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La definición de consenso científico y el debate cambiante sobre la seguridad de los OGM

The Definition of Scientific Consensus and the Shifting Debate on GMO Safety

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Resumen: Algunas personas tienen una actitud negativa hacia los alimentos derivados de organismos modificados genéticamente (OGM). La comunidad científica ve a los OGM de forma más positiva debido a la evidencia que demuestra que no tienen efectos negativos. El debate ha pasado de la evidencia científica a lo que los científicos dicen sobre la evidencia. Al examinar otros consensos científicos, se puede situar el estado actual del debate sobre los OGM en la línea de tiempo entre la especulación y el acuerdo. Existe un retraso entre la formación de un consenso científico y su mayor aceptación por parte del público, y el OGM debate se encuentra en esa etapa intermedia.
Palabras clave: controversia científica; organismos genéticamente modificados; OGM; seguridad alimentaria; sociología de la ciencia.

Abstract: Certain people feel negatively towards foods from genetically modified organisms (GMOs). The scientific community views GMOs more positively due to overwhelming evidence demonstrating no negative effects. The debate has moved from what the science says, to what scientists say about what the science says. By examining other scientific consensuses, one can position the current status of the GMO debate on the timeline between speculation and widespread agreement. A delay exists between a scientific consensus forming and its greater acceptance by doctors, politicians, and the public, and the GMO safety debate is currently in that middle stage.
Keywords: food safety; genetically modified organisms; GMOs; scientific controversy; sociology of science

1. BACKGROUND

Growers and consumers worldwide vary in their acceptance of foods made from, fed, or containing genetically modified organisms (GMOs) (Frewer et al. 2013). Concerns over GMOs affecting human health exist despite the poor semantic value of the term "GMO," as there is no common denominator between different products made with different biotech methods (Tagliabue 2016). The research on the impact of GMOs on consumers, farmers, and the environment is extensive, covering thousands of papers. Their results are consistently positive (Snell et al. 2012; Nicolia et al. 2014; Panchin and Tuzhikov 2017). A 2018 meta-analysis of over 6000 peer-reviewed studies covering 21 years on GM maize alone concluded that engineered corn has higher yields and fewer mycotoxins with no unexpected non-target effects (Pellegrino et al. 2018). Earlier meta-analyses found that adoption of GMOs increases crop yield, reduces chemical pesticide use, and increases farmer profits, particularly for farmers in developing countries (Finger et al. 2011; Klümper and Qaim 2014). The abundant evidence that GMO strains are as safe, if not safer, than conventional counterparts led to news agencies announcing a "scientific consensus" that GMOs are safe, sustainable, and pose no threat to human health or the environment relative to equivalent, non-GMO strains of the same crops (Entine and Wendel 2013; White 2013).

These proclamations are anathema to the anti-GMO movement. To each article reported as a meta-analysis, a reply will be written rejecting that such a consensus exists (Hilbeck et al. 2015; Krimsky 2015). Thousands of papers demonstrating GMO safety are hand-waved off with claims of "insufficient evidence," or dismissed as tainted with political or corporate influence or poor methodology (de Vendômois et al. 2010). A decade later, and negative misinformation about GMOs in the public sphere is no less prevalent today than it was then, even as the scientific consensus has not chainged (Lynas et al. 2025).

The irony is that the few anti-GMO papers in existence are typically those of low quality and high bias. An example was a 2012 paper by Giles-Éric Séralini in *Food and Chemical Toxicology* claiming GM corn causes tumors in strains of rats bred to have tumors. The flaw evident from that sentence describing it, combined with an unacceptably small sample size, no controls in the figures, and an unheard of practice of forcing journalists to sign a confidentiality agreement forbidding them from consulting with other scientists about the paper before reporting on it, earned international condemnation, and the journal retracted the paper (Séralini et al. 2014b). Séralini then republished the paper in *Environmental Sciences Europe*, which admitted that they did not perform any further peer review on the subject (Séralini et al. 2014a). A later paper by Seralini and others claiming the reason nobody can replicate their results is that all laboratory rodent diets in the entire world contain "dangerous" levels of GMOs (Mesnage et al. 2015) was later corrected to include the laundry list of political and corporate conflicts of interest the authors originally failed to declare (The PLOS ONE Staff 2015).

Papers like Seralini's, pre-and post- retraction and republication, are often cited as evidence that there is no "scientific consensus" on GMO safety. Most overt is a 2015 paper, "No Consensus on GMO Safety," by Angelika Hilbeck et al., which cites the republished Seralini paper, uncritically, in the first sentence and claims a "concerted effort" of corporations, scientists, and journalists exists to "construct claims" of a consensus (Hilbeck et al. 2015). Hilbeck's article includes a list of 300 scientists who reject the concept of a consensus on GMOs, namely the affiliates of the "European Network of Scientists for Social and Environmental Responsibility," (ENSSER) which, despite its name, exists wholly as an anti-GMO organization. It was created by Gilles-Éric Séralini, has repeatedly published articles in defense of Séralini, and its president at the time was Angelika Hilbeck. Nonetheless, a general public unaware of these bias and conflict of interest issues may uncritically accept these documents, if not as evidence of GMO risk, then at least as a sign that the debate on GMO safety is ongoing and that a scientific consensus has not yet been reached.

The anti-GMO movement is not the only one to argue over what constitutes consensus, however. Whether scientists have reached a consensus on a matter, and then a consensus on the existence of a consensus (Cook et al. 2016), are highly debated matters among stakeholders and the general public. Even after scientists reach a conclusion, time is needed for the public to become aware of its existence, although whether the public accepts the conclusions of a consensus depends more on their prior beliefs than whether they accept the existence of the consensus itself (Hamilton 2016). The GMO controversy at this point in time is no longer a dispute about what the data says or its quality, but a dispute over who is the credible interpreter of scientic evidence and what is the threshold for evidentiary convergence and institutional endorsement before consensus can be declared.

Here we discuss what constitutes a scientific consensus, and where we are on the path towards one regarding GMO safety, testing the hypothesis that consensus development (and consensus denial) in matters of public health and product safety follow similar patterns. Using the historical analogy of cigarette-cancer research, the article charts the development of a scientific consensus as a sociotechnical construct that emerges from evidentiary convergence and institutional validation, noting that public and political acceptance often lags. The current status of the debate on GMO safety is positioned in this framework. Although this article is conceptual and analytical rather than empirical, it adopts a comparative historical–analytical research design grounded in literature synthesis, comparative case analysis, critical discourse analysis of stakeholder claims, conceptual modeling of the consensus formation process, and documented example analysis to explain how consensus forms, how it is communicated, and why it is sometimes denied.

2. What is Consensus? The Case of Cigarettes Causing Cancer

Several decades ago, if asked whether or not there is a scientific consensus on GMOs, most scientists in the field would say there is not enough data to form one. The key word here is data: a consensus is not based on an opinion poll of scientists, but a systematic analysis of research data.

An illustrative analogy is the consensus on cigarettes causing lung cancer. The majority of cancer researchers are in agreement: smoking increases the risk of cancer. How was this consensus reached? Not everyone who smokes develops lung cancer, or even falls ill, and not all cancers are caused by smoking, including lung cancer. How did scientists find the signal through these outliers?

Lung cancer used to be an exceptionally rare disease, that doctors would encounter maybe once in their lifetime: only 140 cases were noted in the medical literature prior to 1900. That changed when mass production and mass media made cigarettes cheap, easily accessible, and popular. A lung cancer epidemic struck the world, linked in 1898 by a medical student to “tobacco dust” and in a 1912 monograph to “abuse of tobacco and alcohol” as a possible cause, though the monograph noted this hypothesis was “not yet ready for final judgment” (Proctor 2012). In 1939, case-control epidemiology found that lung cancer patients were far more likely to be smokers than the average. This finding was found again in other, larger, case-control studies from several countries. Case-control studies were matched with cohort studies, which follow two groups of people paired in all ways but one [in this case, smoking] over time to see which develops disease and which do not, which routinely found that smoking greatly increased the risk of cancer. Such a pattern typically predates scientific consensus: new studies, with every increasing sample sizes, reach the same conclusions regardless of where in the world they are performed.

A “consensus” was not declared until multiple lines of evidence converged. Animal experiments in which tobacco smoke was distilled and applied to various animals in a laboratory consistently produced tumors. Pathologists noticed that cigarette smoke causes the hair-like cilia of airway cells to die, leading to cancer, and later studies found dead cillia in the lungs of smokers in the areas where cancer was typically developed. Chemists found “practically every class of [carcinogenic] compounds in cigarette smoke” (Proctor 2012). The pathway from smoke to cancer was now completely filled in, with no missing links. In addition to all these papers, one must also note that valid, alternative explanations for the smoking-cancer link were never found.

In 1954, newspapers first reported that smoking was linked to lung cancer, followed shortly by the American Cancer Society's National Board of Directors, British Medical Research Council, Swedish Medical Research Council, International

Union Against Cancer, and so on. At this point in time, it can be stated, the scientific community had officially declared a consensus (Proctor 2012). Nonetheless, a poll in 1954 found that only 41% of Americans thought smoking was linked to lung cancer. That number actually dropped as years passed, thanks to efforts by the cigarette companies, and medical professionals were not exempt. By 1960, two-thirds of doctors did not think cigarettes caused cancer, and 48% themselves smoked. The famous US Surgeon General's report, which led to warning labels on cigarette boxes, did not come out until 1964. No particular paradigm change happened that year: the scientific consensus that cigarettes cause cancer was as solid then as it was when it was announced a decade earlier. The case was closed, and could close no further: the US government had just not yet examined the data themselves yet.

That report (Surgeon General's Advisory Committee on Smoking 1964) was a meta-analysis: a study that analyzes the data from all previous research on a subject objectively and statistically to identify if a consensus is reached. To produce a meta-analysis, one sets up criteria by which a paper is to be included or excluded, such as sample size and statistical power minima, declared conflicts of interest, or having an author with a record of retracted papers. [The Seralini papers would be rejected by any legitimate meta-analysis for either of those reasons.] The analysts gather all papers in the subject that they can possibly find, put them through the same selection process, and ideally transform the results into a format that can be analyzed statistically. The results will either show that a majority of papers support one hypothesis, meaning a consensus exist, or that no such clear pattern exists, either because a similar number of high-quality papers exist that reach different conclusions, or because the number of papers is too small for meaningful analysis.

In summary, as the cigarettes and cancer consensus illustrates, a consensus forms when multiple publications, from multiple lines of investigation by researchers all over the world, reach the same conclusion, with no evidence for a suitable alternative. Regarding human health, a consensus requires epidemiological evidence, experimental evidence, and mechanistic evidence for the link between the disease and its alleged cause. A consensus does not require unanimity or lack of objection, and does not include the public or even doctors: a scientific consensus is a consensus among the majority of the unbiased research. The lag between public acceptance of a scientific consensus is not unexpected, even if it can have signfiicant costs.

2. GMO Safety: What are the Reported Research Results?

Today is not the 1920's. We have many ways to identify carcinogens and spot cancer trends among a populace. If GMOs caused cancer or any other condition, we would know by now, and the same researchers that sounded the alarm on cigarettes would have done the same to GMOs. They have not: quite the opposite. Over 280 scientific and technical institutions such as the American Cancer Society and the Royal Society of Medicine, representing over 140 countries as well as international bodies such as the World Health Organization and International Union of Food Science and Technology, have issued consensus statements affirming the safety of GM crops (Norero 2017), as have at least 129 Nobel laureates (Roberts 2018). These views come from thousands of studies from around the world, including multiple, long term, thorough studies on GMO safety and human and animal health, all dwarfing the discredited Seralini paper in their quality and methodology (Nicolia et al. 2014). Research on GMO safety today is at a point similar to that of post-1954 cigarette safety research: a consensus has been reached and reported with overwhelming evidence accepted by scientific organizations worldwide. The general public has not yet matched the scientific community in percentage accepting this consensus, but one should not expect them to, for many have not accepted the consensus that cigarettes cause cancer either (Parascandola and Xiao 2019).

One must be careful here to clarify exactly what the consensus states: that GMOs *per se* do not pose any risks to humans, and that any particular GMO strain on the market today poses no greater risk relative to *the same strain* without the modifications. Comparing GMO corn syrup to non-GMO blueberries is meaningless at best, dishonest at worse (Tagliabue 2016). In theory, any individual GMO could be harmful, just as any individual non-GMO can be harmful: just ask anyone with allergies to non-GMO peanuts. If a novel GMO does have a risk, the scientists thoroughly investigating GMO safety will find it and declare it, and the product will never go to market. This was demonstrated in an experiment deliberately putting allergen genes from Brazil nuts into soybeans, which found in trials that the resulting product elicited allergic reactions in people with Brazil nut allergies. It makes perfect sense that genes for an allergenic protein from a naturally allergenic plant will produce that same allergen in another plant, and it was extremely easy and uncontroversial to observe this with research (Nordlee et al. 1996). That finding does not in any way mean that all GMOs can cause allergies, let alone the more outlandish conditions attributed to GMOs like cancer, autism, and even homosexuality (Kamiya 2016). The claims of some anti-GMO activists that *all* GMOs are inherently dangerous do not match reality.

Note that Hilbeck et al. make a similar argument, albeit in reverse: that claiming that all GMOs are *safe* is not acceptable, and that every GMO's safety must be individually tested. This is true, but it is a straw-man argument given that individual testing of GMOs has always existed and is widely promoted by defenders of GMOs (Tagliabue 2016), and the results of these tests are the very basis of the scientific consensus. The argument that all GMOs should not be de-tarred with the same brush is particularly disingenuous considering the sources' links to the debunked Seralini paper. The ENSSER scientists are simply not a trustworthy source when it comes to GMOs, as one suspects that no amount of evidence could make them accept that any individual GMO is safe in any way.

The current status on the lack of health risks from GMOs is thus as solid a consensus as that for the presence of health risks from smoking: multiple publications, from multiple lines of investigation by unbiased researchers all over the world, reached the same conclusion. Excluding biased or flawed research, there is effectively no epidemiological evidence, no experimental evidence, and no mechanistic evidence for any link between any disease and GMOs *per se*. The primary difference between the cigarette and GMO safety consensuses, besides their direction, is that the latter is not yet as widely accepted by the general public.

4. From "Teach the Controversy" to "There is No Consensus"

A common misconception is that a scientific "consensus" implies unanimity. It does not, never has, and never could: scientists are as capable of having objectively false beliefs as anyone else, let alone having differences of opinion on how to interpret data. A consensus does not require 100% agreement of all individuals with tertiary degrees: a consensus is a fact-based agreement among an overwhelming majority of those with the least bias and the most relevant knowledge, based on statistical analysis of all the available, high-quality data.

It is illustrative here to compare the anti-GMO movement to other movements that claim a debate or controversy persists rather than a consensus, such the anti-vaccine and anti-evolution movements. Sadly, some M.D. and PhD-bearing scientists believe such myths, and peer-reviewed journals have published [and only sometimes retracted] papers supporting them. UK medical doctor Andrew Wakefield, whose medical license was since revoked, published a thoroughly fraudulent article in *The Lancet* claiming vaccines cause autism (Wakefield et al. 1998). A paper published in *Proteomics* claimed mitochondria are "the missing link between body and soul," demonstrating "a single common fingerprint initiated by a mighty creator" (Warda and Han 2008). A paper from an American professor claiming magnetic anomalies in Earth's core cause COVID-19 and can be prevented by wearing jade amulets was published in a peer-reviewed journal last year (Bility et al. 2020). One cannot stress enough that a single paper does not a paradigm change make or a consensus break, especially if it is retracted or withdrawn for misconduct, error, or nonsensicality.

Corporate or economic interests can indeed influence the behavior of scientists: Andrew Wakefield was paid to fabricate and publish evidence that a particular brand of vaccine was flawed (Eggertson 2010). As mentioned before (The PLOS ONE Staff 2015), corporate influence in the context of GMOs is not where many expect. Like cigarettes, anti-GMO products are a major business. The "GMO-free" label allows a product to be sold at a higher price, even when no GMO versions of said product exist. Examples include GMO-free carrots, GMO-free salt (Twardowski and Małyska 2015), GMO-free water, and GMO-free tableware. The anti-GMO movement, though often painted as standing up to "Big Ag," is a multimillion dollar business with deep corporate ties (Chassy et al. 2014), including not only retailers like Whole Foods and producers like Nestle, but also the pesticide companies that lobby extensively for anti-GMO labeling, as GMOs reduce the need for their insecticides (Klümper and Qaim 2014). While claiming cigarettes are safe is a somewhat different task than claiming GMO-free food is saf*er* than GMO food, the tactic used by the tobacco and organic lobbies is the same: when a scientific consensus emerges that threatens one's business, claim that the consensus does not exist.

The strict guidelines for producing meta-analyses (Moher et al. 2009) exist to weed out low quality or biased papers, and to counter "single-paper-syndrome" where one newsworthy but flawed paper overshadows hundreds of accurate papers. Unfortunately, biased and poor quality meta-analyses exist along with biased and poor quality research. The main issue is "cherry-picking," or only including publications that support ones conclusion in ones review of evidence. In response to a 2014 meta-analysis that concluded GMOs are safe (Nicolia et al. 2014), an anti-GMO author published their own meta-analysis claiming they are not (Krimsky 2015). The former examined 1783 publications, the latter a mere twenty-six. The former is objectively trustworthy and accurately identifies the scientific consensus, the latter may not have been published at all were the author not also on that journal's editorial board (https://journals.sagepub.com/editorial-board/sth).

An important aspect of a scientific consensus is that it is limited to those who have informed opinions. Just as one would not seek out an epidemiologist to repair a broken car, one would not seek an auto mechanic for their opinion on vaccine safety (or at least one should not). A scientific consensus on a subject is not, and never was, the consensus among all *scientists*, but rather only among the population of scientists who are actively studying that subject and are most knowledgeable in the field. The opinion of a degree-holding physicist, geologist, or psychologist on the safety of GMOs is therefore as irrelevant to any scientific consensus on the subject as the opinion of a mechanic, actor, or yoga instructor. If one does not know the science, then one cannot be part of the consensus.

Nor, by the way, is the opinion of a medical doctor on the safety of GMOs particularly meaningful: most M.D.s do not know basic facts about GMOs or agriculture, nor have they likely read the thousands of papers produced on the subject. The case of a pharmacist who intentionally destroyed COVID-19 vaccines because he thought they would "mutate people's DNA" is a clear case of how deeply genetic illiteracy runs among medical professionals (Richmond 2021). Practicing doctors are consumers of science, but not usually its producers: the epidemiologists and clinical trial researchers are the ones who make the scientific consensus. The slow acceptance among doctors that they and their patients alike should probably stop smoking is proof that doctors are historically slow to learn a consensus. This being said, the overwhelming majority of medical organizations today agree that GMOs are safe (Norero 2017).

While it may seem that limiting a consensus to those most qualified to opine about it is restrictive, the truth is that the population of specialists in almost any field is quite large. The UNESCO Science Report estimates 7.8 million researchers exist on earth (UNESCO 2015). The US Bureau of Labor Statistics for 2019 estimated nearly 1.3 billion life, physical, and social scientists work in the USA, over 300000 of which are life scientists (Bureau of Labor Statistics 2020). Not all are qualified to speak on the safety of GMOs, but the small percentage that are still number in the thousands, and those supporting GMOs outnumber those rejecting. Consider the statement published by the American Association for the Advancement of Science (AAAS), which has over 120000 members, stating GMOs are safe and opposing labeling of GMO products (American Association for the Advancement of Science 2012). Hilbeck et al. (2015) erroneously asserts that statement does not reflect consensus because it was rejected by a letter [since deleted] written by 21 scientists supporting labeling (Hunt 2014), even though that letter did not actually reject the claim of GMO safety! Consider too the ENSSER list of 300 "scientists and legal experts," who do not think GMOs are safe (Hilbeck et al. 2015). Not biologists or doctors, but "scientists and legal experts," meaning people in fields wholly unrelated to biology or health, let alone GMO safety. While 300 may impress some people, it hardly challenges the consensus accepted by tens of thousands of relevant scientists worldwide.

To put these numbers into perspective, in 2003 the Discovery Institute, a Creationist organization, put together a list of 1000 scientists who do not accept the fact of evolution. Less than a quarter were biologists, and few of those were actually involved in research that could give them insight into the origin of species. To demonstrate how small this number was, the USA's National Center for Science Education put together their own list: Scientists *named Steve* who accept the fact of evolution. As of today, the "List of Steves" has 1464 signatories (https://ncse.ngo/list-steves). The existence of a few physicists or engineers that take Genesis literally does not in any way weaken the consensus among millions of biologists that natural selection is true.

A consensus, in summary, is not 100% agreement. A consensus means that the majority of qualified people regardless of gender, race, nationality, or name who examine the evidence thoroughly and objectively reach the same conclusion, typically shared via statements by relevant scientific organizations. For GMO safety this point was reached in the early 2010s at the latest. To paraphrase Francis Pharcellus Church, "yes, Virginia, there is a scientific consensus on GMOs." Having thoroughly lost the debate the GMO safety in the face of overwhelming evidence, the anti-GMO movement's present strategy is to claim the debate still continues; but this claim and the existence of an anti-GMO lobby itself does not weaken the consensus any more than the presence of any number of creationists would weaken the fact of evolution and the consensus of its validity.

5. CAN THE GMO CONSENSUS CHANGE?

Some will argue that scientists have been wrong in the past: A consensus can change. This is true, but, contrary to the wishes of tobacco lobbyists, Creationists, and anti-GMO activists, science does not go backwards. While it may take time for scientists to discover a new truth, no amount of time can bring back a disproven fiction. Few expect scientists to reverse course and say cigarettes do not cause lung cancer. In the impossible event that evolution is found to be not true, the replacement would certainly not be Creationism. In the face of the growing consensus, the anti-GMO argument now hinges on the idea that more research will someday reveal a hidden truth about GMOs that is presently unclear, and that one must have faith-based devotion to the precautionary principle and reject dogmatically the consensus of safety until the prophesied day when the evidence that GMOs are unsafe becomes manifest. There are a few reasons why this waiting will go unfulfilled.

The first is that the anti-GMO activists are assuming the consensus of GMO safety is based on absence of evidence: the myth of insufficient data. In reality, it is based on evidence of absence: several thousand papers worth of controlled experimental and long-term observational studies providing clear evidence that humans who eat or produce GMO foods are just as healthy if not healthier than those who do not (Panchin and Tuzhikov 2017; Klümper and Qaim 2014). Indeed, unlike lung cancer and smoking, not a single disease on earth has ever been linked to any particular GMO. For epidemiological evidence, consider the Amish. They have some of the lowest cancer rates among all Americans, yet are enthusiastic growers of genetically modified crops, such as Bt corn, that allow them to use their heirloom mechanical technologies while remaining competitive and sustainable (Porterfield 2016). Perhaps the biggest nail in the coffin of GMO harmfulness is the fact that millions of people inject themselves with GMOs every day: The insulin used by diabetics daily to prevent death comes from genetically modified bacteria. To ironically paraphrase a claim from the anti-vaccine movement: if you would inject it, then why not eat it?

This leads us to the second flaw: the idea that GMOs *per se* can harm ones health does not, and never has, made any sense (Tagliabue 2016). Even without the mountains of evidence that GMOs are safe, one can conclude that GMOs are safe for human consumption based entirely on theory. The process of modifying DNA does not, in any way, pose risks to those who would consume the organism. There is no possible mechanism by which that could occur, and no anti-GMO activist has yet to propose a mechanism. The DNA of a GMO is not different from that of any other organism. The genes are not “loose.” They will not mutate you. To eat a hypothetical tomato with genes from a salmon poses no further risk to human health than eating salmon *alla puttanesca*: the same genes and proteins are swallowed, and all equally destroyed in the digestive tract.

In theory, the process of targeted gene manipulation in GMO production is not only comparable to the mostly unchallenged processes of selective breeding and hybridization, but also is safer. In GMO production, one only changes or adds the genes of interest, while in breeding, one has no control over which traits are transmitted. A good example is the Africanized honeybee, or “killer” bee. In efforts to breed bees with better resistance to tropical weather, scientists accidentally created a breed that was also highly aggressive. If GMO technology existed back then, then a GMO bee suitable for the tropics yet nonaggressive could have been created.

Similarly, there is no reason to assume, for example, that a gene for herbicide resistance will jump from GMO maize to wild plants. The possibility exists, but it is 100% identical to the possibility that any of the other 32000 maize genes will jump from the GMO maize to wild plants, which is also 100% identical to the possibility that any of the 32000 maize genes from non-GMO maize will jump to wild plants, to say nothing of the possibility that genes from wild plants will jump to the maize. Such horizontal gene transfer, though once though rare, is actually quite common [one might say that the scientific consensus on horizontal gene transfer is changing] (Crisp et al. 2015), but there is no theoretical reason why the specific genes modified in the making of a GMO will be more likely be transferred than the others.

The majority of the world’s anti-GMO activists are not knowledgeable in such matters of genetics. A poll showed that 37% of Americans do not think their food contains genes at all, with young and affluent Americans more likely to make this basic mistake (Kirshenbaum and Buhler 2017). One should not assume that all scientists are aware of such facts either.

Note too that non-GMO foods are not devoid of risk. Many people have died or suffered serious disease and disability due to consumption of explicitly GMO-free or “organic” food. An example is the 2016 Hepatitis A outbreak linked to “Nature’s Touch Organic Berry Cherry Blend” (Mollers et al. 2018). Ironically, a product that advertised itself as fighting cancer caused dozens of people to become at risk of liver cancer. In fact, technically, the epidemiological and experimental evidence that this organic, GMO-free product is linked to cancer is stronger than for any GMO in existence! One could thus ask whether there is a scientific consensus on the safety of organic foods: a question far less well studied. The evidence so far suggests that organic crops are equally as safe GMOs: they are not any more or less harmful for the body, and are not more or less prone to causing food poisoning or hepatitis than the same crops grown conventionally. It seems the only measurable difference consistently present between an organic crop and the same crop conventionally grown and/or genetically modified is the retail price (Magkos et al. 2003; Garcia and Teixeira 2017).

6. CONCLUSION

To summarize, as one can learn from examples throughout science history, a consensus is not the united voice of every person with a postgraduate degree. A consensus is the result of the majority of experts in a field objectively evaluating the total body of evidence for quality and significance from multiple avenues and coming to a similar decision on what the majority of high-quality publications conclude. A few publications in any journal, be they un-reviewed or top tier, does not a consensus threaten. A consensus is reached when major and multifunctional scientific organizations from around the world issue statements in agreement on a subject. Groups that formed solely to promote a single viewpoint on that single subject, or a minority of dissidents within a group, do not a consensus threaten. A consensus is based on what the combined research of thousands of scientists from around the world states when analyzed systematically. A celebrity scientist's or popular vlogger's opinions do not a consensus threaten.

We can never convince all humans of all facts, but if a consensus exists, then the scientific community needs to broadcast this reality with same boldness and loudness as those who would misrepresent it. History will be kind to those who spoke truth to pseudoscience

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