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GENE EDITING: THE BOUNDARIES OF HUMAN MORALITY

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ABSTRACT

Revolutionary advancements in gene editing, particularly CRISPR-Cas9 technology, hold immense potential for curing genetically mutated diseases and enhancing human characteristics. However, these developments raise significant ethical concerns about societal implications and the preservation of humanity. The increasing presence of gene editing technologies has sparked intense debates about the moral ramifications of human-driven genetic engineering, including embryo experimentation and social inequality due to limited accessibility. While extensive research has highlighted CRISPR-Cas9's capabilities and associated risks, recent controversial cases have intensified ethical discussions. Addressing these moral challenges is essential to uphold morality and prevent the misuse of such transformative tools. Through case studies, regulatory frameworks, and philosophical perspectives, the scientific community and various organizations have shaped this critical discourse on the appropriate use of genome modification. Contributing to these ongoing discussions, this paper explores the societal dangers and ethical implications of gene editing for future generations, emphasizing the responsibility required to prevent unintended consequences. Ultimately, it provides a comprehensive overview of the factors influencing the morality of genetic modifications and underscores the need for strict regulations to safeguard individuality.

KEYWORDS: Gene, Editing, Human, Society, Morality, Ethics, Crispr-Cas9, Implications

INTRODUCTION

The burgeoning field of gene editing, particularly through the transformative CRISPR-Cas9 technology, is reshaping the scientific landscape. These advancements carry profound societal implications, offering unparalleled opportunities alongside significant challenges. Gene editing promises breakthroughs ranging from curing genetic diseases to enhancing human capabilities. However, such power raises critical ethical questions about human-driven genetic manipulation. Addressing these moral complexities is crucial for responsible progress in this domain. Gene-editing technologies present extraordinary medical potential while sparking concerns about ethical risks, including social inequality, unforeseen consequences, and redefining the essence of humanity.

Key Themes in Gene Editing

From case studies, philosophical discourse, and regulatory analysis, three central themes emerge:

1. Ethical responsibilities and human dignity in altering life.
2. Promising treatments for genetic diseases.
3. Risks of social disparity due to unequal access to advancements.

The rapid growth of gene modification experiments has ignited debates over their morality. This review examines both public and academic perspectives, contributing to ongoing discussions.

Fundamentals of Gene Editing and Genealogy

Understanding genealogy and gene alteration is essential before delving into ethical debates.

"A gene is the basic physical and functional unit of heredity" (National Library of Medicine, 2024). Genes, composed of DNA, dictate inherited traits shaped by evolution. They embody a shared ancestral narrative. Genome editing modifies DNA by adding, removing, or altering its sequences (American Society of Gene & Cell Therapy, 2024).

Two primary types of genome editing, as described by the Harvard Gazette, include:

1. **Somatic Gene Editing:** Targets specific cells of an individual without affecting offspring.
2. **Germline Editing:** Alters all cells, including reproductive ones, passing changes to future generations (Cannon & Cannon, 2024).

These foundational concepts provide context for the ethical implications of genome editing.

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CRISPR-Cas9 Technology

CRISPR-Cas9, known for its precision, affordability, and speed, is the leading genetic editing tool. CRISPR stands for Clustered Regularly Interspaced Short Palindromic Repeats, while Cas9 refers to CRISPR-associated protein 9 (Liu, 2020). Derived from bacterial immune systems, this technology enables targeted DNA edits.

Bacteria store viral DNA sequences within their own genome, forming CRISPR Arrays. When attacked again, they produce RNA segments to identify and neutralize the virus. Scientists have adapted this process for targeted DNA modification. By engineering RNA to match a specific DNA sequence, Cas9 cuts the DNA at that location, allowing for precise edits (National Library of Medicine, 2024).

Ethical Controversies in Gene Editing

Despite its promise, CRISPR-Cas9 has fueled ethical debates. In 2018, Chinese scientist He Jiankui used CRISPR to edit the genes of twin girls, provoking global outcry (Raposo, 2019). Jiankui sought to disable the CCR5 gene, which enables HIV infection, making the twins immune to the virus. However, this violated China's 2003 "Ethical Guiding Principles for Research on Embryonic Stem Cell," which prohibits implanting embryos into a uterus after 14 days of existence (Liao et al., 2007; Raposo, 2019). Additionally, the CCR5 gene influences brain functions, sparking allegations that Jiankui aimed to enhance cognitive abilities under the guise of disease prevention. This raised concerns about "designer babies" and widened socioeconomic divides (The American Society for Microbiology, 2024). During the 2018 Chinese CRISPR babies controversy, the law in China states that scientist He Jiankui's actions were illegal and immoral, punishing him to 3 years in jail (Liu, 2020).

Global Regulations on Gene Editing

Countries worldwide maintain their own legal frameworks to regulate genetic modifications. In a 2020 Forbes article, researchers revealed stricter regulations for heritable germline gene alterations (for reproduction) compared to somatic genome editing (not for reproduction and non-heritable) (Qaiser, 2020). According to their findings:

- Only 40 out of 96 countries have policies addressing non-reproductive germline genome editing; 23 prohibit it outright, while 11 explicitly permit it.
- In contrast, 78 out of 96 countries have regulations for heritable genome editing. Of these, 70 prohibit it outright, five allow potential exceptions (Colombia, Panama, Belgium, Italy, and the UAE), and three are indeterminate (Burkina Faso, Singapore, and Ukraine). Notably, none explicitly permit heritable genome editing.

This highlights the global hesitation surrounding heritable genome editing, driven by ethical and social concerns. Furthermore, the disparity in regulatory frameworks reflects a global ranking system where only scientifically advanced nations can consider such policies. This inequity implies that, if germline genome editing were to be integrated into society, those who can afford these treatments would gain significant advantages, exacerbating socioeconomic inequality.

Ethical Oversight in the Scientific Community

At a smaller scale, sub-societies within the scientific community maintain regulatory frameworks to address ethical concerns, although without the legal authority of governments. For instance:

- The American Society of Gene & Cell Therapy (ASGCT) condemned the premature use of germline gene editing in a 2018 statement following the controversy in China. They asserted that such applications are neither ethically nor scientifically acceptable without extensive research and regulatory approval.
- The International Society for Stem Cell Research (ISSCR) underscores the importance of transparency and social responsibility. Their guidelines emphasize strict ethical limits, including:
    - Prohibitions on reproductive cloning and inter-species chimeras.
    - The "14-day rule," prevents human embryo cultivation beyond 14 days post-fertilization to preserve humanity and respect for life (Alm, 2023b).

The controversy surrounding He Jiankui's CRISPR experiment in China, where human embryos were modified beyond the 14-day rule, highlights the critical importance of such boundaries. The ISSCR also mandates that embryos should not be fertilized solely for experimental purposes, as it dehumanizes human life and violates collective moral standards.

RISKS AND CHALLENGES OF GERMLINE GENOME EDITING

As a nascent field, genetic engineering carries significant risks alongside its theoretical rewards. While the aspiration is to eliminate genetic diseases and create a healthier society, the unpredictable consequences raise substantial concerns.

1. Off-target Effects: Off-target effects occur when unintended areas of the genome are impacted, leading to unexpected mutations that may affect multiple bodily systems and organs (Alm, 2023). This was a critical issue in He Jiankui's CRISPR experiment, sparking global outrage.
2. Mosaicism: Mosaicism refers to a condition in which a genetically modified individual has multiple populations of cells with distinct genetic compositions. This can occur during the early stages of cell division after fertilization (National Library of Medicine, 2024). For example, if a genome edit affects only one cell at the two-cell stage, the genetic modification may fail to work as intended. Potential outcomes include:

- Ineffectiveness of the genetic modification.
- Failed embryonic development.
- Inability to carry the fetus to term.

These risks highlight the unpredictability and ethical complexities of germline genome editing. As a result, strict regulatory control is necessary to ensure safety and prevent misuse of these powerful technologies.

Public Opinion on Gene Editing

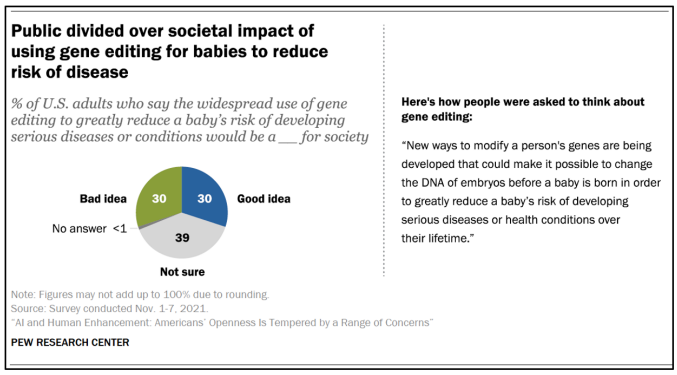
A 2021 survey by the Pew Research Center explored Americans' perspectives on editing babies' genes to prevent serious diseases. Findings were divided:

- About one-third of respondents viewed it as a "good idea."
- Another third viewed it as a "bad idea."
- The remaining third were "not sure," reflecting a lack of sufficient knowledge to form an opinion (Nadeem & Nadeem, 2024).

Another poll compared attitudes toward genetic modification for disease treatment versus physical or intellectual enhancement. This survey showed stark contrasts:

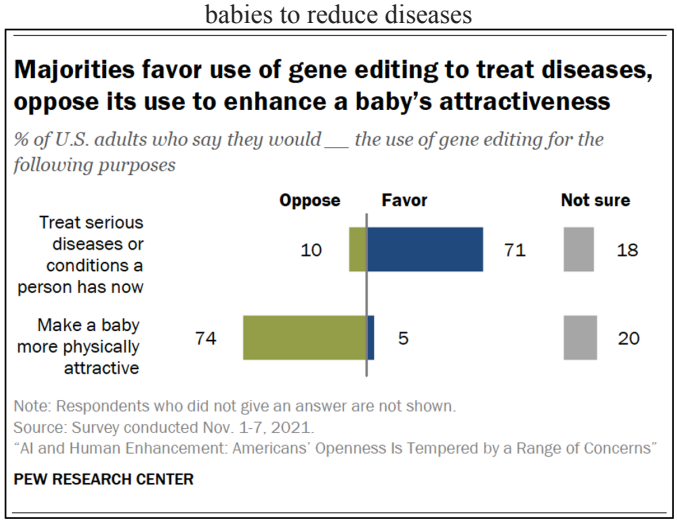
- 71% supported using genetic editing to immunize children against serious diseases.
- 74% opposed genetic editing to enhance children's physical appearances or intelligence (Nadeem & Nadeem, 2024).

The Pew Research Center summarized these results, noting that genetic editing for treating serious health conditions was seen as appropriate, while enhancing intelligence or appearance was considered taking technology too far. These results reveal deep ethical concerns about genetic engineering, especially regarding potential social inequalities, unintended consequences, and challenges to humanity's core values.



Source: Nadeem & Nadeem (2024)

Figure 1: Public Opinion on the ethicality of gene editing in babies to reduce diseases



Source: Nadeem & Nadeem (2024)

Figure 2: Public Opinion on the use of gene editing in babies for various

The overall societal consensus on whether gene editing is good or bad remains split and undecided. However, these survey results highlight the moral tension surrounding genetic engineering. Ethics and humanity play crucial roles in modern medicine and both come into play when considering the morality of genetic manipulation. Both scientists and researchers need to hold a level of ethical responsibility in their work. In the case of manually modifying human genetics, having integrity and responsibility is of the utmost importance. This long debate has deep roots within the field of philosophy. Various philosophers have spoken about this matter, setting their own boundaries to where human interference at a genetic scale becomes inhuman.

ETHICAL CONCERNS AND PHILOSOPHICAL PERSPECTIVES

Philosophical Perspectives on Morality

The ethical debates surrounding gene editing are rooted in philosophical discourse. Key thinkers offer valuable insights into the moral boundaries of genetic manipulation.

1. **Immanuel Kant:** Kant's moral philosophy emphasizes the motive behind actions rather than their outcomes. According to his ethical framework, using germline genome editing—even for a good cause—disrespects human dignity. Manipulating embryos for experiments treats potential humans as a means to an end, violating their inherent value. Kantian philosophy warns against altering future generations' genetic makeup, as it risks compromising individuality and uniqueness (Schmidt, 2024). A specific concern is the potential reduction in genetic diversity. As per Joseph et al. (2022), heterozygosity refers to the genetic variability within a population, which could diminish with widespread genome editing, leading to increased uniformity and loss of individuality.
2. **Jürgen Habermas:** In The Future of Human Nature, Habermas critiques the genetic manipulation of embryos, arguing that it dehumanizes them and imposes restrictions on their future lives. By making children subjects of experimental projects, their autonomy and dignity are compromised. Habermas focuses on the aftermath of genetic editing, emphasizing how altered human nature could fundamentally change what it means to be human (Morar, 2024).
3. **Siddhartha Mukherjee:** In The Gene: An Intimate History, Mukherjee discusses the potential societal impacts of genetic engineering. He raises concerns about using gene editing to address social issues like addiction or deviance, warning that it could exacerbate social divides and lead to stereotyping. Mukherjee also highlights the ethical dangers of genetic profiling, such as preemptively labeling individuals as predisposed to criminal behavior (Mukherjee, 2016a).

The possibility of genes controlling one's behavior and person has been studied and expanded on by American clinical psychologist Erik Turkheimer. Turkheimer studied the correlation between genetics and behavior extensively and created three laws to represent his findings:

1. "All human behavioral traits are heritable. [That is, they are affected to some degree by genetic variation.]" (Chabris et al., 2015)
2. "The effect of being raised in the same family is smaller than the effect of genes." (Chabris et al., 2015)
3. "A substantial portion of the variation in complex human behavioral traits is not accounted for by the effects of genes or families." (Chabris et al., 2015)

Turkheimers three laws on behavioral genetics stem from his research on twins, adopted children, siblings, as well as many other kinships. Though his findings provide valuable information on the role that heritable traits play on a person's character, they cannot answer other more specific questions, as behavior is not something that can be predicted but rather is spontaneous and is what makes the children he researched themselves. Erik Turkheimer's research does nevertheless provide insight into the morality of permanent heritable germline genome modification. Prior to his research, the most prominent issue with adding, subtracting, or wholly changing a genetic sequence was the loss of physical individuality. However, his research on the connection between character and heredity leads us to realize that manually modifying one's genes may in fact lead to them losing the very characteristics that make them human.

When analyzing these findings of various researchers and the issues they bring attention to, there is an unsettling sense of overperfection. Both Habermas and Turkheimer emphasize the idea that altering human DNA to conform to socially idealized traits such as intelligence or beauty risks homogenizing our heterogeneous society. This stems from the prioritization of a "genetically optimized" collective society that prioritizes efficiency and performance over the humane qualities of individuality and diversity, similar to that of a dystopian society. These risks push for increased control over the praised modern gene editing technologies. However, it is crucial to consider that these advancements might lead us to perhaps lose touch with or even redefine what our life means.

CONCLUSION AND FUTURE RECOMMENDATIONS

While gene editing offers a multitude of groundbreaking opportunities to eradicate harmful genetic diseases, a balance with ethical responsibility is essential to success. The miraculous benefits can be easily outweighed by the risk of misuse and irresponsible genetic editing. Germline modification to reduce the risks of a genetic disease is a situation where genetic manipulation should be considered morally acceptable. However, the utilization of genetic manipulation to make a child "smarter" or "prettier" is in all cases morally unacceptable. Firm ethical boundaries are needed to ensure morality in our modern age of unprecedented genetic engineering. To truly understand these boundaries, we must ultimately ask ourselves, "What does it really mean to be human?"

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