# A Policymaker's Guide to the GMO Controversies

BY VAL GIDDINGS | FEBRUARY 2015

*Anyone who follows the news could be forgiven for believing there is a genuine debate over the merits and safety of crops and foods derived through modern biotechnology. There is not.*

Crops and foods improved through biotechnology, popularly known as "GMOs" (for "genetically modified organisms") remain at the center of a maelstrom of conflicting claims and assertions.[1] This is evident throughout all media, but especially on the Internet. It is difficult for a layperson to make sense of it all, and this becomes even more important when the layperson is a decision maker, politician, or government official in a position to make or influence policy decisions. Because bad information makes for bad policy choices we have prepared this report to provide some factual information, with abundant citations from independent third party authorities. Recently there have been some excellent, if whimsical, year-end reviews of various aspects of this manufactured controversy, but still it can be difficult to distinguish truth from illusion.[2]

It always helps to consult the data, so we do that to examine several key questions that have been repeatedly visible on the web and in media of late. These include the economic benefits of GMOs, the U.S. rate of adoption of GMOs, the level of success of the labeling movement, the role of GMOs in affecting weeds and human health, and the sustainability of GMO-based agriculture. In all six cases we find overwhelming evidence for the economic, agricultural, environmental, and health benefits of GMOs.

## SOME BACKGROUND ON THE ANTI-GMO MOVEMENT

Anyone who follows the news could be forgiven for believing that there is a genuine debate over the merits and safety of crops and foods derived through modern biotechnology. There is not. Scientists and farmers are virtually unanimous on the safety and desirability/effectiveness of crops improved through biotechnology.[3] There is, however, definitely a controversy, one largely manufactured by a small handful of committed, anti-

innovation advocacy groups using tried-and-true propaganda techniques to spread fear, uncertainty, and doubt about this important technology, aided by media coverage that is too often uninformed or misinformed about science and agriculture.[4] As with any campaign wanting to hold back technological innovation, the anti-GMO campaign is based both on ideology and vested interests. The ideological protestors simply reject modern technology in foods and want the world to return to a pre-industrial, pastoral system where farmers plowed with horses and reaped with scythes (with a life expectancy of under 35 years, and astronomical infant mortality). In recent years these professional protest industry's opposition campaigns have been heavily aided by interests: in this case the organic food industry, a segment of which has openly adopted a strategy of spreading unjustified fears and disparagement of their competition.[5] For if extremist elements of the organic industry can (despite all evidence) persuade consumers that GMO foods are harmful, the price of foods will not fall as much, providing less competition for high-priced organics. It is, therefore, worthwhile to dig a little deeper into some of the key issues of the controversy that have featured prominently over the last year or so.

## THE ECONOMIC BENEFITS OF GMOS ARE SUBSTANTIAL

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Professional opponents of crops and foods improved through biotechnology have long opposed them based on claims that they are unsafe. But recently they have added to their repertoire of anti-GMO arguments by claiming that they have been a commercial failure, creating more problems for farmers than they solve.

This begs a number of questions: if GM crops have been a failure, why have they been adopted at a rate exceeding anything we've seen for any other agricultural innovation in history?[6] Are the 18 million farmers around the world growing these crops dupes, unable to tell whether they are making or losing money? Why do they keep coming back for the more expensive seeds, year after year? And perhaps most telling, if GM crops have been such a failure, why the massive propaganda campaigns in opposition? Would it not be more cost effective simply to stand back and let the market render its usual verdict on failed products?

There are a number of sources of information on the economic impacts of GMOs. The International Service for the Acquisition of Agri-Biotech Applications (ISAAA) produces an annual report on the adoption of biotech improved seeds, tracks their distribution, and prepares numerous white papers on particular issues, providing a wealth of information about numerous aspects of biotech crops around the world. From their latest annual survey:

> Biotech crops were first commercialized in 1996. [Area] of biotech crops increased every single year between 1996 to 2013, with 12 years of double-digit growth rates, reflecting the confidence and trust of millions of risk-averse farmers around the world, in both developing and industrial countries. Remarkably, since the first plantings in 1996, an unprecedented cumulative [area] of more than 1.5 billion hectares (3.7 billion acres) have been successfully cultivated, an area that is 50 percent more than the total land mass of China or the United States.
>
> Biotech crop hectares increased by more than 100-fold from 1.7 million hectares (4.2 million acres) in 1996, to over 175 million hectares (433 million acres) in 2013. This

> makes biotech crops the fastest adopted crop technology in recent times—the reason—they deliver benefits. In 2013, [the area] of biotech crops grew by 5 million hectares (12.4 million acres), at an annual growth rate of 3 percent. It is important to note that more modest annual gains, and continued plateauing, are predicted for the next few years due to the already optimal (between 90 percent and 100 percent) adoption rates for the principal biotech crops, leaving little or no room for expansion.[7]

Scholarly publications in the peer-reviewed literature tell a similar story of widespread and substantial benefits to farmers and consumers, many in the developing world. The most recent, comprehensive global survey published in *GM Crops & Food: Biotechnology in Agriculture and the Food Chain* shows that:

> …there have been very significant net economic benefits at the farm level amounting to $19.8 billion in 2011 and $98.2 billion for the 16 year period… The majority (51.2 percent) of these gains went to farmers in developing countries. GM technology have also made important contributions to increasing global production levels of the four main crops, having added 110 million tonnes and 195 million tonnes respectively, to the global production of soybeans and maize since the introduction of the technology in the mid-1990s.[8]

It is important to recognize the implications of these numbers. Farmers throughout the world will only choose tools and technologies that work on their farms and that are safe. The land is where they live, raise families, and earn their livings. If a tool or technology does not work the first time they try it, they might give it a second chance. But farmers will not keep coming back to it year after year. It delivers good value, or it gets dropped. Farmers who act otherwise very quickly enter a different line of work.

The most recent meta-analysis corroborates this positive economic impact:

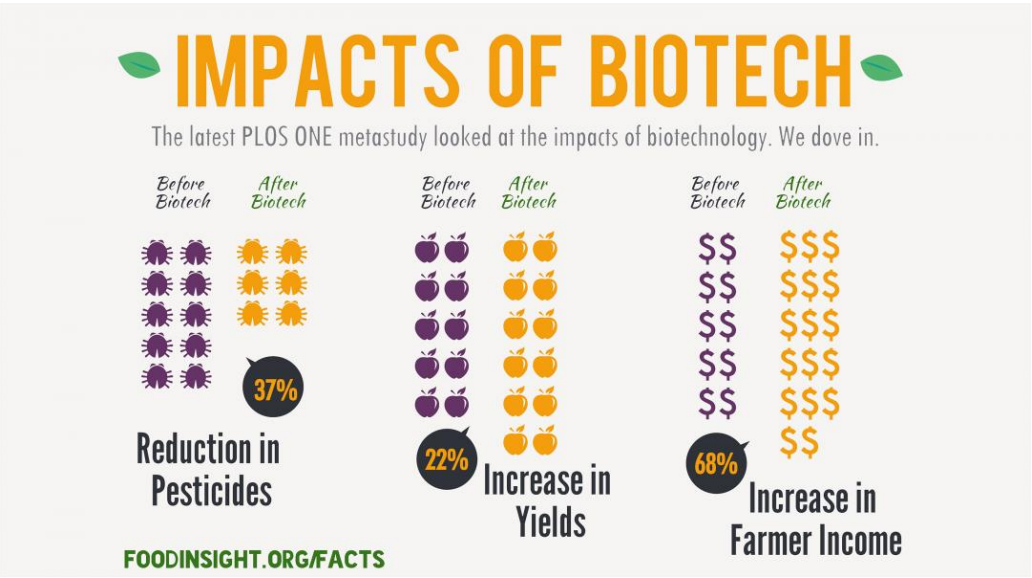


**Figure 1: Impacts of Biotech**[9]

It is these concrete, inarguable benefits of agricultural biotechnology that have driven the rapid adoption and high seed re-purchase rates by farmers.

## THE UNITED STATES IS MAINTAINING ITS STRONG EMBRACE OF GMOS

Given that the United States has long been the leader in both the development and use of GMOs, opponents want to make the case that the leader is having second thoughts about this technology. It is difficult to see how anybody could seriously make this claim. The U.S. Department of Agriculture curates a comprehensive data set on American and world agriculture. Among the parameters they track is the area planted each year with seeds from crops improved through biotechnology. The data are fully consistent with the global patterns discussed above.

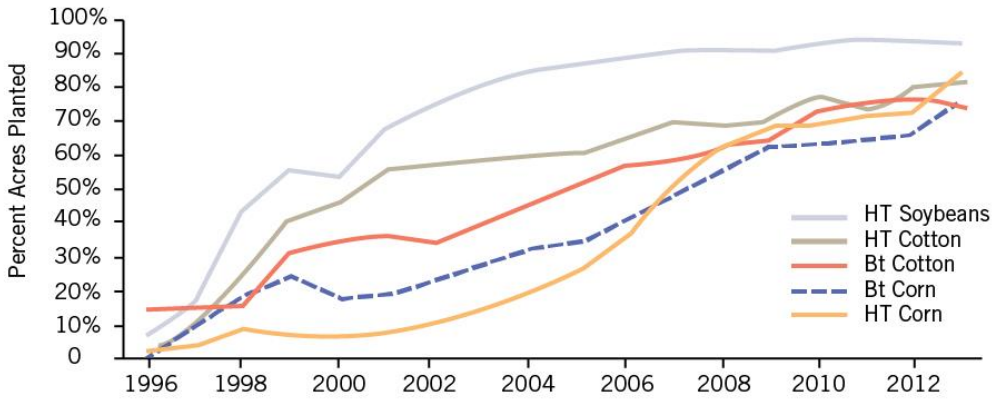


**Figure 2: Adoption of Genetically Engineered Crops in the United States**[10]

The data show clearly a steady and rapid increase in the area devoted to biotech-derived crops over the past two decades. In the space of a generation, biotech crops have become the new, standard, conventional crop in the U.S.—and given the extent to which U.S. harvests are exported, it is increasingly true around the world, especially for the major commodity crops.[11] For the major commodity crops, the only reason the rate of adoption has slowed is because the land area devoted to biotech-improved crops is approaching saturation (rice and wheat are the exceptions, but they are poised to follow).[12] There is no "backing away" evident in the data, either in the U.S. or globally. Indeed, with the recent announcement of Chinese approvals for new biotech varieties, the re-authorization of their own biotech improved rice, and their recent orders for new shipments of U.S. distillers' dried grains, a major, albeit temporary, impediment to the continued growth of international trade in (at least some) biotech-derived commodities has evaporated.[13] And with the successful adoption of Bt brinjal in Bangladesh, and rational moves on field trials by the new government in India, the scope of biotech continues its inexorable expansion into non-commodity, specialty crops.[14]

## FOODS WITH GMO-BASED INGREDIENTS ARE AS NATURAL AS ANY OTHERS

Ag-biotech opponents have long claimed that the processes used to produce genetically improved foods (GIFs) are fundamentally different from those used to develop other foods, using the pejorative term "Frankenfood" to instill fear in consumers.

Such an allegation is false. Plant breeders and credible scientists around the world generally agree that the techniques used to produce transgenic plants, derived directly from natural phenomena, are but an extension of traditional plant breeding, and that the potential hazards are the same.[15] The U.S. National Academy of Sciences agreed with this view in its very first publication in this area in 1987 and has upheld this view in every subsequent study.[16] The Government of Canada in its regulatory structure has specifically repudiated the assertion that plants improved through recombinant techniques are necessarily and intrinsically different from those produced through conventional breeding.[17] The government of Australia has done likewise, and the vast preponderance of scientists around the world concur.[18]

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Indeed, the advent of modern genomics has shown us that genes are shared and transferred widely not only among different species, but between genera, families, and even phyla and kingdoms. Recent discoveries have confirmed that gene exchange was the essential element in the survival of ferns more than 100 million years ago, after the explosive radiation of flowering plants radically changed their environment.[19] This natural gene transfer is just like that used by modern genetic engineers to create plants improved through biotechnology.[20] These natural processes of gene exchange are so widespread among plants, animals, and microbes on planet Earth that the single most common gene in humans is one that came from a virus; as did half of the other genes in our genomes.[21] In fact, humans share 98 percent of our genes with chimpanzees, 92 percent with mice, 44 percent with fruit flies, 26 percent with yeast, and 18 percent with dandelions.[22] Those who claim crops improved through biotechnology are "unnatural" could not be more profoundly refuted by what we find throughout nature.

## FOODS WITH GMO-DERIVED INGREDIENTS ARE SAFE

If agricultural biotechnology opponents made their case against GMOs on their real grounds—their preference for a simpler, pastoral life where we all eat organic foods—they would be dismissed as the Luddite elitists they really are. Knowing that, they base their campaigns on the false assertion that there are unresolved safety concerns about genetically improved foods (GIFs), and that they have been insufficiently studied.

These claims are false, robustly contradicted by the scientific literature, worldwide scientific opinion, and vast experience.[23] Indeed, the global consensus on the safety of these GIFs is stronger than that behind climate change.[24]

Anti-GMO campaigners also assert that there is a dearth of independent research evaluating the safety of crops and foods produced through biotechnology, and that companies hide behind intellectual property claims to prevent such research from being

carried out. These claims are false. The American Seed Trade Association has a policy to ensure research access to transgenic seeds, and Monsanto has a similar commitment.[25] The public sector scientists who made the 2009 complaint cited above, in fact, had the access they sought at the time they made the unfounded complaint.

Furthermore, there has been an abundance of independent research over the years: see Nicolia et al., 2013, the GENERA database at BioFortified.org, and a massive compilation underwritten by the European Union. It has all reaffirmed the findings reached nearly three decades ago, that there are no hazards unique to crops improved through biotechnology.[26]

Some representative voices include those cited below. The first is a statement from the European Commission summarizing their findings at the end of a mammoth program to examine the safety of GM crops and foods:

> Indeed, the use of more precise technology and the greater regulatory scrutiny probably make them even safer than conventional plants and foods; and if there are unforeseen environmental effects—none have appeared as yet—these should be rapidly detected by our monitoring requirements. On the other hand, the benefits of these plants and products for human health and the environment become increasingly clear.[27]

> The main conclusion to be drawn from the efforts of more than 130 [EU-funded] research projects, covering a period of more than 25 years of research, and involving more than 500 independent research groups, is that biotechnology, and in particular GMOs, are not per se more risky than e.g. conventional plant breeding technologies…[28]

The UK's chief science advisor states:

> …because the technique is so sophisticated, in many ways it is probably safer for you to eat GM products—plants that have been generated through GM—than normal plant foods, if you have any sort of reaction to food, because you can snip out the proteins that cause the negative reaction to certain parts of the population.[29]

The U.S. National Academy of Sciences states:

> In contrast to adverse health effects that have been associated with some traditional food production methods, similar serious health effects have not been identified as a result of genetic engineering techniques used in food production. This may be because developers of bioengineered organisms perform extensive compositional analyses to determine that each phenotype is desirable and to ensure that unintended changes have not occurred in key components of food.[30]

The Union of the German Academies of Science and Humanities agrees, stating:

> …in consuming food derived from GM plants approved in the EU and in the USA, the risk is in no way higher than in the consumption of food from conventionally

> grown plants. On the contrary, in some cases food from GM plants appears to be superior in respect to health…. GMO products have been tested to a particularly high extent and are subjected to rigid legislation control.
>
> Food from GM Maize is more healthy than from conventionally grown maize… samples with the highest fumonisin concentrations are found in products labeled 'organic.'
>
> …the dangers of unintentional DNA mutation are much higher in the process of conventional plant breeding… than in the generation of GM plants. Furthermore, GM products are subject to rigid testing with livestock and rats before approval.
>
> Whereas for conventional varieties there is no legal requirement for allergy tests of their products, for GMO products, very strict allergy tests are mandatory… For this reason, the risk of GM plants causing allergies can be regarded as substantially lower than that of products from conventional breeding.
>
> As for claims of "unexpected effects"—to date there are none reported, and According to present scientific knowledge, it is most unlikely that the consumption of …transgenic DNA from approved GMO food harbors any recognizable health risk.[31]

As does the chief scientific advisor to the European Commission:

> If we look at evidence from [more than] 15 years of growing and consuming GMO foods globally, then there is no substantiated case of any adverse impact on human health, animal health or environmental health, so that's pretty robust evidence, and I would be confident in saying that there is no more risk in eating GMO food than eating conventionally farmed food.[32]

The most recent scientific publication in this crowded catalogue examined the effects on livestock of eating feed derived through biotech improved crops over the course of 29 years through more than a trillion meals.[33] This unprecedented observational study not only failed to find any negative impacts, it found that over this period the average health of livestock animals improved.[34]

Despite the overwhelming agreement among scientists documented above, ag biotech opponents continue to assert that this consensus does not exist, and that its absence is demonstrated by "a petition signed by over three hundred scientists."[35] This claim presents no new arguments or data, and ignores the staggering mass of studies already cited demonstrating the safety of these foods, and their unblemished safety record. Instead, it recycles the usual stable of discredited claims such as those of Séralini et al. (see below). It is worthwhile therefore to note that the group behind this press release is comprised of individuals with a long history of opposition to agricultural biotechnology that relies on ignoring or distorting reality. Indeed, the group is merely one element in a campaign that has propagated claims that the biology is unclear despite the fact that the science is far more settled on GM foods than it is on climate change. One blog post from a chef has dismissed them with these words:

> A group of [300] "scientists have signed a letter saying "GMO is bad…" They did so in response to a roundup of more than 2,000 actual studies, almost all done over the last decade, that have failed to produce any evidence that GMO is anything other than plain old food, and some of the safest food we consume.
>
> Forget who they are (they are largely nobodies, often from unassociated fields, and all with past anti-GMO agenda) but… [300]? …Even 9-11 truthers were able to get more than 2000 architects and engineers to sign their loony position. You don't want to know how many nut-jobs still believe they can challenge the scientific consensus on Climate Change and Evolution based on wishful thinking and petition.
>
> Scientific consensus is not done by opinion poll, nor is it done by petition (though if it were these "dissents" would all fail due to the hasty generalisation fallacy). The scientific consensus is a consensus of data, is borne out by peer reviewed study and published work. Thus a meta-analysis of a topic is a perfect way of determining consensus. The consensus, by the way has stood for decades. GMO is not only as safe as any other food, it is provably so (most other food never having been tested) and in fact it is simply food, not magic.[36]

The Australian Agricultural Biotechnology Council (ABC) reaffirmed this judgment, and further showed that European agriculturalists are keen to adopt the technology, and increasingly dissatisfied with the innovation-stifling and scientifically indefensible European regulatory regime.[37]

Ignoring this, proponents of mandatory labeling legislation have claimed nevertheless that there are studies raising legitimate questions about the safety of GIFs. One frequently cited example is that of a long-term feeding study in rats, conducted by a well-known organic advocate and biotech opponent from France, who dissembled the financial conflicts of interest at the foundation of his claims. Biotech opponents claim this study has been wrongly criticized, but the facts show otherwise. The alleged "attacks in the media" aimed at the Séralini "study" were the direct consequence of its unusually poor design, execution, and analysis and the unprecedented media manipulations imposed on journalists prior to its release, in an attempt to spin favorable media coverage.[38] The criticisms of the study and the way it was released were spontaneous and widespread among credible scientists and journalists.[39] That is how peer review works.[40] The criticisms were, in fact, more severe than is commonly seen, but this was entirely due to the extraordinary shortcomings in design, execution, and interpretation of the experiment, and the unprecedented departure from the norms of publication designed to produce slanted media coverage.

Some have claimed that "the French Food Safety Agency and the European Food Safety Authority have functionally agreed with Doctor Séralini."[41] This claim is flatly contradicted by the historical record. Regulatory bodies in Europe and around the world uniformly rejected the study, and have made the following statements:

The European Food Safety Authority: "EFSA is presently unable to regard the authors' conclusions as scientifically sound."[42]

Six French National Academies of Science (Agriculture, Medicine, Pharmacology, Sciences, Technology, and Veterinary Medicine) condemned the study, stating: "Given the numerous gaps in methods and interpretation, the data presented in this article cannot challenge previous studies which have concluded that NK603 corn is harmless from the health point of view, as are, more generally, genetically modified plants that have been authorised for consumption by animals and humans."[43] They further dismissed the study as "a scientific non-event" that served only "to spread fear among the public that is not based on any firm conclusion." These findings were echoed by the French Higher Biotechnologies Council (HCB) and the National Agency for Food Safety (ANSES).[44]

Federal Institute for Risk Assessment (BfR, Germany) responded: "The authors' main statements are not sufficiently corroborated by experimental evidence, due to deficiencies in the study design and in the presentation and interpretation of the study results."[45]

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The Australia New Zealand Food Safety Authority stated: "On the basis of the many scientific deficiencies identified in the study, FSANZ does not accept the conclusions made by the authors and has therefore found no justification to reconsider the safety of NK603 corn, originally approved in 2002."[46] Canada concluded: "The overwhelming body of scientific evidence continues to support the safety of NK603, genetically modified food and feed products in general, and glyphosate containing herbicides."[47]

Indeed, the condemnation of the Séralini study from the international scientific and regulatory community was so deep, broad, and spontaneous, that even Marion Nestle, NYU professor of nutrition and food safety advocate long known for her skepticism of agricultural biotechnology, agreed: "It's a really bad study."[48] One blogger distilled the consensus, and coined the "Séralini Rule": "If you favorably cite the 2012 Séralini rats fed on Roundup ready maize study, you just lost the argument."[49]

In the end, the evidence of the study's inadequacies was so overwhelming that the journal in which it was published retracted it.[50] This elicited much commentary in the blogosphere.[51] Séralini apologists have made numerous false and misleading claims about the retraction, but these have failed to persuade.[52]

It must be noted that in citing the robustly discredited Séralini study opponents illustrate a pattern they have followed throughout their public representations. Repeatedly they cite one or another from a small handful of studies published by well-known campaigners against biotechnology. In so doing they ignore the devastating criticisms they have received from the scientific community (peer review) as well as the vast body of accepted scientific literature contradicting their unsustainable claims. This pattern of advocacy is deemed to be scientific misconduct under widely accepted standards.[53]

At the end of the day, unlike conventional or organic foods, bioengineered foods are routinely screened in the United States and other industrial nations (per regulations rooted in the OECD guidelines) to ensure they have no toxins or known allergens. The emergence of previously unknown, novel allergens is so vanishingly rare as not to constitute even a remotely legitimate concern.[54] No such hazards have ever been reported from commercially

available bioengineered foods in the scientific literature, nor any credible hypothesis through which such hazards might possibly arise.

## GLYPHOSATE (ROUNDUP®) IS ONE OF THE SAFEST AGRICULTURAL COMPOUNDS EVER USED

One particular fringe claim regarding GMO safety, and one that has attracted some media attention, is an allegation that glyphosate is not only unsafe, but causes autism, and a host of other ailments. This claim is, in fact, so erroneous that it doesn't deserve serious attention. But thanks to the opposition propaganda machine, it has recently received wide circulation, and so, perhaps, is worth at least a brief look.[55]

The claim comes from a "Senior Research Scientist at the MIT Computer Science and Artificial Intelligence Laboratory" who has published it, and related claims, in a "pay for play" journal with a negligible impact factor—that is, to be kind, not a frequent or favored resource for those working in toxicology, agriculture, or neurophysiology.[56] Indeed, the journal itself is of such low repute that it has been cited (in conjunction with another of the same author's papers) as the lead case study in "A guide to detecting bogus scientific journals."[57]

In an arena marked by the incredible, it is hard to find claims that are farther "out there" or more divorced from reality than those that have been advanced by Dr. Stephanie Seneff, an engineering PhD who seems to have some difficulty identifying any evils that cannot be laid at the feet of glyphosate, a widely used weedkiller with a particularly benign safety profile.[58]

One can hardly do better than to consult a summary of the data on the safety of glyphosate compiled by independent scientists at BioFortified in 2013.[59] Bottom line: glyphosate is less toxic than table salt, baking soda, chocolate, or caffeine. Yet some would have us believe it is responsible for nearly every ailment imaginable, and these claims find a ready echo chamber in a credulous and scientifically ill-trained press.[60]

The claims made by Dr. Seneff are so outlandish that they cannot be taken seriously. The following points are relevant:

- The paper making these claims was published in an obscure, pay-for-play journal that is not even indexed in the standard catalogue of biomedical journals, *PubMed*;[61]
- The journal is dedicated to a subject matter ("Entropy") far afield from the topic of the paper;
- No credible mechanism is presented, which could conceivably explain the wide range of disparate claims of harm;
- The argument is not based on any demonstration of causality, but on dubious inferences of correlation.

There is a reason scientists are skeptical about correlational analyses: more often than not, they simply don't hold up. One blogger has compiled a long list of spurious correlations that are every bit as valid as those advanced by Dr. Seneff:

- Per capita consumption of cheese (U.S.) correlates with the number of people who died by becoming tangled in their bedsheets;
- The number of people who died by becoming tangled in their bedsheets correlates with total revenue generated by skiing facilities (U.S.);
- Per capita consumption of sour cream (U.S.) correlates with motorcycle riders killed in non-collision transport accidents.[62]

There are obvious problems with correlational studies.[63] Indeed, credible scientists with relevant expertise have considered Seneff's claims in her various recent publications, and failed to find any merit in them.[64] And while the claims are clearly devoid of any credibility or scientific merit, they do fit right in with the fear-mongering anti-biotech campaigns that have been extensively reported in the media in recent years.[65]

Bad as these papers are, and as unsupportable as their claims may be, it remains a matter of concern that the reported incidence of autism spectrum disorders appears to have been on the rise in recent years. But this mystery has been so baffling that some have questioned whether it might be real, or rather some artifact of changes in trends or practices of medical diagnosis and reporting. And, in fact, recent research seems to confirm this hypothesis.[66] It appears that "most of the rise in autism is a statistical mirage." Whether or not this study can be replicated, and whether or not it stands up to post-publication peer review over time, this much is clear: it is a testable hypothesis, based on data.[67] Claims of any link between glyphosate and autism are not.

## MANDATORY LABELING PROPOSALS IN THE US ARE FAILING DESPITE UNPRECEDENTED EFFORTS AND EXPENDITURES

Anti-GMO advocates assert that they are winning in their campaign to free the world of GMOs by pointing to the passage of labeling laws in various states. To listen to them, it is only a matter of time before labeling is required everywhere, and from there it is a short step to the "market" demanding non-GMO food.

Proponents did manage to get a law passed in Vermont in 2014.[68] But if that was a "victory" it was Pyrrhic. As predicted, it was immediately challenged in court (by food companies, not, as opponents claim, by Monsanto), where it is likely doomed on multiple grounds.[69] Passage of similar bills in New Hampshire and Maine require a trigger before they would come into effect, and that trigger—in essence, requiring New York to pass a mandatory labeling requirement—is unlikely to be met. Campaigns mounted in more than 30 states have been conspicuous by their (costly) failures, including expensive battles over the past decade in states like California, Washington, Oregon, and Colorado. Mandatory labeling campaigns have been so unsuccessful that proponents are now shifting the battlefront to municipalities and counties—a clear demonstration of failure to ignite any broad scale movement.[70] But even there, the gains are unreliable.[71] These facts on the

ground give the lie to repeated claims that "98 percent of the population supports labeling!" When one looks beyond carefully set up push-polls, the data show that the vast majority of consumers are satisfied with existing Food and Drug Administration (FDA) labeling policies when they understand them.[72]

Of course, this consistent run of defeats does not mean labeling campaigns are going away any time soon. The easy shift from labeling campaigns to bans confirms that which has long been known, that labeling proponents aren't really interested in labels. Their push for mandatory labels is nothing but a means to an end in a guerilla marketing campaign intended to prevent food companies from selling foods derived through GMOs, and to get consumers to switch to higher-priced organics. Wherever these campaigns pop up, the money trail leads to a small handful of repeat donors coordinated in a well-orchestrated campaign.[73] At that, they are having some success, but as Abraham Lincoln said, "…You can't fool all of the people all of the time."[74]

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Proponents have advanced a number of arguments to justify the legislation they are pushing in State legislatures across the United States. They have claimed these arguments are based in science and experience. They are not. The arguments advanced in support of this legislation are either false, or fatally flawed. They have been put forward in denial of the fact that the objectives this legislation claims to advance are already a reality. And they have been advanced through an indefensible denial of the robust worldwide consensus on the safety of crops and foods improved through biotechnology.

Anti-biotech campaigners have claimed that this legislation is necessary to provide consumers with the ability to choose foods derived from crop varieties other than those improved through biotechnology. But consumers already have multiple means for exercising such freedom of choice: they can buy food labeled USDA organic, because that marketing program prohibits the intentional use of crops improved through biotechnology in organic production.[75] Or they can buy food certified through the NonGMO project, and other private certifying schemes. They can even download a smartphone app with which to scan a product's barcode in the grocery store aisle and determine whether or not it is a genetically improved food.[76] Consumers' freedom of choice is already today a concrete reality made available through multiple independent means.

Biotech opponents have claimed that consumers have a "right to know" what is in their food, and that labels are required to inform them.[77] But existing FDA policy already requires that any novel ingredient that may affect the health, safety, or nutritional value of a food must be identified on the label.[78] Existing federal law requires all food placed on the market to be safe, with criminal penalties for violators.[79] The assertions of biotech opponents also ignore the fact that consumers have a right to labels that are accurate, informative, and not misleading. These legal mandates are already in place, and they ensure that mandatory labeling legislation would fall to a legal challenge if adopted by any state.

In short, the claim, therefore, that labeling is needed to inform consumers of potential hazards is not only unfounded, but the opposite of the truth: the only safety differential ever reported between bioengineered and other foods shows the bioengineered foods to be safer. [80]

But if protecting human health or the environment is not the objective for these anti-technology opponents, what is? To be clear, the real objective behind the campaign for mandatory labeling legislation being advanced in a number of legislatures is to falsely stigmatize foods derived from crops improved through biotechnology as a means of driving them from the market. Proponents of mandatory labels have on occasion been honest in acknowledging these objectives.


**Figure 3: Is Labeling Really About Our "Right to Know"?**[81]

And more recently, again from Ronnie Cummins, "mandatory labeling and bans, or GMO-free zones, should be seen as complementary, rather than contradictory."[82]

It takes very little digging to uncover the motivations behind this organized push for mandatory labeling: it is a fear-based marketing campaign aimed at expanding the market share for organic foods.[83] And this is because these advocates simply distrust technological innovation per se, preferring Americans to live in an idyllic, simpler world that is "back to nature" but totally imaginary. The reality is that a world without GMOs will be a world with higher food prices for working American families. Perhaps labeling advocates can afford to pay higher prices for organic foods at upscale stores such as Whole Foods—which is and should be their right—but using state legislatures to force all Americans to follow this path (e.g., to spend much more for food) is elitist at its core.

In addition to the right to not be deceived or misled, consumers have a right to not be forced to pay more than they need to for food, leaving less money for health care, education and other needs. Compulsory labeling of "GMOs" would deprive them of these rights.[84]

A host of additional claims have been made to advance the mistaken notion that this legislation would meet a need. The facts contradict these claims at each and every turn. Mandatory labeling legislation would add nothing to the consumer choice and safety already provided under existing law and policy, and should be rejected.

## GM CROPS HAVE NOT CAUSED "SUPERWEEDS"

Professional opponents, and even some farmers, have argued that the widespread use of biotech-derived herbicide-tolerant crops has led to the emergence of "superweeds." Such claims are not supported by the data, although unlike the prior issues, this one is a little more complicated.

There is no doubt that weeds that can survive the application of glyphosate are a problem for more farmers today than was the case 20 years ago.[85] But has the rate of emergence of such herbicide tolerance increased since the advent of "Roundup-Ready" (glyphosate tolerant) soy, corn, cotton and canola? The data indicate the answer is no. It must be remembered that most plants are tolerant or resistant to many herbicides—this is why there are multiple herbicides on the market to help farmers manage different weed problems in different crops. This was true before the advent of biotech crops in the mid-1990s, and will be the case forever. And there are data that directly address this question:

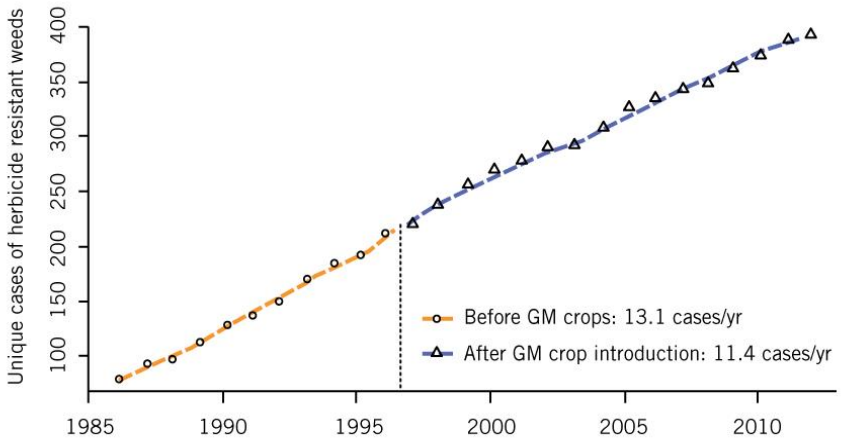


**Figure 4: Unique Cases of Herbicide Resistant Weeds Over Time**[86]

The author of the paper sums up the data presented in figure 4:

> The slope of the linear regression is an estimate of the number of new herbicide resistant weeds documented each year. In the eleven year period before GM crops were widely grown, approximately 13 new cases of herbicide resistance were documented annually. After GM crop adoption began in earnest, the number of new herbicide resistant weeds DECREASED to 11.4 cases per year. The difference in slopes between these two time periods is probably not very meaningful from a practical standpoint. But based on the best data available, we can be quite certain that adoption of GM crops has NOT caused an increase in development of *superweeds* compared to other uses of herbicides.[87]

And if glyphosate tolerance, newly evolved or ancient, were the enormous, widespread problem critics claim, would we not expect to see this manifest in a number of ways, such as reduced yields? But that doesn't seem to be happening.[88] It is certainly the case that some farmers are having real problems, and that glyphosate-tolerant weeds are spreading. But this is no doubt caused by natural selection. Those farmers having the worst problems with glyphosate-tolerant weeds are generally the ones who ignored industry standards for best practices and failed to rotate weed management methods—or their unfortunate, immediate neighbors.[89] History has taught us this is not smart, and some would find it fitting that those farmers who ignored experience are now paying the price. But as natural selection dictates, such problems do not stay sequestered in the fields where they arose, making it important to develop additional methods of weed management so that farmers have more tools to rotate in a more sustainable manner. Of course, the professional protest contingent objects to such innovations, but they are coming nonetheless, and as a recent review concluded, "…the use of [genetically modified herbicide tolerance] technology continues to deliver significant economic and environmental gains to U.S. farmers."[90]

## "GMOS" ARE MORE "SUSTAINABLE" THAN ANY OTHER FORM OF AGRICULTURE

The environmental movement has, over the past five decades, generally been moving in the direction of what we now call "sustainability."[91] This is a term with many different meanings.[92] Perhaps the earliest reflection of this ideal is in the "Great and Binding Law of the Iroquois" which directed that leaders "…shall labor, legislate and council together for the interest of future generations."[93] More specifically, the sentiment invokes an ethical mandate to consider the implications of any action for descendants "unto the seventh generation." In specific reference to agriculture—which is the single human activity with the largest environmental impact—"sustainability" has been used to mean a wide variety of different things. The U.S. Department of Agriculture's National Institute for Food & Agriculture (USDA/NIFA) defines it by referring to "three pillars of sustainability": profit over the long term; stewardship of our nation's land, air and water; and quality of life for farmers, ranchers and their communities.[94]

How does agricultural biotechnology stack up against these criteria? Pretty well.

As to "profit over the long term"—there is no canonical definition of "long term," but let us take it to be seven generations. By that yardstick, the only form of agriculture that has been around long enough to evaluate is "organic" agriculture and its antecedents (although a legitimate argument could be made that this is a stretch, inasmuch as modern organic farming originated in the 1920s).[95] Given the track record of famine, starvation, and environmental degradation associated over the years with the use of organic techniques, the extent to which modern acolytes hail them as being "sustainable" is remarkable.[96] A gimlet eye would assign organic farming as many as three failing grades against our chosen criteria, while giving it credit for providing the impetus, through its failures, for the development of modern agriculture.[97] But how do the products of modern biotechnology fare?

They have delivered results that have led to biotech-improved seeds being the most rapidly adopted new technology in the history of agriculture. In the space of less than one generation, these seeds have been taken up by more than 18 million farmers planting them (legally) in more than 28 countries, and a record of farmers growing them without government approval where and whenever they can get their hands on them.[98] Adding over a hundred billion dollars worth of value to the global economy would certainly seem to give biotech seeds a plus sign in the profitability category.[99]

Stewardship also means different things to different people, but most would agree that good stewardship is served when we follow Wallace Stegner's admonition to "…tread more gently on the land."[100]

One well-known organic advocate has published several papers claiming that crops improved through biotechnology have resulted in an increase in the use of pesticides. This claim is false, and depends on a number of intellectual gymnastics:

- It wrongly conflates "herbicides" with "pesticides" in a way that is flatly misleading. Pesticides are commonly understood to kill pests, usually insects.

Herbicides are used to control weeds, which are certainly pestiferous, but agriculturalists use the different words for very good reasons;

- The argument is based on the misleading measurement "pounds on the ground," when that has long since been supplanted in the weed control literature by the "Environmental Impact Quotient" developed at Cornell University. The EIQ gives a vastly more accurate and useful way to evaluate comparative environmental impacts;

- The argument measures absolute application rates, instead of the far more logical rates per unit yield, which actually show a decline in herbicide usage;[101]

- Such claims ignore the devastating critiques that have been leveled specifically at the author's claims in at least 17 peer-reviewed papers in the literature and several accessible blog posts;[102]

- Such claims are, in fact, directly contradicted by USDA's interpretations of their own data.[103]

Given the dramatic reduction in the use of synthetic inputs, the concurrent explosion in "no-till" agriculture, and all the benefits of improved soil quality and reduced erosion, most farmers would agree emphatically that biotech seeds have improved their stewardship of the land.[104] The Council for Agricultural Science and Technology has in fact looked directly at this issue and conducted a comparative analysis of "GM," conventional, and agricultural production in soy. They found that to be economically viable organic production required prices to be three times higher than they needed to be for other methods.[105]

Some have argued that biotechnology improved seeds are not really sustainable, and that it amounts to little more than swapping out a "chemicals treadmill for a gene treadmill."[106] To the extent that this is true, it is precisely the point.[107] "Mother Nature" has sustained a genetic arms race between plants and animals since the dawn of animals. Plants, lacking legs with which to flee herbivores, have adapted and evolved a huge armamentarium of chemical weapons with which to repel animals. This has led to a gargantuan arsenal of tools distributed throughout the genetic diversity of plants, now brought within human reach for the first time thanks to modern biotechnology.[108] This is, in fact, exactly what Rachel Carson instructed us to do:

> A truly extraordinary variety of alternatives to the chemical control of insects is available. Some are already in use and have achieved brilliant success. Others are in the stage of laboratory testing. Still others are little more than ideas in the minds of imaginative scientists, waiting for the opportunity to put them to the test. All have this in common: they are *biological* solutions, based on understanding of the living organisms they seek to control, and of the whole fabric of life to which these organisms belong. Specialists representing various areas of the vast field of biology are contributing—entomologists, pathologists, geneticists, physiologists, biochemists, ecologists—all pouring their knowledge and their creative inspirations into the formation of a new science of biotic controls.[109]

The recognition is slowly spreading—not only through the environmental community, but now even seeping into political circles—that this is a good thing.[110] The challenges brought by global warming make it an imperative.[111]

As to the impact of seeds improved through biotechnology on the quality of life for farmers, ranchers, and their communities: they have voted with their wallets and their feet, and their verdict is clear.

In sum, though imperfect, it is difficult to find any other approach to agriculture that scores better against the three pillars of sustainability than seeds improved through biotechnology.

## CONCLUSIONS FOR POLICYMAKERS

Although "GMO"s appear controversial if judged by media coverage, in fact the apparent controversies are almost entirely manufactured by opponents with either vested financial interests—particularly the more extreme elements of the organic food community—or with an ideological opposition to innovation in agriculture. On each of the topics of controversy, the truth is the opposite of what most media coverage conveys:

- The United States is continuing its strong embrace of newer seed improvement technologies and their products, and other countries are increasingly following;
- Seeds improved through biotechnology have delivered substantial and significant economic value to farmers and consumers around the world, adding at least $98 billion of farmgate value, increasing production by more than 300 million tons, and reducing pesticide applications by 37 percent;
- The resulting genetically improved foods are as safe as or safer than foods derived through any other method of seed improvement or production, including organic, and no less natural than any other foods we eat;
- Glyphosate (Roundup®) is one of the safest agricultural chemicals ever used, and all credible data and experience confirm this;
- Herbicide-tolerant biotech traits have not increased the frequency of evolution of resistant weeds and have not created "superweeds," although they continue to require proper rotation of weed control measures and good stewardship, just as all agriculture does;
- Mandatory labeling proposals have been such massive, costly, and repeated failures that proponents are shifting from state-level battles to counties and towns where they can more easily deceive and mislead smaller audiences for a time; and
- Crops improved through biotechnology demonstrate superior sustainability, and bring to agriculture conspicuous elements of the classic environmentalist objectives, as prefigured in the writings of Rachel Carson, and corroborated in the views of other founders of modern environmental movements like Patrick Moore and Stewart Brand.

In short, modern techniques for improving seeds and livestock through precision breeding are rapidly becoming the new conventional standard around the world, leaving opposition groups behind to smolder on the ash heap of history.

## ENDNOTES


1. The term itself is nonsensical, clearly capturing all living organisms that do now or ever have existed. The term is wrongly used by opposition groups to stigmatize as "unnatural" and fearful that which is ubiquitous in nature and shown by experience to be as safe as or safer than alternatives. We use the term in this paper for convenience, in recognition of the common usage. "Why the term GMO is 'scientifically meaningless'," *PRI*, November 3, 2014, http://www.pri.org/stories/2014-11-03/why-term-gmo-scientifically-meaningless.
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