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The Future of Germline Engineering

Dear Dr. Ibeh:

I am pleased to present my 2006 Ethics Paper to the REU-RET Program. I have performed research studies using BioEthics books, the Internet, and visiting with my ethics advisor, Dr. Virginia Rider.

The purpose of my paper is to initiate a dialogue on germline engineering. Scientists have been experimenting with gene therapy for years; however, germline engineering is now being proposed on humans. Society must be educated about this topic before they are faced with the ethical question of accepting or denying germline engineering. In order to make the most logical decision, society must become educated on the history, process, and opinions on this phenomenal breakthrough in science.

I hope this report will help educate you, along with others, about the science of germline engineering. If you have any questions, please contact me by email or telephone.

Respectfully,

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The Future of Germline Engineering

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PSU/NSF-REU/RET Program Summer 2006
Ethics paper
June 30, 2006

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Abstract

Genetic engineering has been practiced in our country for years within the food supply. Scientists are now ready to apply a similar process for humans. The future of germline engineering is unknown. The technology is here; however, many people are unaware or too quick to make opinions about this science. The purpose of my paper is to create a dialogue about germline engineering before society is forced to make a quick decision about this technology that they are not ready for. It will be explained how the germline engineering process differs from the somatic cell engineering process. Germline engineering can be used for medical reasons or for enhancement. Both issues will be explored as well as the analysis of possible advantages and disadvantages that come along with both of them. Also, the United States status along with other countries will be analyzed on how they are dealing with the issue of germline engineering.

Introduction

Germline gene therapy is the modification of germ cells (sperm and egg cells). Germline gene therapy is a type of genetic engineering which dates back to the engineering of food in 4000 B.C. (Council for Biotechnology Information), which will be discussed further in the paper. This therapy is commonly discussed with somatic cell gene therapy, which is the modification of all other cells. Germline gene therapy attempts to modify the sex cells, so that modifications will not only affect the subject, but the subject's offspring. These modifications would be in essence preventing inherited diseases and effectively improving genetic characteristics. These modifications of treating or enhancing humans bring ethical questions to many groups of people. The United States government cannot make a unified decision about this controversial science because the legislatures representing the country cannot come to a consensus. Germline gene therapy offers many different procedures and opportunities for advancement for one government to decide upon for a country. Therefore, the government relies on agencies such as the Food and Drug Administration to regulate the procedures of private clinics for the wellness of society. Many religious groups oppose germline gene therapy because it is an attempt to 'play God.' Also, many embryos are disposed during the germline gene therapy procedure causing the controversial issue of abortion to come into play. The problem is that the future of germline gene therapy is unknown. There are many ethical questions that have been raised by few, but have not been heard by many. Germline gene therapy is on the rise and the public must be educated about such a topic. The purpose of the paper is to identify the advantages and disadvantages of germline engineering in hopes of starting a dialogue between peoples about this technology. This study is vital because it forces people to discuss the future. The scope of the paper is not only to convey analysis and research, but to present many ideas in hopes of inspiring others to research and talk among themselves about the technology of tomorrow.

Literature Review

Collapse of the Middle Class. Home page. BuzzFlash. 25 Jun. 2006

< http://www.buzzflash.com/contributors/03/09/04_sanders.html >.

The middle class within the United States is already decreasing making the gap between the high and low class larger than it has been in the past. This could possibly lead to another eugenics system which could be led by germline gene therapy for enhancement purposes.

First Baby in Britain Designed Cancer-Free. Home page. Times Online. 25 Jun. 2006

<<http://www.timesonline.co.uk/article/0,,2-2178178,00.html>>.

In Great Britain, a woman is pregnant with the first baby treated with germline gene therapy to prevent him from having eye cancer.

Gilbert, Scott F., Anna L. Tyler, and Emily J. Zackin. Bioethics and the New

Embryology: Springboards for Debate. Sunderland: Sinauer, 2005.

This book is a 'springboard' for debate discussing bioethics, including germline gene therapy and cloning. Also, analyzing technological advances in history, the book relates advances fifty years ago to the status quo.

History of Genetic Engineering, Somatic Cell Gene Therapy, and Germline Gene Therapy

Germline line gene therapy is not a new topic. It has been used in many of the foods we eat today and also to our animals. However, the idea of applying the technology and applying it to humans *is* a new idea. Farmers have been altering the genes in food since 4000 B.C. to receive more productivity and better tasting crops (Council for Biotechnology Information). Starting in 2005, scientists began engineering tomatoes and broccoli to lower the risk of cancer along with providing more cancer fighting chemicals within the human body (CNN). Also, soybeans are engineered to lower the risk of heart disease (CNN). Some critics vocalize their worries of engineered foods having extra toxins with damaging effects or the loss of bio-diversity in crops; however, despite the critics, genetically engineering foods continue in our society making up approximately sixty percent of all American food (CNN).

The idea of genetically engineering humans came about in the middle of the 1990's. Cytoplasmic transfer, a process involving the transfer of cytoplasm from a donor to an infertile woman, was the first step to producing a bio-engineering baby (Brownlee). After the first baby was born in 1997, the process created multiple ethical questions including the fact that the child had, in fact, three parents: mother, father, and donor (Gilbert, Tyler, and Zackin 210). The donor not only gave her cytoplasm but small pieces of her mitochondrial DNA. She did, in fact, give part of her DNA to the child. Nevertheless, a child having, scientifically three parents, brought about too many ethical questions and the process was discarded. Not long after, scientists found an improved, more ethical way, to genetically engineer humans, somatic cell gene therapy.

Somatic cell gene therapy is a medical treatment that targets and alters abnormally functioning genes (Gilbert, Tyler, and Zackin 195). The results being that the patient was cured. But scientists went a step further and decided that instead of curing a single patient, they would cure the patient and in addition, all of their offspring. The patient's offspring would be protected from possible genetically inherited diseases like eye cancer or multiple sclerosis. Germline gene therapy is the process scientists soon came to discover. The advantage setting germline gene therapy apart from somatic cell gene therapy was the fact that it modified the germ cells (sperm and egg) ultimately modifying all of the offspring cells.

Treatment vs. Enhancement

Germline gene therapy can be divided into two parts: treatment and enhancement. Although it sounds fairly simple, when a new medical technology is introduced, the goal is to find a treatment to advance our society in some way; however, as history shows, society takes these new medical advancements and uses the technology to enhance rather than to treat. For example, plastic surgery was originally introduced into hospitals to allow doctors to reconstruct a person's face or limb that was perhaps altered from a car accident or fire burn (Gilbert, Tyler, and Zackin 2013). However, the technology has initiated new types of enhancement including nose reconstruction, lifting of the eyes, and slimming of the face, most commonly wanted by women trying to conceal their age. As history repeats itself, whatever the technology created, society will always use it for another use of enhancement.

Germline gene therapy brings about many things scientists believe can advance our society in many ways. The most publicized advantage of germline gene therapy is the choice parents have to avoid passing on genetic inherited diseases such as Tay-Sachs to their children. Tay-Sachs is a serious disease that breaks the central nervous system down and for which there is no cure for (Inheritable Genetic Modification). However, other advantages to the new therapy would be allowing an infertile couple to have a healthy child that is related to both of them. Lastly, one of the most debatable topics is allowing parents to 'enhance' their children allowing them to design the children to be healthier, more athletic, intelligent, or attractive, things most people wish for their children (Brownlee). Enhancing children is a technology still being experimented with today as scientists are studying which genes control what traits, but it is a technology that is right around the corner and will be offered soon.

There is no physical evidence or data showing disadvantages of germline gene therapy. It is in the experimental stage with no positive or negative results yet. However, it is up to society to discuss this topic before we are faced with the decision. The first problem seen with germline gene therapy is the risks with scientific experimentation. What if a child is designed poorly and nobody wants it? Some people worry that engineering a child would present the child more as a product rather than one's own son or daughter (Agar). If the child did not turn out like the parents wanted, then it was a gene modifying mistake? Would this lead to parents disowning or returning their defective child like they would a defective fire alarm for example?

Germline gene therapy analyzes a mother's embryos and implants only non-infected embryos back into the woman. Because of the lack of experimentation, scientists are still unsure of how many embryos to implant and therefore insert more than enough to guarantee a healthy pregnancy. However, this has led to an age of multiplicity where the number of twins that are born per year has risen by 67 percent (Brownlee). Not only is this increase large, but so is the cost. With multiple births, not only is there a large hospital bill, but soon comes the issue of supporting the children whether it be from the parents or the public support. Who is responsible? For those parents who can not support their children, the public will end paying support. There are no federal regulations towards this type of experimentation because the fertility clinics receive no federal funding. Anti-abortionists persuaded the United States government to not reject the clinics application for federal aid; however, clinics soon found that they could proceed successfully by the private money they were collecting (Gilbert, Tyler, and Zackin 106). This is an issue that society should take into thought that goes along with germline therapy.

Possible Conclusions of Genetically Enhancing Humans

A society's well being is based on the ethics encouraged in its' country by the way of laws, standards, and religion. If enhancement was put into a society, at first, only the wealthy would be able to afford it because of the expense of the procedure. The wealthy would then become more athletic, more intelligent, more attractive, more everything. Because the poor would not be able to afford the technology, they would stay at the inferior 'normal' level while the 'super humans' would continue to advance themselves causing an increased gap between the high and low class. Today, the middle class is already shrinking with 9.4 million people unemployed and the richest one percent owning more wealth than the bottom 95 percent (The Collapse of the Middle Class). If germline gene therapy increased this gap between the high and low class, there would be a prejudice against those who had not received the gene therapy. A small middle class also relates to the Nazis eugenics system where the Jews were seen as the lower human race and the Germans as the high human race. Eugenics is the idea of improving a certain race by hereditary materials (Collapse of the Middle Class). Some fear that with the separation of humans and superhumans, the two groups would be in constant conflict changing out society drastically from what it is today.

Religious Views

Religiously, people are against germline gene therapy because of the role of God it attempts to play. Also, when sorting out the embryos infected with disease and those unaffected, scientists throw away all of the infected embryos which anti-abortionists have a problem with. In defense, infected embryos are thrown away because few to no people would want to have a baby that would be diagnosed with serious disease like eye cancer. Ethically, when religion takes a part within a technology, people tend to pay attention. However, religious figures have used the same argument against inventions such as the lightning rod as well as the smallpox vaccination which have come to be technologies that we have used and have changed our country and world (Gilbert, Tyler, and Zackin 202).

Government Views

The United States is one of the few countries that perform the preimplantation genetic diagnosis while over forty European countries and some Asian countries have banned sex selection for non-medical reasons. Currently, a woman in Great Britain is pregnant with the first designer baby prevented from having an inherited eye cancer from his mother. However, in the United Kingdom it is illegal to do germline line gene therapy on humans for enhancement purposes by the Human Fertilization and Embryology Act 1990 (Designer Babies to Wipe Out Diseases Approved).

Methodology

For this research paper, online encyclopedias were used as well as the Pittsburg State University Library to become familiar with germline gene therapy and the ethical problems behind it. Also, ethics advisor, Dr. Virginia Rider, gave advice on how to write a clear, specified paper on such a broad topic. The internet was used to gather some information, but was not trusted for specific data unless a governmental or research website.

To produce a fluorescent monkey, scientists injected a genetically engineered sperm with a green fluorescent gene into unfertilized eggs of rhesus monkeys. Only half of the fertilized eggs became embryos (Transgenic Animals).

Preimplantation genetic diagnosis is a process performed on embryos in a Petri dish and is used most commonly for determining the sex of a baby. Using this process, couples can choose the sex of their baby. This process is similar to germline gene therapy in that it includes taking out the embryos, analyzing them, and implanting them back into the mother. Preimplantation genetic diagnosis has a “99 percent certainty” (Gilbert, Tyler, and Zackin 91).

Germline gene therapy has a very complicated method. It uses DNA or RNA to cure defects or diseases. It may also be designed to replace the defective genes. The DNA or RNA are carried by viruses or complexes of DNA to disperse them over a large number of reproductive cells in order to make genetic changes to not the single patient, but the offspring and later generations of the original patient. (Brownlee).

Results

Following the method of germline gene therapy performed on rhesus monkeys, there were five pregnancies from 20 embryo transfers. Otherwise known as ANDi (DNA backwards), one of the monkeys is not the green expected, but slightly fluorescent (Transgenic Animals). Although little physical success, the experiment could be used as a model to better understand the manipulation of genes in primates.

Discussion of Results

The explanation of why only two out of the three monkeys did have fluorescent qualities cannot be explained before further testing is accomplished. However, ANDi is the first demonstration of a primate that developed healthy after genetic alterations.

The success of preimplantation genetic diagnosis points out that a similar procedure like germline gene therapy would also be successful. Also, by altering genes of primates, we can more accurately compare the results to humans. By analyzing the rhesus monkeys and their reaction to the manipulation of certain genes, we can come closer to understanding the effect of human manipulation.

However, the point of error lies in the idea of repeatability. When altering a gene for one purpose, it may alter the same gene’s role in another process. For example, a gene called BMP4 can “induce bone growth, but also induces apoptosis (death of cells) in a different set of tissues (Gilbert, Tyler, and Zackin 204). If a gene is altered for one function, it might cause another unwanted change in a different function. The only way to figure out which genes do what is either by animal or human experimentation which brings about ethical questions. Also, scientists are not sure of what traits to enhance or get rid of. A certain “mutation that causes sick cell anemia is delirious when inherited from both parents, but when only one gene has the mutation, it may offer some protection against malaria” (Gilbert, Tyler, and Zackin 204). Once again, the long-term results of altering certain genes are still unknown. But the preliminary steps of experimenting small animals like mice and the primates must have a high success rate before this technology is will be accepted by humans.

Conclusion

Germline engineering allows to essentially get rid of all genetically inherited diseases, one family at a time. However, society sees many problems with enhancing and altering people's genes for specific traits.

Looking at genetically engineering crops and animals, the process appears to be going successfully thus far. A woman in the United Kingdom is currently pregnant with the first engineered baby whose genes were modified to be cancer-free. Without germline engineering, the woman would have passed on her disease to her child. However, engineers have modified her egg cells to promise that neither she, nor any children will pass on the disease. Scientists are still waiting on the birth to make sure there are no side effects or complications after the birth to conclude that it was the first successful germline gene therapy performed on humans; however, they have made the first baby that has undergone the therapy.

Technology is introduced and is either adopted or aborted. Decisions concerning germline gene therapy are here for medical purpose with enhancing opportunities around the corner. Society needs to begin a dialogue about the technology before it comes with no warning and people are faced to make decision upon a science they know nothing about. Religiously, some people believe that it is playing God. By changing someone's DNA, what makes him or her unique, is changing that person, which is playing a god like figure.

The United States government will continue to play their part and let the public decide whether to leave or adopt germline gene therapy, because of the fear of losing votes or national support. However, the FDA will continue to watch after the clinics to ensure safety to the public.

There are still risks with scientific experimentation because there are no federal regulations drawing a line of what is legal and illegal. It will be up to society, the individual members, to decide whether to surge forward into this advance science or to stay behind.

Recommendations

In order to solve the problem of the public's ignorance to germline gene therapy, the government should publicize this topic either for example mentioning books people have written discussing and posing questions from each side of the topic. For example, in some colleges, they had a required reading book for the freshmen class like the book Enough by Bill McKibben that does this exact thing of mentioning germline gene therapy on humans. Educating society is the best way to ensure that the United States will stay ethically substantial. Educating high school and college age students is also an impressive move because they are the future and the ones that will ultimately be deciding on this technology. The government is correct in leaving the decision to the public, but having the FDA and RAC create standards that clinics must abide by. While keeping American's freedom of choice alive, there are regulations to keep them safe. The problem is that society is ignorant to this germline gene therapy. However, this problem can only be attempted by educating society so that they may decide whether the science will be advantageous or disadvantageous for future generations.

Acknowledgement

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