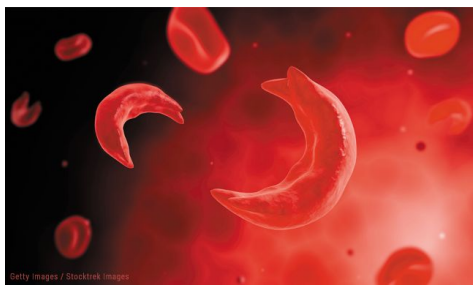
GENE THERAPY AS A SOLUTION TO SICKLE CELL DISEASE

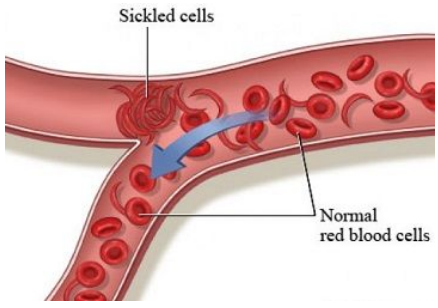
Introduction

The genetic disease I have chosen is sickle cell disease. The aim of this study is to investigate the use of gene therapy as a scientific solution to cure sickle cell disease. It is really important that we find a cure for this disease due to the fact that it causes a painful life time and you die young because of it. The purpose of this essay is to research and show how an experimental technique in which the manipulation of genes is used, can be used to prevent or treat a disease. This essay argues that this technique may in the future, let doctors treat a genetic illness without using drugs or surgery by inserting or manipulating genes of the patient's cells. The main questions addressed in this paper are: Can gene-editing technologies cure sickle cell disease? It is really effective?

This paper begins by an explanation about what is sickle cell disease, why is it caused, what are the consequences, etc. It will then go on to the body where I will explain what is gene therapy, how can it be used to cure sickle cell disease, its benefits and limitations, etc. Finally, I would express my personal opinion and the importance of this cure.



Sickle cell disease is caused by a mutation in the hemoglobin-Beta gene which can be found on chromosome 11. Hemoglobin is a protein find in the red blood cells that transports oxygen from the lungs to other parts of the body. Red blood cells with normal hemoglobin, called hemoglobin-A, are round and smooth and they move freely through the blood vessels. However, people with sickle disease have abnormal hemoglobin molecules, called hemoglobin-S. Their hemoglobin molecules have long, thin shapes which stick to each other causing the red blood cells to become rigid and adopt a half-moon or sickle shape. Their shape causes the red blood cells to pile up and block vessels that can damage organs and tissue.



Sickle cell disease can cause anemia because the bodies of the people with the disease quickly destroy the sickle cells so the amount of red blood cells and of hemoglobin in blood decreases. This disease can also block the flow of the blood through the vessels causing damage to the lung, spleen, kidneys and liver.
About 300.000 babies are born each year with sickle cell disease. Most of the patients live to their 40s because of the blood transfusions, bone marrow transplants and other treatments. But in Africa, most of the people die in childhood. ("Learning About Sickle Cell Disease", 2017)

➔ The key concept that I will focus on is **change**. This is because thanks to the

gene-editing technology we could manipulate the genes of people who suffer from sickle cell disease to get rid of this disease causing a change in their lives.

The related concepts which will be related to my study are:

- **Transformation:** or manipulation of the genes so that we can cure the sickle cell disease.
- **Form:** the form of the red blood cells in people who suffer sickle cell disease cause them blockages in the blood vessels.
- **Function:** people who suffer sickle cell disease have abnormal hemoglobin therefore, their hemoglobin doesn't produce oxygen and doesn't work properly.
- **Movement:** due to the fact that the red blood cells are rigid and sickle-shaped they don't flow properly through the blood vessels.

Body

Gene-editing as a solution to cure sickle cell disease

- There are two types of hemoglobin, the foetal hemoglobin whose production is switched off after birth and them the adult hemoglobin (hemoglobin-A) is produced. But people that have sickle cell disease develop the hemoglobin-S instead of the hemoglobin-A. Dr. Stuart Orkin from the Harvard Medical School says that if the people who inherit this disease are supplied with foetal hemoglobin, they could be protected them from the disease. This is because the foetal hemoglobin produces a substance that can carry oxygen around our bodies. There is a small piece of the BCL11A gene which controls the foetal hemoglobin production. Therefore, by using the gene-editing technologies they can cut that gene so that its stops shutting down the production of foetal hemoglobin so the people with sickle cell disease will start making this hemoglobin in their blood. As well, they will gene.-edit the blood cells from the bone marrow so that they produce foetal hemoglobin and they return it back to this person. (McKie, 2017)
- David Williams, of the Boston Children's Cancer and Blood Disorders Center has discovered a slightly different way of using gene-editing to cure sickle cell disease. He says that if you known BCL11A gene down, it will at the same time, increase foetal hemoglobin. (McKie, 2017)
- In 2008, Dana-Farber Institute in Boston, has corrected sickle cell disease in mice, changing their hemoglobin from defective hemoglobin-S to healthy foetal hemoglobin. ("Gene therapy for sickle cell disease passes key preclinical test", 2017)
- All the investigation and research about finding a way in which gene therapy can cure sickle cell lead to a cure for the disease which was carried out on a 13-year-old boy by Jean-Antoine Ribeil from the Reference Centre for Sickle Cell Disease from the Necker Children's Hospital in Paris. As I said before they cut the BCL11A gene which controls the hemoglobin production and they extracted bone marrow and gene-edited the stem cells so it produces foetal hemoglobin and they returned the altered stem cells to the boy's body through the blood vessels. From this point this altered cells will start making new blood cells with healthy foetal

hemoglobin. After 15 months since the therapy, he doesn't need anymore the medications and his body don't show any sign of the disease. As well, since then, he hasn't had any pain or complications. (Susan Scutti, 2017)

Benefits and limitations

- ➔ **Benefits:**
  - A huge and basic benefit of the use of gene therapy to cure this disease is obviously, that it can eliminate disease. Therefore, thousands of people who are nowadays, suffering from these disease could be saved and the millions of people that would be born we this disease can avoid it.
  - As well, a great point of using gene therapy as a solution to sickle cell disease is that it will help the researchers to create a pill which will boost the foetal hemoglobin in patients with sickle disease and which is simple to administer. This is their ultimate goal. In this way, the cure for this disease could be cheaper and reach everywhere all over the world.
  - Another benefit is that a tool which can gene-edit is already been produced. It is called CRISPR and it is easy to use and accurate. Jennifer Doudna, the Berkeley biologist who was one of the first people to use CRISPR explains that this tool allows to look at specific section of our genetic code and can cut or replace them. This tool is really helpful for scientists because it turns genes on and off. Therefore, the researchers can discover what effect each gene has. This tool can basically manipulate and edit the building blocks of life. (Loria, 2017)

- ➔ **Limitations:**
  - However, there are also some limitations, for example, Eric S. Lander, director of the Broad Institute says that although this tool is already been produced more discussion and regulations need to be done before it becomes free-for-all. And he also says that it is important not to be hard and foolish as the research evolves. (forever, 2017)
  - As well, another limitation would be that the gene-editing technology is just starting, it has only been 10 years since they started reading the first human genome. Furthermore, we should be very cautious and aware before we start rewriting it. Therefore, this disease can be eliminated when this technology is more accurate and reliable than it is today.

Factors which affect the use of gene therapy as a way to cure sickle cell disease

- ➔ **Economic:** A main factor that is crucial for the use of gene therapy to cure sickle cell disease is economic. This is because just the research in the use of gene-editing technologies to cure this disease is really expensive. And as well, when these technologies is finally improved and it becomes available for the people it will be extremely expensive. Therefore, the people who don't have this amount of money and can't pay for this treatment and can't be cured so still lots of people who have this disease will still die due to it.

- **Ethical:** Another factor will be ethical. This is because if this technology is finally develop and the people could have access to it, people could chose what the colour of their child's eyes they would like to be, the colour of their hair, etc. Therefore, this wouldn't be very ethical because these children wouldn't be natural but artificial. But however, if we are talking about diseases that causes death, the situation changes because by using gene-editing technologies we could save lots of lives and prevent people from having the sickle cell disease.

Conclusion

Finally, in conclusion, sickle cell disease is a really painful and worldwide disease which is causing the death of lots of people all over the world. Therefore, scientists are searching for a way in which gene therapy can cure this disease. The solution that they have reach is that if they extract stem cells form the bone marrow and gene. edit them so they produce foetal hemoglobin they would be protected from the disease, due to the fact that foetal hemoglobin produces a substance that can carry oxygen around our bodies. As well, they will cut a part of the BCL11A gene which controls the production of foetal hemoglobin so it will start producing the hemoglobin for the body. All the research and investigation for a solution has lead to finally, applying this gene-editing technology to a boy who suffered from the disease. The result was great, the boy has no longer the disease and he can have a normal life..

Therefore, it is prove that this therapy works and that it can really save lots of lives. I'm sure that this amazing result scientists would be researching in the use of gene therapy to cure other genetic diseases. Although, only a few people has been cured so far, in a couple of years this therapy would be available for everyone. Finally, I believe that gene therapy and gene-editing technologies is the future for science and fro finding solutions to cure genetic diseases.

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