Fall 2012

Genetically Modified Organisms as a Potential Solution for Decreasing Hunger in Developing Nations: An Ethical Paradox

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Fall Semester 2012

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Preface

I first became aware of and interested in genetically modified organisms (GMOs) in the "Politics of Food in America" course I took spring semester of 2012, my junior year at the University of Texas at Austin. I was intrigued by the fact that such a concept was so unfamiliar to the public, yet genetically engineered products were in our everyday foods. Though I received a basic introduction to GMOs through my course, I was curious to learn more about the regulatory practices of GM crops and the political relationships sustained by GM firms and government agencies in the United States. I was also interesting in learning more about the health effects of GM food consumption and the potential environmental implications of growing such resistant crops. My curiosity surrounding the potential ability for GM crops to feed developing states and diminish starvation stems from my first paper with SIT, which I wrote on international food security. After learning the devastating statistics and inherent social and economic problems at the root of food insecurity, I wanted to find an alternative solution. Together, my two curiosities birthed the idea for my ISP paper: GMOs as a Potential Solution to Diminishing Starvation and Malnutrition in developing nations.

Acknowledgements

I would first like to thank the School for International Training (SIT) in Geneva for presenting me with such an incredible and challenging opportunity. I have grown immensely from my experiences here and will undoubtedly return to the United States more knowledgeable and confident. I would also like to thank my family and peers for their unwavering support of my late night researching and continuous complaining. Thank you for reducing my stress level when I needed it most. I would also like to thank all of my interviewees for providing me with their professional opinions on a subject on which I am so passionate. Your knowledge has been incalculably valuable to my own research and personal growth. Thank you for your time, kindness, and expertise. Lastly, I would like to thank my host-mom, Carin, for her guidance and patience. You have truly become a mentor in my life and have helped me recognize the path I am walking. I have learned countless life lessons from you in the past three months, which I will never forget. I will dearly miss our Nordic walking and late night chats. Thank you for your direction, grounding presence, and of course, hospitality.

Abstract

With such a rapidly increasing population, in 2050, mankind will have to produce enough food for nine billion people. With the development of modern biotechnology, genetically modified foods were seen as the answer, as a solution to our flawed global food system. GMOs have long been praised by advocates as the only hope for maintaining agricultural productivity and in turn food security in a world affected by diversity loss, soil erosion, pesticide over-use, food crises, and climate change, but deeper assessments of their health risks and environmental implications prove otherwise. The use of genetically engineered crops to feed the hungry and nourish the malnourished is too normative a concept, proving idealistic and unrealistic, as agribusiness giants who own the patents for the GM crops allow nothing to interfere with profits. Above all else, the world has the capacity to feed itself and therefore, as a planet, we should focus on reallocating our resources to increase access for all. Rather than relying on technology and creating a cycle of dependency, we should work to create biodiversity and natural methods of sustainable agriculture.

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Prologue

The disturbing fact that our planet holds 925 million undernourished people, and over 1 billion overweight, sheds some light onto our severely flawed global food system.[1] Worldwide obesity has more than doubled since 1980 and 65% of the world's population now live in countries where obesity kills more people than malnutrition. Once considered a high-income country problem, overweight and obesity are now increasing in low- and middle-income countries, particularly in urban settings. More than 40 million children under the age of five were overweight in 2010 while a tenth of the world's adult population was obese. Obesity now results in the death of over 2.8 million adults a year, and ranks as the fifth leading risk for global deaths..[2]

On the contrary, the 925 million hungry people make up 13.6% of the estimated world population of 6.8 billion. One in seven people are hungry. Nearly all of the undernourished are in developing countries. Children are the most visible victims of undernutrition. Poorly nourished children suffer up to 160 days of illness annually, playing a role in at least five million child deaths each year. Every childhood disease is magnified by the effects of undernutrition, including diarrhea (magnifying 61% of total childhood cases), malaria (57%), pneumonia (52%), and measles (45%). Undernutrition among pregnant women in developing countries leads to 1 out of 6 infants born with low birth weight. This is not only a risk factor for newborn deaths, but also can also lead to learning disabilities, mental retardation, poor health, blindness and premature death.[3]

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[1] "2012 World Hunger and Poverty Facts and Statistics." *Www.worldhunger.org*. World Hunger Education Service, n.d. Web. 13 Nov. 2012.

[2] "Obesity and Overweight." *World Health Organization*. WHO, May 2012. Web. 13 Nov. 2012. <http://www.who.int/mediacentre/factsheets/fs311/en/>.

[3] *Ibid.*

However, despite these devastating statistics, the world produces enough food to feed everyone. World agriculture produces 17 percent more calories per person today than it did 30 years ago, despite a 70 percent population increase. This is enough to provide everyone in the world with at least 2,720 kilocalories (kcal) per person per day.[4] The principal problem is that many people in the world do not have sufficient land to grow, or income to purchase, enough food. The increase in malnourished people has been due to three factors: 1) neglect of agriculture relevant to very poor people by governments and international agencies, 2) the current worldwide economic crisis, and 3) the significant increase of food prices in the last several years.[5]

Then bring in modern agricultural biotechnology. As many impoverished people in third world countries rely on a single crop such as rice for the main staple of their diet, they do not receive adequate amounts of all necessary nutrients to prevent malnutrition. GM corporations propose that foods staples, such as rice, can be genetically engineered to contain additional vitamins and minerals, promising the alleviation of nutrient deficiencies and decreasing malnutrition.

Agricultural biotechnology, however, is too multifaceted to be evaluated by a single factor. Genetically modified organisms are a hotly debated topic and evoke controversy regarding nutritional value, health risk, environmental implications, intellectual property rights, labeling and consumer choice, politics, corporate responsibility, and ethics.

Introduction

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[4] Food and Agriculture Organization, International Fund for Agricultural Development, World Food Program. 2002. "Reducing Poverty and Hunger, the Critical Role of Financing for Food, Agriculture, and Rural Development."

[5] *Ibid.*

With the development of modern biotechnology, genetically modified foods were seen as the answer, as a solution to our flawed global food system. Genetically modified organisms meant higher crop yields, greater farming productivity, and produce of higher quality due to being engineered to be pest, herbicide, disease, and climate resistant. Consistency was guaranteed, it was too good to be true. And with such resistant genes, fewer pesticides were needed, significantly reducing the environmental impacts of agricultural production. Yet for those who were informed, the public was still skeptical of their food being altered.

In 1998 the GM giant Monsanto launched an aggressive advertising campaign to persuade reluctant Europeans they should accept GM foods:

> "As we stand on the edge of a new millennium, we dream of a tomorrow without hunger… Worrying about starving future generations won't feed them. Food biotechnology will."[6]

This contested the common negative perception of genetically engineered organisms as "frakenfoods" and sparked hope that GMOs could potentially diminish starvation in third world countries. If foods could be fortified with certain nutrients to prevent malnutrition and those crops could be grown in nearly any environment, why not use them to feed the hungry in developing nations? It appeared to be an ethical solution to a questionably moral phenomenon.

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[6] "GM No Solution to Global Hunger." *Bangmfood.org*. Ban GM Food, n.d. Web. 14 Nov. 2012. <http://www.bangmfood.org/feed-the-world/17-feeding-the-world/6-gm-no-solution-to-global-hunger>.

However, it is an ethical complex. When it comes down to it, mankind is altering nature for human consumption, ultimately creating artificial life and then patenting it. Despite the positive feedback GM crops earned for being so productive, efficient, and resistant, they are not always well received. Because modern biotechnology methods such as genetic engineering are so new, not enough studies have been conducted to observe the effects of GMO consumption over a long period of time. This poses health concerns, as there is a large potential risk for consumption of a product that has not been tested.

Some of the main health concerns surrounding GMOs are that they could be potentially toxic, they could create new allergens, and they could create immune problems as exemplified by animals in laboratory cases. Environmental apprehensions include fearing that GMOs could develop resistance and reduce the effectiveness of pesticides, the creation of new gene species through gene transfer to non-target species, and loss of crop diversity. Essentially, the effects are unknown, which adds a large degree of risk to consumption. The controversies surrounding the health and environmental effects of biotechnology will be presented in sections XI and XII.

In addition to health and environmental concerns, the politics that accompany GMOs and GM corporations lack transparency and often deceive the public of or withhold critical information. As the biotechnology industry becomes more concentrated, the power of GMO policy and regulations are kept in the hands of the few as executives of large GM corporations transfer back and forth between large, transnational GM companies and government positions in political offices through the “revolving door.” In an attempt to own most of the world’s food, profit hungry corporations ensure ownership of seeds through ethically questionable patents, locking farmers into a vicious cycle of

seed purchasing and rendering them food dependent. The political and corporate processes of GMOs will be discussed further in sections VII and VIII.

While perhaps the most convincing argument favoring GMOs is that of their ability to potentially end world hunger, critics argue that there is not a global food shortage, but rather an unequal distribution of food. What is needed is greater access to food, not genetically engineered plants. The answer to food security does not lie within the crops of GMOs and many see it as a "quick fix." Others argue that though GM foods are a possible solution to reducing hunger, no large GM corporation would be willing to produce varieties for poor countries unless it were to see a market.[7] Because of the extent of the controversy surrounding genetically modified organisms, it is necessary to evaluate them from a scientific, political, corporate, environmental, and nutritional angle in order to determine whether they or not they are an ethical practice of biotechnology. Only then can we assess if GM foods are an appropriate solution to diminishing starvation in developing nations.

Definition

In order to properly analyze genetically modified organisms, it is first necessary to define them and understand how they operate. The World Health Organization (WHO) defines GMOs as organisms in which the genetic material (DNA) has been altered in a way that does not occur naturally. The technology is often called "modern biotechnology," "gene technology", or "genetic engineering". It allows selected individual genes to be transferred from one organism into another, also between non-

[7] Vidal, John. "Global GM Food Market Starts To Wilt." *Global GM Food Market Starts To Wilt*. The Guardian London, n.d. Web. 13 Nov. 2012. <http://rense.com/general13/globalGM.htm>.

related species. Such methods are used to create GM plants—which are then used to grow GM food crops.[8]

The Science of GMOs: How They Function

Genetic modification allows genes from one species to be moved into another, whereas conventional breeding only involves the same species, or very closely related species, which restricts the gene pool and available characteristics. Most genetic modifications involve genes taken from bacteria, viruses, and other plants. Sometimes, genes have even been transferred from animals to plants.[9]

Agricultural biotechnology has made it possible for plant breeders to cross the species barrier, creating new seeds and plants that have desirable traits with the insertion of genetic material that could not otherwise have been bred into a plant through normal breeding practices in the field. The new traits that plants have been genetically engineered to take on included resistance to the application of herbicides and crops that produce their own pesticides by inserting the gene for the naturally insecticidal bacterium *Bacillus thuringiensis* (Bt).[10]

Insect resistance is achieved by implanting Bt into the food plant. This toxin is currently used as a conventional insecticide in agriculture and is deemed safe for human consumption by the WHO. GM crops that permanently produce this toxin have been shown to require lower quantities of insecticides where pest pressure is high. Virus resistance is achieved through the introduction of a gene from certain viruses, which

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[8] "20 Questions on Genetically Modified Foods." *WHO*. World Health Organization, n.d. Web. 14 Nov. 2012. <http://www.who.int/foodsafety/publications/biotech/20questions/en/>.

[9] Millstone, Erik, and Tim Lang. "Agricultural R&D: Genetically Modified Crops." *The Atlas of Food*. London: Earthscan, 2008. N. pag. Print.

[10] Clapp, Jennifer. *Food*. Cambridge UK: Polity, 2012. Print.

cause disease in plants. Virus resistance makes plants less susceptible to diseases caused by such viruses, resulting in higher crop yields. Herbicide tolerance is achieved through the introduction of a gene from a bacterium conveying resistance to some herbicides. In situations where weed pressure is high, the use of such crops has resulted in a reduction in the quantity of the herbicides used.[11]

History

According to the WHO, the initial objective for developing plants based on genetically modified organisms was to improve crop protection. The GM crops currently on the market are mainly aimed at an increased level of crop protection through the introduction of resistance against plant diseases caused by insects or viruses or through increased tolerance towards herbicides.[12] The first GM crop was produced in 1984. Since then, over 170 different crops have been genetically modified and tested. GM crops were first grown commercially in 1996, in the United States, where the area under cultivation has since increased to nearly 55 million hectares.[13]

The development of biotechnology has been largely conceived and carried out through private sector initiatives, rather than through the public sector. Because the Cold War was over by the 1990s, the US was less interested in taking up the costs of research, and was more inclined to give the task to the private sector, in this case the large agricultural input firms. US hegemony in the global political economy during the early post-war era spilled over into the agricultural sector, profoundly influencing the global

[11] "20 Questions on Genetically Modified Foods." *WHO*. World Health Organization, n.d. Web. 14 Nov. 2012. <http://www.who.int/foodsafety/publications/biotech/20questions/en/>.
[12] *Ibid.*
[13] Millstone, Erik, and Tim Lang. "Agricultural R&D: Genetically Modified Crops." *The Atlas of Food*. London: Earthscan, 2008. N. pag. Print.

food order for decades. The promotion of a protected agricultural sector, the encouragement of transnational corporate investment, and the championing of the Gene Revolution in the developing world provided domestic benefits, both economic and political for the US. The strategy supported farmer incomes at home, it helped expand the global reach of US-based agrifood corporations, and it helped to cement US hegemony and power in the food sector.[14]

By the mid 1970s, the international post-war food order with the United States faced crisis. The order as it evolved created dependence in much of the developing world—dependence on food imports and dependence on foreign corporations for inputs for their own production. As this dependence deepened, developments triggered a major disruption in global food markets that sent food prices soaring.[15]

The acceleration of the globalization of the world food economy in the post-war era was the product of explicit state policies—particularly US policies—that fostered the expansion of world food markets, and in particular the export of grain from surplus countries. States, supported by private foundations and multilateral development agencies, also pushed for the global adoption of agroindustrial models in this era. The result was the development of a globalized world food economy that was built on a premise that served the political and economic interests of rich industrialized countries.[16]

As the world food system developed, the redistribution of surplus and the spread of industrial farming methods, including GM crops, were seen as vital components to the food system. But ultimately, the foundation on which the world food system was built was weak and vulnerable to repeated crises. Instead of resolving the foundation, the

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[14] Clapp, Jennifer. *Food*. Cambridge UK: Polity, 2012. Print.
[15] *Ibid.*
[16] *Ibid.*

policies focused more on global agricultural trade, and more intensive application of scientific agriculture and technology.[17]

Approval Process

So, how were GM foods introduced to the market and approved for consumption? Twenty years ago in 1992, at the end of the first Bush Administration, then-Vice President of the United States Food and Drug Administration Dan Quayle announced the FDA's policy on genetically engineered food as part of his "regulatory relief initiative." The policy, Quayle explained, was based on the idea that genetic engineering is no different than traditional plant breeding, and therefore should require no new regulations. Quayle recommended that there be no regulation at all for GM foods and that biotech products receive the same oversight as conventional products instead of "being hampered by unnecessary regulations." His policy was premised on the notion that genetically engineered crops are "substantially equivalent" to regular crops and therefore should not require safety testing or labeling. [18]

This policy was developed by Michael Taylor, former Monsanto lawyer who was hired by the Bush FDA as the Deputy Commissioner of Policy. "Ironically" the Obama administration also appointed him as the deputy commissioner of foods in 2009, where he now oversees food safety policy. Taylor's appointment was highly controversial, and for good reason. He can be credited for crafting a pseudo-scientific policy, which constructed the framework for helping GMOs avoid necessary scientific testing and common sense

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[17] *Ibid.*

[18] Murphy, Dave. "20 Years of GMO Policy That Keeps Americans in the Dark About Their Food." *The Huffington Post*. TheHuffingtonPost.com, 30 May 2012. Web. 15 Nov. 2012.

labeling.[19]

FDA scientists were outraged and wanted scientific testing of GMOs for fear of unknown, adverse health effects. The concerns of the FDA scientists were explicitly expressed in a memo by FDA compliance officer Dr. Linda Kahl, who claimed that the FDA was trying to “fit a square peg into a round hole,” further stating that "the processes of genetic engineering and traditional breeding are different, and according to the technical experts in the agency, they lead to different risks."[20]

The Quayle commission wanted to be the first in the world to market GM foods with the belief that the American biotechnology industry would reap huge profits “as long as we resist the spread of unnecessary regulations.” The FDA essentially ignored safety warnings from their own scientists. So, in spite of a scientific declaration that there was a difference between genetic engineering and traditional plant breeding, the Quayle/Taylor policy prevailed and remains in place to this day.[21]

The Revolving Door: The Political Relationship Between the Government and the Private Sector

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[19] *Ibid.*

[20] United States of America. Food and Drug Administration. *Statement of Policy: Foods from Genetically Modified Plants*. By Dr. Linda Kahl. N.p.: n.p., n.d. *Comments from Dr. Linda Kahl, FDA Compliance Officer To Dr. James Maryanski, FDA Biotechnology Coordinator About the Federal Register Document*. 8 Jan. 1992. Web. 15 Nov. 2012.

[21] *The Future of Food*. Dir. Deborah Koons Garcia. Lily Films, 2004. DVD. *The Future of Food*. 2009. Web. 13 Nov. 2012.

> "Agriculture biotechnology will find a supporter occupying the White House, regardless of which candidate wins the election in November."
> – Monsanto Inhouse Newsletter, October 6, 2000

The agrifood industry is able to shape its operating environment through direct political means—primarily through efforts to influence regulatory processes both directly and indirectly. Private firms are able to lobby at the international level, in the context of international meetings of bodies that govern the global food system. Industry groups can attend meetings of international environmental agreements, such as the Cartagena Protocol on Biosafety, which addresses the transboundary trade of genetically modified organisms, or meetings of the Codex Alimentarius Commission, which addresses food standards, in order to lobby governments.[22]

Farm and industry groups heavily lobby Congress, the governing body that sets the USDA's authority, and largely support and fund politicians. Their support allows the USDA to "behave less like the industry's regulator and more like its marketing arm."[23] Several of the USDA's top officials are drawn from the agricultural industry. Many former executives of large food and or pesticide corporations like Monsanto, SYNGENTA, Tyson, Perdue, and ConAgra are offered and hold leading positions in the USDA, or vice versa through the revolving door. The "revolving door" is a term used to describe the direct method of influencing regulatory outcomes—typically individuals from the private sector are appointed to government regulatory positions and later back into business as lobbyists.[24] This way lobbyers bring industry viewpoints directly into the

[22] Clapp, Jennifer. *Food*. Cambridge UK: Polity, 2012. Print.
[23] Paul Roberts, *The End of Food*, 182.
[24] *Ibid.*

government regulatory process from which to sway regulators.

Embarrassingly, there are several examples of agricultural industry executives who have moved from the private sector to federal office and some even back again. Linda Fisher, for example, was the Executive Vice President for the Monsanto Corporation and is now the Deputy Administer for the Environmental Protection Agency. She was also a Deputy Administer under George Bush Senior's administration. She has moved back and forth from Monsanto to the EPA **three** times. Justice Clarence Lawrence serves both as Supreme Court Justice and as the Monsanto's Attorney for Regulatory Affairs. Mick Kantor serves as the U.S. Secretary of Commerce and is also on the Board of Directors for Monsanto.[25]

Another frequently cited examples is that of Daniel Amstutz, who served as vice president of Cargill feed grains division and president of its investor services in the 1960s-1970s, only to move on to the position of U.S. Undersecretary of Agriculture for International Affairs in the 1980s. He was then appointed to the office of the U.S. Trade Representative (USTR) as chief agricultural negotiator for the Uruguay Round Agreement on Agriculture. He *then* returned to work in the industry as a lobbyist, as head of the International Wheat Council and as a consultant for Cargill. Another example is Diana Banati, who was appointed as chair of the board of the European Food Safety Agency after having served as a board member of the International Life Science Institute, a lobby organization with members including agrifood giants Monsanto, Dupont, Syngenta Nestlé, and Kraft.[26] The unusual power of such large GMO firms has been

[25] *The Future of Food*. Dir. Deborah Koons Garcia. Lily Films, 2004. DVD. *The Future of Food*. 2009. Web. 13 Nov. 2012.
[26] Clapp, Jennifer. *Food*. Cambridge UK: Polity, 2012. Print.

sustained by their close ties and sizable donations to members of Congress, encouraging and promoting the consumption of GMOs to increase political funding.

Corporate Consolidation

Multinational corporations are combining and consolidating to take over the global food industry. Private corporations have solidified their role as direct mediator between farmers and consumers in a variety of sectors, from inputs, to grain traded and food processing, to food retail. Competition between these sectors for influence within the broader world food economy has only increased the pressure for more concentration. As industry becomes more consolidated, their roles within the global food system have begun to overlap. Transnational corporations in agribusiness hold the ability to shape the world food economy in order to serve their own corporate interests.[27]

Genetically modified seeds, for example, have been engineered to work in union with specific brands of chemical herbicides and pesticides. The lines between the conventionally independent ends of the input business—the seed industry and chemical industry—have become blurred as firms increasingly engage in both businesses and the functions of each are now intertwined.

Perhaps one of the most well known examples of the private sector blurring the line of its role in the global food system is the GM giant, Monsanto. Because Monsanto originated as a chemical company and world leader in global biotechnology, their usage of chemicals was standard and to be expected. However, when they crossed over into the agricultural industry, their usage of chemicals compromised the ethics of capitalism and mass production. Monsanto's crops have been genetically modified to resist the

[27] *Ibid*.

application of herbicides. Roundup Ready Soybeans, soybeans treated with the pesticide for rapid growth, account for ninety percent of all the soybeans grown in the United States. Further, ninety percent of GMOs grown on the *planet* belong to Monsanto. Of all the food sold in American stores, seventy percent contain bioengineered elements.[28]

The US pesticide industry bought out the seed industry. The manufacture and sale of pesticides is dominated by six companies, who between them accounted for 77 percent of the total global pesticides market in 2004. These companies are also fundamentally changing the nature of agriculture through the promotion of GM crops designed to withstand herbicides, thereby encouraging the purchase of the chemicals they sell. They control the vast majority of commercialized GM seeds and are continuing to expand in developing countries.[29]

The market for brand name seeds (those that are protected by patents or other forms of intellectual property protection, including genetically modified as well as hybrid seed) accounts for 82 percent of the world seed market. Three firms: Monsanto, DuPont, and Syngenta control fully 47 percent of the brand name seed market, with Monsanto alone accounting for 23 percent. The top ten seed firms account for 67 percent of that market. With specific crops, the concentration is even more pronounced. The top three firms account for 65 percent of maize seed market, and over half of the soybean seed market. Monsanto alone accounted for 87 percent of the global area planted with genetically engineered seeds in 2007.[30]

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[28] *The World According to Monsanto*. Dir. Marie-Monique Robin. National Film Board of Canada, 2008. DVD.

[29] Millstone, Erik, and Tim Lang. "Agricultural R&D: Genetically Modified Crops." *The Atlas of Food*. London: Earthscan, 2008. N. pag. Print.

[30] Clapp, Jennifer. *Food*. Cambridge UK: Polity, 2012. Print.

Intellectual Property and Patents

Patents have made it possible for these firms to dominate the market for brand name and GM seeds. The idea of patenting life forms such as seeds is in itself a controversial concept. Many argue that nature is a shared commodity, which belongs to everyone and therefore it should not be patented. Critics have raised objections to the patenting of GM crops on the grounds that discoveries about nature should not be patentable.

The 1994 WTO TRIPS Agreement aims to globally conceptualize laws providing intellectual property protection, including the patenting of plants and other life forms, across the globe. Created at the Uruguay Round trade agreement, the Trade Related intellectual Property Rights Agreement (TRIPS Agreement) set out rules on intellectual property, such as patents, as they relate to trade. It requires countries to provide intellectual property protection for inventions, including both products and processes. Importantly for the agricultural sector, this includes microorganisms and biological processes for the production of plants.[31]

This agreement states that plant varieties should be given protection either by patents or by an effective *sui generis* system, domestic protection. The TRIPS Agreement established global rules for intellectual property protection, a feat that transnational corporations in the agricultural biotechnology industry had pushed for years. The TRIPS Agreement essentially allowed GMO firms to globally market agricultural biotechnology products because they were guaranteed that their varieties of seeds would be legally protected from being replicated and sold without compensation to the firm.[32] The TRIPS agreement essentially opened the floodgates for GM corporations to buy out hundreds of

[31] Clapp, Jennifer. *Food*. Cambridge UK: Polity, 2012. Print.
[32] *Ibid.*

seeds companies and start patenting seeds. Because once you own the seed, you own the seed that has to replace that seed, and then you own the marketplace. Whoever controls the seeds controls the food.

Biotechnology companies are investing heavily in research into GM crops, and they want to ensure that they receive a financial return on their investment by controlling who has access to genes and GM plants. They are doing this in two ways. First, they are claiming patent protection for the genes they use and the GM crops and seeds they produce. This gives them control of their "inventions" for 20 years and allows them to charge royalties or license fees for their use. Farmers growing plants from patented seed have to pay royalties on any seed they buy or keep for re-sowing, raising their costs and excluding the poorest farmers from using GM seeds. Secondly, the biotechnology companies are exploring Genetic Use Restriction Technology (GURTs), which ensures that famers using their seed are forced to purchase additional chemicals that need to be applied before the new seeds or plants will function.[33]

[33] Millstone, Erik, and Tim Lang. "Agricultural R&D: Genetically Modified Crops." *The Atlas of Food*. London: Earthscan, 2008. N. pag. Print.

GURTs are also known as “terminator technology” or “suicide seeds” because the seeds are genetically engineered to yield only one planting so they then “commit suicide” and become sterile, preventing farmers from saving seeds. This process essentially locks farmers into a vicious cycle of dependency as they are forced to buy seed after ever planting. Monsanto sends letters warning or accusing farmers of saving seeds. Most farmers pay to avoid lawsuits and are forced to agree not to talk about the settlement to scare other farmers into never saving their own seed.

The patenting of seeds has resulted in the unfortunate decrease of small-scale agriculture. Because the wind and other forces of nature naturally carry seeds, genetically engineered seeds have the potential to be transmitted to other farms. Once a GM seed is cross-pollinated with someone else’s crop, the GM firm who created the seed then owns the crop. It does not matter how the GM seed got onto one’s land, whether it was carried by nature, spilled out of a truck bed, or planted intentionally by a third party. Once it is there, it is infringement on the patent.

There are countless examples of anti-GMO small-scale farms and organic farms that wanted nothing to do with GM crops but were forced into tedious lawsuits because GM seeds landed in their fields. Not only are the farms then sued for stealing a patented seed, but their crops can no longer be considered organic under federal regulations and therefore lose their organic certification and have to be shut down for years until the fields are deemed suitable for organic standards. Small-scale agriculture is diminishing due to the patenting power and legal influence of large GM firms.

The issue of patenting seeds has never been voted on by the people of the United States, nor by the Congress of the United States. It is an extremely controversial issue as GM firms ultimately argue that in patenting a gene, they own wherever that gene goes.

Therefore, if it goes into a plant, they own the plant. If it goes into an animal, they own the animal. It could even be argued that if it goes into a human, they own the human. The patenting of life gives industry the incredible power to own the species of the earth.

Labeling, or Lack There Of

Unlike in Europe, consumers in the United States cannot make an informed decision when purchasing because labels that denote a genetically engineered product are forbidden.[34] This deception is a direct consequence of the principle of substantial equivalence, which considers genetically modified foods as safe as conventional foods if it demonstrates the same composition.

Labeling of GM foods has been a continuous battle zone. In the United States, agribusiness industries believe that labeling should be voluntary and influenced by the demands of the free market. They act on the belief that if consumers show preference for labeled foods over non-labeled foods, then industry will have the incentive to regulate itself. Consumer interest groups, on the other hand, are demanding mandatory labeling. Advocates for labeling of GMOs argue that people have the right to know what they are eating and historically industry has proven to be unreliable at self-compliance with existing safety regulations.

Large GM firms, however, argue that the mandatory labeling of products containing GMOs will essentially have the same effect as placing a scull and cross bones across the product. They fear that because consumers are generally not informed, they will automatically see a product donning a GM label as poisonous due to the common

[34] All 15 countries in the European Union require labeling of GM foods.

misconception that all GM foods are “frakenfoods.” Consumer purchasing power may be dramatically swayed due to lack of information.

This may be the greatest challenge faced be a new food labeling policy: how to educate and inform the public without damaging the public trust and causing alarm of GM food products as GM corporations fear. Who is to be responsible for educating the public about GM food labels and how costly will that education be? Food labels must be designed to clearly convey accurate information about the product in simple language that everyone can understand.[35]

The FDA's current position on food labeling is governed by the Food, Drug and Cosmetic Act, which is only concerned with food additives, not whole foods or food products that are considered “GRAS,” or Generally Recognized as Safe. The FDA contends that GM foods are substantially equivalent to non-GM foods, and therefore should not be subject to more stringent labeling.[36]

Though mandatory labeling has the potential to give consumers misleading information, without labeling, there’s no traceability of the health effects of GM foods and no sole corporate responsibility. If a consumer has adverse health effects to a product, there’s no way to prove that the culprit was genetic engineering since the product is not labeled. Consumers have the right to know what they are purchasing, what they are feeding themselves, and the effects of what they are putting into their bodies.

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[35] Whitman, Deborah B. "Genetically Modified Foods: Harmful or Helpful?" *Csa.com.* CSA, Apr. 2000. Web. 13 Nov. 2012.

[36] *Ibid.*

Health Effects

> "Monsanto should not have to vouchsafe the safety of biotech food, our interest is in selling as much of it as possible. Assuring its safety is the FDA's job." – Phil Angell, Director of Corporate Communication, Monsanto; New York Times, October 25, 1998

Advocates of GMOs argue that GM foods have the potential to provide consumers with more vitamins and nutrients vital to a healthy diet. GMO opposition, however, claims that there is a casual association or direct causation between GM foods and adverse health effects. In order to assess the health effects of GM foods it is necessary to first understand how GMOs are regulated and then to analyze lab studies and evaluate the results of such experiments.

There are three different government agencies that have jurisdiction over GMOs and that are responsible for GM food consumption. The EPA evaluates GM plants for environmental safety, regulating insecticides and herbicides. The USDA evaluates whether the plant is safe to grow and assesses the environmental impact. The FDA evaluates whether the plant is safe to eat and regulates food safety.[37]

The EPA is responsible for regulating substances such as pesticides or toxins that may cause harmful implications to the environment. GM crops such as Bt pesticide-laced corn or herbicide-tolerant crops but not foods modified for their nutritional value fall under the authority of the EPA. The USDA is responsible for GM crops that do not fall

[37] *Ibid.*

under the governing of the EPA such as climate-tolerant or disease-tolerant crops, crops grown for animal feeds, or whole fruits, vegetables and grains for human consumption. The FDA has traditionally regulated pharmaceuticals, cosmetics and food products and additives, not whole foods. Under current guidelines, the FDA does not regulate a genetically modified ear of corn because it is a whole food, but a box of cornflakes is regulated because it is a food product.[38]

Because GMOs are equated to their traditional counterpart, they are easily covered by the regulations of conventional food. This is used to justify the chemical treatment of organisms, allowing the usage of poisonous chemicals and growth hormones such as RBGH and PCB. Even the FDA ignored warnings of their own scientists, who were cautioning that genetically engineered crops could cause negative health effects, and continued to lie about the safety of GMOs. RBGH, which is injected into cows for faster reproduction of dairy, has negative effects on mammary and reproductive glands. PCB, results in symptoms of Hepatitis and Cancer, the toxicity so high that PCB contaminated water killed fish in a mere three minutes.[39] Such poisoning is permissible through Monsanto's heavy influence on policymakers through the "revolving door," as previously mentioned.

An example of such corruption is exemplified by numerous lawsuits. One such example is the 2002 case when Monsanto buried polychlorinated biphenyls, or PCBs, in Anniston, Alabama, poisoning the water and surrounding neighborhoods and causing disease and birth deformities, which Monsanto hid for decades. For nearly 40 years, while producing the now-banned industrial coolants known as PCBs at a local factory,

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[38] Whitman, Deborah B. "Genetically Modified Foods: Harmful or Helpful?" *Csa.com*. CSA, Apr. 2000. Web. 13 Nov. 2012.

[39] *The World According to Monsanto*. Dir. Marie-Monique Robin. National Film Board of Canada, 2008. DVD.

Monsanto Co. routinely discharged toxic waste into a west Anniston creek and dumped millions of pounds of PCBs into oozing open-pit landfills.[40]

In 1966, Monsanto managers discovered that fish submerged in that creek turned belly-up within 10 seconds, spurting blood and shedding skin, dying immediately. They told no one. In 1969, they found fish in another creek with 7,500 times the legal PCB levels. They decided there was “little object in going to expensive extremes in limiting discharges." In 1975, a company study found that PCBs caused tumors in rats. They ordered its conclusion changed from "slightly tumorigenic" to "does not appear to be carcinogenic."[41]

Yet when taken to court, government authorities sided with Monsanto despite sufficient evidence. Monsanto and its corporate successors have avoided a regulatory crackdown, spending just $40 million on cleanup efforts.[42] If Monsanto hid what it knew about its toxic pollution for decades, what is the company hiding from the public now? Cases such as these are not uncommon and almost always favor the GM firm in order to continue receiving immense political funding. Such corruption portrays the weight of the large food industry in policy decisions regarding the regulatory framework of GMOs.

The link between PCBs and cancer is nearly as definitive as the link between cigarettes and lung cancer. A recent GE-funded study—conducted by the same toxicologist who originally discovered that PCBs cause cancer in rats—found no link to cancer in humans. And some independent scientists remain skeptical of any serious health effects from real-world PCB exposure.[43]

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[40] Grunwald, Michael. "Monsanto Hid Decades of Pollution." *The Washington Post*. The Washington Post Company, 1 Jan. 2002. Web.
[41] *Ibid.*
[42] *Ibid.*
[43] *Ibid*.

The two largest health risks associated with GMO consumption are provocation of allergic reaction, or allergenicity, and gene transfer. Allergenicity refers to the potential adverse reactions accompanying the consumption of GM products. Gene transfer from GM foods to cells of the body or to bacteria in the gastrointestinal tract causes concern if the transferred genetic material adversely affects human health. This is particularly risky if antibiotic resistance genes, used in creating GMOs, were to be transferred.[44]

Allergenicity

Many argue that GM foods are designed to produce toxin. GM corn and cotton are engineered to produce their own built-in pesticide in every cell. When insects bite the plant, the poison splits open their stomach and kills them. Biotech companies claim that the pesticide, called Bt—produced from soil bacteria Bacillus thuringiensis—has a history of safe use, since organic farmers and others use Bt bacteria spray for natural insect control.

Genetic engineers insert Bt genes into corn and cotton, so the plants do the killing. The Bt-toxin implanted in GM crops, however, is thousands of times more concentrated than natural Bt spray, is designed to be more toxic and unlike the spray, cannot be washed off the plant. Farmers use it in spray form, and companies claim it's harmless to humans. But people exposed to the spray often develop allergic-type symptoms. Mice

[44] "20 Questions on Genetically Modified Foods." *WHO*. World Health Organization, n.d. Web. 14 Nov. 2012.

ingesting Bt had powerful immune responses and abnormal and excessive cell growth, and a growing number of human and livestock illnesses are linked to Bt crops.[45]

When dispersed by plane to kill gypsy moths in the Pacific Northwest, about 500 people reported allergy or flu-like symptoms. Some had to go to the emergency room. Farm workers throughout India handling Bt cotton then reported the exact symptoms again in 2008.[46] But still scientists and GMO advocates alike argue that because Bt is derived from a natural substance, it is safe for human consumption.[47]

When GM soy was fed to female rats, most of their babies died within three weeks—compared to a 10% death rate among the control group fed natural soy. The GM-fed babies were also smaller, and later had problems getting pregnant. When male rats were fed GM soy, their testicles actually changed color. Mice fed GM soy also had altered young sperm. After GM soy was introduced in the UK, allergies from the product skyrocketed by 50%.[48]

Reproductive problems also plague livestock. Investigations in the state of Haryana, India revealed that most buffalo that ate GM cottonseed had complications such as premature deliveries, abortions, infertility, and prolapsed uteruses. 71 shepherds said 25% of their sheep fed Bt cotton plants died. In the US, about two-dozen farmers reported their pigs became sterile after consuming certain GM corn varieties. Some had false pregnancies; others gave birth to bags of water. Cows and bulls also became infertile when fed the same corn. This may or may not correlate with the escalating

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[45] "Genetically Modified Foods Pose Huge Health Risk." *Opposing Views*. Institute for Responsible Technology, 20 May 2009. Web.
[46] *Ibid.*
[47] *Ibid.*
[48] Lendmen, Stephen. "Potential Health Hazards of Genetically Engineered Foods." *Global Research*. Center for Research on Globalization, 22 Feb. 2008. Web.

incidence of low birth weight babies, infertility, and infant mortality in the U.S. population.[49]

In India, animals graze on cotton plants after harvest. But when shepherds let sheep graze on Bt cotton plants, thousands died. Reports showed severe irritation and black patches in both intestines and liver, as well as enlarged bile ducts. Investigators said preliminary evidence "strongly suggests that the sheep mortality was due to a toxin. . . . most probably Bt-toxin." In a small follow-up feeding study by the Deccan Development Society, all sheep fed Bt cotton plants died within 30 days; those that grazed on natural cotton plants remained healthy. In a small village in Andhra Pradesh, buffalo grazed on cotton plants for eight years without incident. On January 3rd, 2008, the buffalo grazed on Bt cotton plants for the first time. All thirteen were sick the following day and all died within three days.[50]

Gene Transfer

The gene inserted into GM soy transfers into the DNA of bacteria living inside our intestines and continues to function. This means that long after we stop eating GMOs, humans may still have potentially harmful GM proteins produced continuously inside their intestines. Moreover, when evidence of gene transfer is reported at medical conferences around the US, doctors often respond by crediting the huge increase of gastrointestinal problems among their patients over the last decade to GM food consumption.[51]

GMOs produce

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[49] *Ibid.*

[50] "Genetically Modified Foods Pose Huge Health Risk." *Opposing Views*. Institute for Responsible Technology, 20 May 2009. Web.

[51] *Ibid*.

> "massive changes in the natural functioning of (a) plant's DNA. Native genes can be mutated, deleted, permanently turned off or on...the inserted gene can become truncated, fragmented, mixed with other genes, inverted or multiplied, and the GM protein it produces may have unintended characteristics,"

which may be harmful. Assuming that inserted genes are destroyed by our digestive system, as industry claims, is false. They may move from food into gut bacteria or internal organs. If corn genes with Bt-toxin get into gut bacteria, our intestines may become "pesticide factories." However, there's been little research conducted to prove if it's true or false. Agribusiness giants are not looking to find out and neither is the FDA, leaving consumers to take enormous risks.[52]

Potential Benefits

Though there are numerous case studies presenting adverse health effects to GM food consumption, there are also case studies that prove GMOs to be beneficial. One notorious example of the positive potential of genetically engineered crops is *Golden Rice*. The Golden Rice Project was a result of an initiative by the Rockefeller Foundation and based on a widely recognized need for a sustainable biofortification approach to contribute to alleviating the scourge of micronutrient deficiencies worldwide. *Golden Rice* was created to help mitigate the problem of vitamin A deficiency in the world.[53]

According to UNICEF, the estimated number of children deaths precipitated worldwide by vitamin A deficiency (VAD) every year lies at 1.15 million. Many more

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[52] Lendmen, Stephen. "Potential Health Hazards of Genetically Engineered Foods." *Global Research*. Center for Research on Globalization, 22 Feb. 2008. Web.

[53] "Golden Rice Project." *The Golden Rice Project*. The Rockefeller Foundation, 2005-2012. Web.

exhibit VAD-related syndromes, among them loss of sight and increased susceptibility to a number of diseases.[54] Biofortification—the creation of plants that make or accumulate micronutrients—has the potential to reduce these numbers significantly. The aim of biofortification is to improve the primary food source of hundreds of millions of people by increasing the nutritional quality of staple crops.

In this specific case, biofortification is obtained by genetic modification of the rice plant to produce and accumulate provitamin A (beta-carotene) and zinc in the grain, which does not happen in naturally occurring rice plants.[55] For developing nations that are crop dependent a single cereal crop such as rice, as is the case in many Asian and African nations, biofortification provides the vitamins vital to a nutrient-rich diet. GM crops that are biofortified have the potential to contribute to the alleviation of life-threatening micronutrient countries. Biofortification increases consumption of essential vitamin and minerals and can have a huge impact for nutrient deficiencies.

Environmental Implications

GMOs have been praised by advocates as the only hope for maintaining agricultural productivity and in turn food security in a world affected by diversity loss, damaged soils, pesticide over-use, and facing inevitable climate change. There are fierce debates about their ecological safety as well as the broader environment when planted. Much of these debates hinge on scientific evidence, which both sides claim is in their favor.

Some of the main concerns with regard to the environmental footprint of GMOs include: the capability of the GMO to escape and potentially introduce the engineered

[54] *Ibid.*
[55] *Ibid.*

genes into wild populations, also known as outcrossing; the persistence of the gene after the GMO has been harvested, also known as a "super resistance"; the reduction in the spectrum of other plants, or loss of biodiversity; and increased use of chemicals in agriculture.[56]

Outcrossing

Outcrossing is the movement of genes from GM plants into conventional crops or related species in the wild as well as the mixing of crops derived from conventional seeds with those grown using GM crops. Outcrossing may have an indirect effect on food safety and food security. This risk is real, as exemplified when traces of a maize type that was only approved for feed use appeared in maize products for human consumption in the United States.[57] Crops may interact with related wild plants forming crop-weed complexes. If GM plants pass their new traits on to their wild counterparts, those species could be changed in a way that could make them play a different ecological role, potentially enabling them to out-compete other species. We will see DNA from crop to crop interacting in ways we have never seen before.

Super Resistance

From outcrossing stems another concern: the fear that crop plants engineered for herbicide tolerance and weeds will cross-breed, resulting in the transfer of the herbicide resistance genes from the crops into the weeds. These "superweeds" would then be herbicide tolerant as well. Many are worried that with the development of such

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[56] "20 Questions on Genetically Modified Foods." *WHO*. World Health Organization, n.d. Web. 14 Nov. 2012.

[57] *Ibid.*

"superweeds," the herbicides being sprayed will need to be stronger and the GM crops will need to be engineered to be increasingly more resistant.[58]

Over-reliance on and the abundant use of single herbicide and pesticide also lead to resistance in the pest community. The term "superbug" has even been coined to describe such phenomenon. Herbicide-resistant superweeds threaten to overgrow U.S. fields, so agriculture companies are genetically engineering a new generation of plants to withstand heavy doses of multiple, extra-toxic weed-killing chemicals. It is ultimately a more intensive version of the same approach that made the resistant superweeds such a problem. In addition to being able to survive one or two or three specific weedkillers, the intense chemical pressure could cause the weeds to evolve resistance that would apply to entire classes of chemicals.

Loss of Biodiversity

New traits conferred by genetic engineering could offer advantages that could lead to the widespread use of only a few crop varieties – in other words, a loss of biodiversity. Since GM crops reinforce genetic homogeneity and promote large-scale monocultures, they contribute to the decline in biodiversity and increase vulnerability of crops to climate change, pests and diseases, leaving consumers more susceptible to widespread outbreaks of illness. There is also the fear that GMOs are so efficient at killing pests that we'll have fields that have no insects left, so the birds will starve. There

[58] Whitman, Deborah B. "Genetically Modified Foods: Harmful or Helpful?" *Csa.com*. CSA, Apr. 2000. Web. 13 Nov. 2012.

are grave concerns that not only will GMO production result in a loss of plant biodiversity, but a loss of insect and animal diversity as well.[59]

Increased Use of Chemicals

Because of the emergence of superweeds and toxin-resistant insects, GMO opposition argues that stronger and more dangerous chemicals will be needed to combat new strands of super resistant organisms. Rather than Roundup Ready crops decreasing herbicide use, as intended and proudly plugged by Monsanto since 1996 when these crops were first commercially used, herbicide use has gone up 11%. From 1996 to 1999, Roundup Ready crops did result in a 2% decline in herbicide, but since then as resistance has developed, the opposite has been the case. In 2002, for instance, herbicide use for these GM soybeans was up 21%. In 2009-2010, it was up 24%.[60]

Rachel Carson in *Silent Spring* expresses the extreme dangers of conventional farming. In illustrating how connected we are to our Earth, she explains how the chemicals sprayed on our croplands are absorbed by the soil, entering into living organisms, plants and animals, and then into humans, passing from one to another in a chain of "poisoning and death" (Carson, 23). The chemicals also run off into nearby bodies of water, which then evaporate and are emitted back into the air to contaminate living beings.

Potential Benefits

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[59] Gertsberg, Deniza. "Loss of Biodiversity and Genetically Modified Crops." *GMO News and Analysis Food Safety Politics*. GMO Journal, 17 Jan. 2011. Web.

[60] *Ibid.*

Pest resistance: Crop losses from insect pests can be staggering, resulting in devastating financial loss for farmers and starvation in developing countries. Farmers typically use many tons of chemical pesticides annually to prevent crop loss from insects. Growing GM foods such as Bt corn can help eliminate the application of chemical pesticides by acting as an insecticide and reduce the cost of bringing a crop to market.[61]

Herbicide tolerance: For some crops, it is not cost-effective to remove weeds by physical means such as tilling, so farmers will often spray large quantities of different herbicides to destroy weeds, a time-consuming and expensive process. Plants genetically engineered to be resistant to one very powerful herbicide could help prevent environmental damage by reducing the amount of herbicides needed. GM crops are now being engineered to be unaffected by one specific herbicide. Therefore, a farmer can grow a specific crop working in conjunction with an herbicide, which then only requires one application of weed-killer instead of multiple applications, reducing production cost and limiting the dangers of agricultural waste run-off.

Phytoremedication: Not all GM plants are grown as crops. Soil and groundwater pollution continues to be a problem across the globe. Plants such as poplar trees have been genetically engineered to clean up heavy metal pollution from contaminated soil, reducing carbon emissions.

Analysis

Ethicality: Are GMOs an appropriate solution for diminishing hunger and feeding the world?

[61] Whitman, Deborah B. "Genetically Modified Foods: Harmful or Helpful?" *Csa.com*. CSA, Apr. 2000. Web. 13 Nov. 2012.

Given the multifaceted nature of GMOs and the complicated issues that arise with the relationship of GM foods and food security, are genetically engineered crops an ethical solution for feeding the hungry and an increasing population? The short answer is that yes, they can significantly contribute to a reduction in malnutrition in developing nations. Genetically modified crops produce higher yields, greater quality crops, are disease resistant, insect resistant, and drought tolerant, allowing them to be grown and consumed anywhere and granting inhabitants of non-arable land the opportunity to be food independent. Such characteristics allow for the immediate feeding and nourishing of people, thereby diminishing starvation and reducing malnutrition.

Genetically modified crops are also being designed to carry edible vaccines, making pharmaceuticals much easier to transport and administer. Biofortified GM crops such as *Golden Rice* have the potential to deliver vital vitamins and minerals to undernourished inhabitants of single crop dependent states. Genetically engineered plants have the potential to deliver abundant, nutrient-rich food to those in need. But despite all of the optimistic possibilities GMOs could bring to the masses of hungry people in third world countries, there are still several underlying issues that make ethicality of GM products somewhat questionable.

Though the potential health risks and environmental implications associated with GM foods substantially present valid evidence against consumption, perhaps most convincing argument opposing the use of GMOs to feed the world is that GM corporations will not produce for developing nations unless there is a market. The aim of GM giants is not about securing food for the hungry, such as rice for example, but rather, how can a population's dependency on rice be profited from. Relying on that for the basis

of a nation's food system is dangerous as it is essentially placing its own food security in the hands of a corporation whose intentions may not be in the country's best interest.

Terminator technology or "suicide seeds" prohibit famers from saving seeds, which is critical to the practice of agriculture. Because GM seeds become sterile after one planting, farmers are then dependent on large GM firms for seeds and are forced to purchase more after every planting. And because the seed is a patented form of technology, whoever owns the patent holds rights over it. It would not make economical sense for GM firms to design seeds to replenish themselves, as the companies would sell one round of seeds and then stop making a profit. Patenting them forces the farmer to continue purchasing, guaranteeing the GM corporation a steady income. It is also does not make economical sense for a farmer to buy seeds from a GM company as it locks farmers into a vicious cycle of dependency. It costs less to use natural seeds that can be saved and reused than to continue purchasing seeds year after year. Farmers lose their independence, along with "the right to exchange seed with other farmers and reserve seed for the next sowing, and many farmers become trapped in a never-ending spiral of debt."[62] GMO corporations are essentially buying out crops and seeds from developing nations and then making those nations pay a patent fee to grow their own crops.

Using GM crops to feed the masses is also not a viable solution from a nutritional standpoint as it is physically impossible to rely entirely on one fortified crop for all of one's vital, daily nutrients. Is it more reasonable to invest in one nutrient-rich crop at the dependency of technology or is it more reasonable to increase natural, domestic production of crops and biodiversity. A greater variety of produce is more effective in providing nutrients than relying on a single crop in the hands of technology. A wide

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variety of even two given food crops results in a more robust food base. Further, if we rely on the monoculture of one genetically engineered crop and it is struck with disease, the entire planting is ruined and there will be a greater agricultural devastation.

Because of these reasons, genetically modified crops can help contribute to diminishing hunger, but they are not *the* solution to ending it. There are too many implications associated with consuming GMOs that make it such a controversial and hotly debated subject. GM foods are an ethical complex as they are an effective "quick fix" to feeding the undernourished but it is not a sustainable solution to resolving global hunger long-term.

Conclusion

GMOs have long been praised by advocates as the only hope for maintaining agricultural productivity and in turn food security in a world affected by diversity loss, soil erosion, pesticide over-use, food crises, and climate change, but deeper assessments of their implications prove otherwise. Ecological risk is heightened with the increasing push by industry to rely on single technologies such as genetically modified organisms that have worrisome implications not just for human health, but also biodiversity loss and pesticide use. The use of genetically engineered crops to feed the hungry and nourish the malnourished is too normative a concept, proving idealistic and unrealistic, as agribusiness giants who own the patents for the GM crops allow nothing to interfere with profits. Small-scale farmers are put out of business due to the corrupt, political relationship between industry and the government and strict patent regulations within intellectual property rights.

Above all else, the world has the capacity to feed itself and therefore, as a planet, we should focus on reallocating our resources to increase access for all. Placing the fate of global food security in the hands of GM corporations with questionable intentions is not the solution to diminishing world hunger despite the potential nutritional benefits. Essentially, from a cost-benefit point of view, the risks associated with GMOs are too grave. Rather than relying on technology and creating a cycle of dependency, we should work to create biodiversity and natural methods of sustainable agriculture.

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