HUMAN GENETIC ENGINEERING

Human Genetic Engineering: 
History, Methods, and Ethics. 
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Introduction

Technologies developed by humans have aided the rise of civilizations, and allowed humans to survive situations that could have caused their extinction. The domestication of both plants and animals allowed the human race to base their carrying capacity on an artificial ecosystem of their own creation, rather than solely upon the natural environment they inhabit. Introduction of farming technologies raised the potential population of humans (Scarre 2005). In the past few centuries, humankind has found ways to make themselves immune to certain diseases. Now, with the addition of new understanding concerning the genetic structure of *homo sapiens*, biotechnologists are on the verge of finding ways to end the suffering of the millions who are inflicted with genetically inherited diseases (Koshland, 2000). However, with these new technologies come new responsibilities. The same procedures used to relieve pain and postpone death are capable of establishing a new form of eugenics in which genetically engineered individuals are genetically superior to those who are not (McGee, 1994). Additionally, as with any new medical procedure, extensive testing is necessary to establish safe procedures (Shanks, 2005). In studying the history, techniques, and the applicable thoughts of philosophers of the past concerning human genetic engineering, the conclusion reached is that humans are not ready for the full impacts of this technology, nor is it currently ethical to utilize it in an attempt to cure genetically inherited diseases.
History of Genetic Engineering

Humans have a long history of experience with the biotechnology of artificial selection. The first known domesticated species is the dog (Scarre, 2005). Traits originally selected for included docility and obedience, among others. Another species humans modified through selective breeding is cattle. Still today bulls are selected for their resilience and manageability. The harvesting of plants with specific traits eventually led to plant domestication and farming. Modern wheat has three times the number of genes than its original wild form. This change and other came about through long-term, careful manipulation through artificial selection by generations of humans (Reiss and Straughan, 1996).

Humans have recognized the structure of genes for a minute fraction of their history, yet in this time have progressed farther in their manipulation of genes than in the past 14,000 years (Scarre, 2005). In 1857 Gregor Mendel began his experiments with the inheritance patterns of peas that led him to the theory that genes control our physical structure. He even deduced that some genes are dominant while others are recessive (Campbell and Reece, 2005). Forty-five years later in 1902 Walter Sutton and Theodor Boveri hypothesized that chromosomes carry genetic information. By 1953 the combined research of Francis Crick, Rosalind Franklin, James Watson, and Maurice Wilkins allowed Crick and Watson to determine the structure of the nucleic acids that make up the backbone of genes. After 14,000 years of genetic manipulation through artificial selection (Scarre 2005), scientists realized that they may soon possess the technology to quickly add or remove genes coding for specific traits. Since 1953, the pace of human tampering with the genetic code of plants and animals has rapidly increased. Where traditional biotechnologies allowed for the slow change of very few species of close genetic relation, today’s technologies combine the genes of radically differently structured organisms of hundreds of species, over a time span of only a few weeks (Reiss and Straughan, 1996).
Several techniques of genetically engineering human genomes are considered possible by modern scientists. Cloning, somatic genetic engineering, and germline genetic engineering are all considered viable for future generations. Research is currently underway to allow for these technologies to benefit humankind (Shanks, 2005).

Cloning is an example of a process of genetic engineering that may aide humans of the future. In cloning, cells make direct copies of themselves. In reproductive cloning, the cells of a complete organism are replicated to create an exact copy of the original individual (Campbell and Reece, 2005). On February 23, 1997 the media introduced Dolly the sheep as the first successful mammalian reproductive clone (Evans, 2002). In this form of cloning only one out of one-hundred fertilized eggs produce viable offspring. Because of the complexity of humans, as well as the ethical issues involved in making copies of humans while killing hundreds of eggs in the process, most scientists do not focus on the reproductive cloning of humans, but instead on therapeutic cloning. In therapeutic cloning, scientists take cells from healthy organs and grow completely new organs for people who need organ transplants (Campbell and Reece, 2005). The research for these procedures is promising, but also time consuming, challenging, and expensive (Shanks, 2005).

Somatic genetic engineering is the more acceptable form of human genetic engineering, yet is the perhaps less useful. All cells in the human body with exception of eggs, sperm, and the cells that make them are somatic cells. In somatic genetic therapy, genes are directly inserted into cells within an individual, usually to replace genes that cause the cell to malfunction (Stock, 2000). This form of gene therapy is principally considered useful for its capabilities in chemical engineering. Within non-humans, products needed for humans, such as insulin, are mass-produced by inserting specific genes to code for such. Additionally, in humans who have diseases caused by mutations in genes, such as adenosine deaminase deficiency severe combined immunodeficiency (ADA SCID),
the insertion of non-mutated genes can allow for the production of needed chemicals. In 1990 biotechnologists cured a four year old girl afflicted with ADA SCID through somatic genetic therapy. This allowed her to naturally produce needed amounts of adenosine deaminase, a protein used in forming new DNA that consequently aids in immune processes. Somatic engineering is dangerous, however, only one case of human death has occurred so far (Evans, 2002). It only affects the individual that the genes are initially inserted into, and not offspring of that individual, any negative effects should stop with the death of the patient of the therapy. However, for the procedure to take hold, in most instances every single cell of a particular organ, system, or human body must receive corrective genes. In these cases, somatic engineering is not feasible, and cannot help as it is currently impossible to insert genes within every single somatic cell one at a time (Shanks, 2005).

Germline genetic engineering holds more potential than somatic engineering, yet is also more controversial. Germline cells are those cells in the human body that are used for reproduction. They include cells that give rise to eggs and sperm. Germ cells include eggs and sperm (Shanks, 2005). Two forms of germline genetic therapy exist for humans. The first and most promising method is to insert select genes into the pre-embryo when the fertilized zygote has divided into the four or eight cell stage of growth (Anderson, 2000). At this stage the cells are still totipotent, meaning they are undifferentiated and can give rise to any type of cell in the body. These are also known as embryonic stem cells (Campbell and Reece, 2005). Genes inserted at this stage show up in all somatic and germ cells as DNA from the cells initially engineered is copied and transferred to each successive cell. In the second form of germline genetic engineering, new genes are inserted in the germ cells in a human fetus, child, or young adult. This, like somatic genetic engineering, is a painstaking process that gets more difficult the older the patient. Additionally, the offspring of the patient are more likely to feel the extent of the effects, rather than the patient themselves, depending
on the age of the individual the genes are inserted into. Thus the direct insertion of genes into a fertilized zygote in the early stages of growth is the most practical technique (Anderson, 2000).

**Ethical Approach to Human Genetic Engineering**

Various points of view exist concerning the use of human genetic engineering. As soon as scientists realized the potential of manipulating the human genome, people started asking themselves what ends human genetic engineering could and should forward. In 1969 Robert Sinsheimer, a molecular biologist, expressed his beliefs in the positive effects having complete control over what traits people possess. He proposed a revolutionary form of eugenics, in which only genes coding for positive traits could appear in the human race (Evans, 2002). Paul Ramsey, a theologian and ethicist, argued that humans should not pretend that they are God (Ramsey, 1970). Today, both of these extreme sides still exist (Peterson, 2001). On both sides people feel that debate is needed concerning the moral issues involved in human genetic engineering before the technologies are available (Koshland, 2000).

Many have high hopes as to the possibilities human genetic engineering offers. Some feel that it can give humanity control over disease, aging, and death by reinventing medicines, repairing damaged tissues, and preventing rather than controlling diseases. One day children may no longer suffer from genetically caused disabilities from their birth (McGee, 1994). Others focus on the enhancements that genetic engineering can bring about in humankind. Bigger, stronger, more intelligent and less violently aggressive humans who age slower, sleep less, and have a higher memory capacity are considered improvements that genetic engineering could add to humans (Evans, 2002).

Human genetic engineering is not considered positive by all people. Some worry that in gaining too much domination over nature, humanity may completely lose its connection to Earth’s
processes (McGee 1994). This is similar to the argument that humans are playing God by believing they should completely take control over their own creation (Peterson, 2001). Various scientists feel that their colleagues are showing too much faith in science and gaining too much momentum in their research without truly considering the consequences (Reiss and Straughan, 1996). Most feel strongly that utilizing genetic engineering to enhance specific people has too much possibility for abuse and could cause great and irreparable suffering (McGee, 1994).

In discussing the moral ramifications of human genetic engineering, the views of philosophers of the past may help humans today determine the most ethical course of action. Aristotle’s concept of self fulfillment of humans presents a serious issue. It is wise to think of how genetic engineering could change the outcomes of many human lives. The thoughts of such influential persons as St. Augustine and Thomas Aquinas are also applicable to biotechnology and deserve recognition. In addition, David Hume and John Stuart Mills have arguments that aide comprehension of the issues that need thinking through before human genetic engineering is widely used (Cahn & Markie, 2006).

The thoughts of Aristotle, if applied to genetic engineering, serve as a warning to humanity to discover the consequences of our actions. Aristotle taught that observation and analysis of nature is chief to discovering truth. He felt that it is important to gather as much data as possible before coming to a conclusion. From an Aristotelian point of view, the study of all the facts and possible instances that apply to human genetic engineering is essential. People should also ask whether genetic engineering could lead to happiness, which is attained by using reason to drive one’s actions. If deep thought and study causes people arrive at the conclusion that genetically modifying humans is logical, because it may help diseased persons achieve self-actualization, than the process is viable. However, Aristotle might say that people need to find the mean between not using this new technology and using it on everyone. Perhaps only in cases in which a person cannot function
or may die it is right to correct their genes in order to allow them to move towards fulfilling themselves. Based on current knowledge, the view of Aristotle would most likely be that we need to observe more situations to determine whether human genetic engineering is right (Aristotle, 2006).

St. Augustine and Thomas Aquinas also may view human genetic engineering as an unknown ethical entity. St. Augustine would ask whether this new technology could bring greater evil into the world or greater good. The fact that curing genetic diseases could save lives may make it an act of charity and therefore good. Yet the deaths involved in medical research to obtain safe procedures for curing genetic disorders may be seen as evil, or at least as the beginning of corruption of good (Augustine, 2006). Thomas Aquinas would agree with St. Augustine and perhaps Aristotle, yet would ask whether genetically engineering humans would help them work towards the ultimate end of understanding God. St. Augustine and Aquinas both would probably object that changing the creation that was made in God’s image is evil and could lead us away from understanding God (Thomas Aquinas, 2006).

The focus of David Hume’s philosophy shows that different cultures may have diverse opinions concerning genetic engineering. Hume felt that humans need to understand that they are part of the natural order, and are creatures that base their decisions on instinct and habit. In Hume’s way of thinking each individual must come to their own conclusion, based on what is agreeable and disagreeable in their culture, as to whether they approve or disapprove of human genetic engineering. Passion drives our mental lives and so some may accept genetic engineering while others don’t. Thus, those who accept engineering their genes can do so, and those that find it disagreeable do not need to (David Hume, 2006).

John Stuart Mill’s utilitarian philosophy summarizes the ethical approach to human genetic engineering. Mill’s mentality is that things are as right as they make people happy and wrong as
much as they make people unhappy (John Stuart Mill, 2006). Many people do things that bring happiness and try not to bring unhappiness. There are numerous cases of children with sickle cell anemia who must have their gallbladders removed and spend most of their lives in the hospital due to the common strokes that are caused when their unnaturally shaped blood cells block their blood vessels (Evans, 2002). In such instances, it seems easy to use Mill’s principle of utility to justify curing such children before they are born through germ line genetic engineering (John Stuart Mill, 2006). However, for this technology to work, other children and adults who are tested must be suffer, and in rare cases, die. Jesse Gelsinger is an example of such a casualty. He volunteered for genetic therapy at the age of eighteen in order to try to find a cure for a rare liver disease. Jesse volunteered himself for the risky procedure, believing he could save many children from pain. However, because the scientists did not prepare correctly and illegally administered a large dose of an engineered gene that had not been successfully tested yet, even on animals, Jesse died three days later after organ failure (Shanks, 2005). To follow John Stuart Mills’ philosophy, humans need to take the happiness of every person present and future into account (John Stuart Mill, 2006).

According to both old and new sources, it is currently unethical to attempt human genetic engineering. In analyzing the thoughts of past philosophers, it is found that their philosophies point to studying the issue more and comparing the gains and losses it may cause. Gregory Stock and John Campbell, scientists at the University of California, Los Angeles argue that before human genetic engineering is released as a public procedure two criteria must be fulfilled. First, genetic changes to human cells should be safe, reliable, and used only for practical reasons. These changes should only affect the cells being treated, and should not carry over into the next generation, as offspring may have different views on engineering or may want updated versions of genes. The second criteria Stock and Campbell outline is that genetic improvements should have a high promise of benefiting those they are planted in. In addition there is a need for easy procedures that
work well for many people. Also Stock and Campbell feel that genes inserted into embryos and children should have a mechanism whereby they remain inactive until the child is an adult and can make the informed decision whether they wish to use the genes or not. These scientists express their opinions that the technology and research does not currently exist to make human genetic engineering possible under these ethical objectives. They feel that while therapeutic somatic genetic engineering may meet their criteria within a few years, germ line genetic engineering will not be sufficiently understood for several decades (Stock and Campbell, 2000).

Others agree with Stock and Campbell, and believe that humans know too little about their own bodies and that it is very unwise to attempt genetically engineering humans to treat genetic illnesses (Peterson, 2001). They also argue strongly for using genetic engineering only for the treatment of disease, and never for genetic enhancements (Anderson, 2000). Certain researchers even feel that actions need to occur now in order to prevent using these technologies (Peterson, 2001). Inside in vitro fertilization clinics in America, the technology exists for workers to test germline genetic engineering. So many people with fertility problems have a strong drive to bear their own offspring that there are currently few restrictions on in vitro fertilization clinics in the United States. There are no laws against clinics performing germ line genetic engineering on fertilized zygotes. Already clinics such as these advertise choice characteristics in their donors, the next step is actually producing alleles carrying positive traits and producing children with these traits (Capecchi, 2000). Considering the medical risks alone, many feel that measures are needed to stop both germ line and somatic genetic engineering of humans until more information is gathered and the technology is perfected (Anderson, 2000).
Conclusion

Humankind hasn’t studied their own bodies enough to comprehend the outcomes of human genetic engineering. The procedures that may one day cure many genetic problems are now only hypothetical. There is a need for extensive medical research into the methods and reasoning behind genetic engineering. Philosophies studied since Ancient Greece flourished support the need to study further, collect as many facts as possible, and discover the benefits and risks involved in order to determine whether human genetic engineering ought to ever be put into practice. It is practical to attempt more research in medically ethical ways in order to understand the implications of genetic manipulation of the human body. However, even should safe procedures become known, the risks and benefits need deep consideration before wide application occurs. Human genetic engineering is not a safe medical procedure and is not practical. Currently it is unethical to utilize human genetic engineering for any purpose other than research. It has great potential to save, but much potential to harm. Present and future generations should think hard and understand all the facts behind this technology before making prudent decisions about its utilization.
References


