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The Ethics of Genetically Modified Organisms: Are GMOs Helpful or Harmful?

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AP Language and Composition

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1. Background and Problem

1.1. History of the Issue

At present, the genetically modified organisms (GMOs) industry is rapidly expanding and progressing in many ways in different sectors, ranging from healthcare to agriculture. As new GMOs continue to progress and become more sophisticated, differing opinions on policy views have emerged on how regulated the GMO industry should be. Consumers and professionals alike are divided on whether GMOs are safe, ethical, sustainable, equitable, and affordable. GMOs have shown to be very helpful in keeping up with the demand for food as the population continues to increase and helping to create revolutionary technologies that aid humans, but with many unknown adverse effects, the population stays divided on the extent of their use. This confusion, coupled with rampant amounts of misinformation, has kept many in the dark about their potential benefits for the wellness of society, and have remained unaware about how they may pose to be harmful to future generations, especially when it comes to things like biodiversity and the evolutionary repercussions of tampering with genomes. Despite this, GMOs are essential to the continual survival and well-being of humans. GMOs' potential benefits to the health and prosperity of the human race far outweigh the risks and disadvantages.

1.1.1. Early history

Evidence of genetically engineered (GE) Plants can be dated back to around 10,000 years ago in the fertile crescent, which accounts for modern-day Lebanon, Jordan, Syria, southern Iraq, and northern Egypt (Krigmsky, 2019, p. 1). The people of the Fertile Crescent would select favorable plants, usually grains such as wheat, barley, and lentils, which they would plant and cultivate for successively improved crops (Krimsky, 2019, p. 1). This process has been deemed *artificial selection*—the process of narrowing the available gene pool to yield more desirable traits such as larger fruits or better-yielding vegetables (Krimsky, 2019, p. 2). Later, in 700 BC, ancient Assyrians and Babylonians learned the basics of plant reproduction. Through *conscious classical plant breeding*—artificial pollination—they were able to eliminate more of the randomness created by natural pollination by insects (Krimsky, 2019, p. 2). Much later, in 1694, Professor Rudolf Jakob Camerer of the University of Tűbingen, Germany, further discovered the specifics of the reproductive system of plants; plants have both pollen (male reproductive cells) and the stigma (female reproductive organ) (Krimsky, 2019, p. 3). This led to the intentional crossing of plants from different species to create new ones, otherwise known as *deliberate hybridization* (Krimsky, 2019, p. 3). In the 1800s, botanical gardens became more prevalent, leading to more advances in plant breeding (Krimsky, 2019, p. 3). The methods of *inbreeding* (same strain breading, creating a genetically similar offspring to the parental generation) and *outbreeding* (genetically different strains breading, creating wide ranges of genetic variation) became two additional strategies used in plant breeding(Krimsky, 2019, p. 3).

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1.1.2. Middle history

In 1856, a major shift occurred within the realm of genetics when Gregor Mendel, a monk and scientist, performed experiments on pea plants (Ellis, 2003). He created *true breeding* strands—an organism bread with only the same genes over multiple generations—of different types of pea plants to understand the mechanisms by which parental characteristics could be passed on to their offspring (Ellis, 2003). Through many crosses of different pea plants, Mendel was able to discover the basic mechanisms of *heredity*: the passing of genes from one generation to another (Ellis, 2003). He learned the mechanisms by which some traits were passed down; some traits were more dominant than others and would present more within a population (Olby, 2005). His findings, which contained the previously mentioned principles, his laws of inheritance, and more, were presented in 1865 to the Society for the Study of Natural Sciences in Brünn (Ellis, 2003). His findings were rejected and ignored due to the prevailing beliefs of the time until 1900, when botanists Hugo de Vries, Carl Correns, and Eric Tschermak confirmed Mendel's findings through their own experiments (Olby, 2005). Mendel's findings were further distributed by William Bateson, a zoologist from Cambridge, who went on to create the term *genetics* in 1906 (Olby, 2005). In the subsequent years, scientific communities all around the world debated over the legitimacy of Mendel's research and continued to advance the field of genetics and its inner workings (Olby, 2005). Thomas Hunt Morgan introduced the use of fruit flies to genetics as a *model organism*—organisms with short generations and genetic similarity to humans—to GE as opposed to plants, which were used before. Morgan's discoveries with the genomes of flies won him a Nobel prize in 1933 for his pioneering in the field (Olby, 2005). Through the study of multitudes of other model organisms, George Beadle and Edward Tatum discovered a 1:1 ratio of genes to a given enzyme, which gave proof that genes helped yield enzymes (Olby, 2005). In 1953, scientists James Watson, Francis Crick, Rosalind Franklin, and Maurice Wilkins all aided in discovering the double helix structure of deoxyribose nucleic acid, more commonly known as DNA (Olby, 2005). Watson Enric also discovered four kinds of bass pairs with DNA that physicist George Gamow suggested could be the code for amino acids to create proteins (Olby, 2005). He then handed over the problem to biochemists, who, by 1966, had discovered many of the functions of the code (Olby, 2005). In the 1970s, recombinant DNA technologies were introduced so that scientists could directly mutate the genes of organisms in a more targeted manner (Olby, 2005). In 1975, in Asilomar, California, many researchers came together to talk about the potential dangers of taking genes from one organism and inserting them into another (Olby, 2005).

1.2. Contemporary Prevalence of Issue

GMOs began to be widely used in the 1980s and 1990s as scientists discovered that using *plasmids*— a small section of circular DNA— from viruses and bacteria is not as dangerous as originally thought (Allen, 2005). Many still argue that GMOs could have adverse effects on the metabolic functions of organisms and could affect entire ecosystems (Allen, 2005). An example of this was discovered in 1999 when corn was genetically modified to contain genes from bacteria that provided it with insect resistance, but GM corn was killing monarch butterflies (Allen, 2005). This led to many African and European Union countries tightly regulating the use of GMOs and their sale. In the 21st century, GMOs have continued to be used throughout agriculture and even in medicine when treating human genetic diseases, such as sickle cell anemia and Huntington's disease/ cystic fibrosis (Allen, 2005). There have been other controversial uses of GE technology that have been widely rejected by the scientific community, such as when scientist He Jiankui genetically edited children using *CRISPR* technology— a precise gene editing and cutting tool—in 2018 ("Chinese Scientist Employees CRISPR Technology to Genetically Edit DNA of Children and Reports on the Procedure, November 25, 2018", 2019). Professor He edited the genome of two Chinese girls at the embryonic stage to prevent them from contracting HIV later in life without the knowledge of their parents and then presented his findings at the human genome editing summit at the University of Hong Kong ("Chinese Scientist Employees CRISPR Technology to Genetically Edit DNA of Children and Reports on the Procedure, November 25, 2018", 2019). Though Professor He's cause was theoretically good, with the many unknown variables, the impact that the experiment could've had on the twins during development stages and afterwards was completely unknown ("Chinese Scientist Employees CRISPR Technology to Genetically Edit DNA of Children and Reports on the Procedure, November 25, 2018", 2019).

1.3. Complications with Issue

The lack of scientific census over the extent of GMOs' uses and safety has led to a lack of decisive action towards the regulation of GMOs across industries, but if there is an over-regulation of them, there will be significant losses to human progression and preservation (Krimsky, 2019, pp. ix-xxii). If we don't continue to genetically modify

organisms to protect humanity, then how is our current society supposed to support our growing population? GMOs are being closely monitored by the scientific community, which is continuously striving to try to prevent any harm from being done by GMOs (Krimsky, 2019, pp. ix-xxii).

2. Controversy

2.1 Two sides

2.1.1. Side 1: GMOs are you useful and should be used liberally without many regulations.

2.1.2. Side 2: GMO are dangerous and should be heavily regulated.

<table>
<tr><th colspan="2">Controversy</th></tr>
<tr><td colspan="2">1. Genetically Engineered Crops:
Nuance: Do the broader benefits that come with tailored plants outweigh their evident shortcomings?</td></tr>
<tr><th>A. Crops should be genetically modified</th><th>B. Crops should not be genetically modified</th></tr>
<tr><td>- Herbicide-resistant plants significantly decrease the amount of labor required to remove weeds (Krimsky, 2019, p. 39).
- Some plants are engineered to have insect resistance, so harmful pesticides don’t need to be sprayed on them (Food and Drug Administration, 2024).
- GM crops can be tailored to specific consumer benefits, such as having soybeans create healthier oils and GM apples that do not brown when they are cut to reduce food waste (Food and Drug Administration, 2024).
- GM crops have also increased food security due to their increased yield and shelf-life (Food and Drug Administration, 2024).</td><td>- Across the three primary herbicide-resistant GE plants there has been a 239 million kg increase in herbicide use as opposed to if they had not been introduced (Krimsky, 2019, p. 44).
- A common herbicide known as glyphosate that is used on herbicide-resistant plants could possibly be cancer causing (Krimsky, 2019, p. 46).
- Due to the increased use of herbicides, more herbicide-resistant strands of weeds, superweeds, are popping up (Krimsky, 2019, p. 44). In the United States, there have been 14 species that are glyphosate (A Common herbicide used in the United States) resistant (Krimsky, 2019, p. 44).
- Golden rice is a crop engineered to have increased amounts of vitamin A (Krimsky, 2019, pp. 119-125). Many are apprehensive of its widespread use because of the unknown potential health risks (Diaz et al., 2025).
- There is a potential for the creation of new allergies (Allchin, 2014).</td></tr>
<tr><td colspan="2">2. Genetically Modified Animals:
Nuance: Is there an extent to where animals can or cannot be modified?</td></tr>
<tr><th>A. Genetically modifying animals helps humanity</th><th>B. Genetically modifying animals is cruel</th></tr>
<tr><td>- Cattle have been modified to keep them healthier, to change their milk composition, and for tumor prevention (Lievens et al., 2015).
- Salmon has been modified to grow larger and have improved cold tolerance (Lievens et al., 2015).
- Sheep have been modified for greater wool production, animal health, and disease resistance (Lievens et al., 2015).
- Animals have been modified to do molecular farming in order to produce</td><td>- Mice have commonly been used and modified in lab settings, which has raised concerns about their welfare as their use only continues to increase (Dennis, 2002). From 1994 to 2001, there was a 161.3% increase in mice used in labs (Dennis, 2002).
- When animals are GE with new lines of DNA, they can introduce new traits to entice lineages, which can have unintended evolutionary consequences (Dennis, 2002).
- In the initial testing phase of mutations on particular genes, unintended consequences</td></tr>
</table>

biopharmaceuticals through their metabolic pathways and protein production (Lievens et al., 2015). - Some animals, such as pigs, have had genetic modifications in order for them to be fit for animal organs to be transplanted into people (Lievens et al., 2015). - Animals have been modified to be suitable pets (Lievens et al., 2015). - Mosquitoes have been genetically engineered to create a protein called SM1, which helps to prevent malaria (Diaz et al., 2025). - Male Aedes aegypti mosquitoes were modified to have sterile offspring after reproducing (Diaz et al., 2025). They were then set off in Brazilian suburbs, causing the population to drop by 95% (Diaz et al., 2025).	can occur (Dennis, 2002). When given a hormone to increase the expression of their own growth hormones, mice have had increased liver failure, kidney failure, tumor production, and a shorter lifespan (Dennis, 2002).
3. Genetically Modified Organisms in Medicine: **Nuance:** Should humans be genetically modified or should genetic modifications only be used in other organisms for the sake of medicine?	
A. GMOs should be used in medicine	**B. GMOs should not be used in medicine**
- GMOs have revolutionized medicine beyond recognition since before their use beginning in the 1980s (Diaz et al., 2025). Animals have been used to test treatments for human genetic diseases (Diaz et al., 2025). - Baker's yeast has been genetically modified to be a safer Hepatitis B vaccine producer (Diaz et al., 2025). Genetically modifying vaccines make them much safer, inexpensive, and painless (Diaz et al., 2025). - E. coli bacteria have been genetically modified by inserting a piece of DNA to produce insulin to help treat diabetes (Diaz et al., 2025). - Lab-grown mammal cells are used to produce medicine (tissue plasminogen activator) for heart attack and stroke patients (Diaz et al., 2025). - Genetically modified plants have helped create edible vaccines that are more shelf-stable and can be used in parts of the world where refrigerators and sterile needles are limited (Diaz et al., 2025). - Genetic engineering has allowed scientists to make DNA vaccines for major diseases such as cancer, tuberculosis, and HIV/AIDS by stimulating the body's immune system to directly attack the diseases (Diaz et al., 2025). - Some diseases, such as sickle cell anemia, have been treated through stem cell therapy,	- In 2018, Dr. He genetically engineered the germline cells of two twins to be HIV resistant ("Chinese Scientist Employees CRISPR Technology to Genetically Edit DNA of Children and Reports on the Procedure, November 25, 2018", 2019). This proved to be highly controversial since he did not take proper precautions to look out for the long-term adverse effects that it could have had on the twins ("Chinese Scientist Employees CRISPR Technology to Genetically Edit DNA of Children and Reports on the Procedure, November 25, 2018", 2019). - Doing experiments on the human genome opens up the possibility for eugenics, which is a philosophy that studies how some inheritable traits are believed to be superior to others ("Chinese Scientist Employees CRISPR Technology to Genetically Edit DNA of Children and Reports on the Procedure, November 25, 2018", 2019). This philosophy was generally dismissed after World War II when Nazi Germany conducted ethnic cleansing based on it (Wilson, 2024). People fear this type of thinking will be reopen if medicine continues to directly edit the human genome ("Chinese Scientist Employees CRISPR Technology to Genetically Edit DNA of Children and Reports on the Procedure, November 25, 2018", 2019).

where they get the corrected gene is introduced into the bone marrow (Diaz et al., 2025).	- Scientists are still unaware of the long-term effects of medical GMO use from both an evolutionary and medical perspective (Diaz et al., 2025).
4. Economic Impacts of GMOs: **Nuance:** Who is actually benefiting from GMOs?	
A. GMOs benefit the economy	**B. GMOs have negative impacts on the economy and create financial barriers.**
- GE crops tend to produce more crops per harvest than non-GE crops due to insect resistance and an increased yield, leading to more profit per harvest (Brookes & Barfoot, 2014). The added properties of GMO crops also allowe farmers to save on pesticides and herbicides, inadvertently lowering labor costs at the same time (Brookes & Barfoot, 2014). Farmers can spend less time on weeding and pest prevention (Brookes & Barfoot, 2014). - Globally, the use of herbicide-resistant soybean plants has boosted farm income by $4.8 billion in 2012(Brookes & Barfoot, 2014). In the same year herbicide-resistant corn globally brought in roughly $147 million in net farm income gains (Brookes & Barfoot, 2014). - GM soybeans are more cost-effective than traditional ones because they yield six dollars more per acre (Kruft, 2001, p. 3).	- GE crop seeds are significantly more costly than standard seeds (Brookes & Barfoot, 2014). Higher costs can pose a major struggle for smaller farmers in developing nations (Brookes & Barfoot, 2014). This creates a disparity between large and small farms because they can glean all the benefits without taking a large financial hit (Brookes & Barfoot, 2014). - GE plants that have herbicide and pesticide resistance tend to eventually have lessened effects as weeds and pests evolve to have natural resistances (Brookes & Barfoot, 2014). Farms then have to spend more money to have the weeds removed and get improved seeds (Brookes & Barfoot, 2014). - GMOs, especially GE plant seeds, can be subject to becoming patented and labeled as intellectual property (Krimsky, 2019, p. xv). thus, farmers are not allowed to reuse seeds from their harvested GM plants (Kruft, 2001, pp. 3). - Internationally, GM Crops do not sell well as the EU has regulations against them (Kruft, 2001, p. 7). Instead, the EU opts to buy the crops from other nations (Kruft, 2001, p. 7). In 1996, America's export to the EU of soybeans and corn was 3 billion which then significantly dropped by the year 2000 to 1 billion with the increased use of genetic modification (Kruft, 2001, p. 7).
5. GMO Labeling: **Nuance: Does labeling impact consumer behaviors?**	
A. GMOs should be labeled	**B. GMOs should not be labeled**
- The majority of Americans want Foods containing genetically modified ingredients to be labeled; Polls show that up to 90% of Americans want GM foods to be labeled (Burgaard, 2013, pp. 55-56). - Many consumers feel as though there are long-term uncertainties for the health of those who consume genetically modified foods, so for the sake of consumers' choice GMO foods should be labeled (Burgaard, 2013, p. 56).	- Around 2013, more than 70% of processed foods contained genetically modified ingredients (Burgaard, 2013, p. 55). If everything with genetic modifications were to be labeled, it would become somewhat meaningless (Burgaard, 2013, p. 55). - After mandatory labeling went into act in Vermont, public opinion of GMOs dropped by 20% (Gordon, 2018). The officials were hoping in the long run it would have the opposite effect so far those results are yet to be seen (Gordon, 2018).

- To maintain general transparency within the food industry, many believe that GMOs should be clearly labeled (Gordon, 2018). - The labeling of GMOs on trusted brands and products can bring more public faith in the use of genetically modified products (Gordon, 2018).	- Labeling GMO foods is costly and can on average increase the price of good as food packages would need to redesign and package their foods (Burgaard, 2013, p. 56).

3. Conclusion and Limitations

The argument about whether GMOs should be widely used is far more complex than a simple yes or no. With so many unknown repercussions, widespread misinformation, and fear-mongering taking place around the subject of GMOs, it is hard not to doubt if they are something that we should be using. Even when setting all of that aside, the use of GMOs in many cases has created inequity, most of which is financial. If this is the case, should we continue expanding or limiting their use?

I feel as though GMOs should continue to be used throughout many different industries. I believe the positive impacts on food security and advancements in healthcare specifically greatly outweigh the negative ones, many of which are theoretical and are being well-researched and monitored to make sure they do not get out of control. Rather than cutting down on its use, we should instead be focusing on strategies to lower costs and increase access through both government-assisted programs and NGO resources. The government can help with the regulation of GMO use, as they did with the labeling of GMOs, and with oversight on future experiments through the use of ethics boards. NGOs can provide financial help to farmers in developing nations to buy the necessary seeds or provide funding to help families with financial struggles get GMO-based medication if they wish to do so. Such financial programs can be created by connecting nonprofits to private hospitals in low-income areas, which can evaluate and distribute financial aid. Progression should not be stopped out of the fear of change. My limited access to current research sources has confined my knowledge and decision-making in this matter. Not only is genetics a scientific field requiring up-to-date information, but it is also a rapidly expanding field of study with newinnovations coming out constantly. Much of this new information is behind paywalls and rendered inaccessible to the general public. My information is also limited by my inability to conduct comprehensive research on the personal opinions of people now who may have a better understanding of GMO research.

4. Personal Reflection

Before writing this paper, I already had a firm agreement with the wide use of GMOs. By doing this project, I feel as though it has helped me realize that lack of knowledge and strict oversight is a reoccurring reason for much of the doubt surrounding GMOs rather than the GMOs themselves. I think I still have a lot to learn about the inequalities created by GMOs in commercial spaces before I can give a definitive answer about wanting their use to be expanded, but for now, I believe that their use should continue because, ultimately, it is not the technology itself doing harm. The way scientists and corporations apply the technology becomes the issue. GMOs have created a space in many markets to have cheaper resources, but they are still being blocked from the people who could benefit from them the most. I feel like the technology itself is a fantastic innovation that should not be hindered by the fear of those who do not have sufficient knowledge on the topic. However, we should definitely not disregard the warnings of those who do.

5. Conflict of Interest

The authors declare that they have no conflict of interest.

6. Funding Declaration

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