Genetic engineering, starting in the late 1950's, opened up a multitude of doors for scientists and people everywhere. The Union of Concerned Scientists defines genetic engineering as a set of technologies used to change the genetic makeup of cells, including the transfer of genes within and across species boundaries to produce or improve organisms. Genetic engineering is the deliberate modification of the characteristics of an organism by manipulating its genetic material by inserting, deleting or moving a gene sequence. Scientists began developing these techniques approximately twenty years ago and technologies have been progressively improving and advancing this field at an exponential rate. Genetic engineering is one of the few ways we can leave a positive impact on society as seen from a variety of approaches. From an environmental perspective, genetic engineering has many beneficial impacts on agriculture, therefore decreasing hunger. In addition, the reason for the consistent rate of growth and advancement in genetic engineering is due in part to its numerous economic contributions to livestock, agriculture as well as human health and advancement. Not to mention, patients suffering from gene-related illness could now be treated thanks to the discoveries of Watson and Crick, who developed the first techniques in genetic engineering. There are virtually limitless possibilities to the uses of genetic engineering, though this is where the controversy comes into play. There are many ways genetic engineering can be viewed. Genetic engineering should not be suspended due to its overwhelming successes that are yet to come, in turn outweighing the current cons. These successes can be seen in the future of human gene therapy and the discovery of cures to many fatal illnesses.

Human gene therapy can be defined as "Insertion of normal DNA directly into cells to correct a genetic defect. The treatment of disease by replacing, altering, or

supplementing a gene that is absent or abnormal and whose absence or abnormality is responsible for a disease," according to the article "Human Gene Therapy". When it comes to this type of treatment, research is everything. Genetic engineering is opening up doors leading to new concepts that once were never feasible. For example, as seen through the lens of science and technology, Designer T Cells are a breakthrough in pediatric oncology that would not have been discovered without the use of genetic engineering. This type of human gene therapy is used to harness a child's immune system to be able to fight back against cancer cells. This approach, called immunization, works to build up the child's immune system with the goal to fight the cancer. Using Designer T Cells to fight cancer, is an alternative to chemotherapy and was once used in laboratories, but is now being tested on children with some successes. Stated by MD Anderson Cancer Center, "T cells are a major source of immune cells that a human body relies on for detecting and destroying abnormal cells. Most times, a patient's cancer learns to disguise itself and hide from the patient's T cells, leaving an ineffective immune system." ("Cell-ebrating the Use of Designer T Cells and NK Cells") Laurence Cooper, M.D., Ph.D., has invented the gene transfer approach called Sleeping Beauty. This tactic uses genetically altered T cells that are tumor specific helping to rid the patient of cancer. This capability now allows MD Anderson researchers to potentially improve the graft-versus-leukemia (GVL) effect after bone marrow transplantation and, in particular, after umbilical cord transplantation. Cancer research is a main field of study largely affected by genetic engineering, proving just how important this innovation is to society everywhere.

As science progresses, an increasing number of less invasive approaches are being found to aid in the wiping out of certain genetic diseases. Along these lines are Chronic

heart ailments, Asthma, Diabetes, Infertility, Multiple Sclerosis and Cancer, as stated before. Many mothers undergo genetic screening of the fetus to prepare for any genetic disorders or special needs their child may have. There are hopes that genetic engineering can also be used to cure fetal diseases to ensure all babies are born healthy. Another benefit to genetic engineering is in the addition of superior pharmaceutical drugs. This would mean through cloning and other approaches, drugs could be made better with increased benefits and be more affective for patients on such prescribed drugs. Now on the market there are bio-engineered insulin (which was previously obtained from sheep or cows) and human growth hormone (which in the past was obtained from cadavers) as well as bio-engineered hormones and blood clotting factors, according to the article, “What are the Benefits of Human Genetic Engineering?” Genetic engineering can also be used to treat SCID (Immunodeficiency Diseases), which is caused by lack of an enzyme due to a single abnormal gene. The missing gene is introduced into a harmless virus, and then mixed with progenitor cells from the patient's bone marrow. After this is done the gene splices into the genes in the bone marrow and the treated bone marrow produces the missing enzyme. The immune defenses are then revitalized. This breakthrough in genetic engineering called immune therapy helps to restore the patient’s immune system giving them a better chance to beat the cancer. One the other hand, genetic engineering used to help produce new pharmaceutical drugs and alter one’s internal systems may be faulty in that while using such techniques, man will again be a product of mechanics and science. This could lead to a loss in individuality if such tools are placed in the wrong hands. Another drawback of genetic engineering, is how pricey the treatments are.

The Genetics Schools of America state that, in regards to benefits of genetic engineering, “Plant genetics remains a key component of global food security, peace, and prosperity for the foreseeable future. Millions of lives depend upon the extent to which crop genetic improvement can keep pace with the growing global population, changing climate, and shrinking environmental resources.” As resources on Earth decrease, and population increases, genetic engineering is one of the only pieces of science that can help us to maintain the quality of life we currently live. The number of people on Earth is expected to increase from the current 6.7 billion to 9 billion by 2050. To accommodate the increased demand for food, world agricultural production needs to rise by 50% by 2030, according to the Royal Society. Since the amount of farmable land is only limited to a certain extent, and what is left over is being taken over by industrialization, salinization, and desertification, it is no longer possible to open up new land for farming to meet needs. Genetic research and continual improvement in engineering is important to enhance the sustainability of farms. Not only can genetic engineering be beneficial in regards to how long food may last, but it also is beneficial in regards to overall production of a certain crop. For instance, genetic engineering can make foods look or feel more appealing, aesthetically and sensory. Not to mention, the rate of production of crops such as corn, increases greatly. This is important to farmers, consumers, and the rising global population. When a scientist introduces genes into an original organism, whether or not they are changing the true function of the organism, genetic engineering is extremely important modernly to ensure security in agriculture. By developing herbicide tolerant crops, it will overall reduce the application rates for herbicides used on herbicide resistant crops; this is according to the Genetic Modification website. This means that if scientists have to ability

to engineer new forms of herbicide, by implementing new genes into the organism, it will tremendously reduce the amount of herbicide necessary for farming and agriculture. This also reduces the stress load on not only crops, but farmers as well. Farmers continue to stick with genetically modified crops; in fact, they rely heavily on it for abundant food production. GMO Compass provides information supporting this in regards to real world farmers. Research shows that In Spring 2013, there were 90 million hectares of genetically modified plants, which is one million more than in 2012. It is clear that regardless of the increase in public debate surrounding genetic engineering in plants, an alternative is nowhere in sight.

Vaccinations have been around for centuries. Evidence exists that even the Chinese employed smallpox inoculation as early as 1000 CE. It was practiced in many places worldwide in including Africa and Turkey. This evidence is derived from the College of Physicians of Philadelphia. Currently, advanced and innovative techniques in regards to genetic engineering drive the research of vaccines- along with DNA technology, and modified ways of delivery. It is clear that disease targets are widening and further vaccine studies are being conducted to focus primarily on non-infectious diseases. Diseases such as drug or alcohol addiction, or even allergies may have the ability to be treated by genetically engineered vaccines.

World hunger remains to be one of the largest problems we face globally today. However, genetic engineering has the ability to make it become less of a problem. Genetically modified foods grow faster; more abundantly, they are protected from disease, and are more aesthetically appealing to people consuming the foods. It has been noted that genetic engineering cannot help starving individuals because more than enough food is

being produced. Rather, claiming that the real problem lies in that people of developing countries do not have access to land on which to grow food, or do not have the money to buy food( Sarah Sexton).Yet, this statement can be represented as irrelevant. Regardless of how much genetic engineering can positively affect developing nations, it still helps to some extent. For example, if a child does not have access to freshwater in a certain region, that is not a reason to eliminate water as a whole. Time will only tell when all people have access to foods, and when that time comes for all humans, plants, and animals, genetic engineering will be the saving factor in our quality of life.

From an economic standpoint, genetic engineering has generated significant improvements for the farming industry, which have resulted in benefits for both farmers and consumers. The proliferation of these technologies have been inspired by the increases in agricultural productivity which are essential following the "commodity price inflation of 2007/2008, the increased investment in biofuels, growing populations around the world, and the concern about greenhouse gas emissions", according to "The Economic Impact of Genetically Engineered Crops", a publication of Agriculture & Applied Economics Association.

Through biotechnology, scientists have developed insect resistant traits that allow plants to produce naturally occurring chemicals, which provide crops with a natural defense against common insects. The insect resistant traits instilled in many genetically modified crops have proven to be quite efficient because they not only save the farmer money by eliminating the need to purchase pesticides as well as the time and expense of applying them (consider the immense conservation of fuel, water, and containers), but also by improving overall crop yields. Insect resistant traits are also referred to as *damage control*

*agents*, as they reduce the amount of crop losses a farmer experiences. An equation presented in the *Impact of Genetically Engineered Crops on Farm Sustainability in the United States* shows that the observed yield is equal to the potential yield after you subtract the damage, with the potential yield being the yield that would be possible if not accounting for the damage that could be controlled with pesticides or the adoption of genetic engineering techniques. By decreasing the overall costs of damage, genetically engineered traits allow farmers to improve yields and profit when farming marginal land that could not be as profitable with conventional seeds and methods.

However, insects aren't the only pests which have proven to be detrimental to crop yields. The State of Florida, widely known for growing oranges, continues to fight a vicious bacterial disease called "Citrus Greening" that is spreading across orchards all over the state as well as every orange-growing region in the United States. Erik Mirkov, a plant pathologist at Texas A&M University, has contributed much of his time and effort to finding a solution to this problem. Mirkov, along with a group of Spanish scientists have identified a particular defense protein found in spinach, which has the ability to attack various strands of bacteria and fungi. Mirkov and his colleagues then incorporated this protein into an orange tree's DNA as a natural defense. This innovation has been integral in saving Florida's $9 billion citrus industry. From a global perspective, insect resistant traits have shown greater yield effects in comparison to herbicide tolerance traits. This is particularly true in developing nations based on a global survey of genetically engineered crop use. It has been noted that while insect resistant traits increase yield efficiency, herbicide tolerance traits only have the effect of making damage control cheaper and easier.

Not only do engineered genes create larger yields, but they also positively impact farmers' costs related to "crop insurance", with some farmers even receiving insurance premium discounts if they utilize genetically modified seeds. Therefore genetically enhanced crops can save farmers a significant amount of money and are seen as a "good investment" as they allow cultivators to surpass the "Break Even" point, thus improving their potential revenue. Consumers also benefit from the use of genetic engineering technologies in crops, such as insect resistant and herbicide tolerance, as they have shown increases in productivity, reduction in food prices and improvements in environmental quality, such as increased drought resistance.

As briefly discussed, genetic engineering has resulted in significant economic benefits in industries involving animals, such as the cattle industry. Through genetic engineering, this segment of the food supply has increased in yield as well as profitability Recently, cloning has become common among Australian scientists who have begun selling clones of top breeding bulls, whose offspring produce exceptionally more meat, propelling the multi-billion dollar beef and dairy markets. Similarly, the fish industry is also being impacted through genetic engineering, as the growth in the world's population requires increase in the food supply. As an example of the trend of proliferation of genetic engineering within the US domestic market, the submission of an application to the United States Food and Drug Administration to approve the commercial development of genetically engineered Atlantic salmon.

To continue, genetic engineering is worthy of investment because it has proven successful in improving the quality of life as well as lengthening the human lifespan through the use of gene therapies. These benefits have been demonstrated thorough efforts

using genetic engineering to create cures for diseases by means of cell transplants. For example, “regulatory T cells”, or cells that actively participate in immune response, would aid doctors in treating autoimmune diseases such as type 1 diabetes, rheumatoid arthritis, and cases of organ transplants. Furthermore these methods can help keep people alive during the time they are waiting for an organ transplant, through the use of cell transplants that mimic the function of the particular organ the patient needs. Cell therapy, also referred to as immunotherapy, is becoming more popular and has the potential to reduce the need for ongoing treatment using immunosuppressive drugs. There are now dozens of early human trials around the world, according to the *Magazine of the Society for Science and the Public*, and the pharmaceutical industry is beginning to invest. In addition, according to the Worldwatch Institute: Vision for a Sustainable World, “The number of patents pending for human DNA sequences has gone from 4,000 in 1991, to 500,000 in 1998, to several million today.” This statement alone shows how promising genetic engineering is and how positively it affects the market, now and in years to come.

On the other hand, some may say genetic engineering should be suspended because it is unethical and of extrinsic concerns. These concerns include potential health and environment risks, as well as considering deter mining the potential length of suspension and if this should be a national or international movement. According to Anna Kirkpatrick in a petition to the Office of the Auditor General of Canada, there are serious risks of genetic engineering to human health and these include “allergic reactions, increased toxicity, spread of genetic material from crops manipulated to produce pharmaceuticals and the problems associated with increased pesticide applications.” In her petition, she states the concerns for human health and environmental consequences and that genetic

engineering poses a threat to sustainable development. Kirkpatrick raises questions on the production and licensing of genetic engineering along the lines of human health, agriculture, and biodiversity. For example, there was an experiment where yeast was genetically engineered to improve alcohol fermentation which yielded thirty times the concentration of methylglyoxal compared to the controlled non-genetically engineered strain. Methylglyoxal is a highly toxic compound, and this experiment resulted in unexpected allergic reactions. Genetic engineering is advancing to produce prescription drugs such as growth hormones, vaccines, and industrial enzymes. With this advancing production, there is a great risk of genetic contamination. What if a pharmaceutical-producing gene were to leak into agricultural crops? What if cross-pollination were to occur with a non-genetically modified plant and a growth hormone? The consequences would most likely be severe. In Kirkpatrick's petition, she claims that genetic engineering increases dependence on pesticides and other chemicals; the health risks of pesticides are widely recognized. The risks include the linking to various cancers and disorders of the immune and neurological disorders. In addition to health concerns, Kirkpatrick provides evidence for environmental concerns. Genetic engineering will eventually create new species because it combines genetic material from different species of organisms. This biological contamination would be a major threat to the environment, even more than chemical and nuclear contamination to the environment. Genetic engineering is not worth the consequences to human health and the environment, according to Kirkpatrick's petition. Genetic engineering is unethical through extrinsic concerns, however does not pose enough of a concern for its suspension.

Keeping all of this in mind, it is very necessary that we develop a solution to the current setbacks regarding genetic engineering. Further research is needed to understand the economics of the biotechnology industry and how it is affected by regulations and incentives. This may help to further improve the regulatory environment and generate conditions under which GE technologies can provide can provide greater welfare improvements and promote environmental sustainability. In addition, it would be very beneficial to educate the public on the current benefits of genetic engineering. This would be possible through government funded programs like those already intact for diagnosis like obesity and the harmful effects of smoking.

In summation, genetic engineering should not be suspended by any means because it provides countless benefits to society. These benefits can be seen from the perspectives of science and technology, economics, health, and the environment. Genetic engineering is an inevitable notion; therefore research and experimentation should be pursued. However, genetic engineering may be viewed as unethical from animal and human rights activists and scholars that claim that genetic engineering can actually harm health. Despite the unethical consequences, genetic engineering should continue to be researched and applied due to the benefits of expanded knowledge and potential health benefits. Continual development of genetic modification will sustain our ever-growing population for years to come.

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