertilization.

CARBON FOOTPRINT OF NITROGEN FERTILIZER

Agriculture has a major carbon footprint issue. Plants need nitrogen to grow, and that is a limiting factor in natural biomes, and particularly in agriculture. Both organic and conventional farmers get substantial quantities of the nitrogen they need from crops like soybeans, pulses and alfalfa that are legumes. However leguminous crops and other natural sources of nitrogen could never keep the global human population fed beyond something like 20% of our current numbers.

What has been enabling humans to be fed since the early 20th century was a Nobel-prize winning breakthrough termed the Haber-Bosch Process (HB). It allows nitrogen gas from the atmosphere to be turned into ammonia which is the starting point for most of the nitrogen fertilizers that farmers use. The other ingredient for the HB process is hydrogen and it has always been most cost-efficient to get that from natural gas. The use of that fossil fuel comprises a significant "carbon footprint" of fertilizer and that is one of the most significant environmental impacts of global agriculture.

Ironically, when organic farmers use manures or composts from animals fed with conventionally raised crops, they are also tapping into nitrogen that came into the system via the HB process. Cows and pigs and chickens don't make nitrogen, they simple fail to absorb

all of the nitrogen in their feed; what is left ends up in the manures that organic farmers need for their crops.

In summary, the bad news is that both conventional and organic agriculture depend upon a problematic technology. The good news is that there are some recent technological breakthroughs that could solve that problem—but they wouldn't be solutions available to organic farmers, under at least the current USDA organic rules.

The hydrogen in water can be liberated through electrolysis, and if the electricity for that is generated from renewable energy like wind, water or solar energy it would not have the carbon footprint issue. A few start-up companies, funded in part by the US military, have been working out ways to use those sorts of energy sources to run small scale HB processes to make ammonia as a diesel alternative in remote locations. That same process could also be the starting point for fertilizers.

Another way to get hydrogen could be the BioLeaf 2, recently developed by researchers at Harvard. It uses a catalyst to generate hydrogen from water directly using solar energy. This process could be used in conjunction with the small-scale Haber-Bosch alternatives described above.

The end product of these innovations would be "carbon-neutral" nitrogen fertilizer and it could also be made on a distributed basis. By the current organic regulations, however, this nitrogen would be considered off-limits to organic farmers (except through the conventional manure route).

FUTURE OF SUSTAINABLE FARMING

Safe and effective pesticides employed within an IPM strategy can reduce environmental impacts from farming through resource use efficiency and by enabling other desirable practices.

The natural limitation of organic pesticides leads to inferior pest control, compromises to IPM systems, and in many cases the use of less desirable materials.

The organic yield gap means that even moderate expansion of organic farming puts pressure on limited land resources, with negative environmental ramifications.

The state-of-the-art practices for soil building have productivity and environmental pay-offs with regard to water quality and greenhouse gas balance. These practices are best enabled by a suite of technologies, several of which are not available to organic farmers (e.g. synthetic herbicides, biotech crops, precision-suited fertilizers).

Composting has a little-recognized but well documented greenhouse gas problem and organic is also dependent on organic supplement streams originating on conventional farms.

Agriculture has a significant carbon footprint—making the nitrogen fertilizer that feeds the growing human population. Organic agriculture shares in that footprint through its dependence on manures generated from conventional agriculture. New technologies could begin to eliminate that footprint, but their direct use by organic farmers would be denied under current rules.

If society wants a way to "vote for the environment" through food purchases, it needs to either come up with a science-driven certification process or, better yet, foster full mainstreaming of the best agricultural practices regardless of whether they are organic or conventional. For policy makers, advocacy environmentalists, food manufacturers and retailers to pretend that organic is the best direction to pursue for an environmental farming solution is green-washing—at best.

Steve Savage has spent 35+ years working in various aspects of agricultural technology. Trained in biology (B.S. Stanford) and plant pathology (Ph.D. University California, Davis), he has worked for Colorado State University, DuPont, Mycogen and as a consultant for various organizations and NGOs including the CropLife Foundation. He is a contributor to Forbes. His Twitter handle is @grapdoc.

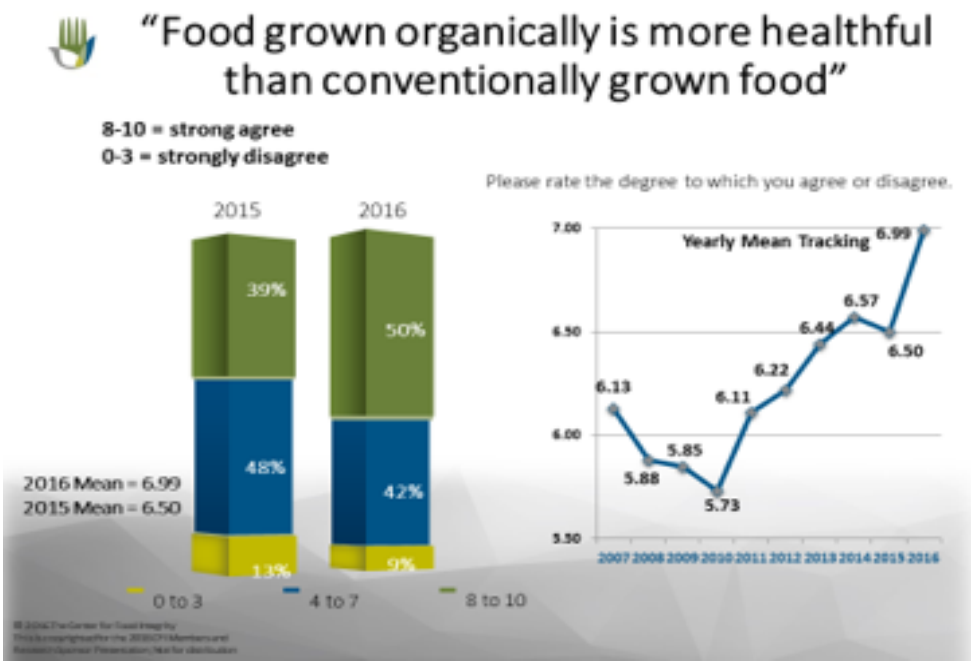
> "How can food producers do a better job engaging in a way that helps people understand that what today's farmers are doing is more consistent with what they want them to be doing than they might realize?"

SHARED VALUES MUST COME BEFORE SCIENCE IN WINNING CONSUMER TRUST ON TODAY'S FARMING PRACTICES

Charlie Arnot, CEO, Center for Food Integrity

Since 2007, the Center for Food Integrity has asked consumers to rate a wide range of statements on the food system. The results show people tend to think organic food is healthier, food today isn't as safe as it was when they were kids, and large farming operations can't be trusted.

Asked to rate agreement on the statement, "Food grown organically is more healthful than conventionally-grown food," half the respondents in CFI's latest study strongly agreed. Around half the respondents gave only middling support to the statement, "Today's food supply is safer than it was when I was growing up." Around half agreed strongly that "Large farms are likely to put their interests ahead of my interests."



It's easy for many consumers to support smaller farming operations that are perceived to be producing food the old fashioned way. This perspective highlights the challenge that the conversation about food is not just about better technology, but finding better ways to support the informed public evaluation of those technologies and our food production system.

What people really want when it comes to food is pretty simple. CFI's studies over the years consistently show consumers top concern as it relates to what they eat is, "Keeping healthy food affordable."

How can food producers do a better job engaging in a way that helps people understand that what today's farmers are doing is more consistent with what they want them to be doing than they might realize? Rather than responding with science, it's important to listen to consumer concerns, acknowledge those concerns and then help people understand what's being done to address them.

Science isn't enough. Science tells us if we can do something while society tells us if we should. Understanding the difference is critical. Scientific verification cannot be substituted for ethical justification. Farmers need to be able to help people understand that they value what is important to them, and then the opportunity to introduce science comes into play.

How technical and scientific information is introduced is key to supporting informed decision making by today's consumers. CFI's consumer research clearly shows that once a values-based connection has been made, permission is granted to introduce technical information. Simply having science on your side is clearly not enough to encourage and support informed decision making. Being right is not enough to assure information is considered in the social decision-making process.

Consumer skepticism about food production is understandable. The consolidation, integration and application of technology that make food safer, more available and more affordable than ever before also prompt concerns about whether science benefits society. In building consumer trust, the goal should not be to win a scientific or social argument, but to find more meaningful and relevant methods to introduce science in a way that encourages thoughtful consideration and informed decision making.

As the distance most consumers have from food production continues to increase along with the level of technology we implement, agriculture must dramatically improve its ability and commitment to build trust with consumers and other stakeholders.

Agriculture needs to find messages that deliver direct benefits to consumers or society in order to build support for today's farming practices. Farm groups need to show that the way today's food is grown is consistent with the values of American consumers.

Building trust requires an increase in early stakeholder engagement, transparency, professionalism, assessment and verification at all levels of agricultural production. People must be given permission to believe that today's food system is consistent with their values and expectations. Failure means we will continue to see erosion in consumer trust and increased restrictions on the farming practices needed to operate efficiently and profitably.

CFI's research provides a model for introducing and discussing complex controversial issues – a model that can be applied when communicating and engaging with consumers to build trust around topics that are critical to the food system's ability to meet growing demand for food while preserving and protecting our natural resources.

ASIAN AGROBIOTECHNOLOGY SLOWED BY PRIVATE-PUBLIC SECTOR TENSIONS AND NGO ACTIVISM

Mahaletchumy Arujanan, executive director of Malaysian Biotechnology Information Centre (MABIC) and Editor-in-Chief of The Petri Dish, the first science newspaper in Malaysia.

HIGHLIGHTS

- Asian food security challenged by population growth, rising calorie demands that non GE farming cannot meet
- China poised to become biotech powerhouse, but will take own path to reduce private sector involvement
- Bangladesh pioneering insect-resistant eggplant huge success, government controlled
- Adoption of insect-resistant cotton in India faster than in US, but activists blocking further biotech innovation
- Foreign funded anti-GE NGOs spread misinformation, scaring countries from embracing new technologies
- If protesters succeed, Asia will be locked into outdated food production systems that could lead to crisis

A number of factors are expected to challenge Asia's food security status in the next few decades. For the past 25 years, Asia's economy, led by India, China, Japan, South Korea and Singapore, has grown by around six percent a year and already accounts for 40 percent of the global economy (Lagarde, 2016). However, with 60 percent of the global population and two-thirds of the world's poor, many countries are not food secure and climate change and traditional farming practices are threatening its agriculture sector.

As incomes rise, people's calorie demands will increase as diets come to include more resource-intensive food products such as meat, dairy, eggs, fruits and vegetables, and thus resulting in a rapid increase in demand for raw agriculture commodities (Teng, 2015). But the agricultural sector is not well positioned to meet this demand for a number of reasons:

1. **It is not growing in tandem with the population growth. For example, the agriculture performance in South Asia has declined, with GDP falling from 43 percent to 18 percent between 1961 and 2009 (World Bank, 2011).**
2. **Farming community is ageing.**
3. **Climate change has led to an increase in extreme weather. The International Food and Policy Research Institute predicts that Asia's wheat and rice production will be 14 percent and 11 percent lower respectively in 2050 than in 2000 due to climate change (Teng, 2015).**

WHAT ROLE CAN BIOTECHNOLOGY PLAY?

> To meet global food security challenges, Asian countries will have to embrace biotechnology through science-based policies and regulations and also by combating activism against GM technology and crops.

While not all challenges can be addressed through crop biotechnology. Asia is fast adopting biotech crops as one of the solutions. Of the 179.7 million hectares of global biotech crops, 11 percent is in Asia. Currently, eight countries in Asia grow biotech crops while a few others only import them:

Country	Crops	Hectares	Year of adoption
India	Cotton	11.6 M	2002
China	Cotton, Papaya, Poplar	3.7 M	1997 (cotton)
Pakistan	Cotton	2.9 M	2010
Philippines	Corn	0.7 M	2003
Australia	Cotton, Canola, Carnation	0.7 M	1996 (cotton)
Myanmar	Cotton	0.3 M	2006
Vietnam	Corn	3,500	2015
Bangladesh	Eggplant	25	2014

If used more widely, biotechnology would be able to increase yields and reduce loss due to pests and diseases; reduce costs of production (labor and chemicals); develop crops resilient to abiotic stresses and climate change; and develop crops richer in nutritional values. To meet global food security challenges, Asian countries will have to embrace biotechnology through science-based policies and regulations and also by combating activism against GM technology and crops.

ASIAN AGROBIOTECH SITUATION

China is the largest economy and is emerging as a world epicenter in biotechnology research, driven mostly by the government. Agriculture makes up 43 percent of the Chinese workforce. The sector has reached maximum production capacity with current agriculture practices and land area. Scarce arable land, growing population, rapid urbanization, the impact agriculture footprint and a history of rationing are all putting pressure on the government.

China invested heavily in modern biotechnology research as early as the 1980s. Government researchers developed Bt cotton varieties, approved for cultivation in 1997 (Huang, et. al., 2002). Monsanto collaborated with local companies and the Chinese National Cotton Research Institute to release other Bt cotton varieties in the late 1990s. Prior to the adoption of Bt cotton, Chinese farmers struggled with the infestation of cotton bollworm. They were heavily reliant on pesticides that left them with many problems. They used a cocktail of organophosphates, pyrethroids and other chemicals, including DDT and the farmers' struggle ended with the adoption of Bt cotton.

The country is gearing up to be a GMO powerhouse now, but in its own style. In 2014, President Xi Jinping said, "We cannot let foreign companies dominate the GMO market. … China must boldly research and innovate, and dominate the high points of GMO techniques." This was followed by the release of US$3 billion to develop bioengineered seeds.

Bangladesh is moving aggressively into building a domestic GM seed market that is not dependent upon multinational foreign companies. In 2014, Bangladesh became the first country to cultivate genetically engineered eggplant (Choudhary et. al. 2014), a crop heavily infested by fruit and shoot borer, which cannot be controlled effectively using conventional insecticides. It is a critical staple grown by 150,000 small resource poor farmers. A socioeconomic study conducted by the World Vegetable Centre showed 98 percent of eggplant farmers using conventional non-GMO seeds rely on insecticides and 60 percent spray their crops 140 times or more in the 6-7 months cropping season (Alam et. al, 2003).

While the benefits of Bt eggplant are enormous, the adoption rate has been slow because the seeds are only produced by Bangladesh's public research institutes, which are unable to keep up with the demand. Like China, Bangladesh aspires to keep biotech crops in the hands of public sector.

India adopted Bt cotton in 2002, six years after the United States. Before the arrival of Bt cotton, the country faced stagnating production, decelerating cotton yields and overreliance on cotton import. India achieved an adoption rate of 95 percent in 2012,

before the US (James, 2015). In 2015, India displaced China as the number one cotton producing country in the world. Farm income in India was enhanced by an estimated US$18.3 billion from 2002 to 2014. India has also been conducting research on GM mustard, chickpea, rice, cotton, corn, sugarcane and eggplant for decades, but these crops will only see the light of day if it musters the political will to rebuff the anti-GM activist movement.

The Philippines was the first country to adopt a biotech crop, Bt corn, in Southeast Asia, in 2003. The country faces a range of opposition, vandalism and court cases while the farmers are enjoying economic, agronomic and environmental benefits from Bt corn. It's the only country where major church leaders have opposed biotech crops.

Farm level economic gains from Bt corn was estimated at US$89 million for 2014 alone (James, 2015), benefitting, 350,000 resource-poor farmers. Northern Philippines Bt corn growers have witnessed a significantly higher population of beneficial insects such as flower bugs, beetles, and spiders than those farms planted with conventional hybrid corn (Javier et. al., 2004).

In the research pipeline are beta carotene-enriched rice, insect-resistant eggplant and cotton and virus-resistant papaya. Golden Rice is undergoing field trials now. Bt eggplant would be expected to increase incomes by increasing yields, and also by reducing insecticide use by as much as 48 percent. The virus-resistant papaya is projected to increase returns by 275 percent more than conventional papaya (Yorobe, 2009).

In Pakistan, after six years of commercial cultivation, 93 percent of its cotton is biotech. It's estimated that the economic gains from 2010-2014 was US$1.9 billion and US$299 million for 2014 alone. Pakistan has about 900 pending applications from the public sector for various stages of field trials, showing its robust research but slow regulatory process.

Vietnam approved cultivation of Bt corn in 2015.

Myanmar is the only Asian country that grows biotech crops legally without a national biosafety law or guidelines. Bt cotton was first cultivated in 2006 and has resulted in significant benefits for the farmers such as high crop yield, reduced input cost, increase profits, and less exposure to pesticides.

Indonesia, the second largest raw sugar importing country in the world, is most likely the next country in Asia to grow biotech crops. In 2013, it issued food and environmental safety certificates for the country's first home-grown GM drought tolerant sugarcane with commercial planting expected within the next year. Biotech soybean, corn and rice are already undergoing research.

Malaysia is unique among Asian countries. Agriculture only contributed 7.3 percent to the country's GDP in 2010 and is in decline. It's a major importer of food and feed and does not have a big seed industry. While Malaysia was proactive in developing its biosafety law and has a strong commitment to advance modern biotechnology, commercial cultivation is still not a reality. Many scientists are still not used to the tedious regulatory procedures and have given up on GM research. Also, research on biotech crops is done on an ad-hoc basis with no long term vision. Most biotech crops already in the market elsewhere are not suited for Malaysian climate. Bt corn might be the closest for adoption but some studies conclude that importing it is more economically feasible than growing it locally, but the government is now revisiting its plan to grow grain corn.

ASIAN AGRICULTURE AND BIOTECHNOLOGY FACTS

More than 2.2 billion people in the region rely on agriculture for their livelihoods.
Source: ADB (2009)

The stagnant and declining yields of major crops such as rice and wheat can be ultimately linked to declining investments in agriculture. Public investments in agriculture in India, for instance, have been generally the same since 2004.
Source: ADB (2012)

In 2015, it was estimated that biotech crops were grown on 19.7 million hectares of land in Asia - making it the fastest adopted crop technology.
Source: James (2015)

Three of the top ten countries planting biotech crops in 2015 were in Asia. India grew more than 11.6 million hectares of cotton, the People's Republic of China planted 3.7 million hectares of cotton, papaya and poplar, while Pakistan farmed 2.9 million hectares of cotton.
Source: James (2015)

Food and feed crop demand will nearly double in the coming 50 years. Producing meat, milk, sugar, oils, and vegetables typically requires more water than producing cereals - and a different style of water management.
Source: Molden (2007)

There is significant potential for biotech corn in Asia, especially in China, where 35 million hectares could be grown once approved and adopted.
Source: James (2015)

By the third quarter of 2016, the combined rice stocks of India and Thailand have been projected by IRRI to be around 70 percent lower than in 2013.
Source: Mohanty (2016)

BIOTECH PAPAYA RESISTANT TO RINGSPOT VIRUS ILLUSTRATES ASIAN ANTI-GM ACTIVISM

The lack of food security persists in Asia, with farmers struggling to combat low yields, diseases, high production costs, environmental footprints and occupational health hazards due to exposure to chemicals. These problems—many of which could be significantly addressed using crop biotechnology, have not stopped anti-GM activists from crusading against GMOs and biotech crops in Asia. These campaigns are orchestrated almost entirely by foreign organizations with external funding from developed countries, either from affluent Western governments or non-government organizations (NGOs).

The local organizations in each country are well funded by international NGOs. Greenpeace, whose huge budget surpasses the R&D expenses of many countries, channels millions of dollars to splinter groups in developing countries. Major efforts against GMOs are also carried out by "consumer" associations, which often peddle misrepresentations about GM crops. Organic groups and industry also play a role in creating fear about GM technology. The photos below show blatant lies and unethical scaremongering tactics.

Pictures taken outside an organic shop. The words on the first and second panel respectively: "Do you know frog genes are inserted into your brinjal so that they have unusually broad spectrum and monstrous power to resist various infections?" and "Do you know the delicious tomatoes on your plate are inserted with spider genes so that the evil corporations can earn billions of dollars from silk extraction from the tomatoes?"

Thailand's failure in commercializing biotech papaya resistant to ringspot virus illustrates the impact of anti-GM activism. In 2007, activists donned goggles, gloves and respiratory masks and uprooted ringspot resistant papaya in a field trial. Greenpeace demonstrators wearing zombie fruit suits dumped 10 metric tons of papaya in front of the Ministry of Agriculture building. These protests set into motion a countrywide moratorium on all field testing of biotech crops that remains in force.

Activists often speak for farmers without any consultation with them or understanding of the challenges in agriculture. Throughout 2007, activists demonstrated against biotech papaya.

Thai woman trying to save the last diseased papaya tree in her backyard. She never got to see ringspot virus resistant papaya.

India is an epicenter for anti-GM activists who have effectively blocked the introduction of new GM crops beyond Bt cotton. Thousands of movements rally for organic farming and against GM crops, effectively blocking their approval. The NGOs most successful strategy has been filing petitions to the Supreme Court, invoking the precautionary principle to seek moratoria on the release of GMOs. As a result, some important GM crops such as Bt eggplant, *barstar-barnase*, hybrid mustard and golden rice are still awaiting clearance for field trials (Kumar, et.al. 2014)

The Supreme Court permanently stopped field testing of Bt eggplant in 2015. The petition was initiated by a group of scientists, farmers and individuals backed by major international NGOs. Prior to the adoption of Bt corn, NGOs mobilized churches and used religious sentiment to lobby against approvals.

There has been a backlash against some activist NGOs. In a milestone decision in 2015, the Indian government froze the bank account of Greenpeace, a vocal campaigner against GM foods, for misreporting funds and using unaccounted foreign aid to stall national development projects. The government has also launched a crackdown against foreign inflow of money into the country and NGO funding sources are carefully monitored.

Philippines has a strong anti-GM movement and has caused losses to farmers in the millions of dollars. In a milestone decision, the Philippines Supreme Court reversed its decision to halt field trials of Bt brinjal after an appeal by farmers, scientists and other agriculture advocates, who asked the high court to reconsider its December 2015 ruling permanently stopping Bt brinjal field trials.

Pakistan has had its share of scaremongering, carried out in pockets, largely through mass mailings targeting authorities that approve biotech crops and companies that develop them. Character assassination is one of their strategies. Both in Pakistan and Bangladesh,

the media plays an important role in creating the negative perception about biotech crops. In spite of the success of Bt eggplant in Bangladesh, news articles with inaccurate reports make the rounds, falsely reporting that the crop is a failure, despite its overwhelming success.

STRATEGIES OF ANTI-GM ACTIVISTS: MY PERSONAL ACCOUNT

Science literacy is low among the general populace. Throughout my 12-year career as a biotechnology communicator, I have seen the following anti-GM NGO strategies: creating fear; creating doubts; cherry picking data; character assassination; hiding behind anonymous letters; reluctance to attend open discussion; and shutting down meetings when challenged.

My personal encounters provide an insight into the moral view of the activists. At a global meeting on biological diversity in Japan, an activist spoke on why India should not adopt Bt eggplant, but was ignorant about the crop and when asked, could not answer the number of times eggplants are sprayed with pesticides before harvest—a clear example of someone "Speaking FOR farmers and NOT TO farmers".

Below is an exchange I had, also in Japan, with an activist from South Africa, on her claim that Africa should not adopt biotech crops because almost all farms are small.

Me:	**Do you want African farmers to be smallholder farmers forever?**
Activist:	**That is not for me to answer. Let the farmers decide.**
Industry:	**What do you want ag biotech companies to do in Africa?**
Activist:	**Pack your bags and leave Africa.**
Me:	**Why are you deciding for farmers? You should remain with your earlier position that farmers need to decide for themselves. Let your farmers tell companies to leave or to stay.**
Activist:	**We do not have time for further discussion. We are wrapping up. (She literally ran away).**

The moral of the story is that farmers, politicians, policymakers, regulators and the general public must understand the ulterior motives of many anti-GM activists, most of whom are foreigners. They attempt to decide for countries that are thousands of miles away from where they live and for farmers who they have never interacted with.

WAY FORWARD FOR ASIA

Only a focused political effort will move agro biotechnology forward in Asia. Countries should shed their activist-inspired aversion towards the private sector and not fall for the false claim that corporations are establishing a trade monopoly, especially because most of their GM products are being developed by the government. The 18 million farmers who are growing biotech crops are not foolish. Private-public participation to meet the demand of the farmers and enhance research collaboration is a prerequisite to modernize the agricultural sector.

Regulations need to be put in place in Myanmar, Laos, Cambodia and Thailand. The region is rich with agricultural experience and it should not be difficult to develop national legal instruments and risk assessment and management protocols.

The most critical factor is to raise awareness so the public can distinguish between science and pseudoscience, understand the safety and environmental issues and more importantly understand the agenda of the activists and their motives. Politicians, policymakers and regulators should be the key focus of public awareness and understanding initiatives.

Mahaletchumy Arujanan is the Executive Director of Malaysian Biotechnology Information Centre (MABIC) and Editor-in-Chief of The Petri Dish, the first science newspaper in Malaysia. She is also an Adjunct Lecturer at Monash University, Malaysia. She was listed as one of the world's 100 most influential people in biotechnology by Scientific American Worldview 2015. She uses her Facebook page to promote science literacy.

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> "Science is sometimes hard for some people to swallow, but overcoming these barriers to support informed decision making and foster greater trust is possible."

SCIENCE DENIAL IS A GLOBAL ISSUE HAMPERING FOOD TECHNOLOGY ADVANCEMENTS

Charlie Arnot, CEO, Center for Food Integrity

Asia is home to 60 percent of the global population and two thirds of the world's poor. Many countries are not food secure and traditional farming practices are threatening its agriculture sector.

In her paper, Dr. Arujanan notes that as incomes in developing countries increase, calorie demands will also climb as diets include more resource-intensive foods like meat, dairy, eggs, fruits and vegetables. But the Asian agricultural sector is not well positioned to meet demand as it deals with a lagging GDP, an ageing farming community and the impact of climate change.

Another aggravating factor, according to Arujanan, is low science literacy among the general Asian populace, hindering acceptance of new technology. The challenge is certainly not unique to Asia.

In the 17th century, Galileo used science and his powers of observation to declare that the sun, not the earth, was the center of the universe. For his contribution to science and society he was declared a heretic and spent the rest of his life under house arrest.

Scientific consensus tells us that climate change is real and genetically modified (GM) foods are safe to eat. Yet the public debate on topics like these continues.

Genetic modification and other technologies in food and agriculture have provided many benefits to society. Innovation helps us meet one of humanity's basic needs – making safe, nutritious food accessible. Yet despite what science says, GM foods still generate controversy.

A survey from the Pew Research Center says that 88 percent of scientists believe GM foods are safe to eat, compared with only 37 percent of the public. But the survey doesn't explain why so many consumers reject scientific consensus when it comes to GM foods.

Consumer trust research from The Center for Food Integrity (CFI) examines consumer rejection of science.

Regardless of the topic, whether it's global warming, GM foods or myriad other issues, four barriers play an important role in science denial:

1. Cultural Cognition: the tendency of people to conform their beliefs about controversial matters to group values that define their cultural identities. Professor Dan Kahan of Yale equates it to fans at a sporting event. No matter what the issue, they take their cues about what they should feel and believe from the cheers and boos of their team's crowd.

2. Confirmation Bias: the tendency of people to favor information that confirms their existing beliefs and opinions. People tend to look for "facts" that support their existing world view and it's easy to find given the wide variety of programming available online.

3. Tribal Communication: digital technologies have resulted in communication that is more tribal and insular. Digital expert Seth Godin says the internet has not created a single connected universe, but instead has created silos of interest. It's an environment giving those who are passionate about a hobby, issue or cause the power and platform to lead and impact change.

4. Bad News Bias: research shows that a single item of negative information is capable of neutralizing five similar pieces of positive information (Richey, Koenigs, Richey and Fortin 1975). All it takes is for one person – a friend, a reporter, a blogger – in your sphere of influence to make a single bad news claim and trust begins to erode.

Indeed, science is sometimes hard for some people to swallow, but overcoming these barriers to support informed decision making and foster greater trust is possible. CFI's research shows that building relationships based on shared values is the first step to successfully introducing technical information. Too often those in agriculture and food resort to, "If I just give consumers more information and more facts, they'll come to my side." But that approach falls flat.

Science may tell us that we can create/grow/build something, but society is asking if we should. Can and should are two entirely different questions. Scientists have tried to substitute scientific verification for ethical justification with the result being a growing gap in scientific acceptance.

CFI's research clearly shows that when people realize your values are aligned with theirs, they are more willing to consider technical information on an issue as personal as the food they feed their families.

Building trust is a process. Authentic transparency and continued engagement will encourage objective evaluation of scientific information that supports informed decision making. Encouraging informed decision making requires meeting people on their turf, embracing their skepticism and a commitment to engaging over time.

Skepticism in science and technology won't change – and it shouldn't. After all, it was healthy skepticism that drove Galileo and continued scientific discovery. But our approach to communicating science and technology has to change to encourage and support decisions based on sound information.

GMO

BEYOND THE SCIENCE

HOW EUROPEAN-BASED NGOS BLOCK CROP BIOTECHNOLOGY ADOPTION IN AFRICA

Margaret Karembu, director of International Service for the Acquisition of Agri-biotech Applications, Africa regional office (ISAAA) AfriCenter based in Nairobi.

HIGHLIGHTS

- European politicians and anti-biotech groups lobby to prevent Africa from adopting or trading GE crops
- Africa remains laggard in food security and faces growth, population and climate change pressures
- African farmers fared poorly using family agro-ecology techniques
- 'Smart' farming fueled by technology can attract youth back into farming
- Farmer experiences with handful of approved GE crops overwhelmingly positive
- Mozambique planted its first confined GMO field trial for drought resistant corn in February 2016

I grew up in rural Africa, in Central Kenya, in a small village deep down the slopes of Mt Kenya called Gaikundo. For most parts of the year, it was a struggle putting food on the table for our family of 12 and those in the neighborhood. I now know we practiced subsistence farming or what European "greens" have fashionably coined *'agro-ecology family farming'*. This is the type of farming in which farmers focus on growing enough food to feed themselves and their families within their localized ecosystem. The output is mostly for local requirements with little or no surplus to take to the market.

For many of the villagers, we hardly produced adequately to last to the next harvest. Seeds were exchanged freely or barter-traded. It was worse for vegetatively-propagated staple crops— bananas, sweet potato and cassava where, exchanging planting material also meant transferring diseases and pests of mother plants from one neighboring farm to another. Seed systems and hybrid seeds were only slowly being introduced. The majority of farmers were locked up in unsustainable food production modes that further perpetuated the poverty cycle.

That was 50 years ago. Now, farmer practices are beginning to modernize—but we are facing political opposition, mostly from other countries, who seem determined to prevent Africa from joining in a global agricultural revolution.

It was disheartening to learn in June 2016 that the European Parliament adopted a report on the New Alliance for Food Security and Nutrition (NAFSN) stating that any support to African agriculture should be confined to the "agro-ecology family farming level"—the very practices that modern-focused farmers are trying to move away from. Adopted by a large majority of parliamentarians—577 to 24—the report attacked ongoing efforts to introduce advanced technology into African agriculture.

The parliamentarians sharply criticized the bloc of industrialized democracies known as the 'Group of Seven G7's (G7) resolve on intensification of agriculture to address food insecurity. "We have already made the mistake of intensive agriculture in Europe. We should not replicate it in Africa because this model destroys family farming and reduces biodiversity," said Maria Heubuch, a German Green MEP and rapporteur on what has been dubbed "The Heubuch Report".

The New Alliance for Food Security and Nutrition (NAFSN) in Africa is a public-private partnership (PPP), launched in 2012 under the auspices of the G7 to leverage private sector investment in agriculture, with an overall goal of improving food security and nutrition in sub-Saharan Africa. Critics, mainly from the EU Green parties, argue that NAFSN would marginalize small-scale farmers by replicating in Africa the model of the 1960s/1970s Asian 'Green Revolution', based on monoculture, mechanization, biotechnology, dependence on fertilizers, long distribution channels and the production of export crops that may compromise the environment. This is far from the truth. Small scale farming dominates the majority of Asian agriculture. Moreover, African governments are seeking to change the "tired narrative" about poverty and hunger-stricken Africa by adopting proactive proven approaches, research, and modern farming practices with increased private sector participation.

One paragraph in the Heubuch Report argued that introduction and spread of certified seeds in Africa increases smallholder dependence, makes indebtedness more probable and erodes seed diversity. G7 member states were urged not to support genetically engineered crops in Africa.

I have kept in touch with my village roots and can authoritatively challenge this colonial mindset about Africa. The African farming narrative has completely changed in recent decades. We are not an agricultural backwater as European politicians seem to believe but potentially the World's future food basket. More and more farmers appreciate the value of using certified seeds, which greatly out yield farm-saved seeds. Within the eastern Africa region for example, the average adoption rate of improved hybrid maize seed is 44 percent (Marechera, G.,et al 2016), and increasing fast. This has not in any way prevented those farmers who want to use farm-saved seed from doing so or undermined seed diversity.

While the right of those farmers who wish to multiply, use, exchange and sell their own seeds should be protected, this should be reciprocal for farmers who wish to use modern technologies. The guiding principle should be respect for choice and opinions. Farmers need and want choices, not European-imposed restrictions. Without that, how will those transitioning from subsistence to farming-as-a business meet the ever stringent market access requirements in regulations, private standards and consumer demands?

Ironically, Europe has some of the utmost stringent commodity import standards. Most small-scale suppliers from Africa have long since been pushed out of the EU market in favor of large farms. Small African farmers can't compete with this model, which is heavily stacked to shield Europe's market but retard Africa's. A European or global standard is inherently inflexible, and this is most problematic for suppliers that operate under circumstances advocated for in the Heubuch report.

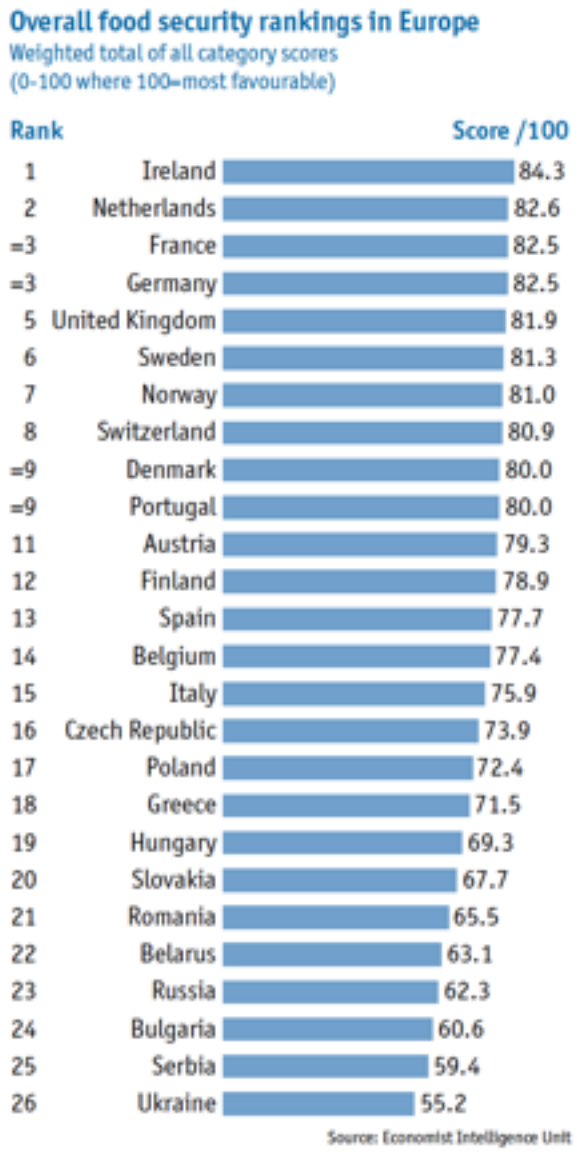
Why would Europe incite the G7 members against funding genetically engineered (GE) crops in Africa? One would be forgiven to think biotechnology is an anathema to Europe. Not so. Europe has approved at least 86 GM crop products (Aldemita et al 2015). In 2014 for example, the EU imported more than 30 million tons of GM soya bean for use as animal feed, making Europe one of the largest regional importers of GMOs in the world. At least 87 recombinant (GE) drugs have been approved by Europe as of 2008 (Paarlberg, 2008).

If Europe is reaping rewards from the biotech trade, why should Africa be prohibited from growing the most technologically advanced and sustainable crops?

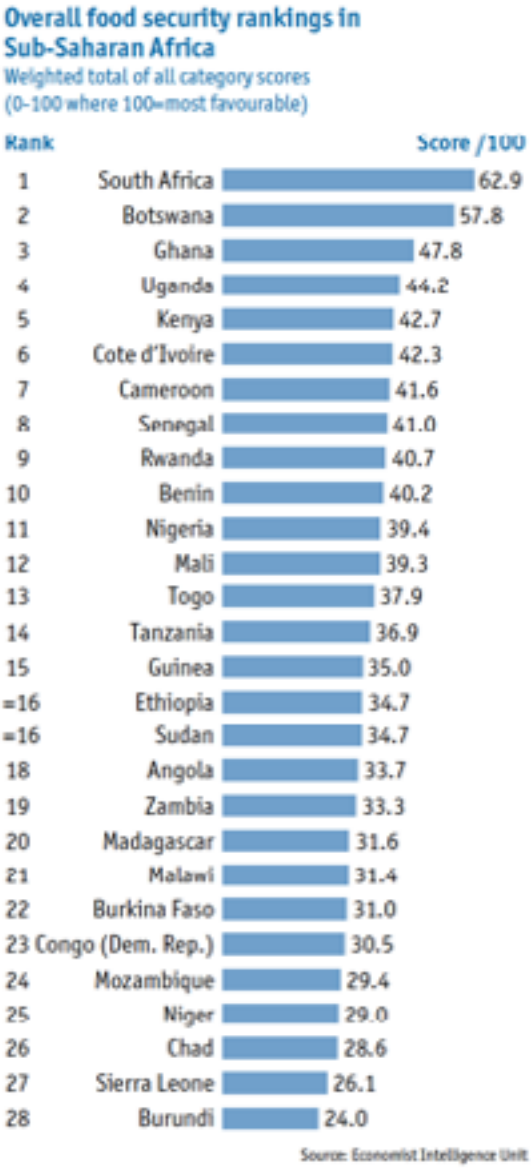
AFRICA AND FOOD INSECURITY

Historical and global experiences indicate technology (in all forms) has provided a bridge between food insecurity and food abundance. According to the Food Security Index 2016, developed western countries hold the highest levels of food security while sub-Saharan African countries are at the bottom of the rankings.

FOOD SECURITY RANKING IN EUROPE 2016



FOOD SECURITY RANKING IN SUB-SAHARAN AFRICA 2016



The Economist Intelligence Unit

Global food security Index 2016 An annual measure of the state of global food security

2016 GFSI overall rankings table

Weighted total of all category scores (0-100 where 100=most favourable)

Rank		Score /100
1	United States	86.6
2	Ireland	84.3
3	Singapore	83.9
=4	Australia	82.6
=4	Netherlands	82.6
=6	France	82.5
=6	Germany	82.5
=8	Canada	81.9
=8	United Kingdom	81.9
10	Sweden	81.3
11	New Zealand	81.1
12	Norway	81.0
13	Switzerland	80.9
=14	Denmark	80.0
=14	Portugal	80.0
16	Austria	79.3
=17	Finland	78.9
=17	Israel	78.9
19	Spain	77.7
20	Qatar	77.5
21	Belgium	77.4
=22	Italy	75.9
=22	Japan	75.9
24	Chile	74.4
25	Czech Republic	73.9
26	Oman	73.6
27	Kuwait	73.5
28	South Korea	73.3
29	Poland	72.4
30	United Arab Emirates	71.8
31	Greece	71.5
32	Saudi Arabia	71.1
33	Bahrain	70.1
34	Hungary	69.3
35	Malaysia	69.0
36	Uruguay	68.4
=37	Argentina	68.3
=37	Costa Rica	68.3

Rank		Score /100
39	Mexico	68.1
40	Slovakia	67.7
41	Brazil	67.6
=42	China	65.5
=42	Romania	65.5
44	Panama	64.4
45	Turkey	63.6
46	Belarus	63.1
47	South Africa	62.9
48	Russia	62.3
49	Colombia	61.0
50	Bulgaria	60.6
51	Thailand	59.5
52	Serbia	59.4
53	Tunisia	57.9
54	Botswana	57.8
55	Peru	57.7
56	Ecuador	57.5
=57	Azerbaijan	57.1
=57	Egypt	57.1
=57	Vietnam	57.1
=60	Jordan	56.9
=60	Venezuela	56.9
62	Morocco	55.5
63	Ukraine	55.2
64	Dominican Republic	55.1
65	Sri Lanka	54.8
66	Algeria	54.3
67	Paraguay	54.2
68	Kazakhstan	53.7
69	El Salvador	53.3
70	Bolivia	51.6
71	Indonesia	50.6
72	Uzbekistan	49.8
73	Guatemala	49.6
74	Philippines	49.5
=75	India	49.4
=75	Nicaragua	49.4

Rank		Score /100
77	Honduras	48.2
=78	Ghana	47.8
=78	Pakistan	47.8
80	Myanmar	46.5
81	Uganda	44.2
82	Nepal	42.9
83	Kenya	42.7
84	Cote d'Ivoire	42.3
85	Cameroon	41.6
86	Senegal	41.0
87	Rwanda	40.7
88	Benin	40.2
89	Cambodia	39.8
90	Nigeria	39.4
91	Mali	39.3
92	Tajikistan	38.6
93	Togo	37.9
94	Tanzania	36.9
95	Bangladesh	36.8
96	Syria	36.3
97	Guinea	35.0
=98	Ethiopia	34.7
=98	Sudan	34.7
100	Yemen	34.0
101	Angola	33.7
102	Zambia	33.3
103	Laos	32.7
104	Madagascar	31.6
105	Malawi	31.4
106	Burkina Faso	31.0
107	Congo (Dem. Rep.)	30.5
=108	Haiti	29.4
=108	Mozambique	29.4
110	Niger	29.0
111	Chad	28.6
112	Sierra Leone	26.1
113	Burundi	24.0

Germany and France—which have opted out of cultivating GMO crops—both ranked 6/113; in contrast, Kenya ranked 83 and Mozambique 108. Modernization of the agricultural sector in the 1940s spurred productivity in Europe and ended food dependency in the United States. The Green Revolution, which harnessed the use of advanced genetics and used synthetic fertilizers and pesticides, helped Asia close to filling the gap with the industrialized countries. Africa was left behind.

It is critical that African countries that face immense food security challenges due to rapid population increase, low agricultural productivity and climate change are given an opportunity to make their own decisions about the choice of agricultural tools without undue interference from food secure countries. The global population is expected to grow to 9.7 billion in 2050 and 11.2 billion in 2100, according to the United Nations, with roughly half of the growth taking place in Africa. The UN predicts that by 2050 the human race will require 60 percent more food—100 percent more in the developing world. There is no safety or environmental reason for Africa to be blocked from charting its own course on GE crops.

AFRICAN CROP BIOTECH ADOPTION

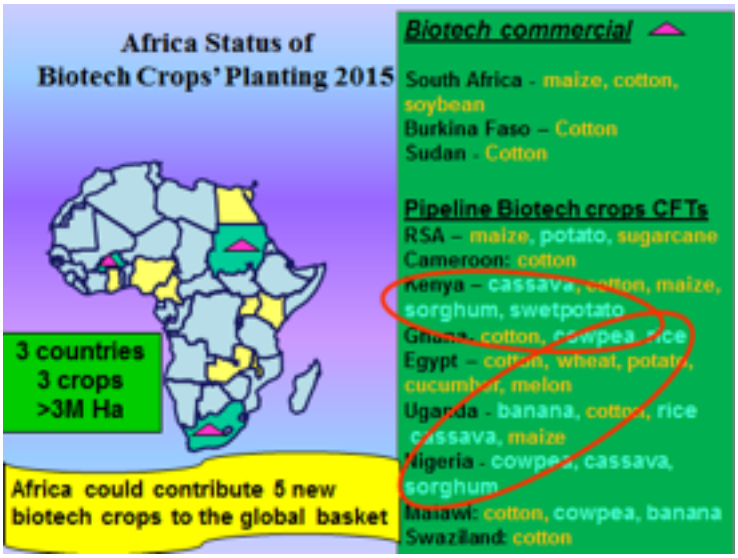
Corroborating other findings from credible institutions including the European Food Safety Authority, the US National Academies of Sciences, Engineering, and Medicine found no difference in risks to human health between currently commercialized GM crops and conventionally (including organic) bred crops. These reports have documented that GE crops have allowed farmers to reduce chemical pesticide, translating into more money for farmers who are better able to support their families and lower food prices for consumers.

The accumulated hectarage of biotech/GM crops planting between 1998 and 2015 in Africa stood at 3.5 million with an estimated economic benefit of ~ USD $2 billion (Brookes and Barfoot, 2016). Three countries maintained the lead in adoption: South Africa at 2.3 million hectares, Burkina Faso with 350,000 hectares and Sudan at 120,000 hectares.

Heavy reliance on rainfed agriculture makes farming in Africa unpredictable. A devastating drought in South Africa in 2015, for example, contributed to a massive 23 percent decline in intended plantings, demonstrating the vulnerability of the continent to climate change. The drought led to a decrease in the production of biotech crops from an anticipated record of 3.0 million to 2.3 million hectares. An approval of drought tolerance trait in maize under WEMA—the Water Efficient Maize for Africa project in 2015, was a timely development. The public-private sector partnership is being implemented in five countries: Kenya, Mozambique, South Africa, Tanzania and Uganda.

African scientists are conducting GM crop trials on key food security crops, which include: banana, cassava, cowpea, sweet potato, maize, potato and rice—some of which are nearing commercialization. In addition to South Africa, Burkina Faso and Sudan, which have commercialized biotech crops, eight others—Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria, Uganda and Swaziland—are conducting trials on crops with traits relevant to African agricultural challenges. They include: drought tolerance, pest and disease resistance, nutritional enhancement, nitrogen and water use efficiency and salt tolerance for which the 11 African countries are conducting trials on. Africa could contribute five new biotech crops to the global food security basket in the coming years.

Source africenter.isaaa.org



Many African scientists, farmers and policy makers are eager to see GE crops more widely embraced. I have been tracking African farmers who have started growing GE crops and their testimonies are inspiring. Take the case of Maria Swele, a 35-year-old woman from Limpopo province in South Africa. Maria has won the local award for youth and technology adoption twice in a row, becoming a role model for many young people in her region.

Her story underscores the changing agricultural narrative within Africa's small-scale agricultural scene:

[Maria Swele on her farm]

I was inspired into Bt cotton farming 4 years ago by my former employer Mr. Frans Mallela--himself a large-scale farmer. He discouraged me from taking up a clerical office job but instead try out 5 hectares of Bt cotton and that has made all the difference in my life. In 4 years, I have increased area of production tenfold to 50 hectares of Bt cotton. Venturing into Bt cotton enterprise has been rewarding, enabling me to purchase 2 tractors, a car and a house. I have also managed to pay for my younger sister's education. Attending to our crops is so much easier and has drastically reduced labour. We no longer need to carry crude tools to weed and spray as most of this is now done mechanically.

Elameen Alzain, 45 years old, is a cotton farmer from Sudan who uses seeds engineered with the natural bacteria Bt (Bacillus thuringiensis), which fights bollworms (and is used in spray form by organic farmers):

"When you plant Bt cotton, you are assured of high quality and quantity. There is no guarantee with the old varieties. I saw an opportunity to improve my lifestyle. The yields were very high and with no bollworm damage, I realized I could make big savings."

In Burkina Faso, 38 year-old Sibiri Antoine Nikiéma, a farmer in Lado (Saponé), began growing insect-resistant cotton. With the increased proceeds, he has acquired a bicycle, a motorbike and built a family house, and now comfortably pays school fees for his children:

> *I am very satisfied with Bt cotton due to its many advantages, especially in terms of monetary returns. Bt cotton has improved the quality of our lives and the labour is not as tedious as before since we don't spray that much now – from 8 sprays to just 2. My colleagues and I are relieved from harmful chemicals sprayed to Bollworm.*

If we could replicate these scenarios and extend it to 60 percent of the African population that is now directly engaged in the agricultural sector, Africa could make a quantum jump in productivity and draw back many young people who are shunning farming in favor of elusive "smart" technology-driven enterprises in big cities. Every farmer in Africa and indeed farmers everywhere are looking for better tools, competitive yields and socio-economic empowerment, not the reverse!

BIOTECH POLITICS

The biosafety regulatory landscape has improved significantly, but challenges remain. In 1998, South Africa was the only country with a biosafety law. By 2016, 19 African countries had developed biosafety legislation, and even Zambia, long a center of hostility toward GM crops, has responded to the ongoing drought crisis by indicated it is favorably inclined to allow importsof GM food. Nigeria, Africa's most populous country, enacted its law in 2015, and four crops--insecticide resistant Bt cotton; Bt cowpea (a legume); iron, zinc, protein and Vitamin A fortifiedand nitrogen efficient sorghum; and salt tolerant and water efficient rice--are undergoingconfined field tests. The same year, Kenya's National Biosafety Authority received for the firsttime two applications for open field cultivation of genetically modified maize and cotton.Initiatives to operationalize biosafety laws in other countries as well as regional biosafetyharmonization efforts have continued.

Despite these gains, counter-productive debates and political misgivings continue to slow downprogress with the technology—mostly perpetrated by non-African based groups, and often fromEurope. NGOs such as Greenpeace, Friends of the Earth, GeneWatch UK, ActionAid and GMFreeze and their affiliates in Africa claim GM crops would mortgage the agricultural sector tolarge multinational corporations, harm biodiversity, undermine small farmers and expose theirpopulations to the potential health hazards of consuming GM food.

According to Greenpeace, "GMOs should not be released ... since there is not an adequatescientific understanding of their impact on the environment and human health." Zakiyya Ismail, acampaigner for the African Center for Biodiversity, has said, "There is no consensus around thesafety of GMOs and there should be long term studies into them

before they are released intothe food supplies." Jason Tutu, the communication leader of Food Sovereignty Ghana claimed,"GMO products carry known health risks such as organ damage, sterility, infant mortality, birthdefects, low sperm quality and increase risk of cancer."

No health or science agency in the world has documented links between GM foods and anyhealth hazard, let alone cancer.

THREE CASES DESERVE MENTION

- In November 2012, Kenya declared a ban on genetically modified grain imports. The decision emanated from a publication of a paper by French researcher Gilles-Éric Séralini, which featured grotesque pictures of rats with bodies twisted by cancerous tumors supposedly caused by GMO feed and glyphosate, a herbicide paired with some GE crops. The author's conclusions and experimental design were heavily criticized, and the paper was retracted and then republished in "free for all" non-peer reviewed online journals, and again greeted with harsh criticism from scientists. But the damage was done with the original publication, and it had a ripple effect across Africa. Kenya banned GMO imports and cultivation, and it remains in place today (2016). As a result, young people are discouraged from venturing into biotechnology-related courses and there has been a drastic reduction in number of applications for processing of GMO-related requests, denying the government revenue.

- In 2014, the Head of the European Union delegation in Kenya, on live TV, made a highly discriminatory 'warning' to Kenyan farmers that Kenya risked losing the Europe export market if it adopted biotech crops. "We have had a huge discussion on GMOs in the EU and have made it crystal clear to farmers in South Africa and here in Kenya that we are not in favor of GMOs. Farmers who grow GM crops will have difficulty exporting their produce to the EU," he said. While the statement was later retracted, with the office of the head of delegation acknowledging its inaccuracy, these sentiments demonstrate the level of foreign interference, which helps explain the slow progress with the sector.

- In March 2015, ActionAid-Uganda admitted as misguided and inappropriate its campaign on genetically modified foods in which it suggested a link between GMOs and health problems, including cancer and infertility. Action Aid's UK headquarters apologized to the Uganda government, saying, "ActionAid and ActionAid Uganda remain sorry for any past suggestion we have made of a link between GM food and health concerns." But the damage had been done. The country and many others in Africa have seen an upsurge of activism against

> the technology even as scientists work hard to apply biotech tools to address the many pest challenges facing key staple crops such as banana bacterial wilt, banana biofortification, cassava mosaic and brown streak viral diseases, sweet potato weevil and potato late blight among several others. In each case, there are biotech tools that could offer comparative advantages against other conventional breeding methods. A Biotechnology and Biosafety Bill to regulate responsible use of the technology remains locked in parliamentary debate.

A few private European food importing companies have consistently misrepresented the official EU position on biotechnology. These misrepresentations have been perpetuated by insufficient knowledge about the magnitude of GE trade in EU on the part of African export traders and the deliberate misinformation spread by some foreign-funded anti-biotech interest groups about the official status of the technology in the EU.

To a large extent, these misconceptions have created confusion and complicated policy choices for African countries as vested anti-biotechnology and anti-business ideologies find their way into government offices and influence decision makers. In some instances, African fresh produce exporters to the EU are pressured to declare their goods are GMO-free even when there are no GE versions of their products.

Maize is the major staple of 300 million Africans. In the period, 1996-2015, biotech maize was successfully grown globally in about 15 countries by millions of farmers on 600 million hectares, who benefitted from $50 billion in increased revenues. Ironically, farmers in African countries (except South Africa), where the need for improved maize is greatest, suffered a big opportunity cost because they were denied the choice to adopt biotech crops. Lack of, and/or unpredictable regulatory environment, weak political support and misinformation are the greatest contributors to this loss.

This affirms the need for continuous exploration of new crop improvement opportunities to provide sustainable solutions to food and nutrition security. Priority for application of modern biotechnology in Africa should, and must focus on improving food security and environmental sustainability.

Moreover, African agriculture is currently characterized by ageing farmers, as the youth shun farming to look for white collar jobs. The young, who are flexible and willing to adopt technology, are no longer enthusiastic about old farming methods as they are tedious and lead to low rewards. However, with the narrative changing in South Africa, Sudan and Burkina Faso, where young farmers are now willing to take up farming because of the access to high yielding seeds and labour-saving technologies, African policy makers should rebuff EU ideologies that want to take the continent back to the dark ages.

To entirely exploit and benefit from modern biotechnology, Africa needs to focus on three strategic areas:

- Accelerate adoption of those proven biotechnologies that are appropriate in addressing Africa's unique challenges
- Encourage collaboration and partnerships that will increase the probability of delivering approved biotech crop products to farmers within a reasonable time frame
- Reposition Africa towards being a global player in development and ownership of emerging technologies such as genome-editing that can be applied within existing policy infrastructure.

Margaret Karembu, Director of International Service for the Acquisition of Agri-biotech Applications, Africa regional office (ISAAA) AfriCenter based in Nairobi, is a senior level environmental management specialist and communication trainer. She is chairperson of the Open Forum on Agricultural Biotechnology in Africa (OFAB), Kenya chapter and has contributed to international journal papers, book chapters and policy briefs on agri-biotechnology and biosafety. She holds a PhD in Environmental Science Education from Kenyatta University, Kenya, where she taught for more than 10 years prior to joining ISAAA.

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> "Building trusting relationships with consumers is about making what farmers are doing relevant to them and helping them understand that farmers share their values when it comes to issues important to them."

NEW TECHNOLOGY ADOPTION IS THE ETHICAL THING TO DO

Charlie Arnot, CEO, Center for Food Integrity

Embracing technology in order to improve efficiency, protect and preserve natural resources, feed a rapidly growing global population and many more positive impacts is ethically and morally appropriate.

In 1950, the U.S. population was 154-million and one farmer produced enough in a year to feed 30 people. We've more than doubled the population and one farmer today produces enough to feed 160 people. Today's farmers produce an amazing 262 percent more food with two percent fewer inputs such as labor, seed, animal feed and fertilizer.

The so-called "Green Revolution" refers to technological advances 50 or 60 years ago that paved the way for global agricultural productivity increases. Things such as high-yielding varieties of seed, chemical fertilizers, irrigation and new methods of cultivation are credited with saving the lives of a billion people. Something similar needs to happen again and efforts are being made in Africa as evidenced by the experience of Ms. Karembu documented in her paper, "Biotechnology Adoption in Africa."

Karembu says respect for choice and opinions should be the guiding principle in the ongoing discussion of modern technology adoption in Africa. "Without that, how will those transitioning from subsistence to farming-as-a business meet the ever stringent market access requirements in regulations, private standards and consumer demands?"

The modern row crop technology famers in Africa so desperately seek to adopt is but one of many advances in agriculture that have taken place in the last half-century. Improved animal health products and housing systems help keep animals that produce food healthier and more productive. New gene-editing technology holds the potential for life-changing applications in plants, animals, people and essentially any kind of organism.

As global population sprints toward 9.7 billion by mid-century, estimates point to the need

for 100 percent more food by mid-century. It's especially critical in Africa where around half the population growth is expected to take place.

Agriculture must produce more, using less through innovation and the responsible use of technology, which farmers, when allowed to, have been doing for decades. It is in humanity's best interest to use technology in food production because it allows us to feed a rapidly growing global population.

But, that message alone won't generate public support for today's agriculture technology. The Center for Food Integrity's consumer trust research survey shows much stronger support for the notion of teaching developing countries how to feed themselves than to export food to them.

What consumers care about most, according to the research, is having access to healthy, affordable food. Farmers, whether in the U.S., Africa or anywhere else, are more likely to build support for modern farming technology by talking about what they do on the farm today that helps keep food healthy and affordable.

Many people are uncomfortable with modern food production systems and the size and scale of today's farming operations. That's understandable. With a predominant "big is bad" mindset, many people believe today's food producers place profit ahead of public interest.

Building trusting relationships with consumers is about making what farmers are doing relevant to them and helping them understand that farmers share their values when it comes to important issues like protecting soil and water and providing healthy, affordable food. CFI's peer-reviewed and published trust model shows that communicating with shared values is three-to-five times more important to building consumer trust than simply providing information.

Food and agriculture must change the conversation and transparency is the key. CFI's research proves that as those in the food and agriculture increase transparency, they also increase consumer trust. The link between transparency and trust is real, direct and powerful.

The new reality is that consumers expect more than quality and safety. They also expect the supply chain to be transparent. Farmers and food companies who believe these are not their issues do so at their own risk. They can no longer assume that the public knows they care about the food they produce. This makes them susceptible to the belief that they're no longer worthy of public trust. The volatile, "I'm right, you're wrong" nature of today's conversation about food further reinforces that distrust.

As a result, those in food production must commit to transparency, be willing to engage in a dialogue with consumers and answer their questions in an honest, open manner. Effectively

demonstrating transparency will help increase trust in their processes and products, while supporting consumers in making informed decisions. Some farms and food companies have embraced this reality and pulled back the curtain.

As consumers are bombarded with conflicting information, it is understandable that new technology is being met with skepticism and society's increased demand for transparency must be satisfied. While the demand for more information is accompanied by an obligation for consumers to objectively examine the data and to focus on the need for safe, healthy, affordable, responsibly-produced food, it's the food system's responsibility to embrace the skepticism and communicate in a transparent manner.

GMO

BEYOND THE SCIENCE

PERPLEXING CASE OF CONSUMER CONFUSION ABOUT GE FOODS IN A 'FAKE NEWS' WORLD

Brandon McFadden, assistant professor in the Food and Resource Economics Department, University of Florida.

HIGHLIGHTS

- Consumers have little knowledge, many misconceptions about agriculture, genetics
- Most believe conventional breeding alters fewer genes than GE
- Opinion polls unreliable signal for informing public policy about GE food
- Large agriculture companies viewed more skeptically than organic, natural food sectors
- Skepticism about scientific evidence on safety, benefits of GE foods confounding

Despite a lack of basic knowledge about agricultural production, consumers are taking a more assertive role in the food value chain. There is much to applaud about the vibrancy of a market that offers consumers what they want. But, as research in behavioral economics has shown, they may not always know what they want or logically evaluate the alternatives, particularly when it comes to public policy in which the consequences and costs are often far from obvious. Research has shown that people are poorly educated about basic science and genetics, which is one of the key reasons why there is so much conflicting results stemming from consumer polls regarding food.

A majority of consumers mistakenly but consistently believe that all unprocessed food is "as nature made it." This is simply not true. Consider ancient maize, for example. It's believed that corn was first developed about 7,000 years ago when early agriculturalists

> "Research has shown that people are poorly educated about basic science and genetics, which is one of the key reasons why there is so much conflicting results stemming from consumer polls regarding food."

began modifying a wild, inedible grass called teosinte. Many people do not realize that it took thousands of years of modifications to create modern corn (sweet corn is only a few hundred years old). When Oklahoma State agricultural economist Jayson Lusk and I conducted a survey on attitudes about what we eat, we found that approximately 49 percent of respondents thought the genetic structure of corn had never varied prior to genetically engineered (GE) corn, which was first grown in 1996.

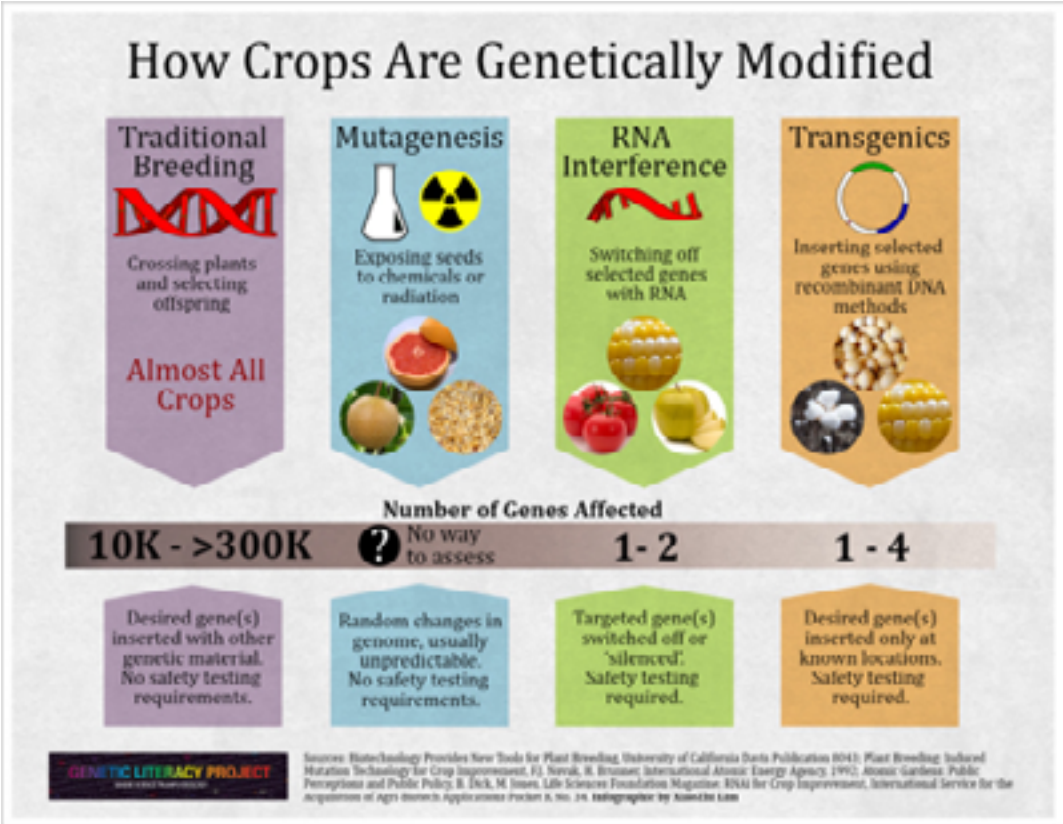
Our survey also showed that 34 percent of respondents thought genetically engineered (GE) tomatoes contained altered genes but non-GE tomatoes did not, and 32 percent thought fresh vegetables did not contain DNA. In addition, respondents thought that more than 50 percent of corn and wheat acreage was GE. The actual acreage of GE corn is 92 percent, but there is no commercially approved GE wheat. These findings underscore how challenging it is to understand consumer skepticism about GE food. Even in countries such as the United States, consumers have little knowledge and many misconceptions about genetics and agriculture production in general.

NATURAL CONUNDRUM

A lack of knowledge about genetics does not preclude a majority of consumers from believing that the GE breeding technique is "playing with nature." Nearly half of consumers are unaware that other breeding techniques, such as mutagenesis and wide crossing, also alter genes. How various breeding techniques alter genes is shown in the infographic below.

Note that the two conventional breeding techniques, crossing plants and mutagenesis, result in the most number of affected genes. The perception that the GE breeding technique is distinctly unnatural may be exacerbated by associations with terms such as genetic engineering, genetic modification (GM) and genetically modified organisms (GMOs).

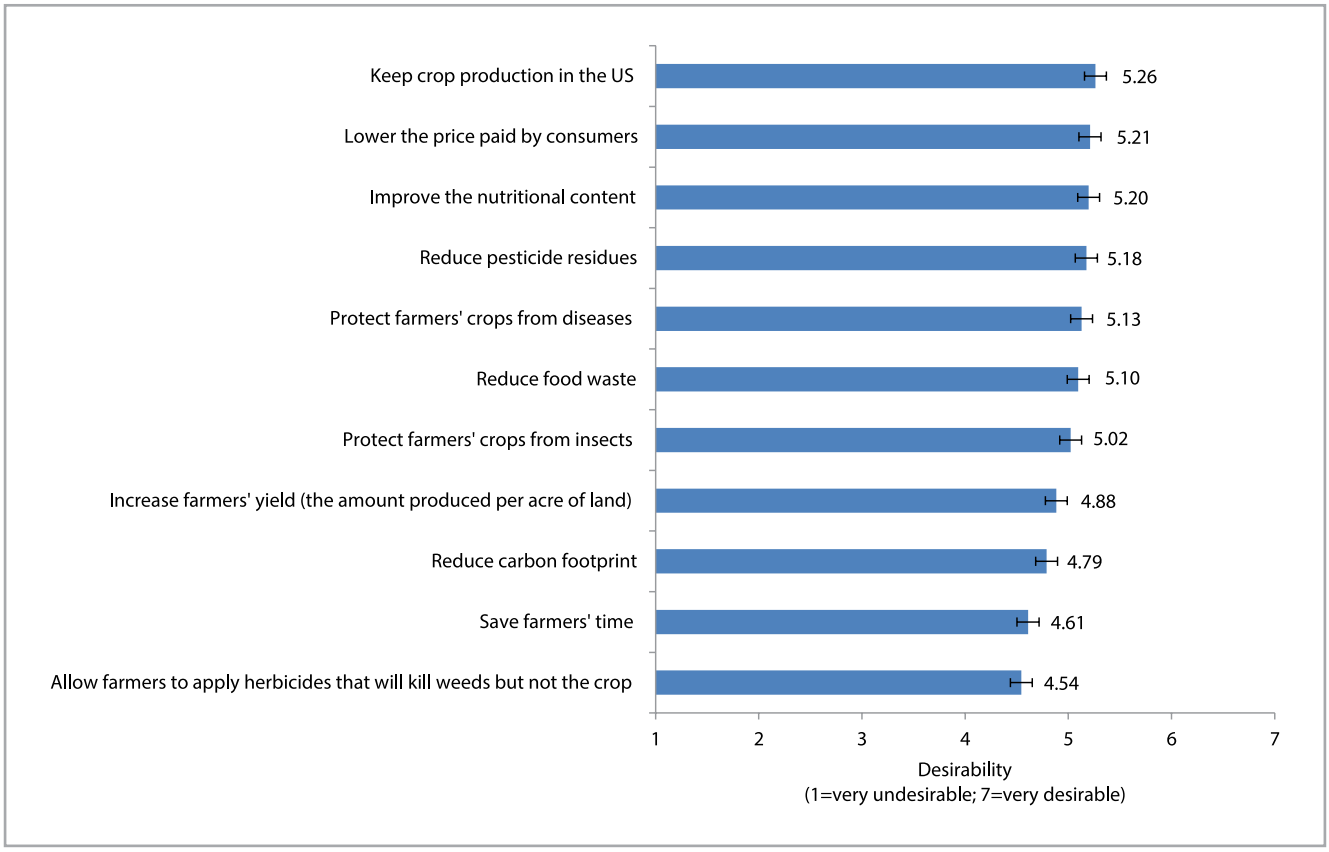
When Professor Lusk and I asked questions about how many genes are altered by various breeding techniques, a significant proportion of respondents thought GE altered more genes than most other breeding techniques, with the exception of hybridization which is a conventional breeding technique that has been used since the 1920s involving the crossing of two genetically different plants. Many thought traditional selective breeding, which affects tens or hundreds of thousands of genes randomly, did not alter any genes. Respondents viewed it as the most "natural" breeding technique.



A joint 2016 study by psychologists at the Universities of Pennsylvania and Toronto found a near majority (45%) perceived GE food as "unnatural" and intrinsically disgusting, and thought "GE food should be prohibited no matter the risks and benefits." Our research has shown that GE animal products are viewed as more offensive than GE vegetables or fruits, and fresh GE foods are viewed as more offensive than processed GE foods. On average, respondents ranked beef as more desirable than corn or apples when all were non-GE. However, if all were GE, then respondents ranked corn or apples as more desirable than beef. These findings indicate that consumer aversion to GE foods is not uniform across all food products.

DOES IT MATTER WHO BENEFITS FROM GE FOODS?

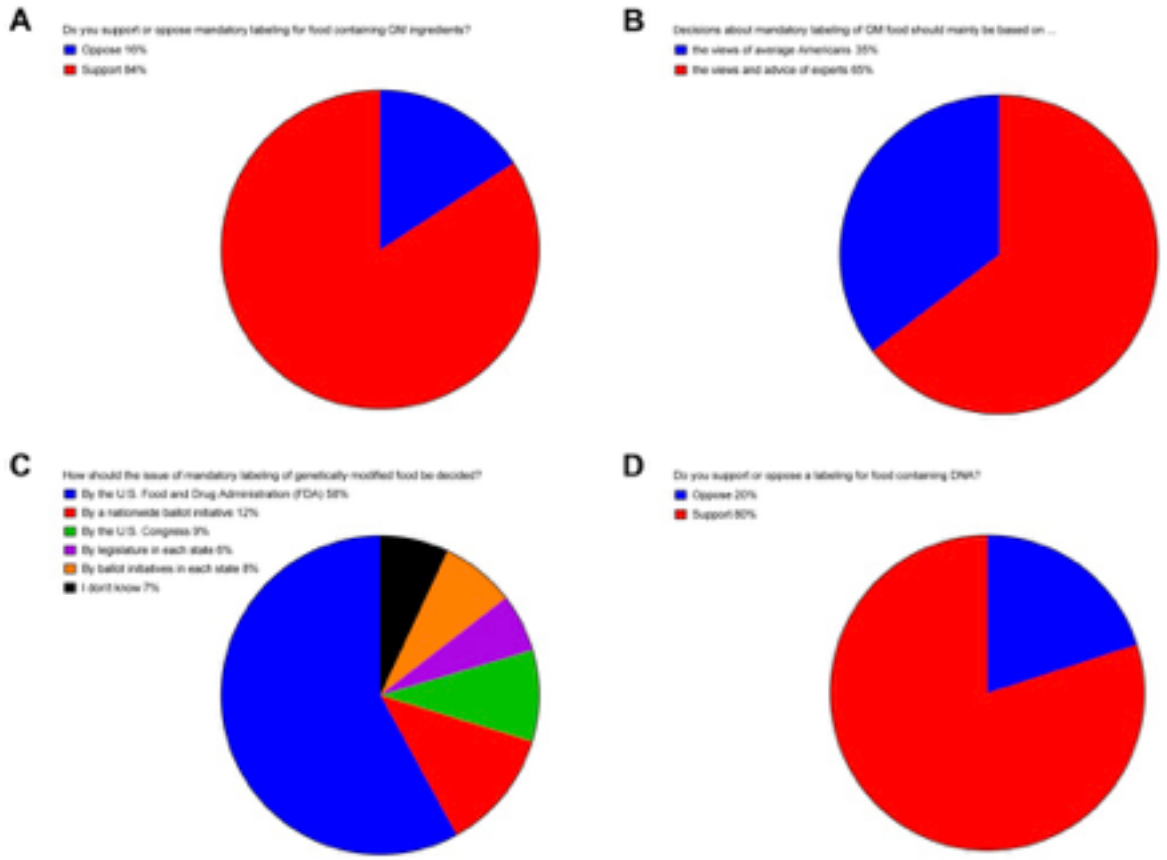
GE foods are often discussed as a dichotomous choice in which all GE food must be good or bad. However, reasons why a specific GE food was developed—whether it is perceived as benefiting consumers or producers—affected attitudes significantly. Currently, the majority of GE foods on the market, such as herbicide-tolerant and insect-resistant soybeans and corn, have been developed to benefit producers rather than consumers (although consumers do reap some benefits in lower prices). In these cases, consumers may perceive that they are being asked to bear some potential risk without any obvious benefit. Applications with more direct-consumer benefits, such as increased nutrition or keeping prices lower, were rated as more desirable.



Consumer benefits may not be enough of an incentive for some vexed consumers. The Pennsylvania-Toronto researchers found 46 percent of respondents supported a ban of all GE food regardless of the benefits. This absolutist stance is troublesome as the GE breeding technology was most likely used because other breeding techniques could not provide the same results or consumers did not make the connection between producer and consumer benefits (i.e., lower production costs resulted in lower consumer prices). If breeders could obtain the same results using traditional breeding practices, they most likely would because the governmental regulations associated with getting a GE food to market are more burdensome.

FAILURE OF POLLS TO CAPTURE ACCURATE CONSUMER SENTIMENT ABOUT LABELING

Advocates of mandatory labels for GE foods often brandish consumer studies to lobby policy makers to pass legislation they claim that consumers desire. But what consumers desire is not as clear as labeling proponents suggest since opinions in surveys are often driven by how the questions are framed, as our research has shown.



Claims that a majority of consumers support mandatory labeling is over-simplified. Although 84 percent of those surveyed support mandatory labeling for GE foods, the majority of respondents (65%) thought decisions about mandatory labeling should be based on the views and advice of experts and not on the views of the average consumer. In fact, a majority (58%) indicated that the issue should be decided by the US Food and Drug Administration and not by popular vote.

Underscoring the "disconnect" between the public's demands and their biotechnology IQ was the fact that 80 percent of respondents indicated that they support mandatory labeling for all food containing DNA. This is a ridiculous demand because all plant- and animal-based foods contain DNA.

It should also be noted that there is a potential cost (which could be considerable, although research on this is conflicting) associated with mandatory labeling. Yet, consumers are completely rational to want what to them seems like free information that may be beneficial to a decision-making process at some point in the future.

When all of these findings are taken together, it is clear that consumer opinion polls are inadequate to conclude that policy makers should legislate mandatory labeling and raise serious doubts about their usefulness as a basis for public policy surrounding GE food.

CHEMOPHOBIA AND GE FOODS

Another consumer concern about food containing DNA is an aversion to unfamiliar chemicals like deoxyribonucleic acid (DNA) being in their food. A 1983 April Fools' Day edition of the weekly newspaper in Durand, Michigan, reported that "dihydrogen oxide" had been found in the city's water pipes, and warned that it was fatal if inhaled, accelerated corrosion, and could produce blistering vapors. The report led to a brief petition to ban the 'dangerous chemical.' Dihydrogen oxide is the chemical description of water. This hoax illustrates how a lack of scientific literacy can make something consumed everyday sound scary when called by its chemical name.

A similar reaction was found when people were queried about sodium chloride—common table salt. Approximately 34 percent of respondents who thought it was okay for a food with added salt to be labeled "natural" did not think that a food with added sodium chloride should be labeled as "natural."

Distaste for chemicals is also germane to consumer aversion to GE foods because of pesticides used in food production. Although pesticides are used by both organic and conventional farmers, consumers perceive pesticides as being used only by conventional farmers, and even more so by farmers using GE seeds. Unsurprisingly, research has shown that consumers dislike pesticides, particularly synthetic ones, and are willing to pay to reduce exposure to them. Consumers least desired a GE application that allows farmers to apply herbicides directly to the crop (e.g., GE seeds paired with glyphosate or 2,4-D).

While perceptions about negative effects of GE food are sometimes a moving target, the herbicide glyphosate (active ingredient in Roundup and paired with numerous GE crops) is often at the center of controversy. The dislike for glyphosate is compounded by the negative association many consumers have with Monsanto, the company that discovered it. Glyphosate has become a symbol of consumer aversion to GE foods: a chemical produced by a large corporation bundled with proprietary seed (patent protection for Roundup expired in 2002 and the first generation of glyphosate-tolerant seeds went off patent in 2014).

Some argue that people want mandatory labeling because it allows consumers to easily identify food produced by large agribusinesses which produce crops that are "soaked" in chemicals. But a 2016 National Academy of Sciences, Engineering, and Medicine (NASEM) report concluded that insect-resistant crops are clearly associated with a decrease in the number of insecticide applications. The report indicated that the use of insect-resistant crops or herbicide-resistant crops neither decreases nor increases on-farm biodiversity.

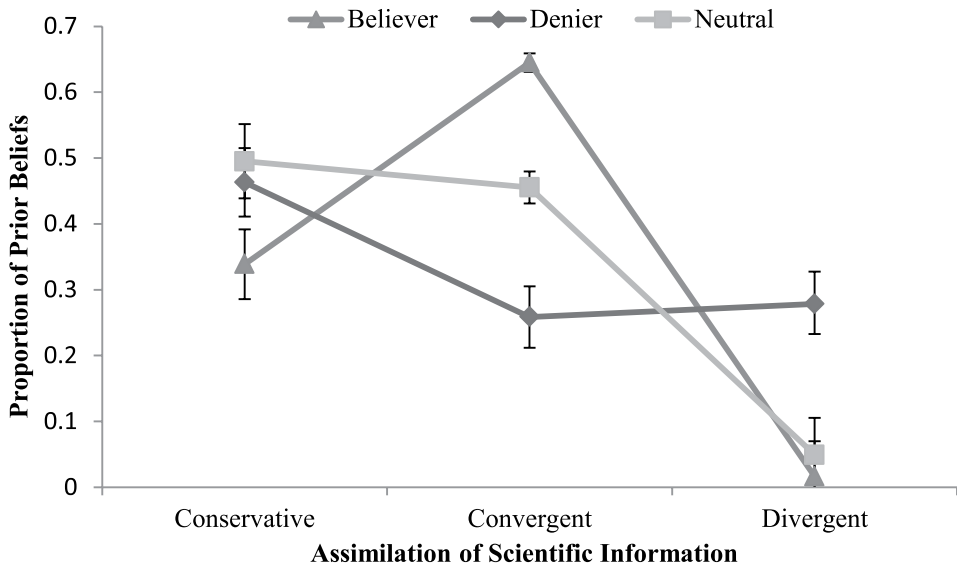
Resentment of large corporations along the food supply chain does not appear to be consistent. Take for example, Monsanto and Whole Foods. According to annual reports, in 2014, Monsanto's revenue was $15.8 billion and Whole Foods' revenue was $14.2 billon.

Yet, some consumers view Monsanto as emblematic of "industrial agriculture" but not Whole Foods and the multi-billion-dollar organic and natural food industries.

WHY CONSUMERS DISMISS SCIENTIFIC EVIDENCE

Research shows that information and opinions issued by scientific organizations do not necessarily change perceptions. This is especially true for people whose beliefs conflict with the information communicated by scientific organizations prior to receiving the information. Research has also shown that strongly-held perceptions can have a powerful effect on how new information is assimilated. More than 275 independent global organizations have concluded that GM crops are safe, but this has not convinced some consumers to change their perceptions.

This figure is from our 2015 study in which respondents were provided with information from scientific organizations stating that GE food is safe to consume and poses no greater risk than commodities made using conventional breeding techniques.



The Conservatives represent beliefs about GE food safety was unchanged after receiving the information. After receiving the information, respondents in the Denier category (GE food is not safe to consume) were less likely to be in the Convergent category (GE food more safe after receiving the information) and more likely to be in the Divergent category (GE food less safe after receiving the information) than the Believer (GE food is safe to consume) and Neutral (do not know GE food safety) categories. This indicates that the consensus opinions had almost no impact on 'true believers'—a conclusion unsurprising to those debating controversies such as climate change, vaccine safety, or evolution.

Theories that attempt to explain why people might dismiss scientific evidence often rely on political ideology or cultural values to explain divergence from scientific evidence. The Anti-Reflexivity Thesis posits that conservatives trust science that provides innovations for

economic production—like GE foods—and distrust science that identifies negative impacts of economic production—like climate change. Liberals behave in an opposite manner.

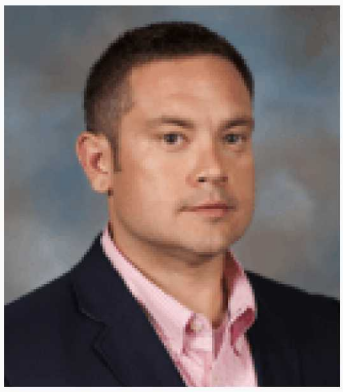
The Cultural Cognition Thesis posits that people are psychologically disposed to form perceptions about risk and policy beliefs based on shared cultural values and 'tribal identification'. Cultural values are determined using two scales: one scale determines whether a person is egalitarian or hierarchical, and the other scale determines whether a person is communitarian or individualistic. People who are more hierarchical and individualistic are more accepting of evidence that supports the deregulation of commerce—like GE foods. Those who are more egalitarian and communitarian are more accepting of evidence that supports the regulation of commerce—like climate change. Dan Kahan, the major proponent of this thesis, claims that aversion to GE food is not dependent on cultural values or political ideology, and therefore neither theory gives much insight into why some people are unaccepting of scientific evidence about GE food.

Consumer aversion to GE food is perplexing. The average consumer does not put much effort into the estimated 200 or more food-related decisions often made each day. As research has shown, this level of decision overload undoubtedly creates the need to use mental shortcuts, which are often useful, but can lead to errors in decision-making. The lack of perfect information and the overwhelming decision load associated with food consumption creates a situation where misperceptions about food production and food technology persist.

Consumers likely see labeling as an answer to reducing the contradictory reality of both too much ideological information and a lack of scientific information about GE foods. However, labels, including the newly passed US law on mandatory labeling, do not indicate the problems or benefits associated with a particular application, and may only act as a scarlet letter or skull-and-crossbones—which is the stated desire of many pro-labeling activists. Most of the tens of thousands of individual products carrying a Non-GMO label do not have a non-GE counterpart. Therefore, the underlying motive of some labeling is more about marketing and stigmatization and less about providing consumers with useful information to assist in decision-making.

"The underlying motive of some labeling is more about marketing and stigmatization and less about providing consumers with useful information to assist in decision-making."

Brandon R. McFadden is an assistant professor in the Food and Resource Economics Department at the University of Florida. His research focuses on consumer behavior, food choice, and attitudes toward contemporary agriculture production. This includes the effects of advertising on GMO labeling initiatives and cognitive biases on genetically modified goods and global warming.



> "Consumers don't simply want to know whether something 'can' be done, but rather whether it 'should' be done. Is it the right thing to do?"

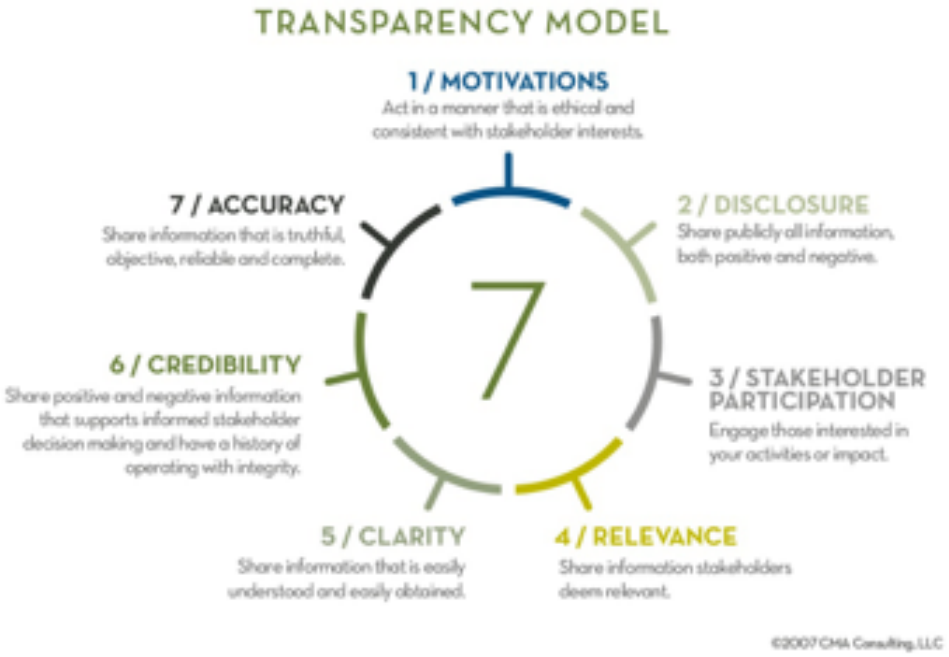
TRANSPARENCY HELPS FOOD PRODUCERS INCREASE TRUST PROCESSES AND PRODUCTS

Charlie Arnot, CEO, Center for Food Integrity

Consumers are, indeed, taking a more assertive role in the food value chain. It's right to applaud the vibrancy of a market offering consumers a wide variety of market choices despite a general inability to logically evaluate alternatives. But, food companies will give their customers want they want, regardless of the science.

Research by the Center for Food Integrity (CFI) shows consumers hold food companies most responsible for demonstrating transparency. One of the ways is to share a wide variety of information about their food purchases.

CFI's research proves that as those in the food system increase transparency, they will also increase consumer trust. The link between transparency and trust is real, direct and powerful. But, transparency can be an elusive term, so CFI set out to define it.



Consumers were asked who they hold most responsible for demonstrating transparency when it comes to food production. Food companies? Farmers? Grocery stores? Restaurants? The research shows that consumers hold food companies most responsible not only for areas we might expect like labor issues, human rights and business ethics, but also for the impact of food on health and the environment, food safety, and even animal well-being, an area one might logically assume people would hold farmers most responsible for.

An online survey of 2,000 people also asked precisely what consumers want and expect food producers to be transparent about – policies, practices, performance or verification. Consumers responded that it's transparency in a company's or organization's practices that count most toward building trust. That's because practices are a demonstration of a company's values in action, and CFI's research shows shared values are the foundation for building trust.

CFI's research identifies the six areas in the food system most important to consumers. They are: impact of food on health; food safety; impact on the environment; human and labor rights, treatment of animals raised for food; and business ethics in food production.

"Impact of food on health" and "food safety" are the most important. For these issues, consumers want information on the product label. This includes all ingredients regardless of quantity, allergens and preservatives, as well as disclosure of any ingredients derived from genetic modification. For other issues, engagement and access to information are key themes.

Consumers want to be able to engage via the company's website and they expect information to be provided in easy-to-understand language. This not only includes communication in areas of health and safety, but also environmental performance, labor and human rights, animal well-being and business ethics. When regulations are violated, corrective actions should be provided on the company website.

Results of third-party audits should be publicly available. Third-party audits of animal well-being and food safety practices are the minimum level of investment for transparency, but because it's somebody from outside an organization reporting on performance, a third-party audit doesn't reflect the organization's values and therefore is not enough.

Storytelling and providing examples of business practices are important. Actually showing and talking about what you do is key to being transparent. Merely making policies available to the public isn't enough. Policy is the way a company or organization articulates motivation. Practice is the way commitment is demonstrated. Practices are a reflection of a company's internal motivation; they are a demonstration of a company's values in action. And, demonstrating shared values is the foundation for building trust.

Food companies that believe these are not their issues do so at their own risk. The survey reflects a new reality in which consumers increasingly expect their favorite brands to assure more than quality and safety. Consumers today expect the supply chain to be transparent about everything from production practices to ingredients.

Equally important, food companies must understand that simply reporting facts and science does not fulfill their definition of transparency. Consumers don't simply want to know whether something "can" be done, but rather whether it "should" be done. Is it the right thing to do?

Large companies and farms producing food today are susceptible to public sentiment that profit is being placed ahead of public interest. Food recalls, incidents of environmental degradation, undercover video investigations, and food fraud are some of the things that provide reinforcement. Additionally, unlike past generations, most consumers have no direct link to agriculture and food production.

As a result, food producers must commit to communicating the ethical foundation of their work. They can no longer assume that the public knows they care about the products they provide; the animals they raise or environmentally-responsible on-farm practices. They must be willing to engage in a dialogue with consumers and to embrace and answer their questions in an honest, open manner.

CFI's research helps the food system better understand what it takes to earn and maintain consumer trust. Increasing transparency and improving their engagement with consumers will help align food system practices with consumer values and expectations, while supporting consumers in making informed decisions. By doing more to transparently communicate about the production practices used to produce food today, food companies and their suppliers can build consumer trust.

There is no longer any question that effectively demonstrating transparency will help food producers increase trust in their processes and products. Some farms and food companies have embraced this reality and are opening doors to an increasingly curious public. The process isn't a simple one, but the reward – earning consumer trust – is worth the effort.

WHEN CELEBRITY AND SCIENCE COLLIDE: HOLLYWOOD AND THE ANTI-BIOTECHNOLOGY FOOD MOVEMENT

Julie Kelly, cooking instructor, food writer, blogger and a Mom who lives in the Chicago area. In 2015, she got passionate about GMOs. Kelly is a contributing writer to the Wall Street Journal, National Review, Huffington Post and other media outlets.

HIGHLIGHTS

- Hollywood is in our homes daily, often spreading misconceptions about science, and GE crops in particular
- Gary Hirshberg, founder of Stonyfield Organic and Just Label It, is the key celebrity organizer
- Gwenyth Paltrow has emerged as the face of “celebrity moms” who question the safety of GE foods
- Mark Ruffalo questions GE foods but also rejects biotechnological solutions beyond food, such as the gene edited mosquito that could curtail the Zika virus
- Celebrity misinformation campaigns have filled a void created by the agricultural and food industries, which have been reticent to defend the science of biotechnology

While the Internet and social media are valuable tools for disseminating information about complicated subjects like science and agriculture, it has also given rise to a modern-day monster: the expert celebrity.

From movie stars to television chefs, a cadre of self-promoting yet often ill-informed celebrities are influencing the public discussion about topics way beyond their expertise, particularly about scientific issues like vaccines and biotechnology.

The explosive growth of cable television and more recently of the Internet has led to a celebrication of everyday life—Hollywood has invaded our homes in an oddly intimate way. Celebrities have long weighed in on public issues, which is okay if the issue is what clothes to wear next season, but science is different: it actually can impact people's lives.

If "Big Bang" star Mayim Bialik talks about Zika's impact on the brain, we might be interested because she has a PhD in neurosurgery—she has genuine credentials. But science-educated stars are few and far between. For example, campaigns led by Robert Kennedy, Jr., reality TV star Jenny McCarthy and her former husband Jim Carrey and flip comments by Bill Maher have convinced a lot of credulous fans to forgo getting their kids vaccinated—the lowest vaccination rates in the country are in the swanky Hollywood suburban playgrounds. And that's just one of many misguided celebrity-driven campaigns.

Celebrities may have any number of motives for injecting themselves into the middle of debates over controversial, scientific issues. Ego, for example. It's a way to get publicity for themselves (McCarthy is more known now for her anti-vaccine activism than for her acting.) And as we know, stars are eager to follow the cause du jour. It is "science-as-fashion."

While some people wisely ignore celebrity advice, their ill-informed and selectively ignorant comments can sway public opinion in destructive ways. That's what's happening in the ongoing debate over our food and farming systems. In the last few years, movies such as 'Consumed' and 'GMO OMG' have fueled misperceptions about genetic engineering. And celebrity chefs such as Tom Colicchio have joined the fray, partnering with other anti-GMO chefs in a Facebook page, Chefs Against GMOs, and making appeals in Washington and on TV shows. But Hollywood is where anti-GMO groups draw their most visible campaigners.

A slew of Hollywood celebrities, have lent their names to one anti-GMO or pro-labeling campaign or another, among them a fading generation of actors and musicians: Morgan Freeman, Paul McCartney, Dave Mathews, Danny DeVito, Woody Harrelson and Neil Young, to name just a few. But there are some younger faces who have lobbied hard against modern agriculture, mostly B-list actresses, with Gwyneth Paltrow the most prominent. They rail against GMOs in an effort to persuade consumers our food system is hopelessly broken, and that crop biotechnology is scary, unnatural and part of a corporate conspiracy to control the world's food supply. It's easily dismissible nonsense to those who know the consensus science, but their distortions have consequences outside of clickbait headlines.

Paltrow has emerged as the face of the anti-GMO movement over the last few years. It's unclear exactly how or why she decided to take up this cause except that she has worked closely with one of the most powerful figures in the organic movement, Gary Hirshberg, founder of Stonyfield Organic, who also started Just Label It, which has campaigned for

mandatory labels. Just Label it and the organic industry in general have spent hundreds of millions of dollars in recent years to demonize conventional agriculture and mislead consumers into thinking organic food is healthier, safer and more nutritious than conventional food.

Although state-of-the-art meta studies conclude there are no meaningful differences, and some research shows organic farming is more stressful on the environment than farming using advanced technology including genetically engineered crops, organic companies peddle that narrative in hopes of driving consumers toward their pricier products. As the self-appointed priestess of all that is healthy and good in the world, Paltrow promotes organic food, which is by definition non-GMO.

Hirshberg has fueled and funded anti-GMO advocacy under the guise of promoting mandatory GMO labels. He has organized several anti-GMO groups, and has used celebrities like Paltrow to push his agenda. At his invitation, Paltrow was featured at a press conference on Capitol Hill in August 2015 to voice her support for mandatory GMO labeling. A bill the organic industry opposed had just passed in the House, and Paltrow wanted to use her powers of persuasion to stop the bill from advancing in the Senate:

> *I'm not here as an expert, I'm here as a mom who honestly believes I have the right to know what's in the food I feed my family. And we don't even know, the science is still inconclusive about GMOs, there are arguments they could possibly be harmful and there are arguments that they could be incredibly beneficial. But at this point, we just don't know.*

The presser echoed widely on social media, but most disturbingly, her comments were reported uncritically by major media sites, giving her credibility on an issue she did not deserve.

Here is where Paltrow is wrong. We do know that GMOs are safe. They hold tremendous potential and promise to alleviate global hunger now and into the future as food demands are expected to nearly double by 2050.Nearly every major independent scientific organization and governmental agency in the world, including most recently the National Academies of Sciences, Engineering and Medicine (NAS), have affirmed that genetically engineered crops and food are just as healthy and environmentally safe as other conventionally grown foods, including organic. American farmers have been using genetically modified seeds for 20 years and most of the corn, soy, cotton and sugarbeets grown are from those seeds. This has cut down on the use of pesticides (since some of those crops have been developed to include natural pesticides already used by organic farmers), which has reduced crop losses and increased yield, a huge boon to both farmers and consumers.

In its analysis of the GMO controversy, the NAS also noted several problems with mandatory labeling, such as higher costs to consumers and the probability that companies might eliminate genetically engineered ingredients in order to avoid labels. The report also outlined several crops that can only be achieved through genetic engineering that boost nutrients, withstand climate challenges and resist crop diseases. Promising new crops in the pipeline include nutritionally enhanced rice and bananas and disease-resistant cassava, a plant that hundreds of millions depend on every day. So, it's galling for an ultra-rich celebrity to spread falsehoods about a technology that can feed and fortify the diets of hundreds of millions of poor people around the world.

That wasn't the last we heard from Paltrow. In April 2016, she made a brief cameo in a video sponsored by Just Label It (with Hirshberg taking a star turn) entitled "GMO Transparency in the Real World." A harried mother attempts to use her smart phone to scan a QR code on a can of soup to see if the soup contains GMOs (QR codes are anathema to the pro-GMO labeling crowd). As she stumbles to use her smart phone, and her kids smash a watermelon in the aisle, a fresh-faced Paltrow appears from the dairy aisle, asking the distraught mom if she has a scanner on her smart phone that she could use.

Paltrow isn't the only actress to play the "I'm not an activist, I'm a mom" card. Around Mother's Day 2015, several B-list mom-actresses appeared in a "Moms Against GMOs" video produced by another Hirshberg group to talk about GMOs, including Sarah Michelle Gellar, The Talk's Sarah Gilbert, UnREAL's Constance Zimmer, Once Upon a Time's Ginnifer Goodwin, Furious 7s Jordana Brewster, The Biggest Loser's Jillian Michaels, Mariel Hemingway and Sharon Osbourne. They pledged to protect their "little ones" from the dangers of GMOs: "This Mother's Day, give moms the right to know what's in the food we feed our kids. Tell the FDA to require GMO labeling."

These actresses are now part of a coordinated, calculated attack on American agriculture and an attempt to stop millions of farmers from using technological tools necessary for their livelihood and America's food security. They are part of a destructive campaign to hurt American farmers and our overall agricultural and food system.

Since a bill requiring mandatory GMO labels passed Congress and was signed into law by President Obama in August 2016, the GMO labeling groups have been more forthcoming about their true motives. Anti-GMO activist and Institute for Responsible Technology founder Jeffrey Smith, who makes regular appearances on Dr. Oz and other celebrity-type shows, acknowledged their real agenda:

> *Labeling GMOs was never the end goal for us. It was a tactic. Labels make it easier for shoppers to make healthier non-GMO choices. When enough people avoid GMOs, food companies rush to eliminate them. Labeling can speed up that tipping point—but only if consumers are motivated to use labels to avoid GMOs.*

Some celebrities brazenly profit by spreading misinformation about biotechnology. Jessica Alba parlayed her fame into selling organic, non-GMO products as part owner of The Honest Company. She boasts about the naturality of her products, from organic baby formula—"meticulously blended using non-GMO, naturally derived, organic"—to organic tampons to non-GMO lip balm. Many items brandish a non-GMO label. Alba explains her "healthy" eating habits as trying "to have the least amount of GMOs and pesticides— you have energy, aren't starving and don't have to count calories."

Actor and ' progressive' environmental activist Mark Ruffalo, who does not have a college education, has embraced any number of controversial causes, from fracking to GMOs, where the science is contested. He became a rock star in the anti-GMO community, even confronting Monsanto CEO Hugh Grant in a CBS green room rant before a joint TV appearance and later bragging about it.

"You are wrong," he lectured Grant. "You are engaged in monopolizing food. You are poisoning people. You are killing small farms. You are killing bees. What you are doing is dead wrong. It's the horrible stuff you guys do that makes you and your company horrible. People like you and your company are horrible because ... you are horrible."

He has more than 2 million followers on Twitter—that's scary. His obsession to demonize genetic engineering took a bizarre turn earlier this year when he started tweeting that the Zika virus was caused by a chemical manufactured by an obscure Japanese company that has a research pact with Monsanto, the bete noire of anti-GMO activists. By doing so, he deflects attention from what experts now say is the only feasible solution to containing Zika—the release of genetically engineered sterile mosquitoes to drive out the poison-carrying ones.

CHEF ATTACK

Many celebrity chefs have taken up the anti-GMO crusade, apparently believing their ability to run a restaurant or cook on television gives them special insight into how food is grown on a farm. Tom Colicchio, the star of Bravo's Top Chef program, gathered signatures of more than 4,000 chefs on a petition he delivered to Capitol Hill in March 2016 demanding mandatory GMO labels and rejecting a Senate bill that would have made the labels voluntary.

He claims he only supports the "right to know." But his twitter feed is filled with anti-GMO propaganda and like most activists in the GMO labeling movement, he is also broadly against the technology. In a December 2015 op-ed in the New York Times entitled, "Are you eating Frankenfish?" Colicchio warned readers that the newly approved GE fast-growing salmon could escape enclosed tanks and "endanger native species"—claims multiple US and Canadian regulators have reviewed and rejected as untrue. Colicchio has also come out in opposition to insect-resistant eggplant, grown with government developed seeds distributed free to farmers in Bangladesh, which has reduced the spraying of dangerous chemicals by 85 percent.

"Why are celebrities getting so much traction in their campaign against GMOs? They are filling an information void left by the scientific and agricultural communities. Scientists are reluctant to engage the public, either out of trepidation or arrogance, convinced that "science will win" the day."

Why are celebrities getting so much traction in their campaign against GMOs? They are filling an information void left by the scientific and agricultural communities. Scientists are reluctant to engage the public, either out of trepidation or arrogance, convinced that "science will win" the day. Infighting has plagued the science communications effort as leaders dispute the best way to fight misinformation from people like Paltrow and Ruffalo.

Some want to take a submissive approach and others want to fight fire with fire. The agricultural community and companies that benefit from genetic engineering aren't standing up to defend the technology, either.

> Hit the mute button when they start opining on serious policy issues that have considerable consequences for vulnerable people around the world.

While science and farming communicators struggle with how to best educate consumers and the media, organic executives and celebrities are defining the narrative on GMOs. This is not without serious ramifications if we turn away from genetically modified crops. Food prices will rise and farmers will be forced to use more insecticide and more toxic herbicides. It's wonderful to celebrate the performances of TV, movie and music celebrities, but their opinions on science issues are no more relevant now than they were waiting tables in Hollywood and Nashville looking for a break. Hit the mute button when they start opining on serious policy issues that have considerable consequences for vulnerable people around the world.

Julie Kelly is a cooking instructor, food writer, blogger and mother of two who lives in the Chicago area. In 2015, she got passionate about GMOs. Kelly is a contributing writer to the Wall Street Journal, National Review, Huffington Post and other media outlets.

> "If the public doesn't trust the use of innovation and technology in the food system, producers can kiss their social license goodbye."

CFI RESEARCH: DOES CELEBRITY VISIBILITY ON FOOD ISSUES TRANSLATE TO CREDIBILITY?

Charlie Arnot, CEO, Center for Food Integrity

There's no doubting science and farming communicators have struggled with how to inform consumers and the media on genetic engineering and other agriculture technology advances. But, the Center for Food Integrity's (CFI) research shows that consumers don't necessarily place a high degree of trust in celebrity experts. The research also shows it is, indeed, possible to introduce science into conversations with a skeptical public, but only after establishing shared values.

In CFI's studies, consumers were asked to rate the level of trust they have in 15 sources of information on food. Family Doctor rated highest. University Scientists and Dietitians were also in the top five along with Family and Friends. Who was at the bottom of the list? Dr. Oz. – and Food Babe finished only two spots higher. The results indicate there's a big difference between visibility and credibility.

Farmers and food-makers have traditionally tried to convince consumers that modern farming technology is good for society by telling them how much more grain can be grown today on an acre of land compared to 50 years ago or how much more food can be processed and preserved efficiently and affordably because of modern machines and processes.

That's the wrong starting point. Before citing facts and data, the food system must ask if its processes are sustainable and ethically grounded.

CFI has conducted extensive consumer research since 2007 and found that many people are uncomfortable with modern food production systems and the size and scale of today's farming operations. The research routinely finds that consumers believe large farms and large food companies are more likely to put their interests ahead of consumer interests.

This matters, because when a company or an industry segment loses consumer trust, they also lose the social license to operate. Social license is the privilege of operating with minimal formalized restrictions based on maintaining public trust. Social license is granted

when you operate in a way that is consistent with the ethics, values and expectations of the local community, customers, regulators, legislators and the media.

Once lost, either through a single event or a series of events that reduce or eliminate public trust, social license is replaced with social control, which is accompanied by regulation, legislation, litigation or market action designed to compel an entire industry to perform to the expectations of its stakeholders. Operating with social license is flexible and low cost. Operating with social control increases costs, reduces operational flexibility and increases bureaucratic compliance.

This atmosphere also squelches innovation and ultimately erodes the ability to produce healthy, affordable food.

We know technology and innovation help farmers produce more using fewer resources, which is critical in order to produce the food we need for a growing global population. But, if the public doesn't trust the use of innovation and technology in the food system, producers can kiss their social license goodbye.

That's why it's so important to begin a discussion about sustainability by ensuring ethical grounding in all aspects of the food system. CFI's sustainability model has three parts. Sustainability requires ethical grounding first and foremost, then scientific verification and economic viability. In other words, the food system must first earn trust, which then opens the door to the science. Of course, any business can't be sustainable without economic viability.

There are a number of barriers to consumers integrating scientific information into their decision-making process. The influence of group values, confirmation bias, scientific illiteracy, the tribal nature of online communication and other factors all pose challenges to successfully introducing technical information into the social conversation about food and agriculture.

Supporting informed decision making requires communicators to embrace a new approach. Barriers can be overcome by following the formula developed through CFI's research. It begins by identifying and communicating values from a credible messenger, then incorporating technical or scientific information that encourages informed decision making.

The foundation for specific strategies for effective communication include identifying relevant audiences, creating messages that audiences find believable, communicating those messages through the right channels, and developing a long-term values-based engagement strategy that starts with listening and embracing consumer skepticism.

Everyone understands ethics, but understanding how to demonstrate them in a way that builds consumer trust can be challenging. CFI has conducted some of the most extensive research to understand how to build consumer trust and we help our members put it to good use every day. It involves personal engagement, honest dialogue and throwing open the doors of transparency.

As we increase both the distance most consumers have from food production and the level of technology we implement, we must dramatically improve our ability and commitment to build trust with consumers and other stakeholders who grant social license. To be successful, food and agriculture must build and communicate an ethical foundation for their activity and demonstrate a commitment to practices that are ethically grounded, scientifically verified and economically viable.

SHOULD UNIVERSITY AGRICULTURAL RESEARCH SCIENTISTS PARTNER WITH INDUSTRY?

Paul Vincelli, extension professor and Provost's Distinguished Service Professor at the University of Kentucky.

HIGHLIGHTS

- Biases, conflicts of interest come from many sources, including associations with industry, advocacy groups, other non-profits
- Industry funding of studies on GE crops does not appear to be important bias source
- Personal experience suggests corporations receptive to negative results, as they improve products, limit liability
- Limited resources for much agricultural research without industry support
- Dubious "shill" accusations against biotech scientists discourage public engagement, depress discourse

Agricultural scientists who interact with the public often feel under enormous scrutiny. One of the most common concerns is that professional ties with industry—especially obtaining funding from industry—compromise scientific credibility. This concern is particularly acute in the area of genetically engineered crops (GE crops, commonly known as GMOs).

Research into genetically engineered crops is not my specialty—my work is focused on plant pathology—and I have never solicited nor received private-sector funding on this issue. Over my career, my industry interactions have dealt with non-GMO products for plant disease control. My interest in GE crops arises from their potential to address

genuine human needs and to reduce the environmental footprint of agriculture. And I am concerned that a dark shadow has been cast over many independent scientists because of their collaborative efforts with various stakeholders, including companies.

BIASES FROM MANY SOURCES

Across multiple disciplines, industry-funded projects may be more likely to report positive outcomes, or less likely to report negative outcomes [1-4]. However, industry funding is not always associated with biased outcomes [5, 6]. Furthermore, many sources of funding—NGOs, non-profits, other civil and governmental organizations—may engender conflicts of interest (COIs) and biases that influence reported research. Powerful biases may arise for non-monetary reasons [7] in both researchers and in non-researchers...possibly including you and me.

Regarding GE crops, I am aware of three journal articles on the topic of industry funding and bias. In the first [8], the authors found no evidence of bias due to financial COIs (studies sponsored by an industry source that may benefit from the outcome), but they did document bias associated with professional COIs (where at least one author was affiliated with a company that could benefit from the study outcome). In that study, among the 70 studies examined (see their Table 2), 61% had either a financial or a professional COI. Among the much larger sample size (698 studies) examined by Sanchez [9], the majority had no COI, and only one quarter had "COIs related to author affiliation and/or declared funding source."

A recent study by Guillemaud et al [10] had similar findings: among 579 studies with definitive COI information (see their Figure 3), the majority did not report a COI. How-ever, among those with COIs, there was a higher probability of reported outcomes favor-able to the GE crop industry. In addition to these journal articles, another independent analysis [11] suggested that industry funding did not bias study outcomes for GE crops, but these data have not been analyzed statistically nor published in a peer-reviewed journal.

Thus, while evidence to date shows that the majority of studies on GE crops are not influenced by COIs, some fraction is so influenced. Therefore, there is value in remaining alert to the possibility of bias and in continuing to practice full disclosure. I believe it is important to remain alert to COIs and biases of all sorts—not only those associated with corporate influences, but also those of NGOs or other civil organizations that may have explicit or implicit agendas.

Some people simply do not trust corporations. This is understandable, given the indefensible behavior of some in business, such as the tobacco industry, the chemical industry, Exxon, and Volkswagen [12-15]. Consequently, some members of the public perfunctorily dismiss commercial-sector scientists who may have solid scientific skills and high personal integrity. I personally must admit to a measure of distrust of corporations, which may even express itself occasionally as an anti-industry bias. But I also believe it is unwise to categorically reject all industry-funded data, solely on the basis of their provenance. In fact, I would label such an attitude a bias itself. Thoughtful, evidence-based analysis must always trump bias and ideology...and does, for a good scientist.

Why do researchers accept industry funding? Public-sector and private-sector scientists may share common interests. Industry scientists and I share a common interest in knowing what works in the field and what doesn't. Consequently, industry sources provide funding for field tests of their products for plant disease control. Furthermore, public funding for science in the USA is insufficient to support even a fraction of the worthy research projects. Inadequate funding can quickly and thoroughly undercut a career in science at any stage. Since researchers are hired to do research on important topics and not to whine about the difficult state of public funding, some will welcome funding from commercial sources, if it allows them to continue to do research they believe is intellectually compelling, important to society, or both. Also, industry scientists may have knowledge, skills, and facilities that we public scientists may not.

MY FUNDING CHOICES: SCIENTIFIC RIGOR COUPLED WITH PERSONAL INTEGRITY

Discussing my own practices should provide an idea of how many scientists work. Roughly half of my funding over the years has been from industry, primarily to support product testing for plant disease control. I have commonly tested synthetic fungicides, but I have also tested natural products of various sorts. In fact, commercial pesticide manufacturers can fairly accuse me of an anti-pesticide bias. I say this because I have tended to favor testing products that might be perceived as more consistent with sustainability (biocontrol products, for example) than applications of synthetic chemicals, often requesting limited, or no, funding for such tests. Besides industry funding, I have received federal funds for research and outreach on detection and management of plant diseases.

I publish all efficacy trials in Plant Disease Management Reports. We commonly publish data showing inadequate efficacy or phytotoxicity, and I never consider funding sources when the report is drafted. In fact, the reports are drafted by the Senior Research Analyst who conducts the field work, and he doesn't know who provided funding nor for what amount. Thus, our testing program does not suffer from publication bias. This approach is not exceptional [16, 17].

I accept no personal gifts—monetary or material—from private-sector sources.

I have no hesitation about challenging multinational corporations. For example, I provided a degree of national leadership in challenging a major pesticide manufacturer over certain uses of a commercial crop fungicide. I was one of the lead authors of a letter to the US Environmental Protection Agency raising questions about the paucity of public data to support "plant health" claims. I gave a similar talk in a major scientific conference, the 2009 American Phytopathological Society meeting.

Several factors may help me and other scientists to offset natural human tendencies towards bias:

- **Personal integrity.** Scientists like to live with integrity, no differently from the activists who may challenge us. For me, personal integrity is a core personal value. While this may be naïve, I believe that it helps to inoculate me against biases due to source of funding.
- **Desire not to be wrong.** Long ago I learned that the most important thing a scientist has is her/his credibility. Having been very publicly wrong once on a professional issue, I decided that, forevermore, I would be impeccably faithful to the scientific method. Better to express scientific uncertainty than to be wrong again! These thoughts help me be watchful for personal biases, and they help me maintain my fidelity to scrupulous scientific practice.
- **Personal growth.** Experience with endeavors in personal growth, as well as with meditation, have "turned up the volume" on those surprising and unwelcome inner thoughts such as biases, allowing me to recognize them for that they are, and to make more principled choices.
- **Curiosity.** Good scientists are intensely curious, and given time, that trait often overcomes the preconceptions and biases that one can't help but have as a human being.
- **Scientific culture.** I seek peer input and peer review all the time. It not only improves my work; it helps guard against biases. Peer-review is an important component of modern science and it helps to reduce the influence of bias due to funding source. Good "scientific culture" goes along with this concept of peer review. I enjoy witnessing and participating in the frequent scientific discussions that happen informally and spontaneously among excellent researchers in my department. Such exchanges are always collegial yet they are quite direct; creative thinking is welcome yet statements of fact must always be evidence-based. If you have a bias based on your funding source, it won't help you one bit in the face of respectful interrogation by highly intelligent, intensely curious, deeply knowledgeable professors of science.

A common concern is that providing funding buys "access" to researchers. This may sometimes be the case, but for me, this criticism doesn't fit. I am an Extension Specialist—everybody has access to me and my expertise. I don't recall a single instance in my entire career when I failed to return a phone call or email from anyone. In fact, it is a federal requirement that Extension programming be grounded in engagement with diverse stakeholders—including, but certainly not limited to, industry [18].

WHAT HAPPENS WHEN DATA FALL SHORT OF COMPANY EXPECTATIONS?

We regularly see poor product performance in our experiments. In a memorable instance, we observed visible injury to a creeping bentgrass putting green from a particular formulation of the widely used fungicide, chlorothalonil. On the day of application, the turfgrass was suffering exceptionally severe drought stress, due to an irrigation equipment failure, which probably was a predisposing factor.

I notified the company of my observations, which is my standard practice if a product provides unexpectedly poor performance or unexpected phytotoxicity. This is not to provide the company the opportunity to "help me see the error of my ways." Rather, this is simply good scientific practice. I want industry scientists to collect their own samples, so that they may better understand the poor results obtained; and to offer hypotheses or insights that may account for the unexpected results, as they often know things about their product and its performance that I do not.

In the case of the turfgrass injury caused by chlorothalonil, a company representative and I visited the experiment together and shared observations. I listened to the representative's hypotheses and shared my own. After the meeting and additional lab work, I reported my findings in various outlets. In my research program, unfavorable results get reported no differently than favorable results.

I must state emphatically that, in my 34 years of product testing for plant disease control, I cannot recall a single instance where a company representative attempted to pressure me to report "favorable results." Company representatives do not like to receive bad news, but in my experience, almost every company representative I have interacted with has been professional enough to recognize the importance of discovering the limitations of their products sooner rather than later. The consequences of introducing an inadequate product can be catastrophic for a corporation.

CORPORATE FUNDING FOR OUTREACH

What about private-sector funding for outreach? To my knowledge, such funds are never provided with a quid pro quo that the scientist will make particular claims about a company's products. To the contrary, private-sector representatives take note of speakers whose scientific understanding is consistent with their own. They may approach those speakers to discuss possible support for outreach, but without specifying the content of such presentations. Although I refuse industry funding for all aspects of GE crops, I do not suspect undue industry influence when funds are provided for travel expenses or supplies of invited speakers. Even honoraria or stipends for speaking engagements don't particularly concern me. This is true for such funding across the full spectrum of possible funding sources, ranging from advocacy groups for organic agriculture to multinational pesticide manufacturers. I want to see the scientific methods and data, no matter who did the study.

WHO SHOULD PAY FOR RESEARCH?

Should publicly funded professors even do product testing? Yes: there is a public interest in independent assessments of how products perform. The more public data on performance, the better.

If you agree that third-party testing is desirable, the question arises, "Who pays for it?" I believe that, usually, the manufacturer is responsible, not the taxpayer. Of course, this raises concern about funding bias. If a researcher wishes to avoid funding bias, can they tap into other sources? Not in my discipline. Pools of public funding for product testing are essentially non-existent.

What about studies of possible impacts of products to the environment? Who should pay for that? Again, in my opinion, such costs fall to the manufacturer, although in some cases, there is a compelling public interest that justifies the use of public funds for product testing.

Final thoughts: Does industry-researcher cooperation undermine the credibility of scientific research?

For me, the answer is, "No." We should be cognizant of possible biases and COIs due to source of funding—whether the source is industry, NGOs, advocacy organizations, or other sources. Disclosure is critical [7, 19]. However, industry scientists are often excellent scientists who take pride in their work, no differently than any industry critic. Yes, we should exercise a degree of caution when reviewing industry-funded research, but the same holds for research funded by advocacy organizations, since each has an agenda. Personally, in all cases, I will not reject either source out of hand; I will judge the work based on its scientific merit.

Sometimes the bias against industry-funded research on GE becomes hurtful, especially in the social media. Witnessing dedicated public servants being unfairly attacked as "industry shills" is demoralizing to public scientists, and it has the unintended consequence of discouraging public engagement by scientists who already have very busy professional and personal lives. Such unfounded charges are not only divisive and unproductive: they are unkind and can be abusive. (Sadly, unkind behavior can be found in all sides of the GMO debate.)

My freedom from industry funding on all aspects of GE protects me from similar accusations. Yet it doesn't surprise good scientists that, after years of studying the scientific literature, I independently arrived at an understanding very similar to that presented in the report of the National Academy of Sciences, Engineering and Medicine (NASEM) published earlier this year [20]. This isn't because industry has somehow influenced me or the members of the NASEM review committee. It is because there is a substantial body of credible

science supporting the conclusions presented in the NASEM report. In reviewing the body of peer-reviewed scientific literature on GE crops, one is likely to arrive at similar conclusions. I had an identical experience with the scientific consensus on climate change [21]. Ultimately, with enough careful study of evidence from credible sources, fidelity to good scientific practice, and a degree of humility, it is hard not to arrive at findings rather similar to those of journal-published experts of a scientific discipline. They actually do know something about their subject after all.

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HOW 2016 TRANSFORMED THE GMO DEBATE AND PAVED THE WAY FOR CONSUMER ACCEPTANCE

David Ropeik, instructor in the Environmental Studies Program, Harvard Extension School.

HIGHLIGHTS

- 2017 may be a turning point in public acceptance of GE foods
- Federal law requiring labeling of GE foods defused opponents key issue
- Labels on many popular items unlikely to scare consumers away
- Gene editing, new scientific techniques undercut claims GE foods unsafe because they are unnatural
- Media criticism of 'science denial' of GE opponents likely to increase

Earlier that day, the four friends had played a round of golf. It had been baking hot for a month but the grass on the course was still green. Afterwards they had cooled off with papaya smoothies in the club house, and then headed back to Arthur and Felicia's place for dinner. Now they were clearing the table.

"The salmon was great, hon," said Felicia. "Firm. Fresh."

"I got it at Bounty of the Sea," Arthur replied. "They have the best stuff. Farmed, but so fresh."

"The potatoes au gratin were great too," said Phyllis, one of the guests. "Crisp, clean, almost sweet!"

"And the apple pie!?" said Latrell, Phyllis' boyfriend. "To DIE for! So juicy. It's not even apple season. Where'd you get such fresh stuff?"

"Whole Fruits," Arthur replied. "They fly in fresh produce from all over the world."

Salmon. Potatoes au gratin. Apple pie a la mode. A delicious meal. And all of it the product of genetic engineering (GE): the AquaAdvantage salmon, approved in Canada a few years ago and now in the U.S. and many countries, an Atlantic salmon genetically modified to include a growth gene from another salmon species so it will grow faster, need less food, produce less waste, and reduce the cost to consumers; the Innate potatoes, a hybrid created not by adding a gene but simply by turning one off to prevent the potatoes from bruising and turning brown when they're dropped, and made in cheese curdled with chymosin protein taken not from a calf's liver but by splicing the gene from the calf that produces it into bacteria that then churn out mass quantities of that same natural protein; non-bruising Arctic apples that use the same genetic modification used in the potatoes, fresh although they had to be shipped from New Zealand; served with ice cream from cows fed on "Bt" corn that had been genetically altered to carry a gene from a bacterium that produces a natural insect repellant frequently used on organic farms.

And that was after a round of golf on grass created with biotechnology by splicing genes from various types of grass into a hybrid that stays green even though it requires less water, fertilizer, and grows more slowly so it needs less mowing. Followed by smoothies made from genetically modified papayas from Hawaii, where the insertion of a gene from a virus that was threatening to wipe out the plant essentially vaccinated the plant against that virus, saving the entire papaya industry in Hawaii.

Arthur and Felicia, Phyllis and Latrell, had truly had a GE day. The interesting thing was, they neither knew, nor cared.

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Only a few years before, the whole idea of creating new hybrid plants and animals by genetic engineering had been a controversial issue. That controversy had been driven in large measure by environmentalists who worried about what tinkering with genes would do to human and environmental health and by the organic food industry that wanted to protect their approach to agriculture, and their profits. Frankenfoods, these GE products were called. Dangerous. Unnatural. Genetic engineering, opponents ominously warned, was like "playing god." These crops, they said, were the spawn of the commercial agriculture industry, mass scale agriculture that was ruining the natural world. Mega corporations like the great industrial Satan Monsanto were threatening human and environmental health, GE opponents warned, by creating whole new species in the laboratory, not the garden, taking genes from one species and sticking them in another, producing transgenic hybrids that Mother Nature could never create.

It was a passionate campaign to stigmatize the whole concept of genetically modified foods as dangerous, in order to kill an entire technology that deeply offended strongly held values and beliefs. And the fears of this "unnatural" process resonated with a public

already concerned about the damage that many modern technologies, and corporations, had done to the natural world.

The seed companies and farmers and food producers who benefited financially from GMOs—genetically modified organisms—fought the fearmongering with public relations campaigns and lobbying in Washington D.C. and state capitals, and massive spending to defeat the laws that opponents proposed to try to kill what the supporters of genetic engineering preferred to call agricultural biotechnology.

The scientists that had helped develop these powerful biotechnological tools also fought back against the fearmongering, arguing that opponents were being irrational and that their ideology distorted their view of the facts. Scientists pointed to decades of research on the effects of each individual new GE hybrid on both human health and the environment—research that consistently found no evidence of harm to people, and environmental effects that were negative in some cases, positive in others, similar to the effects of all new food crops, GM or not, and nowhere near the doom-saying catastrophe that opponents predicted.

"Caught in the middle were the news media, which initially trumpeted the alarms of GMO opponents but gradually had begun to report that those fears were not supported by the evidence, and how opponents were doing just what they lamented when political conservatives refused to accept the evidence about anthropogenic climate change ... they were denying the science facts ..."

Caught in the middle were the news media, which initially trumpeted the alarms of GMO opponents but gradually had begun to report that those fears were not supported by the evidence, and how opponents were doing just what they lamented when political conservatives refused to accept the evidence about anthropogenic climate change...they were denying the science facts, blinded by their values as to what the research actually said.

The effect of this fight was predictable. It got lots of attention, and the acronym "GMO" was stigmatized in the public mind. Opinion surveys found that a majority of the public thought genetically engineered foods were potentially risky, and wanted products containing GE ingredients to be labeled so consumers would be informed and have a choice about what to eat. This was predictable, a reflection of the fact that people inherently want choice when faced with any sort of potential risk more than it reflected deep public apprehension

about GMOs. One survey taken at that time found that people also wanted food labeled if it contained DNA.

More probing research found that public fears of GE food were like many others, widespread but shallow. When more thoroughly questioned, most people didn't know anything about the issue. Few knew what GMOs were, how they were made, or about the scientific evidence that had found no human health risk. Like many controversies, the fiercest fighting over GMOs had been between combatants with a direct stake in the issue, either because the technology offended their values, or for economic reasons. The general public didn't know much about the matter.

That was the general state of things in 2016, after the fight had been escalating for more than a decade: a mildly concerned public only casually aware of the issue, a highly motivated core group of opponents warning that GMOs and 'corporate agriculture' posed a profound threat to human and environmental health, and GMO advocates fighting back to preserve an agricultural technology that they said offered broad benefits to human, animal, and environmental health, and plenty of profit.

But that summer things started to shift, and they shifted because of a significant miscalculation by opponents of GE food. Anti-GMO activists had largely lost their fight to kill the technology on scientific grounds alone; the evidence of health and environmental harm just wasn't there. So they had focused on fighting for labeling, believing that people would be afraid to buy products that contained GE ingredients. The opponents were encouraged by surveys and headlines suggesting that their views had caught on. They hoped that labeling—putting on packages what they saw amounted to a skull-and-crossbones danger sign—would scare buyers away, and that the technology they couldn't kill with scientific argument would be rejected at the cash register.

"Anti-GMO activists had largely lost their fight to kill the technology on scientific grounds alone; the evidence of health and environmental harm just wasn't there. So they had focused on fighting for labeling ..."

This tack was understandable. It had worked in Europe, where a few early GE products were labeled and brought to market by food producers as test cases, one product at a time. That allowed opponents to focus their attacks not on the technology generally, but

with high profile campaigns targeting those individual products. That worked, in no small part because environmental concerns were uniquely high in Europe, and trust in government health and safety regulators was particularly low, due to a series of events, like the Mad Cow disease outbreak in the 1990s that had put the food supply and the public at risk. As a result, many European governments were being much more precautionary about environmental issues generally, and genetically engineered agriculture specifically, than governments elsewhere. This approach also allowed those governments to damage America's significant advantage in the global agricultural market, in which U.S. producers had been selling GE crops for years.

So in light of how labeling had helped kill GE agriculture in Europe, and having failed to make their case to regulators based on the scientific evidence, and sensing that public apprehension about GMOs was rising, opponents of the technology in the United States made labeling the centerpiece of their campaign.

And it seemed to be working. In a market where sales of organic food and anything labeled 'natural' had already been growing for some time, companies got thousands of their products stamped with a "Non GMO" label (as certified by an avowedly anti-GMO organization supported in part by the organic food industry). Food companies put the 'Non GMO' label on products from water to salt that couldn't possibly contain GE ingredients in the first place.

In addition, some manufacturers switched the ingredients in some of their most popular products, so they could label them "GMO free" to protect sales. And many grocers that sold both conventional and organic foods promised to label all their products. There were some positive results from their campaign. Farmers who had chosen to grow GE versions of their crops, which increased productivity, reduced the use of more toxic pest control chemicals, and reduced need for soil-damaging tillage practices, begrudgingly switched out of those crops as the market for them shrank.

Buoyed by these successes, GMO opponents pressed for a national law requiring labeling of any foods containing GE ingredients, hoping that such a label would scare consumers away. Against powerful agricultural and commercial interests in Washington, they had no luck in Congress or with federal agencies. So they campaigned at the state level to establish labeling requirements, and though they failed to overcome massive spending by corporations to defeat public referenda in several states, the Vermont legislature passed GMO labeling requirements with a July 1, 2016 effective date. Food retailers were thrown into turmoil.

Many major food companies, especially those with deep enough pockets to afford to create new labels, did so, and all sorts of foods hit the shelves in Vermont with labels like "produced with genetic engineering" or "partially produced with genetic engineering".

Some labels included websites like whatsinmyfood.com that consumers could visit to find out more. Some companies stopped selling some items in Vermont, where sales of products containing GM ingredients weren't substantial enough to warrant the re-labeling costs.

Before anyone could measure what impact this was having on sales, GE opponents finally got what they wanted in Washington: mandatory labeling. Congress, acknowledging that 50 different labeling systems in 50 different states would be unmanageable for food companies that sold products across the country, created a single national labeling requirement. The law allowed either printed text on the label, a symbol indicating the presence of GE ingredients or an electronic code that allowed shoppers to access more information through their smart phones.

Many of the major opponents of GE foods applauded passage of the labeling requirement, including the mainstream Organic Trade Association and the Whole Foods company. But the more strident anti-GMO critics complained that the labels weren't clear (i.e. dramatic/scary) enough and didn't provide real choice. Over the next two years, they fought every decision the FDA and USDA made as those agencies develop detailed rules for the labels. But having won the main battle on which they had focused, many opponents of GE food now gradually edged back from their blanket rejection of the entire idea of agricultural biotechnology. They had claimed they just wanted consumers to have a choice, and now that consumers had that choice, it was harder for GE opponents to credibly find other ways to try and kill the whole technology, which their demand for labeling had really just been a cover for all along.

They had made their stand on the battleground of labeling, and won, but with the passage of the labeling requirement they now began to lose the war.

There were several reasons for this. First, while the labeling fight had been coming to a head, more and more reputable scientific evidence confirmed that GMOs didn't pose the risks that opponents claimed. As the evidence grew ever stronger, the news media increasingly covered the fight over GMOs as they had come to report on the issues of climate change and childhood vaccines; these were battles about values and politics, in which the basic science had been resolved and one side just didn't want to accept what the evidence clearly indicated. GMO opponents were increasingly depicted negatively, as fearmongering science deniers.

The labeling law also weakened the opposition by bringing an important aspect of the science of genetically altering food into clearer focus. The government had to choose which among a burgeoning array of genetic engineering techniques even qualified for labeling under the new law. That helped dramatically increase awareness that the science of bioengineering food had grown much more complex. What had started 30 years earlier

as a process of bringing a beneficial trait from one species into another—the transgenic approach of using "foreign genes" to create what opponents called Frankenfoods—now also included techniques like CRISPR-Cas9 that allowed scientists to turn up or down the traits already coded for in the natural genome of the plant or animal, or to transplant the genes that expressed a favorable trait in one plant or animal into the genomes of plants or animals in the same species.

The science had become more sophisticated, able to create hybrids the way they'd been created for thousands of years, mimicking what happened in nature rather than creating seemingly new chimeras. That made the whole process behind GMOs far less troubling, psychologically, to many people. The central fear had always been that GE foods were unnatural. Research in the psychology of risk perception had found that people are generally more worried about human-made risks than those which are natural. Putting a gene from a Brazil nut into a soybean or utilizing bacteria genes to create new foods was not natural. But enhancing or silencing the expression of a trait already in the soybean, or transplanting a gene that expressed a favorable trait from one soybean into seeds of the same species, was just doing in a lab what nature can do. In the debate about which technologies should be covered by the labeling law, the public learned that the technology was no longer as UNnatural as opponents claimed.

And many GE foods produced without transgenics were coming to market. Governments in several countries, even precautionary Canada, approved as safe various genetically modified foods that had been under review for years, from apples to potatoes to mushrooms. Many of these products offered a wide range of benefits, and not just to farmers or food companies, but direct benefits to consumers; lower prices, reduced spoilage, reduced allergenicity, improved animal welfare, and sometimes improved nutrition.

The third impact of labeling that weakened opponents' efforts to resist the entire technology came from the labels themselves; not specifically from what they said or showed, but just by their proliferating presence. Surveys taken to see how people reacted to the labels confirmed what earlier research had suggested, that most consumers don't read labels, and that many who do assume that if something is on a food label, it must have been approved as safe. A sizeable minority of shoppers did initially wonder whether the labels suggested some problem or health concern about GE foods, but as with public attitudes about the issue prior to the labels, that concern was shallow. Sales of most labeled products stayed the same. The fear of GMOs that opponents had created and banked on to scare consumes away when the labels showed up ended up taking only a small bite out of sales of a narrow range of products sold in a minority of stores and markets.

And even that hit was temporary, because as the labels proliferated and appeared on thousands of popular products, the presence of the label quickly became so familiar that it merely took its place among the "all-natural" and "organic" and the "non-GMO" labels cluttering store shelves across America. For many of the products whose sales did fall, that drop was short-lived.

These consumer reactions were consistent with the psychology of risk perception. Now people had choice, and the perception of risk is such that when we have choice, concern about any risk associated with that choice goes down. Also, the labels quickly became familiar, and psychologists have found that while a new potential threat is worrying, once we have lived with that risk for a while with no widespread or obvious negative effects, what felt scary at first feels less so. Just after the labels hit the shelves, a small percentage of shoppers logged onto websites or checked those electronic codes with their smart phones to find out more about what GMO ingredients were in their food. But within a few months the number of people doing so rapidly declined.

In short, the presence of the labels did not cause nearly as much concern, or lost sales, as opponents of GE foods had hoped and GE proponents had feared. The labels revealed that the fear activist opponents felt so deeply was never as deep in the psyche of the general public as the opponents had counted upon. Along with ever-growing scientific consensus that GMOs posed no human health risk, the media increasingly put opponents on the defensive as science deniers. With increasingly sophisticated and more 'natural' GE techniques producing a growing range of products with direct-to-consumer benefits, the release of the GMO labels that opponents had fought so hard for, and food companies had feared so deeply, actually began to contribute to a wider acceptance of the technology.

The controversy continued but it changed in several important ways. Some of the major opponents of GE foods who had helped lead (and fund) the battle for labeling quietly faded from the fight, ceding leadership to more adamant crusaders who were fighting a larger battle over about how technology, including large-scale commercial agriculture and its use of synthetic chemicals, had harmed human and environmental health. The fight against GE foods was just one battleground in that much larger and ongoing war.

But by the time Felicia and Arthur sat down to dinner that August evening in 2020 with Phyllis and Latrell, the GMO battle had died down significantly. The labels had been out for many months now. People were used to seeing them, and were mostly ignoring them. New GE foods were coming to market, including not only crops used as ingredients in other products but whole foods—fish and meat and fruits and vegetables—that people ate directly. There were fewer battles in legislatures, fewer controversial statewide referenda questions. The social media pages of GMO opponents still warned about the dangers of GE foods, but there were fewer stories in the general media about the supposed risks of GMOs and more about the new products being developed.

Fears about GE foods were no longer as frequently on the public's plate. Increasingly, such foods were on actual dinner plates, including the meal the two couples enjoyed that night. Those foods had all been labeled, but no one at the dinner party had cared about what the labels on the food had said, nor about the process by which those foods had

been produced. They just wanted food that was delicious, affordable, fresh and healthy, and thanks in part to developments in the summer of 2016, the foursome at dinner were like most of the public—fully comfortable that genetically engineered foods met all those criteria.

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> "Consumers want authentic transparency. They want all the details – the good, the bad and the ugly – so they can decide for themselves."

BUILDING TRUST FOR FOOD TECHNOLOGY, INNOVATION IS A LONG PROCESS

Charlie Arnot, CEO, Center for Food Integrity

Growing public acceptance of genetic modification technology is a sign that farmers and food-makers are closer to meeting public expectations than some might want you to believe. Traditionally, public trust of our food and the people who grow it have been taken for granted. Family farms and all they represent are deeply rooted in our culture. As the food system has become more integrated, with larger farms and companies producing food, the public wonders whether the food system is still worthy of their trust.

It would convenient if the social decision-making process were logical and rational – that we live in a world where 2 + 2 = 4, the earth is round and hydrogen and oxygen combine to make water. But it's more complicated than that.

Today's environment is one in which many factors drive consumer opinions, feelings and beliefs – particularly when it comes to controversial emotion-laden issues – and facts are only one element in the decision-making equation.

Focus group research conducted by The Center for Food Integrity (CFI) a few years ago invited participants to give their reaction to the statement that GMOs have been used for 20 years with no reports of ill health effects. It was meant to impart reassurance that the technology is safe.

Focus group participants weren't comforted.

"This is beyond scary to me," one woman replied. "I feel like I've been deceived. The fact that we've been eating this stuff [for decades] ... why weren't they providing more information all along about what I'm eating?"

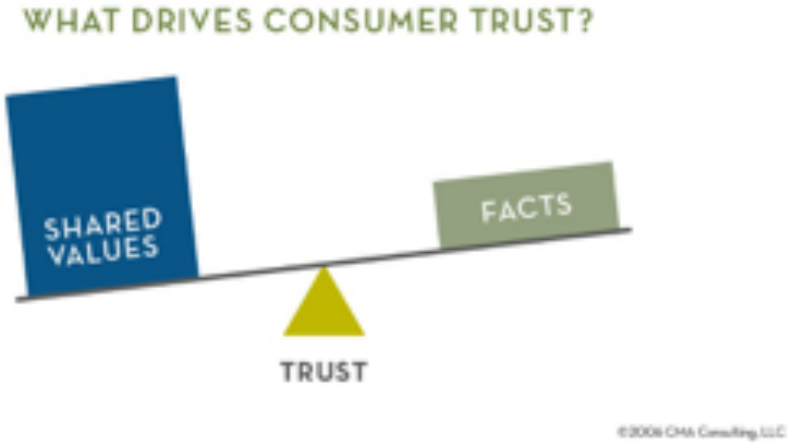
The reaction drives home the point that consumers want authentic transparency. They want all the details – the good, the bad and the ugly – so they can decide for themselves. When GMOs were introduced, both scientific studies and regulatory bodies concluded

they were safe, so not much consideration was given to providing additional details to the public. Though unintentional, this lack of transparency eroded consumer trust in GMO technology and the food system in general.

Authentic transparency can transform a relationship that is tarnished with suspicion by reducing fear of the unknown and creating a platform for building trust. CFI's consumer trust research proves that as those in the food system increase transparency, they will also increase consumer trust.

Including information on product labels is important but only one of many practices that demonstrate transparency. CFI's research shows offering engagement opportunities through websites and providing protection for whistleblowers also ranked high among practices that demonstrate transparency. Practices are a demonstration of a company's values in action, and CFI's research shows shared values are the foundation for building trust.

Shared values are three to five times more important than skills, expertise or science according to CFI's peer-reviewed and published trust model. Consumers don't simply want to know whether something "can" be done, but rather whether it "should" be done. Social acceptance must come before scientific verification.



Winning consumer trust begins with demonstrating that you care about the topics they care about most – safe food, protecting the environment, quality nutrition, appropriate animal care, and others. As a wise person once stated, "People don't care how much you know until they know how much you care."

The application of technology in food and agriculture has provided countless benefits to society – from refrigeration to precision planting, from pasteurization to drought-tolerant hybrids. Innovation and technology help us meet one of humanity's most basic needs – the need to provide safe, nutritious food for our children and our children's children.

But more must be done. Producing food has more impact on the planet than any other human activity and we have to produce more food, using fewer resources every year. The responsible use of technology is key to addressing this moral imperative.

Our challenge is not just better technology, but finding better ways to support the informed public evaluation of those technologies and our food production system. While we know that science alone will not build public support for complex, controversial technology, we need to encourage earnest consideration of scientific consensus in the social decision-making process when it comes to innovation and technology that drive agriculture and food.

Consumer concern and skepticism about food production are understandable. The consolidation, integration and application of technology that make food safe, available and affordable also prompt concerns about whether science benefits society or only those who control it as well as skepticism about the motivation of those in food and agriculture.

Our goal should not be to win a scientific or social argument, but to find more meaningful and relevant methods to introduce science in a way that encourages thoughtful consideration and informed decision making.

— GMO —

BEYOND II

THE SCIENCE