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The Disparity Between Scientific Consensus and American Public Opinion of Genetically Modified Organisms and Genetic Engineering

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Abstract

Genetically modified organisms (GMOs) and genetic engineering (GE) are accepted as safe and useful by the consensus of the scientific community. Their diverse utility has shown promise in addressing major challenges of the 21st century, including world hunger, global warming, and the prevalence of diet-related diseases (e.g. heart disease, cancer, diabetes, etc.). A 2014 Pew Research Center survey revealed that while 88% of scientists agreed that GM foods were safe to eat, only 37% of American consumers agreed. Furthermore, only 35% of U.S. adults trusted scientists to accurately inform the public about GMOs. To explain this disparity, I synthesize information about stakeholders in GMOs and GE, demographics linked to acceptance and denial, interpretation of scientific consensus, psychological mechanisms controlling bias, and poor practice of science. Analysis reveals that the disparity in GMO and GE perception between the scientific community and the American public was caused by bad science, foreign political agendas, profit-driven media, and psychological factors, such as intuitive expectations, soft attitudes, and the backfire effect; furthermore, I show that despite innate conduits for bias development, educated, high income, and youthful demographics will shrink the gap between scientific consensus and public opinion if GMO education and equal access to education increase.

Keywords

Genetically Modified Organisms, GMOs, Genetic Engineering, Consensus, Public Opinion

Disciplines

Agriculture | Environmental Health and Protection | Food Science | Nutrition | Public Health

Comments

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Genetically modified organisms (GMOs) and genetic engineering (GE) are accepted as safe and useful by the consensus of the scientific community. Their diverse utility has shown promise in addressing major challenges of the 21st century, including world hunger, global warming, and the prevalence of diet-related diseases (e.g. heart disease, cancer, diabetes, etc.). A 2014 Pew Research Center survey revealed that while 88% of scientists agreed that GM foods were safe to eat, only 37% of American consumers agreed[1, 5]. Furthermore, only 35% of U.S. adults trusted scientists to accurately inform the public about GMOs[3]. To explain this disparity, I synthesize information about stakeholders in GMOs and GE, demographics linked to acceptance and denial, interpretation of scientific consensus, psychological mechanisms controlling bias, and poor practice of science. Analysis reveals that the disparity in GMO and GE perception between the scientific community and the American public was caused by bad science, foreign political agendas, profit-driven media, and psychological factors, such as intuitive expectations, soft attitudes, and the backfire effect; furthermore, I show that despite innate conduits for bias development, educated, high income, and youthful demographics will shrink the gap between scientific consensus and public opinion if GMO education and equal access to education increase.

The Stakeholders in GMOs and GE

Before running into the maze that is the mechanisms of science denial, identifying the stakeholders in GE and GMOs will provide insight to the environment that has allowed this disparity to form. GE in agriculture has encountered fierce resistance by numerous ideological groups and powerful corporations and governments[6]. In an increasingly globalized economy, evaluating a global summary of major events in GE will serve an appropriate milieu to assess recent American perceptions of GE technology.

Government

The European Commission instituted a mandatory GMO label on food products; many of its members, including France and Germany, banned the growing of GMOs entirely[6]. India has refused to authorize GE rice varieties, leading to a regulatory system that constrains the introduction of new varieties based on transgenic technologies[6] (which incorporate DNA from a foreign agent). These policy obstructions were largely instituted as a result of poor investment choices[6]. While the U.S. invested in genomic technology (e.g. disease resistant crops), Europe heavily invested in improving chemical processing (e.g. development of better pesticides)[6]. To save face politically and protect commercial profits[6], Europe legislated GMOs in a way that had far-reaching effects on American perception of GE. In the U.S., labelling GMOs is the norm[6]. The U.S. encourages companies to use GMO labelling, and is on track to enforce GMO labelling laws as soon as 2020.

Farmers and Agricultural Giants

Farmers are important stakeholders in the growing of GMOs. They have experienced an average increase of 68% in profits as a result of GM crop adoption, while the total production costs are increased by 3%[6]. This result is calculated from increasing yield and decreasing costs, such as cost of pesticides[6]. Harder to estimate benefits have been observed, including lowering yield instability and reducing adverse health effects by noxious pesticides[6]. Contrary to popular arguments involving contractual obligations and agricultural giants, such as Monsanto, farmers are rarely punished for sowing seeds. Punishment is made possible by national patents, which are unlikely to hold overseas, and their local enforcement varies[6]. Realistically, agricultural giants would lose money if they pursued every farmer who sows the wrong seed. Instead, targeting individuals who blatantly violate patents is profitable for the presentation of a deterrent.

Scientists

Researchers are stakeholders with a unique insight to the future of GE. Energized by the recent development of CRISPR gene-editing technology, some experts have drawn attention to the fact that GE is in its infancy. Through the educational-industrial complex[6], GE is expected to advance to a cutting-edge technology in pursuit of profound solutions. New generations may adapt to new technology in ways that are difficult to foresee, as history has proven time and again.

The Gender Gap of GM Food Opinion: Characterizing the Disparity

Understanding how demographics perceive GM foods is useful in strategizing solutions to the disparity. Seventy percent of women view GM foods as unsafe compared to just under half of men[2]. Studying this discrepancy reveals a larger pattern for the disparity between the scientific consensus and public opinion. Elder et al. employed a 2014 Pew Research Center survey on science issues to test several hypotheses regarding the gender gap in attitudes towards GM foods[2]. By isolating several demographics, they uncovered how particular demographics perceive GM foods.

Predictive Demographics of Positive GM Food Attitudes

Education is a significant predictor of concerns about the health effects of GM foods[2]. Greater education had a positive, significant coefficient in all versions of their models, indicating that rising education is linked to falling concern for GM food safety[2]. This finding can be applied broadly to the U.S. population in order to characterize the distinction between the minority that supports GMOs and the majority that is skeptical or anti-GMO. Rising income is associated with falling concern for GM food safety, though this result may be a byproduct of increased scientific confidence among those with high income[2]. Interestingly, the reduced production cost of GM food, combined with the value of the “non-GMO” label, would suggest that lower economic classes are more inclined to purchase GM food; however, this finding implies that falling income is associated with rising concern for GM food safety.

Nonpredictive Demographics

Counterintuitively, church attendance does not predict greater concerns for GM food safety[2], which seems to contradict the observation that anti-GMO advocates argue scientists should not play God. Given growing partisan polarization around science-related issues such as global warming and vaccinations, Elder et al. hypothesized that political variables are significant predictors of GM food safety attitudes; however, neither ideology nor partisanship are significant predictors of these attitudes[2]. This surprising result may be explained by “soft attitudes” described by Ruth et al. Since these malleable attitudes towards GMOs may influence willingness to expose attitudes[5], people may be less likely to share opinions of GMOs based on political beliefs. Women are more liberal and Democratic than men; however, this does not explain the gender gap on GM food safety[2]. This finding is distinct from that of “political variables” because it explicitly names the Democratic party. While the two major U.S. political parties have not adopted strong stances, stances may manifest in the coming years as GE progresses.

Predictive Demographics of Negative GM Food Attitudes

Racial and ethnic minorities have significantly greater concerns about the safety of GM foods than whites[2]. The statistical impact of race is not resistant to the incorporation of scientific knowledge, suggesting that skepticism of non-whites towards GM foods may be rooted in a broader distrust of science[2]. Parenthood is a robust predictor of greater concerns about the safety of GM foods[2]. This finding is explained by parents' concern for healthy meal plans.

Perception of Scientific Consensus and Reaction to Consensus

Understanding how the public interprets scientific consensus is useful in diagnosing the insult that causes disparity. In May of 2016, the National Academies of Sciences, Engineering and Medicine (NASEM) concluded that there is "no substantiated evidence of a difference in risks to human health between currently commercialized [GE] crops and conventionally bred crops" and "no conclusive cause-and-effect evidence of environmental problems from the GE crops"[3]. Even when consensus is appropriately communicated, public opinion surveys reveal that the public sometimes misunderstands scientific consensus or whether consensus exists in the first place[3]. Landrum et al. designed a study to explain this phenomenon.

The Experiment: Relating GMO Purchasing Habits to Reception of Consensus

Prior to the experiment, participants were asked how often they purchase foods with a non-GMO label[3]. In the control condition ($n = 100$), the average score was 2.77 out of 5 (*Median* = 3, or "Sometimes select foods with non-GMO label", $SD = 1.09$)[3]. The group employed five messages to probe how GMO purchasing habits are related to the reception of GMO consensus messaging[3]. Two messages, NASEM and NOBEL (a letter drafted by 100 Nobel laureates), expressed GMO safety compared to conventionally bred crops; two messages, ENSSER (a statement drafted by the European Network of Scientists for Social and Environmental Responsibility) and KRIM (an article by Sheldon Krimsky and Tim Schwab), denied GMO consensus; one control message described the history of baseball[3]. Message language was simplified and aided by graphics to increase the likelihood that participants would read the entire text[3]. Participants answered questions about the messages they read, their GMO opinions, and their perception of what constitutes scientific consensus[3].

The Backfire Effect May Explain Asymmetric Results

Most participants interpreted the messages as intended: 95% of those who saw the NASEM message and 83% who saw the NOBEL message interpreted those messages as meaning GMOs are safe, whereas 77% of those who saw the ENSSER message and 62% of those who saw the KRIM message interpreted those messages as meaning people should withhold judgement[3]. Participants interpreted the two consensus messages as more representative of the scientific community than the two anti-consensus messages[3]. Landrum et al. found that the more frequently participants reported purchasing non-GMO labeled food items, the less consensus messages were interpreted as representative of the scientific community and as being strong arguments. However, frequency of purchasing non-GMO labeled foods did not influence anti-consensus messages like it influenced consensus messages[3]. Therefore, at least in the short term, appeals to experts and presentation of hard facts do not appear to effectively change attitudes about GMOs[3].

The asymmetry between purchasing habits and response to scientific consensus may be explained by Ruth et al., who observed the “backfire effect” in their study[5]. Peer-reviewed studies support that decisions related to GM food have been largely mediated by emotion[5]. The backfire effect occurs when individuals respond to their challenged worldview by becoming more obstinate and vocal[5]. Presence of the backfire effect in Ruth et al.’s study suggests it may have been present in Landrum et al.’s study. If it was present, it could explain the asymmetry between purchasing habits and response to scientific consensus. The backfire effect is an important psychological mechanism in the formation of anti-GMO sentiment.

Millennials and the Future of GMO Acceptance

Other relevant findings in Ruth et al.’s study include the characterization of the millennial demographic. Of respondents with negative GMO attitudes, only 25% were millennials or younger; of the respondents with positive GMO attitudes, nearly 50% were millennials or younger ($n = 1050$)[5]. This finding contradicts previous work by Funk et al., and nonprobability sampling procedures could have limited generalizability[5]. If the results are generalizable to American millennials, then the findings offer an optimistic look at the acceptance of GMOs. By viewing the findings through the lens of Elder et al., they imply that prevalence of scientific knowledge and confidence is rising with falling age (assuming the proportions of other demographics remain relatively constant). The increase in confidence may be at least partially attributable to a reduced incidence of the soft attitudes among youth with earlier exposure to information about GMOs.

Intuitive Expectations Are Conduits for Bias Development

Through understanding how an individual develops bias, strategies to prevent bias development may be employed. Despite the perception of far-reaching control over our thoughts and actions, much of thought and action is dependent on subconscious intuitions[1]. These cognitive predispositions can foster biases that, if not resolved via education, solidify into rigid resistance to counter-intuitive ideas later in life[1]. Anti-GMO groups successfully tap into intuitions in order to foster anti-GMO sentiment[1]. Intuitive expectations of the world facilitate the appeal of GMO misrepresentations. These expectations often evoke disgust by calling upon deep-seeded evolutionary adaptations. For example, a popularized anti-GMO advert depicts a scientist injecting a tomato with a needle.

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Figure 1. A popularized anti-GMO image depicting a scientist injecting a tomato with a needle.

This image, when used in anti-GMO adverts, is designed to discomfort viewers who are unsettled by needles and disgusted by tampering with food. These fears are disproportionately large. People are generally more fearful of spiders than of automobiles despite a much greater incidence of injury and death from automobiles than from spiders[1]. Ancient humans were not fearful of automobiles, but they were fearful of spiders. Likewise, ancient humans were fearful of piercing objects and foreign food, thus the visual representation of these fears facilitates the development of anti-GMO sentiments.

Other variations of this archetype include animals engrafted onto the food (e.g. a fish engrafted onto a tomato) and an animal represented as food (e.g. an orange rind in the form of a frog). These animal-food combinations pair well with anti-GMO propaganda because they synergize with another popularized strategy: P DNA does not belong in Q organism, where P and Q are organisms of distinct and often incongruous species. The uninformed public often thinks “I do not want to eat a tomato that tastes like fish, so I will not eat a GM tomato”. This form of subconscious thought is supported by “folk biology”, which assigns intrinsic properties to life (a useful adaptation for expedient responses to living stimuli). Contrary to the image’s message, the DNA contribution of the fish has no bearing on tomato taste. Visual representations of the anti-GMO argument are simple, powerful tools for efficiently spreading misinformation.

Among experts who argue that intuitive expectations are responsible for the disparity between scientific consensus and public opinion, essentialism, teleological and intentional thinking, and disgust are the three primary conduits that allow GM falsehoods to manifest.

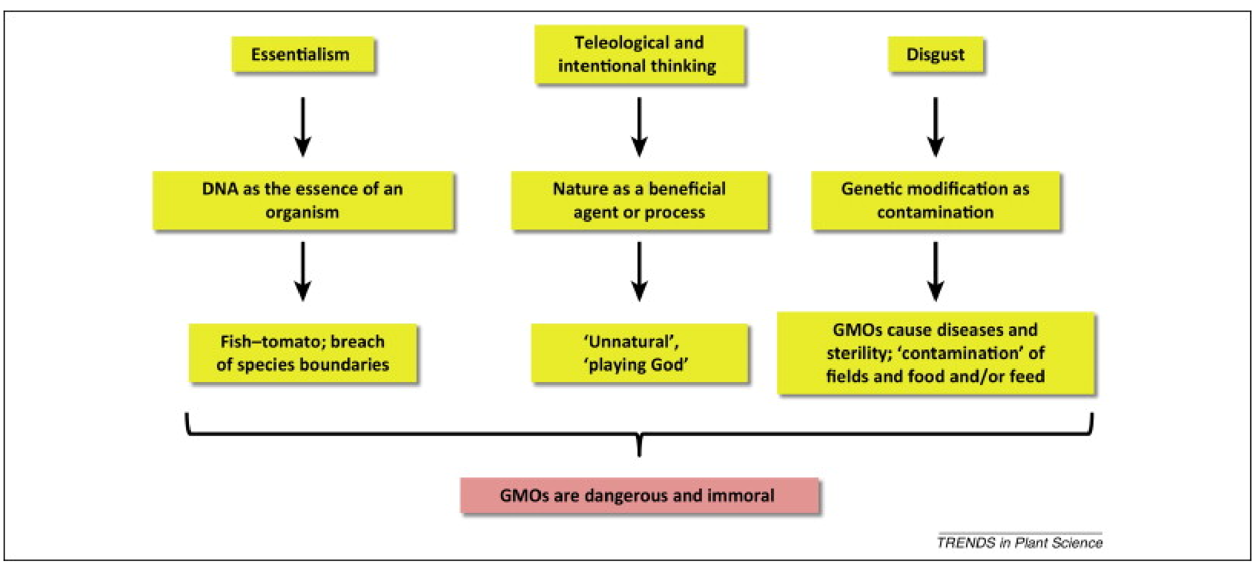

Figure 2. A flow chart depicting how innate mechanisms are manipulated to accept the falsehood that GMOs are dangerous and immoral[1].

These natural conduits obstruct the acceptance of GE and GMOs; however, education can assist in abating the intuitive appeal of negative representations. In effect, this education may include examples like *Bt* corn, which contains less mycotoxins than conventional maize and improves insect biodiversity[1]. Another example is Ranger Russet potatoes, which lack acrylamide, a carcinogen, sometimes present in products of the organic alternative, Russet Burbank potatoes.

Bad Science, Profit Motives, and Political Agendas: The Recipe for Disparity

The Mechanisms of Bad Science

Historically, many examples of bad science have negatively impacted society. Understanding the mechanisms of bad science may help to prevent bad science from further damaging the reputation of GMOs and GE. Studies have established that scientists may be underestimating the number of false-positive results in science due to bias and improper use of statistics[4]. Focusing on the few publications that contradict scientific consensus on GMOs, Panchin et al. proposed how these studies are flawed and unfairly damage public perception.

In statistics, multiple comparisons generate a high risk of bias[4]. The Bonferroni correction is the simplest method for counteracting the multiple comparisons problem[4].

This correction states that if an experimenter is testing *n* hypotheses, he/she tests hypotheses at α level of n^{-1} times what α would be if only one hypothesis was tested[4]. The group probed several highly cited GM food studies for multiple comparisons and recalculated their results with application of the Bonferroni correction[4]. Results were unsupported after the statistical correction[4].

The Cost of Bad Science

A single article claiming a mild difference between GM and non-GM products can incite public debate and cause long-lasting hysteria[4]. Most of the intellectual arguments utilized by anti-GMO advocates are derived from a handful of studies that contain bad science. Though a flagrant article by Seralini was retracted, it continues to be cited by the media[4]. Once bad science gets publicized, robust damage control is unrealistic. Like an unsuccessful product recall, a large portion of the bad science is kept and used by its consumers. Panchin et al. concludes their paper by stating that policy makers, media representatives, and the public should pay less attention to individual articles until their results are confirmed by independent studies supported by statistical evaluation[4]. This caution is sensible to the scientific community, but complex profit motives and political agendas can obstruct adherence to this caution. An impulsive policy change was the European Commission's mandatory GMO labelling of food products, which was largely instituted as a result of poor investment choices that funded GE rival technology[6]. The media was impulsive to publicize Seralini's article because it was presented in a way that targeted intuitive expectations in order to increase readership. The development of bias about GMOs and GE requires intuitive expectations and misinformation to stimulate the expectations. These political and media obstructions are the infectious vector that allows misinformation to spread on a grand scale.

Conclusion

The disparity between scientific consensus and the American public's perception of GMOs and GE manifested as a product of bad science, foreign political agendas, and profit-driven media. Psychologically, intuitive expectations, soft attitudes, and the backfire effect are putative players in the adoption of anti-GMO sentiment. Despite these innate conduits for the development of bias, educated, high income, and youthful demographics have shown the ability to align with the expert community. As equal access to education and education about GMOs and GE increase, new generations are expected to shrink the gap between consensus and public opinion. Complications such as impulsive legislation and media coverage, as was seen in Europe, may arise with changing political variables within the U.S., but given the accelerating advance of GE technology, the importance of GE cements its relevance in the foreseeable future.

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