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ETHICS OF GENETIC ENGINEERING AND GENE EDITING IN HUMANS

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Abstract
The modern biotechnology and medicine have been revolutionized in a short period by genetic engineering and gene editing technologies. Due to the invention of novel and more advanced genome-editing technologies, particularly, CRISPR-Cas9 system, the manipulation of human DNA has become more accurate and efficient than ever before. This group of technologies has enormous potential in curing and perhaps a cure to a variety of hereditary diseases such as Sickle Cell Disease, Cystic Fibrosis and Huntingtons Disease. Gene editing technologies, despite being extremely promising in the field of medical science, are linked with complex ethical, social, and legal concerns of manipulating the human genome. The paper will discuss on the ethical issue of genetic engineering and gene editing, in the case of human beings, using the available academic literature, and ethical debate. The paper covers the main ethical concerns, including the risks of the safety of the technique, the germline editing, the genetic enhancement, the social inequality, and the long-term effects of human genetic modification. The other important element of the research is the importance of ethical governance and international regulation to ensure that using gene editing technologies is responsible. The conclusions made are that although gene editing technologies are potentially very useful in the field of human health and the development of medical science, their implementation requires a strict regulation to avoid their misuse and harm the dignity of human beings. The ethical systems, community engagement and international cooperation have to play a critical role in making sure that the genetic technologies are applied in a responsible and socially beneficial way.

1. Introduction

Background of the Study

The field of genetic engineering and gene editing technologies has evolved fast in the last few decades that have revolutionized the field of modern biological and medical research. Such technologies enable scientists to manipulate the genetic material of living organisms so as to understand the function of genes, cure diseases, and enhance biological characteristics. The development of molecular biology and biotechnology has enabled the manipulation of the DNA sequences with very high degree of accuracy and efficiency. One of the greatest discoveries in this area is the creation of CRISPR-Cas9 system, the groundbreaking genome-editing application that allows scientists to find the desired genes and alter them with incredible precision. The technology has greatly enhanced the rate of genetic studies and provided opportunities to cure mutations that cause diseases in the human genome (Doudna & Charpentier, 2014; National Academies of Sciences, 2017).

Use of gene editing technologies have created a lot of interest in the medical world due to the possibility of treating or in fact curing most inherited diseases due to the technology. Incurable genetic diseases can be treated or prevented with the help of specific gene correction. Indeed, research studies have shown that therapeutic use of these disorders like Sickle Cell Disease, Cystic Fibrosis and Huntington Disease show promising therapeutic use. They are mutations in certain

genes that cause these conditions, and gene editing methods can enable researchers to fix or substitute the weak genetic codes that cause these diseases. Consequently, gene editing can change the future of medicine by bringing more accurate and personalized treatments, alleviation of suffering, and better life quality to patients with genetic diseases (Lanphier et al., 2015; Nuffield Council on Bioethics, 2018).

These positive medical prospects notwithstanding, there is an intricate ethical problem and concern regarding the application of genetic engineering in human beings. One of the greatest concerns is associated with the safety and reliability of gene editing technologies. Although some of the tools such as CRISPR-Cas9 are highly specific, unintended genetic changes may still exist which are known as off-target effects. These accidental modifications can lead to the appearance of the adverse biological effect in the form of newly-appearing genetic diseases or some unpredictable health threats. Besides, when gene editing is performed on germ line cell, embryos, sperm or eggs, the genetic modification is passed to the new generations. This casts grave doubts on the biological and social implications of making any changes to the human genome that can be irreversible and potentially have a significant impact on mankind (Baltimore et al., 2015).

The other serious ethical issue is the prospect of non-therapeutic genetic engineering. Although most researchers advocate gene editing as a cure of severe illnesses, scientists can use the technology to upgrade human characteristics, including intelligence, physical attractiveness or athletic capabilities. This idea, which is commonly referred to as designing babies, brings up the issue of social justice and inequality. In case genetic enhancement is offered to the rich or privileged members of society, it might contribute to the generation of more socio-economic differences and the emergence of a new kind of discrimination based on genetic modification characteristics. These advances may radically transform the attitude of society towards human identity, diversity, and equality (Savulescu, 2016; Sandel, 2007).

Along with these issues, other ethical arguments about gene editing also engage the question of consent, equity, and equity to new technologies. The generation to come cannot give their consent to any genetic interventions that might be directed to their lives, but germline editing may have long-term alterations on their biological traits. Additionally, the unequal access to advanced genetic therapies can bring inequalities to various populations and nations, casting doubts on global justice in healthcare. Researchers in Bioethics and Genetic Engineering note that it is crucial to define ethical standards and regulatory approaches to make sure that gene editing technologies are applied in a responsible manner and are mostly aimed at therapies (Jasanoff et al., 2015).

Therefore, the moral regulation of human genetic engineering is currently among the burning issues of the contemporary scientific and philosophical discourse. The issue of how these powerful technologies are to be regulated so as to achieve the right balance between scientific and human dignity and social justice is a matter of discussion between the policymakers, scientists and ethicists alike. To ensure that the developments of biotechnology are beneficial to the society and that the potential damage and abuses of the genetic technologies are minimized, it is essential to comprehend the ethical implication of the process of gene editing.

Research Problem

The discovery of gene editing technologies and especially the CRISPR-Cas9 system have made it feasible to edit human DNA in a more precise and efficient way than ever before. These developments promise a bright future in the treatment of genetic disorders like the Sickle Cell Disease, Cystic Fibrosis, and the Huntington disease, but these developments also bring about great ethical issues. These issues are the probability of gene editing misuse to non-therapeutic improvements, the danger of unwanted genetic effects, and the likelihood of social disparity, which occurs due to dissimilar use of the technologies.

The other concern that is of critical interest is the aspect of germline editing in which genetic alteration can be passed to the subsequent generations. This brings the issue of consent, safety and the limits of morality of manipulating the human genome. The fact that there are no common ethical norms and rules also makes the use of genetic engineering in human beings a matter of responsibility. Thus, the main issue of this study is the issue of the ethical dilemma of the use of gene editing technologies in humans and the necessity to develop the frameworks of the ethical aspects of their use clearly.

Research Questions

This study seeks to answer the following questions:

1. What are the main ethical concerns associated with human genetic engineering and gene editing technologies?
2. What potential benefits can gene editing provide in the treatment and prevention of genetic diseases?
3. What risks and long-term consequences may arise from modifying the human genome?
4. How should ethical guidelines and regulations govern the use of gene editing technologies in humans?
5. To what extent should gene editing be permitted for therapeutic purposes versus human enhancement?

Aim of the Study

This paper is intended to present the ethical issues relating to genetic engineering and gene editing in human beings. It tries to explore the ethical, societal, and legal issue of using the technology of gene editing, particularly in medical and reproductive cases. The study will also aim at evaluating the potential effect of these technologies on the future generations and the increased organization of the society.

Purpose of the Study

The purpose of this study is to explore the ethical challenges and responsibilities related to human gene editing and genetic modification. It intends to:

1. Identify the major ethical concerns surrounding human genetic engineering.
2. Evaluate the potential benefits and risks of gene editing technologies.
3. Discuss the role of ethical guidelines and regulations in controlling genetic interventions.
4. Provide recommendations for responsible and ethical use of genetic engineering in human health and medicine.

2. Literature Review

Methodology

The research is qualitative due to the systematic review and analytical analysis of the available academic literature. The steps involved in the methodology are:

1. Literature Collection
   Peer-reviewed journal articles, academic books, and official reports pertaining to Genetic Engineering, gene editing technologies and Bioethics will be gathered through reputable academic databases.
2. Thematic Analysis
   The literature obtained will be measured to find out common ethical issues like safety, justice, human dignity, and social implications.
3. Comparative Ethical Evaluation
   Various ethical attitudes and regulatory systems of different countries and international bodies will be contrasted to see how gene editing is regulated in the world.
4. Critical Discussion
   The paper will critically evaluate the advantages and disadvantages of human gene editing, with the emphasis on its effects on medicine, society, and future generations.

Research Design

The research is based on the descriptive and analytical design. The descriptive part seeks to give a clear picture of genetic engineering and gene editing technology, whereas the analytical part will analyze the ethical issues of their use in human beings. In this way, the present research will have the ability to examine the existing arguments and identify the key ethical issues, as well as outline the potential risks and advantages of human gene editing.

Literature Review

Genetic engineering and human gene editing have been the subject of intense scientific and philosophical discourse in recent times regarding the ethical implications of these areas. The recent surge in the creation of modern genome-editing technologies, especially of the CRISPR-Cas9 system has fundamentally changed the field of genetics because now scientists can manipulate DNA sequences with great precision, efficiency, and at comparatively low cost. This scientific breakthrough has speeded up the field of genetics, biotechnology, and medicine, and has generated new possibilities to comprehend gene activity and discover new treatment options to previously untreatable illnesses (Doudna & Charpentier, 2014). Therefore, there is a growing attention among the researchers of Bioethics, Genetic Engineering, and medical sciences towards the assessment of the advantages and the ethical issues of the use of gene editing technologies in humans.

In the past, the study of genetic engineering first involved the alteration of genes of microorganisms, plants and animals in order to enhance the production of agricultural products and to study the biological processes. Nevertheless, the potential of human genome editing has become a scientific goal after the creation of accurate gene-editing methods like CRISPR-Cas9. Doudna and Charpentier (2014) note that CRISPR-Cas9 enables scientists to target particular sequences of DNA and either eliminate, substitute, or alter genes that cause some biological characteristics. The technology has greatly widened the possibilities of the gene therapy field by allowing genetic defects to be fixed directly into the cells of the human being. Therefore, a lot of scientists think that the technologies of gene editing can transform the contemporary medicine and treat genetic diseases, not being limited to treating the symptoms of the sickness.

A large amount of literature has shown the therapeutic promise of gene editing technologies. Many researches have shown that genome editing can offer novel cure to inherited diseases caused by mutated genes. As an illustration, genetic disorders like Sickle Cell Disease, Cystic Fibrosis, and Huntington Disease are caused by mutation in certain genes and they interfere with normal body functions. Technologies in gene editing can enable scientists to fix such mutations on a molecular scale, which can potentially eradicate the cause of the underlying disease (National Academies of Sciences, Engineering, and Medicine, 2017). There are already encouraging findings in this field with respect to experimental therapy, especially with sickle cell disease, where defective hemoglobin genes have been repaired using modified stems cells (Frangoul et al., 2021).

Besides curing the diseases, the gene editing technologies can also help in prevention medicine. It has been argued by scientists that genome editing can be applied to decrease the chances of hereditary diseases by fixing the harmful mutations before they are inherited by the new generations. This fact has created a great deal of hope among medical scientists as it would lead to a considerable decrease in the number of genetic illnesses worldwide (Lanphier et al., 2015). Also, gene editing can contribute to the emergence of personalized medicine, where medical therapy is designed to suit a genetic profile of an individual. These methods would enhance effectiveness of the treatment with minimal side effects.

Along with such encouraging medical advantages, there are also ethical issues in the sphere of using gene editing technologies on humans, which are also highlighted in the literature. The safety and reliability of the genome editing processes are one of the key concerns. Even though CRISPR-Cas9 is well-known as a very specific technology, unwanted genetic alterations, so-called off-target mutations, can still appear in the process of editing. Such accidental changes may cause disruption of other genes or other biological functions, resulting in unexpected medical problems (Baltimore et al., 2015). Since the long-term consequences of such genetic modifications have not been thoroughly studied yet, a great number of scholars believe that, before implementing the technologies of gene editing in clinical practice, caution should be exercised.

The other significant ethical question presented in the literature is the topic of germline gene editing. Germline editing is the alteration of the genetic material of embryos, sperm or egg cells and this implies that changes in the genetic material would be transferred to the successive generations. This brings about intricate ethical issues of consent, responsibility and the future implications of changing the human genome. People who gain such genetic modifications in the future will not be able to give their consent to these procedures, but they will have to face the biological outcomes of these changes in their lives (Jasanoff et al., 2015). It is due to this reason that numerous scientists

and ethicists assert that germline editing must be treated with extreme caution and must be ethically monitored.

The possible social implications of human genetic engineering are also discussed in the literature. A fear is that the editing gene technologies may be applied to non-therapeutic enhancement as opposed to treatment. Genetic technologies may also enable people to improve desirable qualities like intelligence, physical appearance, or athletic capability in addition to treating diseases. This option has raised much controversy concerning the making of the so-called designer babies where parents can choose or alter certain traits of their babies. Critics state that this practice may result in creating new types of social inequality in case genetic improvements are offered to only a very rich group of people or the privileged groups (Sandel, 2007).

Moreover, the application of gene editing to enhance human beings poses questions regarding the boundary of human nature in the practice of science. Other philosophers say that seeking to enhance or create human characteristics by use of genetic engineering might compromise significant moral principles like equality, dignity and embrace of natural human diversity. Savulescu (2016) states that as much as genetic enhancement has some advantages, it also poses a threat of dividing the society between those who have been enhanced and those who have not. These issues underscore the need to scrutinize the ethics of gene editing technologies carefully before permitting the use of the technologies to be widely used.

To address these issues, various global organizations have demanded that clear ethical principles and regulatory frameworks should be set to regulate the research on gene editing. The World Health Organization has reiterated the need of international collaboration in the process of controlling genome editing technologies so that scientific advancements take place in a responsible and transparent manner. On the same note, the Nuffield Council on Bioethics (2018) has advocated that human genome editing must not be allowed when it is not aimed towards the well-being of humanity and when it will not cause social inequality or discrimination.

In conclusion, it is possible to note that in the existing literature, the possibilities of genetic engineering and gene editing technologies are enormous regarding improving human health and advancing medical science. At the same time, the technologies also have complex ethical, social and regulatory issues that are to be considered as well. Most scholars agree that, much as the use of gene editing in the case of therapy ought to be encouraged, there is a need to ensure that powerful technologies are used in a responsible and helpful manner to the whole humanity by ensuring that strong ethical principles and policies throughout the world are in place.

A qualitative research approach will be applied in this research paper to examine the ethical concerns of human genetic engineering and gene editing technologies. Since the subject matter is complicated in terms of moral, social, and scientific issues, the qualitative research paradigm is deemed suitable to research and examine the various approaches that have been proposed in scholarly literature. The subject of the study is to write about academic controversy on the existing gene editing technologies, specifically, CRISPR-Cas9 system, and its impact on human health and society.

Data Analysis

The thematic analysis is used to analyze the information collected. This approach will require the close consideration of the literature on the topic of gene editing in human beings by exploring the most important themes and the common ethical issues associated with it. Some of the key themes that the analysis concentrates on are safety, genetic enhancement, social justice, consent and the long-term impact of genetic modification on the future generations.

In this analysis, the paper contrasts various opinions of scientists, bioethicists, and policy makers. The comparison is useful to outline the points of agreement and disagreement in the literature on the issue of human gene editing in terms of its ethical acceptability and its possible outcomes on the individual and the society.

Ethical Considerations

Because this study is based on previously published literature, it does not involve human participants or experimental procedures. However, academic integrity is maintained by properly citing all sources and acknowledging the contributions of previous researchers. Ethical standards in

research writing are followed to ensure transparency, credibility, and respect for intellectual property.

Limitations of the Study

In spite of the fact that the given research is a thorough analysis of the ethical concerns concerning the human gene editing, it is constrained by the fact that it uses the already published works and theoretical debates. The research lacks experimental facts or direct empirical research. Also, since technologies of gene editing are still evolving at a fast pace, in the future, more ethical issues and scientific advances can arise which are not completely covered in the available literature.

3. Discusion

Summary

In general, such an approach enables the research to discuss the ethical issues of genetic engineering and gene editing in humans in a critical manner. The research is meant to enhance the knowledge of the application of such powerful technologies in the field of modern medicine and society through the analysis of the arguments presented in the literature and the evaluation of various ethical points of view..

Discussion

The modern genetic technologies are being developed extremely fast, which has altered the sphere of medicine and biotechnology greatly. The creation of genome editing methods, especially the CRISPR-Cas9 system, has given researchers a new and unique opportunity to edit DNA sequences in a highly precise and efficient manner. The technological advancements have provided new opportunities to treat genetic diseases and develop personalized medicine. Nevertheless, with all these scientific advances, some critical ethical issues have been raised about how the gene editing technologies should be applied to humans.

The therapeutic potential of gene editing is one of the widely discussed topics in the literature. Researchers and people involved in the field of science claim that gene editing technologies might offer groundbreaking cure to a number of hereditary diseases that could not be treated before. There are genetic disorders like Sickle Cell Disease, Cystic Fibrosis and Huntington Disease, which are caused by mutation in particular genes and gene editing promises to help in correcting the mutations at the core. Medically, this potential is a significant development that can bring a lot of positive change in the health of humans and minimize the amount of genetic diseases that plague the world.

In spite of these promising medical applications, the ethical implications of human gene editing are still quite high. Safety of the technologies of gene editing is one of the main concerns. Even though specific tools like CRISPR-Cas9 are very precise, some unintended genetic alterations can still be present during editing. Such off-target mutations may have some harmful biological implications or new genetic diseases. Since the long-term consequences of gene editing remain not completely studied, numerous scientists stress the necessity of thorough testing and conscientious control of such technologies prior to their application in a broad range of clinical practice.

The other significant question of the ethics is the germline gene editing that is the modification in the genes of embryo, sperm or egg cells. Unlike somatic gene editing, which only impacts the treated individual, germline can offer genetic changes, which could be passed on to the subsequent generations. This poses tremendous ethical challenges of consent, responsibility and the long term consequences of human genome editing. The descendants who inherit such genetic alterations will not be able to agree on the alteration of their genetic composition, which creates ethical issues of human autonomy and rights.

In addition, human enhancement that can be achieved by gene editing has raised a significant amount of controversy among academicians and ethicists. Though the majority of scientists are sure that gene editing can be safe when used in therapeutic contexts, there is a chance that the technology may end up in wrong hands that want to use it to develop such desirable traits as intelligence, physical attractiveness, and sports performance. The fact that it is possible to produce designer babies brings up the issue of social inequality and discrimination. Provided that the genetic improvements are only provided to the wealthy, it can lead to the further widening of the social divide and the creation of new genetic inequities on the society.

Global governance and ethical regulation are also mentioned in the literature discussion as important. Effective ethical principles and regulatory control have been emphasized by the scientific community of the world in the direction the gene editing technologies are to be. Global organizations such as the world health organization and the Nuffield Council on Bioethics have encouraged the world to work together in coming up with regulations that would lead to responsible use of gene editing whereby its primary use is medical.

On the whole, the discussion shows that the technologies of genetic engineering and gene editing have both great opportunities and severe ethical issues. As much as these technologies can transform the face of modern medicine, their use has to be well balanced with ethical issues that safeguard the human dignity, social justice and long term well being of the society..

4. Conclusion

Conclusion

In conclusion, it is possible to state that genetic engineering and gene editing technologies could be viewed as one of the most dramatic scientific developments in the modern world. Genome editing technologies, in particular, the CRISPR-Cas9 system have been developed, and researchers are now able to edit the human genome with more precision than ever before. These technologies have great potential in treatment and prevention of genetic diseases, medical treatment, and personalized medicine.

However, the aspect of ethics of the human gene editing cannot be ignored. The safety questions, long-term genetic impact, the germline change and human enhancement also raise such serious moral issues which need to be explained before these technologies can be widely employed. The accidental genetic implications and the fact that genetic changes may be transmitted to the next generation has necessitated a need to be careful and responsible when it comes to gene editing.

Besides, the concerns of social justice and equality refer to the need to ensure that genetic technologies do not add to the current extent of social inequalities. Ethical governance, international cooperation, and sound regulatory frameworks are needed to make sure that the application and development of gene editing technologies are responsible and will guide the research in the given field.

Last, as much as genetic engineering has a vast promise in the way it has transformed human health and scientific understanding, it must be held under ethics that promote the dignity of human being, protection of the future generation and promotes fairness and justice in the society...

Recommendations

1. Based on the results of the ongoing research, we can make certain suggestions which can assist in applying gene editing technologies to human subjects in a conscientious way:
2. Provide Clear Ethical Principles Governments and global organizations are expected to come up with stringent and elaborate ethical standards that are expected to be used in the application of human gene editing technology. Restrict application of Gene Editing to Therapeutic applications Gene editing must be used mostly as a treatment and prophylaxis tool against serious genetic diseases instead of non-therapeutic human enhancement.
3. Improve International Control There is dire need to have international collaboration among nations to establish uniform standards and regulations that ought to be implemented in conducting genome editing research.
4. Promote Community Mobilization and Engagement The scientists and policymakers should encourage the participation and engagement of the masses in the debate regarding gene editing to enable transparency and democratic politics. Encourage further Scientific Studies Gathering of studies is essential, such that additional information will be obtained on the safety and effectiveness of gene editing technologies in the long term before they can be generalized to clinical practice.
5. Equal Access to Genetic Therapies Policy-makers in the federal government must seek to make genetic medicine benefits accessible to all people irrespective of their economic and social standing.

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