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Genetic Engineering: Stirring up Genes and Opinions

Imagine you're living in the year 2075. Fifty years ago, the process of genetic engineering for gene selection became a popular method for predetermining the physical, mental, athletic, and personality traits of babies. Although parents have been genetically engineering their children for many years, some families still prefer to allow their children's genes to be naturally determined. At the young age of ten years old, most of the students in your fifth grade class had parents who selected genes to improve their child's characteristics. On the other hand, your parents chose not to engineer your genes and allow you be created naturally. On occasion, the other students ridicule you for your slowness on the soccer field, poor math skills, and short stature, but for the most part you can sufficiently compete with your genetically engineered counterparts.

Within the past forty years, genetic engineering has rapidly developed from a complex scientific enigma to a commonly used method for manipulating the genetic makeup of plants, animals, and humans. Those with an understanding of the political, social, and economical outcomes of genetic engineering are very split on the subject. While supporters see the value of employing genetic manipulation to prevent disease, improve human traits, and develop more effective medicines and foods, critics claim that genetic engineering can lead to a vicious society of the genetically rich and the genetically poor. In the meantime, the technologies and methods of genetic engineering are rapidly growing and influencing more related areas of gene

manipulation including cloning, transgenics, and gender selection. With such huge advances in the science of genetic engineering, so have arisen even more controversial developments in the ethical debate over genetic engineering.

Before diving into the differing ethical viewpoints of genetic engineering, it is first necessary to clearly define genetic engineering and the process through which it occurs. According to *Webster's New World Dictionary*, genetic engineering is "the branch of biology dealing with the splicing and recombining of specific genetic unity from the DNA of living organisms as in order to produce new species or biochemical." While this technology may seem like it comes straight out of a science fiction novel, the process that genetic engineering entails is actually quite simple. Robert Baird, in his scholarly article titled "Designer Babies: Eugenics Repackaged or Consumer Options?" states that gene therapy, the most commonly used form of genetic engineering, involves inserting a normal gene into a nonspecific location within the genome to replace a nonfunctional or undesirable gene. Other forms of gene therapy include exchanging an abnormal gene for a normal gene, repairing abnormal genes, or altering the degree to which a gene is "on" or "off," as the online article "Gene Therapy" outlines. All of these methods have proven to be useful and effective ways of performing genetic engineering, but all come with risks and ethical dilemmas.

Since the beginning of civilization, man has been genetically engineering plants and animals without the use of microscopes, petri dishes, or the knowledge of DNA. Natural selection is nature's form of genetic engineering which occurs through the mating or organisms who are the best equipped to survive. Arthur Kerschen, who works as a Research Specialist at the University of Arizona, in his article "Human Cloning and Genetic Engineering," points out that, through the process of natural selection, nature has edited the gene pool to create the

strongest, smartest, and largest humans yet. Compared with the human generation of medieval times, modern humans appear like a race of "super humans," a common fear of those who feel that genetic engineering will create a whole new human race. Man's form of controllable natural selection, known as selective breeding, has been used throughout history. Ever since the first shepherd bred his strongest ram with his fattest ewe, humans have been selectively altering the gene pool. Selective breeding is one of the simplest forms of genetic manipulation with some of the largest results. However, as Sonia Suter shows in her *Berkeley Technology Law Journal* article "A Brave New World of Designer Babies?" genetic engineering differs from natural selection and selective breeding in the sense that genetic engineering manipulates the gene pool by targeting specific genes in individual organisms instead of breeding two animals and hoping for the desired result. Genetic engineering in the laboratory is much more precise than natural selection or selective breeding but is also more untested (Kerschen, 2).

Another, even more controversial, form of genetic engineering is the cloning of humans using the nucleus of a single somatic cell. Cloning is a more extreme form of genetic engineering that completely replicates the cell and DNA of the original cell, which Don Peysum explains in his web article "Human Cloning and Genetic Engineering: Ethical?" While scientists are unsure about the potential uses of cloning, they speculate that cloning could be a viable source for reproduction, organ donations, or genetic manipulation. After all, they say, identical twins are, in a sense, nature's clones and share 100% of their genes. However, critics claim that "cloning involves unethical experimentation, threatens identity and individuality, turns procreation into manufacturing, and means despotism over children and the perversion of parenthood" (Peysum, 1). Sociologists fear that cloned "children" will cause family problems when an adolescent clone resembles her mother and catches the sexual attention of her father. Another concern is that the

clone would be deprived of a true "sense of self" in the way that the clone would already have all of its dreams, expectations, failures, and disappointments pre-determined because it would be reliving the life of the older organism. While cloning may not be as logical or feasible an option as gene therapy, the future of the human population may lead toward a society of clones created to contain a few select genes.

A related branch of genetic engineering involves the mixture of plant, animal, and human genes to create transgenic organisms. These organisms contain a transgene introduced by technological methods rather than through selective breeding. Linda MacDonald is a bioethicist whose research encompasses the legal, ethical, and social impact of emerging technologies and "evolving notions of personhood." In her internet article, "Ethical Issues in Genetic Engineering and Transgenics," explains the various uses and methods of the mixtures of genes from different species. Transgenics allow scientists to develop organisms that express a novel trait not normally found in that species, for instance a mosquito that provides humans with the vaccine for tetanus when it bites them to drink blood (MacDonald). Possible transgenic combinations can be broken down into three categories: plant-animal-human combinations, animal-animal combinations, and animal-human combinations. A popular use for transgenics includes pig organs that humans can use for organ transplantation. However, with the combination of animal and human genes, there is a small but significant risk of the transmission of fatal zoonotic diseases, such as mad cow disease of bird flu. Ethicists are concerned about the potential of transgenics to blur the lines between species and to redefine exactly what it means to be a human. However, the simple genetic engineering of humans using only human genes creates much fewer zoological issues (MacDonald).

Now that a background of genetic engineering has been established, it's important to outline the forms of genetic engineering or gene therapy that already exist. The most popular method of gene manipulation today is pre-implantation genetic diagnosis, or PGD (Baird, 2). This technique is currently used as a last resort for people at risk of passing serious disorders on to their children and is quite expensive. The process of PGD begins with in vitro fertilization using sperm and egg cells from the mother and father of the expected newborn. Once fertilized, embryos are grown to the eight-cell stage, at which point one or two cells are removed and checked for genetic disorders or diseases that the parents find undesirable (Baird). Only embryos that lack such genetic variants are introduced into the mother's womb to be developed and birthed. This method raises many controversial ethical issues, one being that PGD seems to prevent diseases or undesirable characteristics only by preventing the existence of the patient (Baird). Such opposing views regarding PGD exemplify the common concerns that critics raise against genetic engineering as a whole.

In addition to PGD, scientists have determined two main techniques for carrying out genetic engineering through gene therapy. The first method, somatic cell gene therapy, focuses on manipulating the cells of an existing human being (Baird, 2). In somatic cell gene therapy, a person with an undesirable disease or trait, say diabetes, may alter his genes to eliminate the symptoms of this disease (Gene). Scientists would then isolate the specific gene, if possible, that affects the likelihood a person will contract diabetes and either replace the gene, turn it off, or repair the gene. A major problem with somatic cell gene therapy, however, if the fact that most traits, including eye color, athleticism, intelligence, likelihood for disease, etc. are affected by more than one gene, making gene isolation close to impossible. In addition to the difficulty of finding the specific gene that affects a condition, scientists are unsure of any possible outcomes

of altering genes. The human genome and our whole bodies are a maze of complicated biological signals, pathways, and interrelationships. As associate professor of ethics at Victoria University of Wellington, Nicholas Agar, points out in his web article "Designer Babies: Ethical Considerations," a positive change upstream could cause a negative affect downstream. So while that person with a potential to have diabetes may undergo somatic cell gene therapy and live free of the high blood sugar and loss of energy that comes with the disease, he may now have issues with his heart or lungs. Gene therapy has the potential to be very useful as a biological technology, but it comes with many risks and dangers.

The second type of gene therapy, germ line gene therapy, has more permanent results than somatic cell gene therapy. While somatic cell gene therapy changes only the organism that undergoes gene therapy, germ line gene therapy affects many generations to come (Baird). The process of germ line gene therapy begins with in vitro fertilization. Before allowing sperm to fertilize eggs, scientists already monitor and alter any potentially undesirable traits. Then once the sperm fertilizes an egg, a process similar to that of pre-implantation diagnosis occurs. The main difference between PGD and germ line gene therapy, however, is that scientists actually alter genes in germ line gene therapy whereas they simply test genes in PGD (Suter, 6). Germ line gene therapy then causes the newly changed gene to be reproduced in every cell of the new organism, including the reproductive organs. The altered genes are then passed from parent to offspring throughout the generations. This method of gene therapy would be very useful for elimination horrible genetic diseases or creating innate immunization for future generations states Andrew Pollack, author of the *New York Times* article "Engineering by Scientists on Embryo Stirs Criticism." An adult with a genetic propensity toward alcoholism may have his offspring undergo germ line gene therapy in order to turn off the gene that causes him to drink so

often. Not only his children, but his grandchildren and great grandchildren will also have that gene turned off because of the germ line gene therapy. Ethicists argue that altering genes now is unfair for future generations because these changes affect future descendants without their permission. Especially when physical or biological traits are manipulated, the risk of creating a completely different race of humans in the future increases because of genetic engineering (Suter, 4).

As mentioned earlier, scientists have identified two main uses for genetic engineering through gene manipulation. The most popular, and, as a result, most ethically supported use for gene therapy is to eliminate genetic disease and prevent viral disease as Dick Thompson explains in his *Time* article "Designer Babies." Obviously, the most effective way to rescue future generations from suffering from terrible diseases like AIDS, cancer, or the flu is through germ line gene therapy. In addition, future populations could easily receive permanent vaccinations through somatic cell gene therapy to fight against rapidly spreading viral diseases like chicken pox, H1N1, or strep throat. Not only could scientists use gene therapy to prevent diseases that plague humans during their lives, but it could also be possible to "greatly increase life spans. Some estimates [speculate] that 100-150 years could be [normal]." If scientists can successfully alter human genes to slow the effects of time and prevent humans from aging, it could become normal to slip into death without losing eyesight, suffering from arthritis, or failing to remember names. Of course, sociologists and ethicists worry that such changes to the lifestyle and social structures of the human population could compromise the way humans value life. However, most scientists point out that removing the risk of disease from the lives of human beings will be a valuable and noteworthy accomplishment.

Problems will arise, however, when [people will seek] gene therapy to alleviate a condition that is less than life-threatening and perhaps considered by some to simply be one of life's inconveniences (Suter, 6). The second and most controversial use of genetic engineering is to determine a person's physical, mental, and personality traits. Parents already attempt to make their children above average by sending them to private schools, enrolling them in club sports, and buying them everything the children desire (Thompson, 4). Providing parents with the option to modify their children to be genetically superior would open up a whole new set of problems. Parents could assemble kids genetically to be smarter, to be more athletic, or to have a particular hair or eye color. In addition, people who are unsatisfied with such trivial characteristics as hair color may undergo somatic cell gene therapy to genetically change the color of their hair instead of simply dying it the new color (Baird, 2). This type of unnecessary use for genetic engineering is by far the most controversial in ethics and will definitely lead to the most debate and legislation for future generations.

A major problem that has arisen with the prospect of genetic engineering and gene therapy, and one that will most likely continue to escalate, is that "defining 'illnesses' appropriate for treatment may become difficult" which the article "Ethics of Genetic Engineering: Introduction" makes clear. It is difficult to find definitions of disease suitable to serve as moral guidelines for genetic technologies. Some define a disease to be a state to which society takes a negative attitude. If this is the correct definition, then would it be ethical to attempt to "cure" some of such "social disorders" as autism or homosexuality using gene therapy? (Agar, 1). Some moralists fear that trying to determine which conditions qualify as diseases could offend those who possess the disease, claiming that those people who do not possess the genes for a positive trait may develop a negative self-image and/or inferiority

complex. If this were the case, then attempting to cure the human population of such a disease, like ADHD, would cause the world to view those with this manageable disorder as inferior and insignificant (Suter, 5). As a result, ethicists feel that society must be extremely careful when determining which diseases or traits qualify as diseases to avoid creating even more of a conflict.

In addition to the concern of making portions of the population feel substandard, the rise in use of genetic engineering could potentially create a race of "super humans" (Suter, 6). Genetic engineering, many people fear, because of its expensive cost, will lead to a two-tier society of the genetically haves and have-nots. Those who were genetically modified at birth to be superiorly intelligent, athletic, or beautiful will, in a sense, rule over the naturally born humans. Because of this genetic hierarchy, it is likely that individuals will be more willing to manipulate their children to be brighter, better looking, more musically inclined, or whatever the parents thinks would give the child an advantage (MacDonald). Many sociologists are troubled by the thought that a genetically superior version of the human race could easily attempt to eradicate the inferior races like Hitler's Nazi s attempted to kill all German Jews. Genetic enhancement could create thick barriers in the social structure that could ultimately lead to war, genetic cleansing, or a slave race (Suter, 6).

Although the topic of genetic engineering first breached public attention in the late twentieth century, its controversy has risen in the past few years. While it still doesn't lie in the foreground of political or religious topics, genetic manipulation effectively splits those who have an understanding of the issue. According to an Internet survey conducted through Facebook, 41% of respondents supported genetic engineering when told the definition and 38% opposed. However, when the uses of genetic engineering, such as designer babies or disease eradication, were used to provide respondents with an illustration of genetic engineering, the difference

between supporters and adversaries of gene manipulation grew dramatically. These results show that the general American public has a brief knowledge of genetic selection and can be easily swayed depending on the way in which genetic engineering is presented. Hopefully this general lack of understanding about genetic engineering by many Americans will change in the future as the topic gains more political attention.

The political, scientific, social, and religious worlds have already seen troubling debates over the ethics of genetic engineering to alter the genes of humans. While many advocates of genetic engineering feel that gene therapy is the future of human medicine and will be the best technological advancement in many centuries, critics of the effects of genetic engineering argue that once we begin to consciously design ourselves, we will have entered a completely new era of human history in which human subjects, rather than being accepted as they are, will become just another kind of object, subject to parental whims and market forces. Without doubt, the subject of genetic engineering is controversial and will continue to become even more contentious in the years to come. The most optimal case, which corresponds to be the best approach to genetic engineering, would be one that capitalizes on the ability to use gene manipulation to eradicate disease, but limits the power of parents to determine the traits and characteristics of their children. In the end, however, if those in contact with genetic engineering, whether they be scientists, politicians, religious leaders, celebrity activists, or concerned citizens fail to proceed cautiously and ethically into the world of gene manipulation, a world not unlike that of the prejudiced fifth grade classroom could easily arise and come to define the human population.

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Appendix I

The basis of the primary research completed for this research paper was a short survey of questions carried out through Facebook. Data was gathered between the dates of January 27th and February 2nd for a total of 31 responses. Responders ranged in age from 15 to over 60 although the majority lied between the ages of 18 and 25 and 70% of those questioned were female. Responders were asked the following questions and gave the corresponding answers:

- How much do you know about genetic engineering?

  Nothing: 5 16.1%

  Very Little: 6 19.4%

  Little: 6 19.4%

  Some: 11 35.5%

  Much: 2 6.5%

  Very Much: 1 3.2%

- If you were told the definition of genetic engineering is "The deliberate modification of the characteristics of an organism by manipulating its genes," would you support or oppose this subject?

  Support: 12 41.4%

  Neutral: 6 20.7%

  Oppose: 11 37.9%

- A designer baby is a baby whose characteristics were specifically selected by his or her parents through genetic engineering. On a scale of 1-5 (5 being high) how likely would you be to specifically select your child's traits if the technology were available and reasonably priced?

1: 16	55.2%
2: 5	17.2%
3: 5	17.2%
4: 1	3.4%
5: 2	6.9%

- If you were told that some of the uses of genetic engineering would be to eliminate some serious diseases like cancer, diabetes, and AIDS, would you support or oppose genetic engineering?

Support: 21	72.4%
Neutral: 4	13.8%
Oppose: 4	13.8%