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Our GMO Labeling Debate: Human Health, the Environment, and the Precautionary Principle

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Human Health, the Environment, and the Precautionary Principle

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A C K N O W L E D G E M E N T S

This research and project has been two years in the making. I was studying abroad in Geneva, Switzerland in a program talking about International Politics and Multilateral Diplomacy through SIT. When we discussed war, we would mention a number of factors that often led to the conflict or affected the standard of living during and after the conflict. Food security was regularly one of the issues on that list. I approached the topic of GMOs for my capstone research that semester by considering how they could be used in developing countries or in times of crisis to address food security. I have to thank Penka Jane for listening to me shape my ideas and questions at the very beginning of this project. Our conversations over coffee at the UN library helped me rein in my ideas and made the foundation of my research possible. I also want to thank my family and friends who have served as a sounding board for my ideas over the past two years. Their patience and guidance has been invaluable For this I am most sincerely grateful.

I also want to thank my thesis committee who helped guide me through my research over the past year. As I entered my senior year, my research questions were innumerable and unwieldy. From the very beginning, you helped me corral my ideas and crystalize my thought process into a workable project. To Sharon Crary and Angela Castañeda, thank you for helping me as I ventured into somewhat new and unfamiliar fields. You made it possible to ground my research in disciplines where I lacked experience.

A very special thanks to my thesis supervisor. Jen Everett, I have absolutely loved working with you. Thank you for pushing me, for always adding another question for me to consider. Those questions helped me deconstruct many of my assumptions and are what have made this project so much more of a learning opportunity for me. Thanks for having the patience throughout much of this fall and winter as I struggled to define my project and tame it into a manageable entity. I so appreciated our meetings every Monday and Friday. You have helped me grow and made this process so much less daunting. I thank you from the bottom of my heart for your labor of love.

INTRODUCTION

A Debate 20 Years in the Making

Genetically modified foods first began entering the market just 20 years ago in 1996. [1] Since then, there has been a maelstrom of debate over the potential risks that GMOs pose to humans and the environment. This public discourse has driven much of the research on GMOs, attempting to establish the safety of new transgenic plants. It was a small flap of butterfly wings that rippled outward, generating momentum towards our modern debate over the safety of GMOs.

In 1999, a lab study conducted at Cornell University found "that pollen from genetically modified Bt corn could kill the larvae of monarch butterflies." [2] This case rapidly gained attention in the media. The day the results were published, Greenpeace International "demanded that authorities in the United States, Argentina, Canada, and the European Union take immediate action and prohibit the growing of genetically engineered maize crops." [3] Greenpeace's media campaign only escalated with public protests and lobbying which continued throughout the rest of 1999. [4] In the next two years, a research team made up of scientists in the Midwest came together with the US Department of Agriculture and the National Center for Food and Agricultural Policy to research the effect that Bt corn has on butterflies in the field. They found

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[1] José L. Domingo, and Jordi Giné Bordonaba. "A Literature Review on the Safety Assessment of Genetically Modified Plants." *Environment International* 37, no. 4 (February 5, 2011): 734-42. p735

[2] Henk van den Belt. "Debating the Precautionary Principle: "Guilty until Proven Innocent" or "Innocent until Proven Guilty"?" *Plant Physiology* 132, no. 3 (July 01, 2003): 1122-126. p1122

[3] Ibid, p1122

[4] Ibid, p1122

that “Bt corn pollen poses little risk to monarchs on a national scale.” [5] Similar results were found in Europe “with a calculated mortality rate of less than one individual in every 1,572 for the butterflies and one in 392 for the moth in the worst case scenarios.” [6] Ultimately, GMOs were not found to negatively impact butterfly populations. However, this has not stopped the public discourse regarding the safety of GMOs.

Today, much of the GMO debate in the United States is centered around the issue of mandatory national labeling. The most recent federal attempts to pass labeling legislation have failed with HR 1599: Safe and Accurate Food Labeling Act of 2015. This act is popularly known as the Deny Americans the Right-to-Know or the D.A.R.K. Act. With the defeat of the DARK Act, state legislation has risen to the forefront of the labeling debate. Vermont passed legislation in 2014 that requires all food products sold in the state to be labeled if they contain GMOs. This legislation will take effect in July of 2016. Based on the marketing and labeling costs, “food companies can't create different packaging just for Vermont, [so] it appears that the tiniest of states has created a labeling standard that will go into effect nationwide.” [7]

Who’s Who

The debate over legislation is largely motivated by the opinions of the public sector. In the battle over genetically modified organisms (GMOs), there are two major parties in the

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[5] EE Ortman, Barry BD, Buschman LL, Calvin DW, Carpenter J, Dively GP, Foster JE, Fuller BW, Helmich RL, Higgins RA et al. “Transgenic Insecticidal Corn: The Agronomic and Ecological Rationale for its Use. *BioScience* 51, no. 11 (2001): 900–903. p900

[6] Janet E. Carpenter, "Impact of GM Crops on Biodiversity." *GM Crops and Food* 2, no. 1 (February 02, 2011): 7-23. p7

[7] Dan Charles, and Allison Aubrey. "How Little Vermont Got Big Food Companies To Label GMOs." *NPR*. March 27, 2016.

debate. In one corner are those opposed to the use of GMOs and across the boxing ring are the groups who support GMO research and utilization. The two camps are vehemently opposed to one another, often falling into ad hominem attacks that oversimplify the views of the opponent.

At a March Against Monsanto in Chicago last year, a counter protester described the various types of people leading the march. Julie Kelly described the march as an eclectic group of protesters and counter protesters. Those opposed to Monsanto included “aging hippies, ragtag Millennials wearing gas masks, and granola-ish mommies with children dressed in bee costumes.” [8] These individuals are all in some way counter cultural. They are protesting for different reasons yet united by their common concern over the issue of GMOs. Representing the opposition was what Kelly described as “a small but valiant group of folks” which included “scientists, farmers, writers and moms like me who believed they might have a chance to inform the misinformed and reason with the unreasonable.” [9] Overall, Kelly was derisive of the anti-GMO protesters. She unequivocally dismissed the fears and concerns of those opposed to GMOs. In this blog post, Kelly begins to construct the very stereotypes that I have found most interesting as I delve into my research regarding GMOs.

I have identified six main archetypes that can characterize the primary arguments for and against GMOs. These are all overwrought caricatures, depicted in the tone of derision promoted by individuals like Kelly. Those opposed to GMOs include the overly invested worry-wart

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[8] Julie Kelly. "Pro-GMO Marchers Shocked at Unfocused Anger of March Against Monsanto Protesters." Genetic Literacy Project. June 1, 2015. https://www.geneticliteracyproject.org/2015/06/01/pro-gmo-marchers-shocked-at-unfocused-anger-of-march-against-monsanto-protestors/.

[9] Ibid

helicopter moms, aging hippie environmental nuts on a crusade to save the planet, or young progressives from expensive universities raised to question the establishment and Monsanto. The group of individuals that are supportive of GMOs includes such caricatures as the scientific naysayers, the idealistic humanitarians with their heads buried in the sand, or the greedy capitalist executives at Monsanto. Both of these camps are only becoming increasingly polarized.

The first demographic that I listed in opposition to GMOs was the “wary mother,” highly concerned about GMOs in the foods she feeds her children. This character is focused on the potential health risks of potential health risks of GMOs. Mothers fear the impact that GMOs could have on the health of their children. Do genetically modified (GM) foods fundamentally alter our DNA? Does the widespread use of GMOs in processed foods pose a threat to future generations? Are there chances that “unnatural” GMOs can make us sick? Is there really enough testing on the long term health effects to make sure that these foods are safe to eat? Ultimately, these questions are the prime motivation behind the “right to know” argument. Consumers want to know the potential health implications of the foods they eat. This “right to know” will be more deeply discussed in the following chapter regarding the prevalence of GM species in the modern American diet.

The “new age hippies” that protested the intensive farming practices of the green revolution have adapted to the times to critique the effects of the gene revolution. These individuals are overly concerned with the effects GMOs can have on our biosphere. Do GMOs overpower “natural” varieties? Is cross pollination putting us at risk of superweeds and monocultures? Are we overtaxing our soil with intensive farming methods and unnecessary chemical additives? These concerns are representative of the argument that GMOs may have an adverse environmental effect. This group requests labeling so that they can decide whether their food is grown in a sustainable fashion.

The "young, over-educated, outspoken, anti-capitalists" rage against the corporate ethics of companies like Monsanto. The do not want to support companies that they find morally reprehensible. Does Monsanto destroy the business of the small farmer? Does big agribusiness provide adequate working conditions for their laborers? Do rich companies, armed with the patents of genetic engineers, hold food starved countries in a choke hold with no access to reliable food sources? This demographic is highly socially conscious and fights for labeling that will allow them to boycott products which are created by companies with business ethics they don't support.

Collectively, the "wary mothers," "new age hippies," and "anti-capitalists" are all concerned about the nature of the research that has been conducted on GMOs. They wonder whether the existing research touting the safety of GMOs is funded by companies like Monsanto. They wonder if scientists are really really in touch with the day-to-day concerns of consumers. There is a deep seated lack of faith in those who support the use of GMOs, as represented by the remaining three stereotypes.

The "scientific naysayers" are individuals steeped in the data who place their faith in the evidentiary support for GMOs. Are those opposed to GMOs just like global warming deniers with no regard for real data? Are worried moms fabricating issues like they did with vaccines and autism? Do those opposed to new farming practices have any idea that these genetically engineered plants are the perfect response to deforestation and rising world populations that are needing more food? These arguments are based in a body of data that relies on quantifiable facts and an ever growing body of research regarding the effects of GMOs. However, scientists are not the voices most commonly heard in the public debate over the ethics of GMOs.

The "myopic humanitarians" are the idealists who want to promote the positive applications of GMOs. How could high yield varieties alleviate food shortages in countries lacking food security? Are nutrient enhanced species of GMOs a useful tool in combating childhood malnutrition? Which countries could be most positively impacted by the application of new farming methods that take advantage of GMO technology? Though they are not particularly vocal in the labeling debate, they are valuable representations of some of the voices that support continued research and use of GMOs.

The "greedy capitalists" include the companies that design GMOs and come under an immense amount of fire from the anti-GMO community. They are the entities that have the strongest bargaining power in this debate and are quick to defend against the GMO critics. Are small farmers simply stealing our seeds, cheating us out of the intellectual property that our scientists worked so hard to design? What is the problem with making a profit if that is what American capitalism is based on? Why are we villainized for designing seeds that ultimately create higher yield to support the growing world population? Why must we bear the brunt of the cost should labeling legislation be imposed? The companies that design GMOs have an immense amount of financial investment in this issue and are the loudest voice supporting continued GMO research and utilization. They are opposed to labeling on account of the increased costs it would impose and the fear mongering that occurs throughout the debate.

A Rhetorical Lens

The public rhetoric and the individual motivations are really what provide the momentum for the debate over GMOs. Kelly's comments characterizing those with different views from herself are emblematic of the deep ideological divides dictating the debate over GMOs. Rather than discussing the validity of any arguments for or against the labeling of genetically modified foods, often consumers are engaged in ad hominem attacks regarding the other camp. Instead of being about the issues, this debate has become about the positions. The nature of the debate over GMOs is highly Manichean at present. Neither side is willing to listen to the other or see the validity of opposing arguments. Instead, the debate over GMOs is large us versus them, good versus bad, cautionary versus foolhardy.

I am fascinated with the polarization surrounding this debate and the rigid sense of certainty that each party holds. The archetypes described above provide the passion that perpetuates this conflict. Said passion motivates individuals to take action and push for greater research. I want to approach this project by investigating the public rhetoric in the debate over labeling products that contain GMOs. Kelly's comments characterizing those with different views from herself are emblematic of the deep ideological divides dictating the debate over GMOs. Rather than discussing the validity of any arguments for or against the labeling of genetically modified foods, often consumers are engaged in ad hominem attacks regarding the other camp. Instead of being about the issues, this debate has become about the positions. The nature of the debate over GMOs is highly Manichean at present. Neither side is willing to listen to the other or see the validity of opposing arguments. Instead, the debate over GMOs is largely us versus them, good versus bad, cautionary versus foolhardy.

This highly polarized debate over GMO legislation is what truly provides the inspiration for this body of research. The caricatures described above are only effective because they represent such vocal parties within the debate over GMOs. Their passion is reflected in the countless blog posts and journalistic articles on this issue. The vocal archetypes are useful because they guide much of the populist rhetoric regarding GMOs. Certainly there is a scientific debate as well that grounds the broader discussion of GMOs and their effects. However, the archetypes listed above are what drive the public discourse and therefore what will drive this research.

The coming chapters will break down the validity of existing arguments for and against the labeling of GMOs. I will begin with a chapter on the regulation and legislation of GMOs. This provides helpful contextualizing information on where American citizens, the United States government, and international governing bodies stand on the issue of GMOs. Legislation of labeling is the most recent focus of the GMO debate here in America so this chapter will be important for mapping out the most recent developments in the GMO debate.

This research will address the scientific support for some of the most vocal archetypes in the GMO debate: the "over anxious mothers" and the "new age hippies." The health effects range from the potential genetic effects of GMOs in the bloodstream to evidence of certain illnesses brought about by consumption of GM foods. The research on the health effects of

GMOs can bolster the claims of both the “over anxious mothers” opposed to GMOs and the “dispassionate scientists” who see no scientific evidence that GMOs adversely affect humans. The environmental chapter also incorporates a number of conflicting viewpoints on the risks of high yield intensification, excessive chemical usage, and genetic drift decreasing biodiversity. In this chapter, the “dispassionate scientists” are pitted against the “new age hippies” though different pieces of scientific proof support the arguments of each camp.

The bombastic state of this debate between GMO supporters and opposition has left left my own views in muddled disarray. I intend to clarify my own mind as to whether the concerns regarding GMOs merit comprehensive national labeling legislation. Though this research will not address all of the archetypes and parties of the debate that I described above, I want to take advantage of the scientific resources available to better understand the positions of the “overbearing mothers” and the “modern day hippies.” Are some of the fears of GMOs scientifically grounded? Has science proven the safety of the foods we eat? Is there sufficient risk to necessitate mandatory labeling. In light of these questions, I will analyze the implications of Vermont’s labeling legislation and the weight of the scientific evidence to better understand some of the the primary rhetorical tropes of the GMO debate.

L E G I S L A T I O N

What am I Eating?

In the pursuit of full disclosure, legislative attempts to regulate GMOs are focused on the labeling of GMOs. Listing the potentially modified ingredients on packaging is the most direct way for companies to disseminate information regarding the potential presence of GMOs in their products. Given the prevalence of genetically modified foodstuffs in the market though, it is difficult to calculate the potential cost of comprehensive GMO labeling. There are currently 18 different USDA approved genetically modified crops, though only 10 are grown in the United States and only 9 are food products (See Appendix 1). The 9 eight different genetically modified foods grown and available in the U.S. are corn, soybean, potato, papaya, squash, canola, alfalfa, apple, and sugar beet though this does not include the GM products available in the US but produced elsewhere. [10] The two largest domestically produced and consumed genetically modified crops are corn and soybean which can be found in processed foods throughout the market. [11] The fact that “more than 90% of all soybean, cotton, and corn acreage in the US is used to grow genetically engineered crops” shows the way that GMOs dominate American agriculture. [12] While cotton does not work its way into food, products derived from genetically modified soybean and corn are commonly incorporated into processed foods.

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[10] David Johnson, and Siobhan O'Connor. "These Charts Show Every Genetically Modified Food People Already Eat in the U.S." *Time*. April 30, 2015. http://time.com/3840073/gmo-food-charts/.

[11] United States Department of Agriculture (USDA). June 2002 Acreage Report. Washington, D.C.: National Agricultural Statistical Service, 2002.

[12] Johnson and O’Connor, 2015

Corn is ubiquitous in processed foods, making it a significant part of American diets. Corn can be directly consumed, added into processed foods as starch or sweetener, or fed to the livestock that we eat. It can be found in crackers, juices, sodas, breads, sweetened snacks, and ever so much more. [13] Because corn is so heavily utilized in the American diet, its effects can be found in our bodies whether it be from the weight gained through the consumption of high fructose corn syrup infused products or the biochemical presence in our very hair follicles. [14]

In light of the pervasive presence of corn in American diets, it is important to note the proportion of corn grown in the US that is genetically engineered. Time reported back in 2015 that "more than 90% of all soybean, cotton, and corn acreage in the US is used to grow genetically engineered crops." [15] As of a USDA study published in 2014, "HT corn accounted for 85 percent of corn acreage in 2013" and Bt corn "was planted on 76 percent of corn acres in 2013." [16] The USDA describes herbicide tolerant (HT) crops as those which "have traits that allow them to tolerate more effective herbicides, such as glyphosate, allowing adopters control pervasive weeds more effectively." [17] Corn is just one of many HT modified plants. To address

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[13] Woolf, Aaron. *King corn*. [New York, NY]: Mosaic Films 2007.

[14] Ibid

[15] Johnson and O'Connor, 2015

[16] Jorge Fernandez-Cornejo, Seth Wechsler, Mike Livingston, Lorraine Mitchell, "Genetically Engineered Crops in the United States" *USDA Economic Research Report Number 162,* (February 1, 2014): p1-60. p6

[17] Ibid p7

specific threats that affect corn crops, engineers have designed Bt corn which "controls the European corn borer, the corn rootworm, and the corn earworm." [18]

Genetically modified corn is the primary means of remaining competitive in current corn production. Michael Pollan of the University of California Berkeley Graduate School of Journalism has a succinct way of articulating the ultimate goal of the genetic modification of corn over the last 50 years. In King Corn, he says to Cheney and Ellis that "what you are growing is an industrialized corn. It has been changed over the last 20, 30, 40, 50 years with one goal in mind, which is yield." [19] In order to remain competitive and financially viable in the booming corn market, all growers must focus on quantity. This edges out smaller farmers so that the largest producers dominate the market through the utilization of genetically engineered corn.

Due to the ubiquity of corn and soybean derivatives, it remains difficult to calculate the actual amount of commodities in American food markets that contain GMOs. Largely thanks to the large market application of corn and soybeans, it's estimated that "70-80% of the foods we eat in the United States, both at home and away from home, contain ingredients that have been genetically modified." [20] The ubiquity of GMOs means labeling would be difficult to label the wide array of products that contain genetically modified components. Consequently, some companies have found it more economically convenient to remove all genetically modified foods from their products. This includes recognizable brands like Annie's, Ben and Jerry's, Blue

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[18] Ibid p6

[19] Woolf, 2007

[20] "Grocery Manufacturers Association Position on GMOs." *GMA*. September 23, 2013. http://www.gmaonline.org/news-events/newsroom/.

Diamond, Chipotle, Glutino, Snyders of Hanover, Stash Tea, The Republic of Tea. [21] [22] [23] It eliminates the necessity of labeling those foods that do or do not have genetically modified ingredients. Additionally, the removal of GMOs can become a marketable trait for companies. However, for companies unwilling to make a blanket ban on all GMO foods, mandatory labeling could have a profoundly negative impact on advertising and product sales.

Allaying Consumer Fears

The ultimate necessity of labeling is still a matter of debate. The primary articulation of consumer demands can be described as the "right to know" argument. At its origin, the right to know is a demand for corporate transparency. The appeal for transparency may be motivated by any number of reasons: concerns about human health impacts, environmental effects, or the business practices of companies that use genetically modified foods. The first collection of concerns falls under the broad category of potential health risks which could include such issues as genetic transfer, traceability, or the impact that GM foods could have on human RNA. The second group of concerns encompass the potentially adverse environmental impact of using GMOs due to risks from cross pollination and the potential risk of eventual monocultures within formerly diverse species.

Transparency via clear labeling will allow consumers to make their own decisions about consumption based on their personal convictions or motivations. In spite of diverse motivations

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[21] Agorist, Matt. "400 Companies That DO NOT Use GMOs in Their Products." *The Free Thought Project*. November 01, 2013.

[22] "G-M-Over It." *Chipotle*. 2016. http://chipotle.com/GMO.

[23] "Our Non-GMO Standards." *Ben & Jerry's*. 2016. http://www.benjerry.com/values/issues-we-care-about/support-gmo-labeling/our-non-gmo-standards.

for requesting labeling, the blanket statement that consumers use to incorporate all these arguments is that they have a “right to know.” The “right to know” argument was very impactful in the debate over labeling legislation in Oregon. Deana Grobe and Carolyn Raab conducted a study of Oregon voters following the failure of Measure 27 which was intended to enforce the labeling of genetically modified goods in Oregon. Their study found that individuals who voted for the measure most commonly cited the “right to know” as their primary reason for support. [24] Many voters also mentioned such concerns as personal health and business practices but the emphasis on “right to know” is telling. This shows that regardless of the motivation or the potential impact on purchasing patterns, that voters still felt they had a fundamental right to know the contents of the food they were consuming. The right to particular labels is not unprecedented. Similar federal legislation “already requires labeling that lets consumers know whether foods have been previously frozen, made from concentrate, pasteurized, or irradiated.” [25] If consumers have a right to know regarding these issues, then it is not without reason that consumers have a right to know whether food products contain genetically modified products.

Consumers continue to question whether genetically modified foods are “safe” which ultimately boils down to the question of whether or not they are biologically harmful to humans when eaten. In a direct response to the question “Are foods from GE plants safe to eat?” the FDA posts the succinct response “Yes. Credible evidence has demonstrated that foods from the

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[24] Deana Grobe, and Carolyn Raab. "Voters’ Response to Labeling Genetically Engineered Foods: Oregon's Experience." *Journal of Consumer Affairs* 38, no. 2 (2004): 320-31. p327

[25] Andrea Rock. "GMOS in Food - Consumer Reports." *Consumer Reports*. October 2014. http://www.consumerreports.org/cro/2014/10/where-gmos-hide-in-your-food/index.htm.

GE plant varieties marketed to date are as safe as comparable, non-GE foods." [26] This simplistic affirmation does not begin to address many of the fears consumers have regarding GMOs. For one, the FDA does not mention or describe any specific studies, facts, or statistics that address the issues of genetic transfer, long term effects, or nutrition. Rather, such a terse response feels insufficient, as though the limited response is some form of obfuscation. The other links and descriptions on the FDA page stress that products have to undergo significant testing prior to FDA approval and that there are regulations in place for all new agricultural products. Though the level of specificity regarding regulation is heartening, the actual affirmations of GMO safety and nutrition are vague, relativistic, and feel nonspecific.

The limited information provided by the FDA is not representative of the information available regarding GMOs as thousands of studies of GMOs have been conducted over the past couple decades. A list of these scientific articles and their sources has been compiled by an Italian research team and organized according to topic: environmental effects, gene flow, GMO interaction with humans and animals, GMO assessment, GMO food and feed consumption, and traceability. [27] With this preponderance of research, "the U.S. Food and Drug Administration has concluded that bioengineered foods are as safe as their conventional counterparts." [28] According to the FDA, "foods from GE plants must meet the same food safety requirements as foods

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[26] U.S. Food and Drug Administration. "Consumer Info About Food from Genetically Engineered Plants." October 19, 2015. http://www.fda.gov/Food/FoodScienceResearch/GEPlants/ucm461805.htm.

[27] Alessandro Nicolia, Alberto Manzo, Fabio Veronesi, and Daniele Rosellini. "An Overview of the Last 10 Years of Genetically Engineered Crop Safety Research." *Critical Reviews in Biotechnology* 34, no. 1 (2014): 77-88.

[28] Grobe and Raab, 2004, p320

derived from traditionally bred plants." [29] This makes a very clear statement about how the FDA has chosen to respond to GMOs. Under this policy, genetically altered foods are seen as fundamentally equitable to non GM food products, tested for the same markers of safety or risk. This shows that the FDA does not believe that genetically altered plants are categorically different from non GM varieties.

To Each His Own, The States Decide

Legislative responses to the labeling debate have thus far, only been effective at the state level. Even that success has been incredibly limited. At the time of writing, the only states that have passed legislation regulating the labeling of GMOs are Vermont, Maine, and Connecticut. Thus far, 31 other states have attempted some legislation. For some, legislation was introduced in the House but quickly defeated. Other states halted progress in the Senate. For several states, legislation was sent to committees where it lost momentum and was ultimately left unaddressed. In total, 16 states have yet to attempt some form of legislation.

The first state to have successful GMO legislation put in place was Connecticut. The law, Public Act No. 13-183 or An Act Concerning Genetically Engineered Food, was signed into effect on June 25th, 2013. The act was alternately known as Substitute House Bill No. 6527. The first bill of its kind, Public Act No. 13-183 very clearly laid out the terminology that was necessary to codify this type of legislation. The terms defined in the context of this act include several of the terms previously described in this research: food, label and labeling, natural food, raw agricultural commodity, genetic engineering, and processed food. The high level of

[29] FDA, 2015

specificity within this law is notable because of the novelty of GMO legislation. This bill is the first model on which future legislation will be based. In order to give the legal rationale for GMO labeling, extensive background articulation of terms and concepts is imperative.

The Connecticut legislation is well articulated and lays out the necessary steps for the enforcement of this law, though it has not yet gone into effect. The law states that it will not be enforced until,

> the Commissioner of Consumer Protection recognizes the occurrence of both of the following: (1) Four states, not including this state, enact a mandatory labeling law for genetically engineered foods that is consistent with the provisions of this subsection, provided one such state borders Connecticut; and (2) the aggregate population of such states located in the northeast region of the United States that have enacted a mandatory labeling law for genetically-engineered foods that is consistent with this subsection exceed twenty million based on 2010 census figures. [30]

This introductory paragraph describes the two roadblocks facing this piece of legislation, the legislative endorsement of four other states from the north-east, and the minimum population requirements. Thus far, only one other state has legislation for the labeling of GMOs, Maine. [31] The same enforcement limitations are in place for both states so this means that neither Connecticut nor Maine currently require food providers to display GMO contents.

The delayed enforcement of legislation for GMO labels makes an interesting statement about the effectiveness of regulating GMOs through this form of legislation. Some consumers

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[30] Connecticut House of Representatives. *Substitute House Bill 6527, Public Act No. 13-183, An Act Concerning Genetically Engineered Food.* June 25, 2013. p9

[31] Maine House of Representatives. *An Act To Protect Maine Food Consumers' Right To Know about Genetically Engineered Food and Seed Stock*. 126th Maine Legislature, 2014.

are profoundly concerned that implementation thresholds are a means to further delay legislation in a way that will delay product transparency and have an adverse impact on individual and environmental health. [32] However, legislators offer concerns about what rapid application of GMO labeling legislation would do to food producers and distributors within states. There is the chance that immediate implementation of mandatory GMO labeling “would cause food companies to stop shipping their products to Maine because of the cost of labeling them differently for one small state market.” [33] Maine specifically has as much as 90% of their food imported and therefore is illustrative of the risk potential for adverse market effects with legislation implementation. [34] Other smaller states in the north-east and New England area would likely experience similar difficulties.

Vermont has enacted key legislation with national effects that is proving some of the concerns above to be unfounded. In 2014, the Vermont House and Senate passed H112: An act relating to the labeling of food produced with genetic engineering. The law clearly states that “food offered for sale by a retailer after July 1, 2016 shall be labeled as produced entirely or in part from genetic engineering if it is a product: (1) offered for retail sale in Vermont; and (2) entirely or partially produced with genetic engineering.” [35] The Vermont legislation is remarkable when compared to the Connecticut and Maine legislation in that it does not impose

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[32] Byrne, Matt. "Genetically Modified Foods Need Labels Now, Maine Lawmakers Told." *Portland Press Herald*, April 30, 2015.

[33] Ibid

[34] Ibid

[35] Vermont House of Representatives. *H112: An act relating to the labeling of food produced with genetic engineering.* Vermont General Assembly, 2014. p10

the same delayed implementation caveats but would instead immediately go into effect. Due to the failure of national legislation with the DARK Act in March of 2016, Vermont H112 has made Vermont the first state to enact mandatory GMO labeling.

Corporate responses to the institution of Vermont's legislation has been grudging at best. Major companies like Campbell Soup Co., Kellogg, Mars, ConAgra, and General Mills have all stated that they will roll out GMO labels on all of their products nationally. [36] Though the Vermont law only dictates labeling requirements within the state, the companies have chosen to enact national labeling campaigns. An Executive Vice President and the COO of General Mills, Jeffrey Harmening said that "we can't label our products for only one state without significantly driving up costs for our consumers and we simply will not do that," and consequently "consumers all over the U.S. will soon begin seeing words legislated by the state of Vermont on the labels of many of their favorite General Mills products." [37] Inadvertently, one of the smallest states in the country has pushed GMO labeling for the entire nation.

Labeling a Nation

Congress has made several attempts at passing national GMO labeling legislation though the most recent push at the time of writing occurred in the summer of 2015. The act H.R.1599 Safe and Accurate Food Labeling Act of 2015 was passed in the House July 23, 2015 and was sent to the Senate where it was "referred to the Committee on Agriculture, Nutrition, and

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[36] Rathke, Lisa. "Vermont to Target "willful Violations" of GMO Labeling Law." *Concord Monitor*, April 10, 2016.

[37] Charles and Aubrey, 2016

Forestry." [38] This law was not nearly as detailed as the Connecticut legislation passed in 2013. The proposed bill gave a specific legal definition for GMOs versus "natural" foods, discussed the specifics of labeling non-GMOs, and then left the actual enforcement of the proposed law in the realm of vague non-specifics. The bill proposed that the Secretary may require labeling if,

> (A) there is a material difference in the functional, nutritional, or compositional characteristics, allergenicity, or other attributes between the food so produced and its comparable food; and (B) the disclosure of such material difference is necessary to protect public health and safety or to prevent the label or labeling of the food so produced from being false or misleading in any particular. [39]

This statement sounds familiar to the earlier FDA regulations on GMOs. If the food is deemed to have different qualities than their natural counterparts, then additional labeling or regulation is necessary. However, it is unclear within the law what constitutes a sufficient difference to warrant legislative interest.

The proposed bill also stressed the importance of product regulation. The drafted legislation stated that "it shall be unlawful to sell or offer for sale in interstate commerce a nonregulated genetically engineered plant for use or application in food." [40] This definition extends to any "food produced from, containing, or consisting of a nonregulated genetically engineered plant." [41] This, admittedly convoluted, description of the regulatory requirements is what provides a level of protection for consumers. Not only are raw agricultural products

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[38] U.S. Congress. House of Representatives. *Committee on Energy and Commerce. H.R.1599 Safe and Accurate Food Labeling Act of 2015.* 114th Cong., 1st sess., 2015. H. Rep. 114-208.

[39] Ibid

[40] Ibid

[41] Ibid

required to be regulated, but also all processed foods derived from genetically engineered species. The final important aspect of this selected text is that these regulations would cross state boundaries. This means that companies would have to maintain uniform regulations across the country, in spite of different states that may not require any GMO regulation. It would be a way of ensuring minimum levels of testing and regulation and validating the Vermont legislation that has already made significant strides towards a national GMO labeling.

International Regulations

The European Commission takes a much more precautionary approach to GMO labeling. In the European Union, labeling of GMO products is necessary for foods intended both for human consumption and animal feed. [42] All steps of the food production process fall under the dictates of mandatory labeling. Each country within the EU is free to add additional GMO regulations to suit their domestic needs. The European Commission is aware of the fact that different geographical demands or environmental concerns may dictate the heightened control of genetically modified substances in certain countries. Therefore, additional GMO regulation is left to the discretion of independent states under the auspices of the European Commission. [43] Historically, it has been individual European countries pushing for a precautionary approach that have motivated regulation for the rest of the continent considering the fact that, "the first

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[42] Council of the European Union. "Council Conclusions on Genetically Modified Organisms (GMOs): 2912th Environment Council meeting." *EFSA* (2008): 1-5.

[43] Ibid

biosafety laws were adopted in Denmark in 1986 and Germany in 1990, [while] EU biosafety regulations followed in 1990." [44]

Formal international organizations (FIOs) have a unique power to regulate the trade of GMOs without the limitations of national legislation. If international politics can enforce labeling of GMOs, then there is a very limited need for independent national legislation. This would render state legislation unnecessary here in America. Thorpe and Robinson articulate the effectiveness of FIOs to work outside the limitations of national government by "developing international norms and guidelines that may in turn impinge upon the behavior of a nation state." [45] Under this rationale, FIOs like the WTO have a level of autonomy that can be far more effective on an international scope than the legislation or regulation of independent nations.

Under the auspices of the WTO, discussions regarding GMOs take place in forums like the Committees for Technical Barriers to Trade (TBT) and Sanitary and Phytosanitary Measures (SPS), the Committee on Agriculture, the Working Group on Trade and Transfer of Technology, the Committee on Trade and Environment (CTE), the Committee on Trade and Development (CTD), or the Dispute Settlement Mechanism (DSM). [46] These committees all serve different

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[44] Harmut Meyer. "Systemic Risks of Genetically Modified Crops: The Need for New Approaches to Risk Assessment." *Environmental Sciences Europe* 23, no. 1 (2011): 1-11. p3

[45] Andy Thorpe, and Catherine Robinson. "When Goliaths Clash: US and EU Differences over the Labeling of Food Products Derived from Genetically Modified Organisms." *Agriculture and Human Values* 21, no. 4 (April 15, 2003): 287-98. p288

[46] Atul Kaushik. "The Emerging Global Biotech Trade Regime: A Developing Country Perspective." In *Trading in Genes: Development Perspectives on Biotechnology Trade and Sustainability*, edited by Ricardo Meléndez-Ortiz and Vicente Sánchez. Sterling, Virginia: Earthscan, 2005. p246-249

purposes and fulfill vital roles yet none directly addresses the regulation of GMOs in international trade or labeling. The WTO and its related committees have failed to create meaningful agreements that will actually lead to a significant change in the regulation of GMO trade or an appropriate committee to address these issues in a comprehensive fashion because they lack the consensus and means of enforcement necessary to impose lasting change in GMO regulation. Instead, individual state responses are far more effective because they have the means of instituting and enforcing such regulations.

Where Americans Stand

Voter support for GMO labeling legislation is currently concentrated in certain demographics. In Oregon, Ballot Measure 27 sought to gauge voter support for GMO labeling. [47] In an analysis of Oregon voters, Grobe and Raab found that "52% of those in favor [of imposed GMO labels] had incomes below $40,000… and 43% of those in favor were more likely to live in urban areas." [48] It is not the upper-middle class suburbanites who have the highest support for GMO labeling, but rather lower income urban dwellers. Based on these results, GMO labeling would be most impactful for those with limited means and a concern about purchasing food with full disclosure of GMO contents in foods.

On a national scale, the Pew Research Center has made a survey of Americans and their opinions of GMOs. They found that women are more likely to think GMOs are unsafe than men,

[47] Grobe and Raab, 2004, p320

[48] Ibid 325

and blacks and hispanics are more than whites (See Appendix 2). [49] The level of education showed the general trend that the more education a person had obtained the more likely they were to believe GMOs are generally safe. [50] The more scientific knowledge one claimed to possess, the more likely one was to think that GMOs are generally safe. [51] Though these are limited results, they do speak to the general trends of American consumers. The results of this survey may break down some of the stereotypes regarding the demographics of those particularly concerned about GMOs. This polling information paints a picture that represents the archetypes that will guide this research.

[49] Cary Funk, and Lee Rainie. "Chapter 6: Public Opinion About Food." *Pew Research Center*. July 01, 2015. http://www.pewinternet.org/2015/07/01/chapter-6-public-opinion-about-food/.

[50] Ibid

[51] Ibid

POTENTIAL HEALTH EFFECTS

One of the prime sources of concerns regarding GMOs is the potential health effects. The primary character illustrating this aspect of the GMO debate is the “over-anxious mother” who fears for the effect that GMOs could have on the health of her children. Some argue that consuming GMOs could allow genetic material into the human body that would fundamentally alter the human genome. Additionally, there are a number of studies that have been done on mammals which show a correlation between certain ailments and the consumption of genetically modified foods. Granted, this evidence does not prove direct causation but there is a sector of the scientific community that has voiced significant concerns regarding the safety of GMOs.

The “dispassionate scientists” described in the introduction would rebut the fears of the “anxious mothers” by pointing out that all GMOs in the market are heavily tested for “substantial equivalence” with their non-genetically modified counterparts. Based on the current body of evidence, “dispassionate scientists” would argue that there is not presently any means for genetically modified DNA to enter the human genome, nor is there proof that GMOs directly cause adverse health effects in humans.

The validity of the aforementioned research based on correlative data and the ambiguity of scientific jargon surrounding GMO safety are the two main arguments that I intend to investigate in this chapter. Are GMOs truly holding invasive and pervasive genetic material that will hijack our DNA or is the DNA of GMOs fundamentally no different than any other food we put into our bodies? Are there a host of potential health effects we subject ourselves to when we eat GMOs or are these studies just pointing to correlations observed in small rodents that will never affect humans? Should I support the labeling of GMOs so that I can consciously know what risks I face when I open a box of my favorite snack foods?

To guide the discussion of these questions, I turn to the critics themselves. I found two articles which confront one another and present the various arguments of the “concerned mothers” with a response from the “dispassionate scientists.” Representing the “concerned mothers” is Arjun Walia on Collective Evolution with a 10 point list of the health concerns related to GMOs published in April of 2014. The first several points build upon one another, building a case for justified fears about the health risks of GMOs through inductive logic. [52] In response, Layla Katiraee posted a ten point response on the Genetic Literacy Project a year and a half after the Collective Evolution article. [53] Katiraee has a PhD in Molecular Genetics from the University of Toronto and focused her thesis research on genomic imprinting.

I have chosen these two articles to guide this article as they summarize the main health arguments against and in defense of GMOs. They are real life examples of the archetypes described in the introduction. Each side passionately believes that the other has their head buried in the sand and points to the scientific support for their position. I will dig into the studies that these two articles reference to establish the scientific support for these opposing views.

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[52] Arjun Walia. "10 Scientific Studies Proving GMOs Can Be Harmful To Human Health." *CollectiveEvolution RSS*. April 8, 2014. http://www.collective-evolution.com/2014/04/08/10-scientific-studies-proving-gmos-can-be-harmful-to-human-health/

[53] Layla Katiraee. "10 Studies Proving GMOs Are Harmful? Not If Science Matters." *Genetic Literacy Project*. November 13, 2015. https://www.geneticliteracyproject.org/2015/11/13/10-studies-proving-gmos-are-harmful-not-if-science-matters/.

Based on my analysis, I will begin to construct my own assessment of the necessity of GMO labeling based on adverse health effects.

Hiding in the Blood

The first several points in Walia's article pertain to the genetic effect that GMOs could have on the human body when introduced into the bloodstream. Genetically modified foods broken down during digestion have the opportunity to enter the bloodstream through the GI tract where it could reproduce with human DNA. Walia does note that GMO genetic material has not been found within human cells though the article maintains that other research suggests this may be possible.

One particular Hungarian research team partnered with researchers from Harvard and Johns Hopkins to investigate the presence of genetically modified genes in the human bloodstream. They investigated the blood of men, women, and pregnant women, and the blood in fetal umbilical cords. [54] The research team was looking into the presence of genes broken down from food that entered the human bloodstream. Fragments of genetic material could be as short as 200 base pairs or as long as 10,000 base pairs. The researchers broke down the fragments of genetic material into three groups based on the lengths of the strands: longer than 10,000 base pairs, between 10,000 and 200 base pairs, and less than 200 base pairs. The first group with the

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[54] Sándor Spisák, Norbert Solymosi, Péter Ittzés, András Bodor, Dániel Kondor, Gábor Vattay, Barbara K. Barták, Ferenc Sipos, Orsolya Galamb, Zsolt Tulassay, Zoltán Szállási, Simon Rasmussen, Thomas Sicheritz-Ponten, Søren Brunak, Béla Molnár, and István Csabai. "Complete Genes May Pass from Food to Human Blood." *PLoS ONE* 8, no. 7 (July 30, 2013).

longest segments of genetic material were those with the greatest presence in the human bloodstream. [55]

If these fragments managed to enter blood cells, they could theoretically bond with human DNA and alter the genome. The joint Hungarian and American research team found,

> Based on the analysis of over 1000 human samples from four independent studies, we report evidence that meal-derived DNA fragments which are large enough to carry complete genes can avoid degradation and through an unknown mechanism enter the human circulation system. [56]

The evidence of GMO DNA in the human bloodstream raises several key issues regarding the potential for genetic transfer. There is a level of uncertainty regarding the potentially significant presence of genetic material from GMOs that lingers in the human body after food is consumed. If scientists don't know how how food DNA can enter the bloodstream, then that could show that there is simply too much risk involved to allow the continued production and consumption of genetically modified foods.

The potential effects of cell free DNA (cfDNA) from food were not considered until the widespread consumption of GMOs. The research team stated that "DNA from consumed food is usually not considered as a possible source of cfDNA since during food digestion all macromolecules are thought to be degraded to elementary constituents such as amino acids and nucleotides." [57] However, fears regarding GMOs and the presence of cfDNA opens up questions of whether genetic material from GMOs could theoretically blend with human genetic material.

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[55] Ibid, p2

[56] Ibid, p1

[57] Ibid, p2

The research team found that the two primary foods with cfDNA in the bloodstream were both varieties of GMOs with “over 25,000 sequence reads aligned to plant chloroplasts, among which Solanum tuberosum (potato) and/ or the closely related Solanum lycopersicum (tomato) were the most abundant.” [58] If GM cfDNA has the largest presence in the human bloodstream and said genetic material could bond with human DNA, then there may be reasonable cause for concern regarding the safety of genetically modified foods.

If cfDNA cannot be tracked or controlled, it could have effects on the human genome that we cannot anticipate. One alarmist quote from the Hungarian research teams article would seem to support these fears, “in one of the blood samples the relative concentration of plant DNA is higher than the human DNA.” [59] This high presence of DNA is relevant because “fragments large enough to carry complete genes can pass from the digestive tract to blood.” [60] If full genes are able to be transferred, then they could theoretically bond with human DNA. This key sample that shows a high presence of plant DNA shows the potential for significant genetic material to, quite literally, bleed into human circulation.

The concerns raised by this article regarding cfDNA are not as alarming when put into context. The vast majority of DNA from the food we eat is broken down in the course of digestion and “the presence of foreign DNA in human plasma is not unusual.” [61] The presence of cfDNA from genetically modified foods is no more pernicious than cfDNA from any other food

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[58] Ibid, p3

[59] Ibid, p1

[60] Ibid, p3

[61] Ibid, p9

that may be floating in our bloodstream. That genetic material which does manage to escape the digestive system is “absorbed into the surface of blood cells” and never has the opportunity to bond with human DNA. [62]

The “concerned mothers” would argue that just because cfDNA is not unusual does not mean that GM cfDNA is not harmful. Walia points to a study which found that genetically modified DNA can be found in maternal and fetal blood. [63] This raises the issue of how GMOs could potentially affect the health and development of children and could have effects of future generations who have never personally consumed genetically modified foods. Because genetically modified foods have been available for a quarter of a century, there is an entire generation that may have inadvertently consumed genetically modified foods without having had the option to make the conscious choice as a consumer. As a result Walia argues, these individuals could have adverse health effects from GMOs that they never had the opportunity to avoid. Genetically modified DNA in maternal and fetal blood points to the danger of the generational legacy of GMOs. These products could have unintended health effects on the accidental consumers of genetically modified products.

The study Walia references was a Canadian study through the University of Sherbrooke published in the journal Reproductive Toxicology which investigated the presence of pesticides related to GMOs found in the blood of pregnant women and their fetuses. The study specifically investigated the Bt Cry1Ab gene which helps with insect resistance. The researchers, Aziz Aris

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[62] Ibid, p1

[63] Walia, 2014

and Samuel Leblanc are faculty of Medicine and Health Sciences. They make a distinction regarding the terms they use in this study,

> The Cry1Ab toxin is an insecticidal protein produced by the naturally occurring soil bacterium Bacillus thuringiensis. The gene (truncated cry1Ab gene) encoding this insecticidal protein was genetically transformed into maize genome to produce a transgenic insect-resistant plant. [64]

The protein is naturally occurring and has been adapted through genetic modification to appear in maize. This toxin is also used in insecticides that are applied to genetically modified plants. Aris and Leblanc studied the blood of 30 different pregnant women and their fetuses and found that traces of the "Cry1Ab toxin was detected in 93% and 80% of maternal and fetal blood samples." [65]

There are several concerns with this study. For one, it is a small sample size with only 30 women. Additionally, Katiraee points out that "the researchers' measurements were based on an experiment/assay designed to detect Bt's Cry1Ab in plants, not in humans." [66] She compounds her critique saying that the presence of this gene could be from genetically modified foods eaten or that the toxin could be present from pesticides containing Cry1Ab. [67] The inability to identify the source of the toxin casts some doubt on the ultimate guilt of GMOs as a whole. Her final indictment of the research is stated particularly bluntly, "Humans lack the receptors for the

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[64] Aziz Aris, and Samuel Leblanc. "Maternal and Fetal Exposure to Pesticides Associated to Genetically Modified Foods in Eastern Townships of Quebec, Canada." *Reproductive Toxicology* 31, no. 4 (February 13, 2011): 528-33. p529

[65] Ibid, p2

[66] Katiraee, 2015

[67] Ibid

protein [Cry1Ab], so it has no impact on us.” [68] If we lack the fundamental components for bonding with these toxic proteins, then the presence of Cry1Ab in the blood is a moot point.

Observed Health Effects of GMOs

When one observes protesters at anti-GMO rallies, they generally tout research that shows the correlation between the consumption of GMOs and a host of adverse health conditions. These points can include such concerns as gluten disorders, tumors, hormone imbalances, birth defects, and mental disability. All of these ailments were connected to Bt proteins or glyphosate, toxins regularly used in pesticides. Certainly, GMOs require a host of sprays and chemical treatments to ensure that they have the highest possible yield as will be discussed in the environmental chapter. However, this is also true of the majority of agro-industrial farming methods. Points three through nine in Walia’s article reference the health effects of glyphosate and Bt proteins found in pesticides and herbicides rather than GMOs themselves. [69] The increased potential for health risks will come back into consideration with our later discussion of the herbicide and pesticide applications necessary to ensure the success of GM crops.

These points do raise a question about the nature of research into the effects of GMOs. All of the studies raised by Walia were based on animal studies or correlative data. [70] Many of the animal studies were done on smaller, less complex animals like mice, rats, rabbits, fish, or birds. Those studies conducted on larger mammalian animals more similar to humans (read

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[68] Ibid

[69] Walia, 2014

[70] Ibid

sheep, and cows) did not show any health effects that differed between conventional or genetically modified diets. [71] Based on Magaña-Gómez and De La Barca's research, any adverse health effects were not found in humans or were purely based on correlative data. This would suggest the need for longer periods of research and human trials to truly affirm the claims of "dispassionate scientists."

The Magaña-Gómez and De La Barca meta-analysis of available GMO research did open up questions for future research that perhaps give credence to the fears of those opposed to GMOs. The study found that "there were no effects at the macroscopic level; however, organelles and other subcellular structures are clearly affected, as shown at ultramicroscopic levels. [72] It is not clear whether these risks are brought about by glyphosate or GMOs themselves. What this ambiguous claim would suggest is that large life forms do not have significant observable differences due to consumption of genetically modified foods; however, smaller life forms may have significant changes from consumption of GMOs and these changes are particularly evident at the cellular level. It remains to be seen how smaller changes or effects may impact larger life forms in the long run.

There is no doubt that further research would be helpful to authenticate and reinforce the claims made by both the "concerned mothers" and "dispassionate scientists." One of the primary cries raised by the anti-GMO community is that there is insufficient non-biased research to support claims of the safety of GMOs. In a meta-study of GMO safety assessment published in

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[71] Javier A. Magaña-Gómez, and Ana M Calderón De La Barca. "Risk Assessment of Genetically Modified Crops for Nutrition and Health." *Nutrition Reviews* 67, no. 1 (2009): 1-16.

[72] Ibid, p13

Environment International, José L. Domingo and Jordi Giné Bordonaba found that “most of the studies demonstrating that GM foods are as nutritional and safe as those obtained by conventional breeding, have been performed by biotechnology companies or associates, which are also responsible of commercializing these GM plants.” [73] There's an inherent distrust of the body of research that currently supports the use of GMOs. Therefore additional non-biased research must be conducted to ensure the safety of GMOs and the lack of health risks to consumers.

[73] Domingo and Bordonaba, 2011, p741

POTENTIAL ENVIRONMENTAL EFFECTS

Modern farming practices are focused on intensification for higher yield. Realistically, this means that "irrespective of GM crops, agriculture profoundly impacts environmental resources and can result in a decline in biodiversity that has been observed in numerous ecosystem."[74] The Green Revolution profoundly altered the way we think about agricultural production and intensification. That trend has continued into the Gene Revolution so that now we are planting ever stronger species of plants. The "new age hippies" worry that the genes from these plants could significantly alter the surrounding ecosystems.

There is a term used by critics to describe genetically modified foods that creates an aura of mystery and fear around the application of GMOs. On protest signs, one can regularly see GMOs referred to as "frankenfoods." This name calls to mind Mary Shelley's bumbling monster, terrorizing villages and threatening civilians. It is a highly strategic rhetoric designed to articulate the "fear that man's hubris will lead to the creation of new species of plants or animals that will disturb the natural order and lead to deadly consequences." [75] The plants we grow based on biotechnological advancement have the potential to profoundly change our ecosystem though it remains to be seen whether they are the threat that "frankenfoods" seems to suggest.

The potential risks that GMOs pose in the environment are related to the issues of intensive farming practices, the use of herbicides and pesticides, and threats biodiversity through

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[74] Guy R. Knudsen, "Impacts of Agricultural GMOs on Wildlands: A New Frontier of Biotech Litigation." *Natural Resources and Environment* 26, no. 1 (2011): 13-17. p14

[75] B. David Naidu, *Biotechnology and Nanotechnology: Regulation Under Environmental, Health, and Safety Laws*. Oxford: Oxford University Press, 2009. p141

genetic drift. Intensive farming practices utilized in crops with high yield traits exacerbate problems of soil depletion that occur with traditional farming methods. Traditional farming methods also utilize significant pesticides and herbicides though it remains to be seen whether the introduction of GMOs leads to an increase or decrease in chemical use. The final issue addressing this this chapter is genetic drift which refers to the idea that GM plants could share their genes with weeds or wild variants. This would increase the strength of weeds and increase species homogeneity. Both pose risks to the biodiversity within an environment. Based on the scientific data available, I will assess the validity of claims made by "new age hippies" regarding the looming specter of "frankenfoods" and what they could do to our environment.

Intensification

One of the key traits GMOs are designed to promote is higher yield. It is economically beneficial to intensify agriculture, growing greater amounts of food on the same or smaller amounts of land. This is a way to decrease the costs and increase the profits of agribusiness. Certainly there is an observable increase in yields since the introduction of GMOs seeing as "the average yield impact across the total area planted to these traits over the 18 years since 1996 has been +11.7% for maize and +17% for cotton." [76] This shows that due to the introduction of GMOs, yield has increased by more than a tenth for at least one transgenic variety. There is the notion that this increased intensification of agriculture ultimately leads to greater sustainability in the long run. This argument is based on the premise "that through 'sustainable intensification,' crops with higher yield will prevent the destruction of forests intended for the creation of new

[76] Graham Brooks, and Peter Barfoot. "GM Crops: Global Socio-economic and Environmental Impacts 1996- 2013." *PG Economics Ltd*, May 2015. p12

land plots. [77] This is certainly a strong argument theoretically and strongly supports the assessment that higher yield species have an overall positive effect on sustainability efforts in modern agribusiness.

Observing the change in land use over time is difficult considering the fact that researchers cannot simultaneously observe the use of land for traditional farming methods and for GM crops. There are a number of factors which complicate this comparison. For one, the global demand for food has increased with rising population over time such that the demand cannot be held static. This opens up the question of whether additional plots for farming are due to increased demand or the result of particular farming methods. Additionally, regional comparisons are not ideal for analyzing the differences between GMO and non-GMO farming systems. There are cultural factors, historical factors, political factors, and environmental factors which make it difficult to compare different countries and their land use throughout the adoption of GM crops. Consequently, researchers have turned to mathematical analysis and modeling to hypothesize how land usage differs following the adoption of GMOs.

Research published in the Proceedings of the National Academy of Sciences of the United States of America modeled the changes in land use based on adoption of high yield farming from 1961 to 2005. Their model found that in a hypothetical setting, "increases in food production were realized by expanding farmland instead of increasing yields, finding that between 864 and 1,514 million hectares would have had to be converted to agricultural

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[77] Clive James. "Global Status of Commercialized Biotech/GM Crops: 2013" *ISAAA Brief, no. 46* Ithaca, New York, 2014.

production, depending on the living standard assumed." [78] This model lacks some specificity in whether higher yield farming methods include GM varieties or not. However, a similar modeling study published in AgBioForum found that globally, "2.64 million hectares of land would probably be brought into grain and oilseed production if biotech traits were no longer used." [79] These theoretical models are certainly alluring but they are tempered by examples of various countries in South America. In Argentina and Brazil, GM favorable government policies "[caused] the expansion of soybean acreage into areas previously planted to other crops or used as pasture, as well as into some natural areas." [80] The opportunities provided by higher yield crops are theoretically limiting the destruction of wildlands and pastureland, but these benefits can be negated through regional farming practices or government policies.

An Abundance of Chemicals

Popular rhetoric from "new age hippies" of "helicopter moms" would suggest that unknown chemicals applied to crops are always increasing and are only causing genetically modified strains to deviate further from their non-domesticated cousins. Talking about chemical additives can be rather vague for many who are unfamiliar with the types of additives that go into modern agricultural practices. In fact "since 1996, the use of pesticides on the GM crop area was reduced by 550 million kg of active ingredient [which is an] 8.6% reduction." [81] Overall this means that the widespread usage of pesticides, though still widely utilized, no longer uses as

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[78] Carpenter, 2011, p5

[79] Ibid, p5

[80] Ibid p5

[81] Brooks and Barfoot, 2015, pg13

much of the key active ingredients. It is important to note that there are limitations to this fact. It only addressed the use of pesticides and not herbicides.

The "concerned mothers" and "new age hippies" would likely be unimpressed with this evidence. The study above would suggest that the necessity of incredibly strong pesticides has actually decreased meaning that the amount of nonspecific "chemicals" that our caricatures fear has decreased since the institution of GMOs. However, within the very same study it was found that, "in some regions where GM HT crops have been widely grown, some farmers have relied too much on the use of single herbicides like glyphosate to manage weeds in GM HT crops and this has contributed to the development of weed resistance." [82] As generations of weeds are subjected to repeated use of particular herbicides, they can build up a tolerance which will lead to stronger super weeds in the long run. This requires additional genetic modification and consequently novel herbicides to address the genetic changes of invasive species.

Similar phenomena have been recorded for pesticides. When studying the reduced use of pesticides on Chinese farms, "field data collected in 2004 indicates that these benefits are being eroded by an increasing use of pesticides aimed at the control of secondary pests" (Jacobsen et al., 2013, p653). The demands of secondary pests show the weakness of Brooks and Barfoot's analysis of pesticide usage over the past 20 years. Perhaps there is a decreased overall use of pesticides but researchers are regularly having to design newer and stronger strains of herbicides

[82] Ibid, p16

and pesticides to address the ironically inconvenient way that "technological advancement is... helping to augment nature's diversity and expand adaptive capabilities. [83]

Organizations and individuals have been voicing concerns regarding the environmental effects of GMOs since shortly after their initial implementation. The example of butterflies in the Mid-West raised back at the start of this research shows the origins of concerns regarding the effects that GMOs and excessive chemical treatments can have on surrounding plant and insect life. While farmers only intend to kill harmful pests, many benign varieties of insect also suffer. [84] "New age hippies" would argue that if herbicides and pesticides can potentially have a negative effect on humans, then GM varieties that require novel chemical treatments are an unnecessary threat to consumers.

Genetic Drift

To understand the threats to biodiversity, we must first clarify the idea of genetic drift. Through cross pollination or cross breeding, "genetically modified plants, animals, or microbes can impact the environment through invasiveness of the GMO or of organisms with which they hybridize, loss of biodiversity, and adverse effects on nontarget organisms." [85] This point raises a number of the concerns voiced by the "new age hippies." Hybridization can, in a manner of speaking, infect wild or non-domesticated populations with genetically modified traits meaning that new wild varieties lose some level of genetic autonomy. Those opposed to GMOs fear that

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[83] Sven-Erik Jacobsen, Marten Sørensen, Søren Marcus Pedersen, and Jacob Weiner. "Feeding the World: Genetically Modified Crops versus Agricultural Biodiversity." *Agronomy for Sustainable Development* 33, no. 4 (March 19, 2013): 651-62. p652

[84] Naidu, 2009, p38

[85] Knudsen, 2011, p14

increased hybridization will lead to a loss of biodiversity and could potentially give rise to monocultures. These concerns are very difficult to test for because in controlled research or lab environments, it is impossible to take into account all non-target organisms that may exist in natural ecosystems.

If a GMO field is cultivated adjacent to a non-domesticated ecosystem, there is a potential for cross pollination and the genetic superiority of the high yield trait. This will cause the genetically altered traits to enter the ecosystem and edge our natural competitors. For example, a study published in the journal Environmental Biosafety Research was done in Japan which observed the way soybean varieties hybridized in field tests. The research team found that between GM and non GM varieties of soybeans, "hybridization frequencies ranged from 0 to 0.097%" with the highest percentage being exhibited in fields that were planted with a mixture of the two varieties of soybeans. [86] Previous studies in 2002 found slightly higher results with a "hybridization frequency of 0.23–1.69%." [87] The researchers attribute variance in results to different flowering periods and the styles of adjacent cultivation. [88] If there is differing evidence of hybridization and genetic drift within a specific species due to growth conditions in these studies pertaining specifically to soybeans, then it is impossible to extrapolate findings uniformly to all genetically modified species.

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[86] Aki Mizuguti, Kentaro Ohigashi, Yasuyuki Yoshimura, Akito Kaga, Yosuke Kuroda, and Kazuhito Matsuo. "Hybridization between GM Soybean (Glycine Max (L.) Merr.) and Wild Soybean (Glycine Soja Sieb. Et Zucc.) under Field Conditions in Japan." *Environmental Biosafety Research* 9, no. 1 (2010): 13-23. p19

[87] Ibid, p19

[88] Ibid, p19

Many studies have been conducted on various different species to assess the relative fitness of wild species after the integration of genetically modified traits. One such study published in the Annals of Botany compared the yield and reproductive capabilities of canola hybrids after a year of cross pollination. The research team found that "both back-cross genotypes, BC_1–Bn and BC_1–Br, displayed reductions in plant size relative to the F1 parent and were the least vigorous plants." [89] The second year of growth after transgenic contamination occurred led to the creation of inferior plants that lacked the genetic capacity to thrive compared to wild varieties. This contradicts some of the theoretical arguments that cross pollination of GMOs with wild varieties will lead to the introduction of GM traits that will render the wild species inferior to GM varieties. At most, the traces of transgenic traits benefited plants that received drift-level glyphosate treatments. [90] In the wild where cross pollination occurs, the introduction of transgenic traits did not significantly improve the survival rates of contaminated wild varieties.

"New age hippies" voice concerns about the way that genetic drift could contribute to a decrease in biodiversity. Theoretically, as transgenic traits are introduced in the wild through cross pollination, plants possessing transgenic traits would have greater genetic viability than uncontaminated varieties and eventually lead to genetic homogeneity that favors genetically modified plants. As evidenced by the study on canola, this is not necessary the case and transgenic traits does not determine the success of a generation of plants. Therefore, GMOs do

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[89] Londo, J. P., N. S. Bautista, C. L. Sagers, E. H. Lee, and L. S. Watrud. "Glyphosate Drift Promotes Changes in Fitness and Transgene Gene Flow in Canola (Brassica Napus) and Hybrids." *Annals of Botany* 106, no. 6 (September 18, 2010): 957-65. p960

[90] Ibid, p963

not universally lead to a decrease in biodiversity. Instead, more extensive testing must be conducted to observe the ways that transgenic species interact with their wild counterparts.

BALANCING RISK

The Precautionary Principle

The fact that the scientific community is divided on the safety of GMOs shows that balancing utility against risk is incredibly important in the public discourse surrounding GMOs. The "nervous mothers" and "new age hippies" would argue that there is insufficient evidence to prove that GMOs are not harmful. Their opponents, the "scientific naysayers" would argue that there is insufficient evidence to prove that GMOs are harmful. The contradictory evidence provided by the scientific community means there is debate over which side of the argument is saddled with the burden of proof. That is to say that depending on how the question over the risks of GMOs is phrased, one side or the other will be required to generate reliable research to appease the other. In the Business and Professional Ethics Journal, J.A. Burgess and A.J. Walsh present the philosophical and ethical articulations of this conflict. They place the pro-labeling and anti-labeling arguments against one another,

> "(1) There is no solid evidence that genetically modified food is harmless, therefore it is probably harmful."
>
> Versus
>
> "(2) There is no solid evidence that genetically modified food is harmful, therefore it is probably harmless" [91]

The fact that these two representations of the debate over GMOs exist simultaneously shows in part why the debate is so heavily conflicted. Those for labeling believe that the onus of evidence falls to those who voice concerns about the safety of GMOs. Those against labeling are of the

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[91] J.A. Burgess, and A. J. Walsh. "Consumer Sovereignty, Rationality and the Mandatory Labelling of Genetically Modified Food." *Business and Professional Ethics Journal* 18, no. 3 (1999): 7-26. p15

opinion that the burden of research must fall to those who are thoroughly convinced that GMOs are entirely safe.

Realistically, neither one of the questions above are ideally suited to addressing the debate over GMOs because they fail to create a solid case for or against GMO usage. These types of questions are essentially defensive rhetoric. Burgess and Walsh state it best saying that "the lack of evidence in and of itself benefits neither side; it tells us nothing about the rationality of either position." [92] Neither argument proves itself but calls for the opponents to find evidence that disproves.

A far better way of organizing the debate over GMOs is through the precautionary principle. The precautionary principle is a way of analyzing risk and predicting the potential outcomes. Ostensibly, the precautionary principle is intended to address "cases in which our scientific knowledge of the harmful effects of a proposed activity is significantly incomplete." [93] This statement is deceptively simple, but it is really showing how the precautionary principle can address the failures of the defensive rhetoric that I described previously. Clearly requiring one side to provide proof for another is ineffective. Therefore, the precautionary principle takes note of that research that is absent or insufficient and then builds an action plan for addressing the perceived risk. It is also important to note that this caveat requires scientific evidence to bolster to legitimacy of claims of risk. For those who are adamant in their rejection of GMOs on

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[92] Ibid, p15

[93] Neil A. Manson. "Formulating the Precautionary Principle." *Environmental Ethics* 24, no. 3 (2002): 263-274. p264

scientific grounds, "there are two aspects of systemic risk, the widespread impact on the ecosystem and the widespread impact on health." [94]

The precautionary principle can directly respond to the aforementioned sources of scientific risk and presents an action plan for addressing said risks. There are three necessary components to the precautionary principle,

> 1)The damage condition: this is the potential risk
>
> 2) The knowledge condition: this is the scientific evidence or proof that supports the claim in the damage condition
>
> 3)The remedy: this is the proposed plan of action, the way to address the damage condition based on the information obtained in the knowledge condition [95]

Based on this construct, the damage condition would be that there are adverse health effects and environmental impacts from the consumption and production of GMOs. The knowledge condition would be the thousands of studies that have been done to assess the validity of these claims. Based on my analysis, the findings from this body of research are contradictory and warrant a remedy to the damage condition.

The options for remedy under the third point of the precautionary principle are varied. Some proposals to limit GMOS include "implementing a ban, imposing a moratorium while further research is conducted, allowing the potentially harmful activity to proceed while closely monitoring its effects, to just conducting more research." [96] In fact, insufficient research is one

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[94] Taleb et al., 2014, p9

[95] Manson, 2002, p265

[96] van den Belt, 2003, p1123

of the most commonly voiced complaints regarding GMOs. One stark statistic is that "in 2014 in the US almost 90% of the corn and 94% of the soybeans are GMO. Foods derived from GMOs are not tested in humans before they are marketed." [97] Additionally there is not an international consensus on how to regulate GMOs and "no standardized design to test the safety of GM foods yet exists."[98]

This research has chosen to forgo the proposals listed above in favor of considering mandatory labeling legislation. In part, this research focus on labeling is because that is the focus of current legislation regarding GMOs. The DARK Act in Congress and the various laws passed by state legislature all pertain to the matter of labeling rather than any of the limitations or regulations described above. The upcoming legislation from Vermont has yet to be put into effect so it remains to be seen how the federal government will respond to the market adopting national GMO labels.

Labeling legislation makes consumers aware of potential risk at present and opens the door for additional discussion of regulation in the future. It is a response that validates potential risk but allows consumers to make a decision regarding the knowledge condition in relation to the damage condition. In this fashion, labeling fits well within the precautionary model of response. Because there is a presumed risk and gaps in scientific evidence, the response is precautionary but not an absolute limit on further research and exploration. With GMO labels,

[97] Taleb et al, 2014, p9

[98] Magaña-Gómez and De La Barca, 2009, p3

the affected products can still be on the market but it is up to the consumer to make their own evaluation of risk.

Clowns to the Left of Us, Jokers to the Right, Here I am Stuck in the Middle with You

When I began this research, I found myself aligning most closely with the "anti-capitalists" and the "new age hippies." Based on previous research, I can see a host of concerns regarding corporate ethics and the neo-colonial tendencies of agribusiness in the developing world. Those issues related to the power of companies like Monsanto and Dupont have not dissipated. However, those concerns were not the focus of this research.

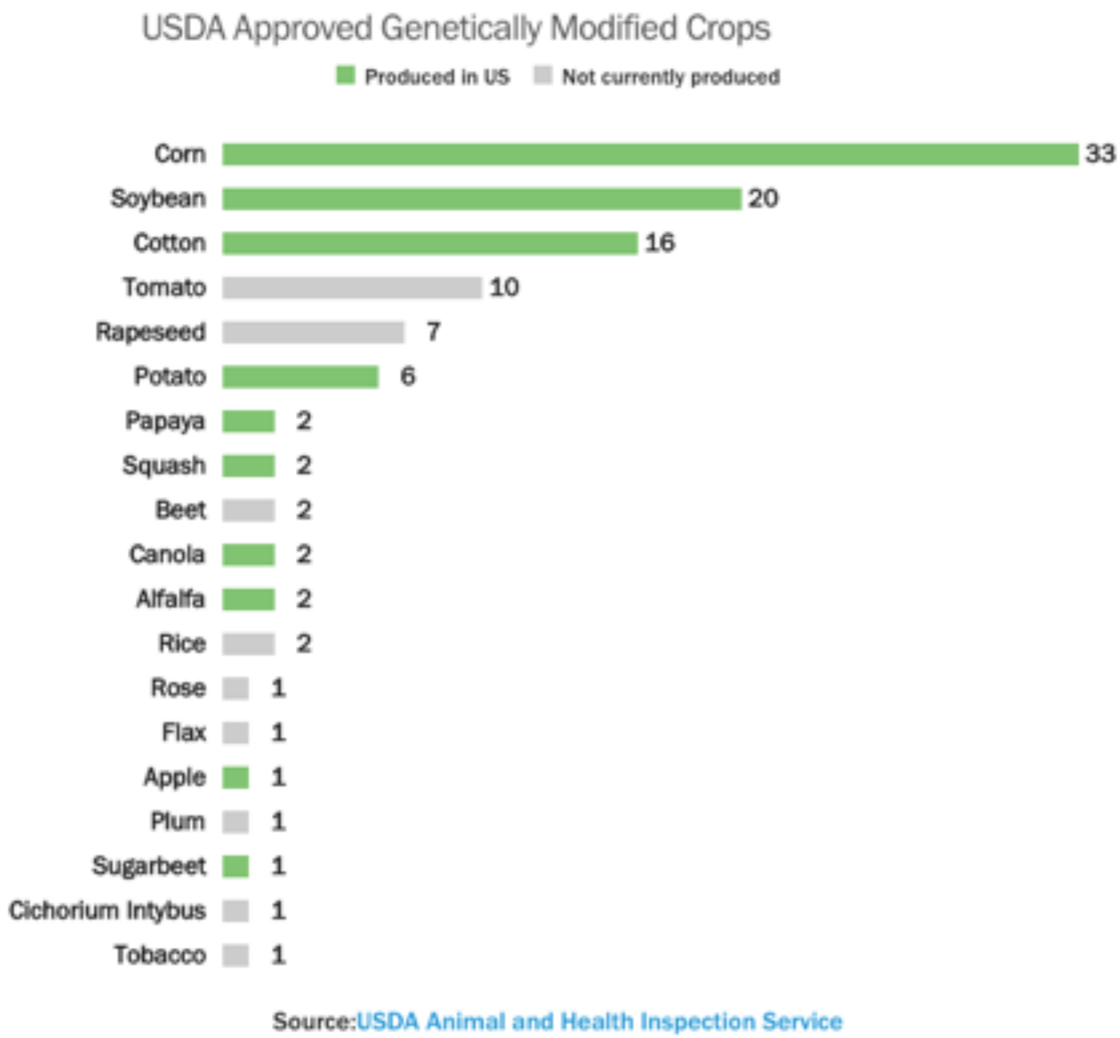
Following my research on the potential health and environmental effects of GMOs, I find myself less concerned than when I embarked on this research. The health effects are largely unconvincing for me. Based on the research conducted by Spisák et al., I am not alarmed by the presence of cfDNA in the blood nor do I think it will affect any part of the human genome. I do believe that many of the other documented health risks connected to the toxin glyphosate are legitimate and can have a negative impact on human health or standard of living. However, the widespread use of glyphosate in pesticides used irrespective of transgenic status leads me to take issue with modern pesticide usage rather than GMOs themselves.

Environmentally, I also take greater issue with modern farming practices than with GMOs. The high rates of intensification and chemical applications occur whether fields are planted with transgenic seeds or traditionally bred varieties. Therefore, the environmental effects that I find most alarming are associated with agribusiness as a whole rather than GMOs. The potential for genetic drift and decreasing biodiversity is something I would suggest for continued research. Each species of GMO affects the surrounding environment differently based on the timeline of the growing season, the use of space to isolate certain plants, and the diversity of plant life within the ecosystem. I cannot make sweeping generalizations about the risk of genetic drift but would instead suggest more rigorous testing of each transgenic species before it is released on the market.

What the rhetorical approach to these topics has shown me is that both sides of the argument over GMOs have defensible evidence, but there are excessive communication barriers that obstruct consensus. Based on my archetypes and Kelly's descriptions of rallies, neither camp is willing to dignify the views and evidence of the other. Individuals may go to the effort of educating themselves, but the win-lose nature of this public discourse has dissuaded a productive assessment of the evidence for each position.

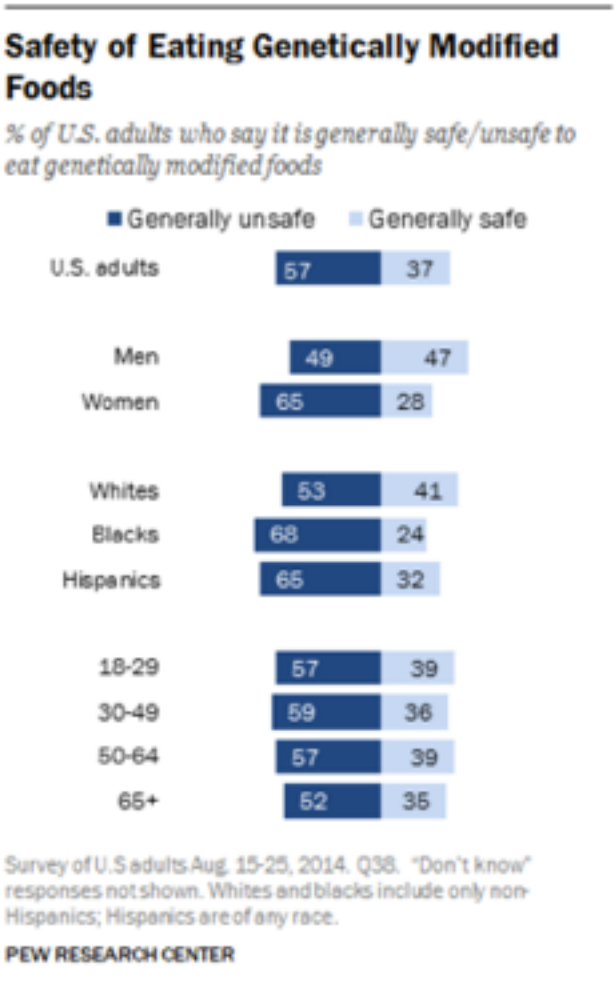
APPENDIX

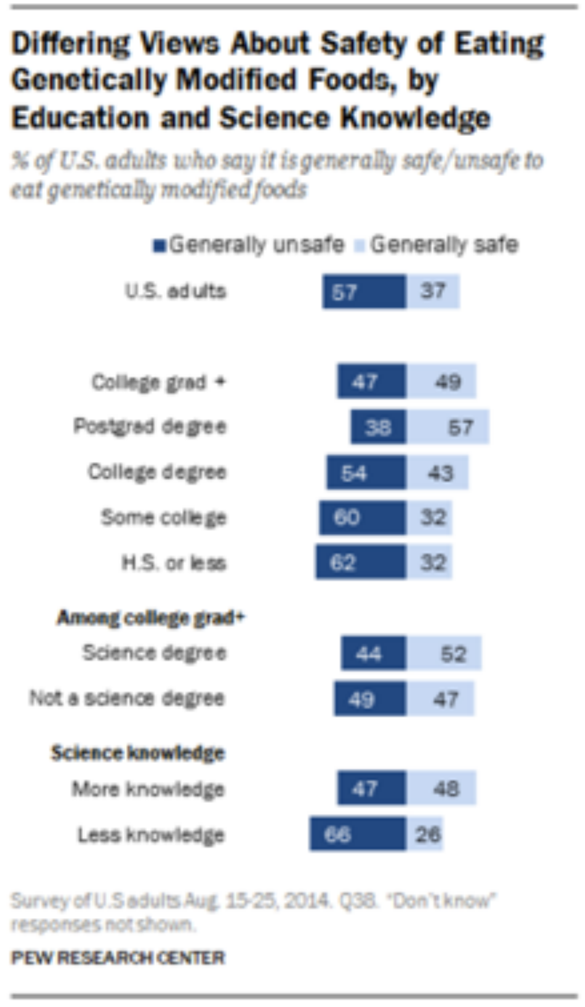
Appendix 1: The number of species of different GM crops produced in the US [99]



[99] Johnson, 2015

Appendix 2: Pew GMO Questionnaire Results [100]





[100] Funke and Raine, 2015

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