

Gene Therapy: An advance in Science

Background:

- “When a gene is damaged, the blueprint for the construction of the protein it codes for is imperfect: the resulting protein is therefore abnormal. The goal of gene therapy is to cure a genetic disease by repairing the damaged gene responsible for the disease. It involves introducing a normal copy of the gene into cells containing the damaged version. The cells then can produce the normal protein.” (Lexicon encycloBio, 2007)
- Humans get genes from both parents; therefore, each individual contains two copies of almost every gene. (Access Excellence About Biotech)
- The majority of people aren't negatively affected by their defective genes because they have a second copy of the gene to compensate for it. (Access Excellence About Biotech)
- There is an exception: The male sex chromosomes X and Y contain just one copy of the genes. In the event that one of those genes is defective, the normal gene can override the defective gene and avoid the symptoms that come along with the potential disease. It merely compensates for the tasks that the defective gene cannot complete. (Access Excellence About Biotech)
- However, that is not the case if the recessive gene is dominant. It would simply supersede the normal gene and give you the disease. (Access Excellence About Biotech)
- Males with a recessive gene of the X-chromosome will get the disease, because as a male you inherit only a single copy for the gene in the X-chromosome; in essence there is no normal gene that can pick up the defective genes slack and complete its duties. (Access Excellence About Biotech)
- Genetic diseases caused by defective genes may have beneficial effects as well as their apparent damaging effects. (Access Excellence About Biotech)
- An example of the possible beneficial effects includes the sickle-cell gene. A person with two copies of the recessive gene gets the disease. A person with one normal and one recessive gene does not get the disease. In addition to that, the person has the ability to defend against contamination by the parasites that carry malaria. (Access Excellence About Biotech)
- Gene therapy is a technique used to replace a recessive gene with a normal functioning gene. (Gene Therapy, 2007)
- A clone is made of the normal gene and then that clone is what is used to replace the recessive gene. (Gene Therapy, 2007)
- Gene therapy also repairs recessive genes, and adjusts the point at which a gene is turned on and the point that it is turned off. (Gene Therapy, 2007)
- It removes the source of the disease and allows the body to produce the correct enzymes and proteins needed to attain a healthy body that is disease free. (Gene Therapy, 2007)
- A vector, also known as a carrier molecule, is used to transport the gene into the patient. The vector that is most recognized by scientists is a virus, and it is capable of carrying human DNA to the patients “target cells”. (Gene Therapy, 2007)
- There are several forms of vectors that are utilized in gene therapy: Retroviruses, Adenoviruses, Adeno-associated viruses, and Herpes simplex viruses. (Gene Therapy, 2007)

- There are also methods of non-viral gene therapy such as directly inserting DNA into the desired “target cells”. However, these methods simply are not practical for the mere fact that the variety of tissues that it can be used for is limited and it requires immense quantities of DNA. (Gene Therapy, 2007)
- It is a clinical study at the moment and is not offered to everyone; however, there are many candidates for future trials, such as Lesch-Nyhan syndrome (an unexplainable series of impulses to self mutilate) and Phenylketonuria (caused by a deficiency in the gene which provides the liver with the enzymes needed to function and be healthy; it can cause mental retardation). (Access Excellence About Biotech)
- Diseases such as the two mentioned could be treated and the lives of many would be helped if gene therapy were practiced. (Access Excellence About Biotech)
- The Human Genome Project has successfully identified the 30,000 genes in the human body; it will allow for further research of the function of genes, variations in DNA sequences, etc. It is the foundation for the future of gene therapy. (Genomic Research, 2007)

Statement of the problem:

- Some diseases that cannot be treated by available therapy can be treated by gene therapy; however, gene therapy is not currently available to the public. (National Institutes of Health, 2007)
- The goal is to make gene therapy readily available and begin using it as an alternative to certain medicines and treatments with undesired side effects. (National Institutes of Health, 2007)
- Clinical trials are being held to do genetic testing on mutations in genes. The types of trials vary and they are open to the public. (Clinical Trials, 2007)
- Gene therapy is being tested in relation to many different diseases, but one of the main areas of focus is on the treatment of cancer. (National Cancer Institute, 2006)
- Researchers for the National Cancer Institute are using several different approaches to treat cancer. “In one approach, researchers replace missing or altered genes with healthy genes. Because some missing or altered genes (e.g., p53) may cause cancer, substituting “working” copies of these genes may be used to treat cancer.” (National Cancer Institute, 2006)
- The National Cancer Institute is also using gene therapy to increase the body’s potential of defending against cancer cells. (National Cancer Institute, 2006)
- The development and progress that the researchers have made so far has sparked the interest, involvement, and support of many people. Scientists from the National Cancer Institute are researching ways to make the cancer cells more responsive to treatments, such as chemotherapy. In doing so, there will be a better chance of the treatment working and killing the infected cells. Another approach was to extract healthy cells and give them a gene that will make them more tolerant to the effects caused by cancer killing treatments. Then they would put the altered cells back into the patient and give them the chemotherapy treatment without the adverse side effects. (National Cancer Institute, 2006)
- Whether the study being done is geared toward cancer research or any other disease, scientists are making alterations in the viruses that are injected during gene therapy so

- that they are safer and more effective in delivering the genes to the cells. Certain genes that are inserted may prevent reproduction of a disease, while others may prevent the actual disease itself. (National Cancer Institute, 2006)
- One major problem of gene therapy is that it is not entirely accurate in the cells that it infects with the virus. In some cases it infected several different cells, which included not only cancer cells but healthy cells as well. Furthermore, if it is inserted in the wrong location, it could cause damaging alterations in the normal DNA and possible cancer. (National Cancer Institute, 2006)
 - In order to overcome this problem and make gene therapy foolproof, scientists have to figure out how to insert genes to the body in a more effective and proficient way, as well as creating vectors that can specifically find the target cells in the body and not infect any of the other cells. (National Cancer Institute, 2006)
 - Once researchers can perfect their methods of inserting genes and learn everything there is to learn in order to perform gene therapy successfully without fail, the public will have access to such treatment without the unfavorable side effects of other medicines.
 - The National Institutes of Health propose more accurate dosing of medicine. They will no longer have to base the dose of medicine on the weight and age alone; they will be able to give the perfect dose for that patient according to their genetic profile. (National Institutes of Health, 2007)
 - By learning the unique genetic make up of each patient, the National Institutes of Health propose that the pharmaceutical companies will be able to go further and produce drugs that are compatible with people who have particular genetic profiles. (National Institutes of Health, 2007)
 - The National Institutes of Health also stress the fact that patients will no longer have to go through trial and error with the doses of medicine that they are receiving. It would eliminate unsafe medicines and adverse reactions; it would improve the medical, pharmaceutical, and health fields overall. (National Health Institutes, 2007)

Epidemiologic picture of problem:

- Every single person carries roughly six genes that are defective. (Access Excellence About Biotech)
- One out of ten people will develop a genetic disorder inherited from their parents. (Access Excellence About Biotech)
- In a single patient, mutations in their genes are capable of causing over 2,800 different health-related conditions. (Access Excellence About Biotech)
- Five percent of children admitted to children's hospitals have a disease that traces back to a single gene defect. (Access Excellence About Biotech)
- A child whose parent has a defective gene has a fifty percent chance of getting the genetic disorder. (Genomic Research, 2007)
- When you inherit a copy of the recessive gene from both parents, you have a one hundred percent chance of getting the disease. (Access Excellence About Biotech)
- There is a twenty-five percent chance of having a child with an autosomal recessive disorder if both of the parents carry the gene; even if neither of the parents have the disorder. Fifty percent of the children will carry the gene but will not have the

disorder, and twenty-five percent will neither have the disorder nor carry the gene. (Genomic Research, 2007)

- Although genetic disorders are typically recognized at birth or early childhood, it can take as long as adulthood before any signs of the disease is apparent. (Access Excellence About Biotech)
- Genetic disorders affect all races, they do not discriminate. That is because no matter what race you are, every human carries six defective genes. (Access Excellence About Biotech)
- “Researchers study genes from people in different population groups to find the genetic differences that are unique to *certain diseases*, not to particular ethnic and racial groups. Occasionally, however, scientists do study members of certain groups because a disease is much more common in that group. The gene linked to Tay-Sachs disease, for example, was identified in Ashkenazi Jews.” (National Institutes of General Medical Sciences, 2005)
- Currently, Gene Therapy is not available to the public. It is an attempt to prevent disease and reverse the effects of those that are already present. Gene Therapy has undergone much research, development, and scientific experimentation. It would be a great leap forward if it were accepted as a usable method of treatment. (Access Excellence About Biotech)

Solutions to the Problem:

National Institutes of Health (<http://www.nih.gov>)

The National Institutes of Health is an organization made up of scientists, researchers, and doctors who are pro gene therapy. They yearn to veer away from using a standardized method of prescribing medicine to patients. By using genetic information they can get a more accurate analysis of what each patient needs and will be able to give them the exact dose that is sufficient for their unique genetic profile. This will be especially helpful in the future because not only would it provide the correct doses of medicine to the patients, it would initiate a speedy recovery, and avoid any reactions that could occur from having too much of the medicine.

National Library of Medicine (<http://www.nlm.nih.gov>)

The National Library of Medicine is a terrific reference to many sites with information regarding: gene therapy, developments with medication, treating cancer, preventing mental retardation, among many other things. It also gave access to Web sites that had listings of clinical trials that was open to the public. Each trial is geared towards a specific disease and most of them are held over duration of one year. It was very informative and useful in my research. It has lists of frequently asked questions and answers; they informed people of what has happened leading up to this point in gene therapy development, as well as what is expected to happen in the future. It gives information and links to find out more about the completion of the Human Genome Project, and how it was that scientific research that gave spark to the development of gene therapy today.

National Cancer Institute (<http://www.cancer.gov>)

The National Cancer Institute is a government agency devoted to cancer research. NCI is currently working on developing methods of gene therapy as an alternative to the painful somewhat effective treatments of chemotherapy and other cancer killing methods. By targeting and killing cancer cells, enhancing cancer fighting cells, or developing cells so that they can more easily fight off the effects of chemotherapy, the scientists are working on every possible aspect of cancer research and treatment to make it possible to have gene therapy as an approved method of treatment.

Internet Resources:

Some other Web sites that provide information regarding Gene Therapy are: Access Excellence About Biotech at <http://www.accessexcellence.org>, Clinical Trials at <http://clinicaltrials.gov>, and Genes & Populations at <http://publications.nigms.nih.gov>.=

Bibliography:

(2005, February). Genes & Populations. Retrieved November, 2007, from National Institutes of General Medical Sciences Web site: <http://publications.nigms.nih.gov/genepop/index.html>

(2007, August 6). Gene Therapy. Retrieved November 22, 2007, from Human Genome Project Information Web site: http://www.ornl.gov/sci/techresources/Human_Genome/medicine/genetherapy.shtml

Gene Therapy - An Overview. Retrieved November 22, 2007, from Access Excellence About Biotech Web site: http://www.accessexcellence.org/RC/AB/BA/Gene_Therapy_Overview.html

(2007, November 16). Genomic Research. Retrieved November 22, 2007, from Genetics Home Reference Web site: <http://ghr.nlm.nih.gov/handbook/genomicresearch?show=all>

(2007, May). Genes Mutation Pentalogy of Cantrell. Retrieved November 22, 2007, from Clinical Trials Web site: [http://clinicaltrials.gov/ct2/show/NCT00477932?recr=open&cond="Genes"&rank=1](http://clinicaltrials.gov/ct2/show/NCT00477932?recr=open&cond=)

From Genes to Personalized Medicines. Retrieved November 22, 2007, from National Institutes of Health Web site: http://www.nih.gov/about/researchresultsforthepublic/Genes_PersonalizedMed.pdf

Gene Therapy. Retrieved November 22, 2007, from Lexicon encycloBio Web site: http://www.cite-sciences.fr/lexique/definition1.php?idmot=65&radiob=1&recho=gene%20therapy&resultat=1&num_page=1&habillage=standard&lang=en&id_expo=2&id_habillage=15

(2007, November 15). Genes and Gene Therapy. Retrieved November 22, 2007, from National Library of Medicine Web site: <http://www.nlm.nih.gov/medlineplus/genesandgenetherapy.html>

(2006, August 31). Gene Therapy for Cancer: Questions and Answers. Retrieved November 22, 2007, from National Cancer Institute Web site: <http://www.cancer.gov/cancertopics/factsheet/Therapy/gene>

Back to Betty C. Jung's Web site	http://www.bettyjung.net/
Back to Fact Sheet Directory	http://www.bettyjung.net/Pch202fs.htm

Gene Therapy (Class Handout)

“When a gene is damaged, the blueprint for the construction of the protein it codes for is imperfect: the resulting protein is therefore abnormal. The goal of gene therapy is to cure a genetic disease by repairing the damaged gene responsible for the disease. It involves introducing a normal copy of the gene into cells containing the damaged version. The cells then can produce the normal protein.” (Lexicon encycloBio, 2007)

- The desire to make gene therapy an acceptable method of treatment has increased since the completion of the Human Genome Project.
- The Human Genome Project has successfully identified the 30,000 genes in the human body; it will allow for further research of the function of genes and variations in DNA sequences. It is the foundation for the future of gene therapy. (Genomic Research, 2007)

Background on defective genes:

- Every single person carries roughly six genes that are defective. (Access Excellence About Biotech)
- One out of ten people will develop a genetic disorder inherited from their parents. (Access Excellence About Biotech).
- In a single patient, mutations in their genes are capable of causing over 2,800 different health related conditions. (Access Excellence About Biotech)
- A child whose parent has a defective gene has a fifty percent chance of getting the genetic disorder. (Genomic Research, 2007)
- When both parents carry the same recessive gene, the child will get the disorder. (Access Excellence About Biotech)
- Although genetic disorders are typically recognized at birth or early childhood, it can take as long as adulthood before any signs of the disease is apparent. (Access Excellence About Biotech).

What is gene therapy in simple terms?

- Gene therapy is a technique used to replace a recessive gene with a normal functioning gene. (Gene Therapy, 2007)
- A clone is made of the normal gene and then is used to replace the recessive gene. (Gene Therapy, 2007)
- Gene therapy also repairs recessive genes, and adjusts the point at which a gene is turned on and off. (Gene Therapy, 2007)

What are the methods of gene therapy?

- A vector, also known as a carrier molecule, is used to transport the gene into the patient. The vector that is most recognized by scientists is a virus, and it is capable of carrying human DNA to the patient’s “target cells”. (Gene Therapy, 2007)
- There are several forms of vectors that are utilized in gene therapy: Retroviruses, Adenoviruses, Adeno-associated viruses, and Herpes simplex viruses. (Gene Therapy, 2007)
- There are also methods of non-viral gene therapy such as directly inserting DNA into the desired “target cells”. However, these methods are not practical because the variety of tissues that they can be used for is limited and it requires immense quantities of DNA. (Gene Therapy, 2007)

Availability:

- Some diseases that cannot be treated by available therapy can be treated by gene therapy; however, it is only available as a method of treatment when administered at a clinical trial. (National Institutes of Health, 2007)
- Currently gene therapy is not available to the public. It is an attempt to prevent disease and reverse the effects of those that are already present. Gene therapy has undergone much research, development, and scientific experimentation. It would be a great leap forward if it were accepted as a usable method of treatment. (Access Excellence About Biotech)