CRISPR Technology and Ethical Implications

Abstract

CRISPR is a novel tool for genetic engineering that provides high efficiency, specificity, and treatment opportunities. However, it also generates significant ethical issues, especially in human genetic modification. The following paper discusses the moral issues, examples of use, social concerns, and emerging legislation regarding CRISPR technology. By analyzing case studies and evaluating their strengths and weaknesses, the paper's author seeks to present a realistic view of how using CRISPR positively advances human health without compromising ethical standards.

Keywords: CRISPR, gene editing, ethical concern, genetic engineering, risks and its rules, social concern

Introduction

CRISPR, or Clustered Regularly Interspaced Short Palindromic Repeats, has become one of the revolutionary tools at the molecular level of every living organism and has immense potential for application in medicine, agriculture, and biotechnology. The value of this concept is not in the technical realm as much as in therapies for previously untreatable genetic diseases, leading to new treatments and better health. Nonetheless, new opportunities are open with CRISPR, and an extensive list of ethical issues are associated with using this technology for human genetic editing. Originally, the delineation of the human germline demonstrated freedom on issues concerning genetic enhancement, the emergence of other consequences, and the possible amplification of social divide. In the analysis of the socio-ethical implications of germline genome editing, as pointed out by Ishii^1, there is a need to deliberate extensively. This paper will focus on discussing the relationship between the scientific potential of CRISPR and its ethical issues and then try to find out how to use the technology in human genetics in a beneficial way.

Ethical Concerns in CRISPR Applications

CRISPR technology has quite many ethical considerations, especially when it comes to human gene editing. One of the main worries is the risk of eugenics, which may thus result in societies in which enhancement is only possible for those who can afford it. ^2The concern over access seems even more worrying; Egelie et al.^3stress that proprietary regimes for biotechnological innovations contribute to unequal access to CRISPR technology, thus aggravating existing inequality in health. In addition, germline editing has raised serious ethical issues concerning consent, especially for future generations who cannot come and express the same. ^1

Eugenics and Social Division

In addition to using CRISPR technology for genetic improvement, the social implications include eugenics. This deepens the societal cleavages whereby the few individuals who can afford to access the available innovations are the only ones who benefit from the enhancements. Thus, creating the likely emergence of a society whereby genetic advantage is packaged and sold, and the existing disparities in the society will be worse off

Access and Equity

Another unpopular item is the availability of the CRISPR technique. According to Egelie et al., ^3, the current threat of proprietary interests will also ensure that only high-income individuals can enjoy the benefits of CRISPR. This restriction could increase the disparity between health risks and access to treatment, which is already a significant problem; marginalized populations are worse off.

Consent and Future Generation

Germline editing raises concerns about consent, given that future generations are affected by the modifications made in their genes even though they have not consented to any. ^1 Unlike many clinical procedures whereby a patient agrees or accepts a treatment, be it surgical or otherwise, in germline editing, future people cannot consent to change the human genome.

Risks of Unintended Consequences

Off-target effects, in which unintended genome portions are changed, are ethically problematic. 4 This is so because undesired side effects may be revealed regarding health implications, thus demanding substantial safeguarding measures and ethical actions when using CRISPR tools.

Case Studies in CRISPR Gene Editing

Different case studies have been conducted on CRISPR technology, revealing its potential in gene therapy. A well-known case is the approach of genetic diseases, including sickle cell disease and β- thalassemia, with the help of CTX 001, a CRISPR-Cas9 treatment. The preliminary data provided by Frangoul et al.^6 also show that this approach can reprogram hematopoietic stem cells to produce fetal hemoglobin and maybe a cure for such patients. Furthermore, CRISPR has been applied to congenital heart disease. Seok et al.^7 used CRISPR-Cas9 to fix genes that cause heart disease, thus proving the ability of engineering to address the origin points of diseases. Furthermore, CRISPR has been useful in amplifying the effectiveness of cancer treatments by modifying T cells that target cancer-related biomarkers, increasing the selectivity and efficacy of treatments ^4 These are clear indications of the effectiveness of CRISPR in modifying therapies across different specialized medical fields.

Clinical Applications

CTX001 in Genetic Disorders

CTX001 for sickle cell disease and β-thalassemia major is a breakthrough in gene therapy. ^6 CTX001 enhances fetal hemoglobin by modifying Hematopoietic stem cells and is potentially curative for these genetic diseases.

Congenital Heart Disease

Seok et al. seven also described the technique of CRISPR-Cas9 for treating genes that cause congenital heart disease. This approach focuses on the genetic factors that lead to the formation of an abnormal heart and hence offers a specific approach to the problem.

Cancer Therapies

CRISPR improves cancer treatments by modifying T cells to identify and eliminate cancer symptoms. ^4 This accuracy increases the impact of cancer therapy and decreases harm to normal cells, which is an innovative development in cancer immunotherapy.

Societal Implications of Human Genetic Modification

Human genetic modification via CRISPR technology has a wide variety of implications in society; thus, it is important to provide a closer look. The problem is that genetic equality is at risk since only people with sufficient money to pay for CRISPR technologies can have a chance to make use of them. According to Subica^9, when access is unfair, other groups, especially the vulnerable, may be further away from achieving better health. In addition, gene selection for 'designer babies' foregrounds another social issue of what is considered appropriate in terms of genes and the consequence of such selection. Wiley^5 points to the fact that this may reduce the value of diversity in humanity, as everybody will be the same. Besides, the efficiency of using CRISPR for genetic modifications raises questions regarding the consequences for successive generations and possible off-target effects, which nobody can predict at present. ^1 Furthermore, the possibility of using CRISPR brings into question the effective concepts of human identity and choice, and that is why the problem of genetic modification should be discussed in an open forum. ^8

Genetic Inequality

CRISPR technology is still available only to a certain extent to everyone, which can cause potential problems with genetic bias. ^9 The unfavorable situation with the availability of genetic technologies will only deepen existing health and social inequality.

Designer Babies and Societal Values

Questions have been raised about the acceptability of the idea of a 'designer baby, 'that is, selecting or modifying the genetic characteristics of the baby, as an outright effort to go against accepted ethical norms of society. ^5 Generally, such a model of selecting or modifying particular genes may lead to reducing the amount of genetic diversity in human beings, which goes against the accepted value of human variation.

Long-Term Effects and Uncertainty

Research on the consequences of genetic modifications is limited, and the potential for unanticipated genetic changes is associated with substantial risks. ^1 Concerns regarding using CRISPR in human genetics require careful and restrained utilization.

Human Identity and Agency

One of the major themes of the CRISPR revolution is the purposeful rewriting of the human code of existence and an invitation to question the parameters of human peculiarity and choice. ^8

Regulatory and Policy Development

The quick progression of CRISPR has led to improvements in these regulatory policies to tackle important biosocial concerns of genetic modification in people. Different countries have started the development of guidelines underlining ethical issues connected with gene editing. The National Sciences Academy and the National Medicine Academy of the United States of America have proposed recommendations for regulating germline editing, calling for public involvement in the decision-making of germline editing. ^8 The European Society of Human Genetics has provided guidelines for germline editing, emphasizing the need for preclinical research before the clinical application of germline editing.^10 Also, Egelie et al. show that regulatory agencies are turning. That is why Boni et al.^11 state that adaptive regulatory

approaches are necessary for ethical supervision to meet the rapidly developing gene editing technologies.

National Guidelines and Public Engagement

National Academy of Sciences and National Academy of Medicine guidelines for germline editing in the United States involve stakeholders' engagement in making decisions to ensure that the ethical standards upheld are those of society. ^8

European Approaches to Regulation

The European Society of Human Genetics has similar views when it comes to germline editing; it supports the need for more research, especially before their use on human beings, meaning that before they are used on humans, more preclinical studies ought to be conducted, all in a bid to eliminate risks that may be associated with the premature use of the technologies avert .^10

Transparency and Inclusivity

Egelie et al. 3 suggest that transparency and inclusiveness should be given priority when conducting regulatory discussions. Transparency and communication with multi-stakeholders are crucial for the effectiveness and appropriateness of regulation in this area.

Adaptive Regulatory Frameworks

In their paper, Boni et al. 11 discuss innovation in regulatory policies for biotechnologies, including CRISPR. The authors call for dynamic frameworks that can accommodate changes in the field. They posit that synthesizing knowledge from science, medicine, and business is the best approach to creating regulations that can effectively address the issue of ethical oversight as it follows pace with science and technology.

Benefits and Arguments Supporting CRISPR's Medical Use

However, before advancing to the ethical issues concerning the application of CRISPR technology, there are strong reasons for using CRISPR for medical purposes. Perhaps the largest advantage of gene therapy is its capability to cure genetic conditions that were otherwise incurable.^6 For example, the CRISPR-Cas9 therapy, CTX001, recently underwent clinical success for treating sickle cell disease and β-thalassemia, indicating the significant potential to improve patient's quality of life in the long run.^11 Also, the ability to develop accurate disease models utilizing CRISPR significantly speeds up the discovery of novel targets for treatment, which is especially important in combating new diseases.^3Furthermore, it is claimed that through offering one-off, corrective treatments instead of long-term interventions for diseases, CRISPR significantly cuts the overall cost of human health care.^4

Curative Treatments for Genetic Disorders

Therapies inclusive of CTX001 are examples of CRISPR-Cas9 that can treat genetic disorders, for example, sickle cell disease and β-thalassemia. ^6 Through modifying the genetic mutations that cause such diseases, CRISPR takes a long-term or permanent cure since patients' quality of life will be enhanced greatly.

Advancement of Medical Research

Boni et al. 11 noted that interdisciplinary cooperation among science, medicine, and business enhances the research and development process. This approach is very important in optimizing the utilization of CRISPR technology to generate accurate disease models and identify new treatment targets.

Cost Savings in Healthcare

CRISPR-based therapies can result in considerable savings in the healthcare system. ^3 CRISPR means that the patient does not need lifelong monitoring of a particular disease and, as a rule, receives constant treatment with expensive and often ineffective drugs.

Regulatory Support and Ethical Oversight

Adequate and ethical guidelines when developing regulatory systems to support the use of CRISPR technology can maximize the technology's benefits while preventing its risks. 4 Perfect regulation is key to maintaining public confidence and ensuring that all uses of CRISPR technology are ethically acceptable.

Conclusion

CRISPR is an exciting technology in genetic modification with great promise in genetic disorders therapy and medical research. However, this powerful tool is coupled with numerous ethical considerations best captured in the current article. The questions related to genetic enhancement and equality in the availability of CRISPR are cases that prove the necessity of moral regulation. The examples of different case areas of the utilization of CRISPR in gene therapy, including the treatment and cure formulas of sickle cell disease and congenital heart disease, show how beneficial and, at the same time, how risky the technology is.

Moreover, the implications of changing the human genetic code are that discussions regarding its usage must be societal, meaning features must be multiplexed for all values. There is a gradual change in the regulatory frameworks that seek to tackle these ethical issues with special focuses on such tenets as trust, public participation, and flexibility as apt to the ever-dynamic technological environment. Lastly, although CRISPR technology has so much potential for medical advancement, all stakeholders, scientists, ethicists, and the public must work together towards the use of CRISPR technology in a manner that honors ethical principles and is available for all. The road ahead should provide the same level of advancement in CRISPR, together with the ideas of moral and socially responsible work, to create a future that will benefit people’s genetic modification without losing the essence of ethics.

References

1. Ishii, T. Germline Genome-Editing Research and Its Socioethical Implications. *Trends Mol. Med.* 2015, *21*, 473–481, https://doi.org/10.1016/j.molmed.2015.05.006.
2. Seiter, K.; Fuselier, L. Content Knowledge, and Social Factors Influence Student Moral Reasoning about CRISPR/Cas9 in Humans. *J. Res. Sci. Teach.* 2021, *58*, 790–821, https://doi.org/10.1002/tea.21679.
3. Egelie, K.; Strand, S.; Johansen, B.; Myskja, B. The Ethics of Access to Patented Biotech Research Tools from Universities and Other Research Institutions. *Nat. Biotechnol.* 2018, *36*, 495–499, https://doi.org/10.1038/nbt.4165.
4. Baltimore, D.; Berg, P.; Botchan, M.; Carroll, D.; Charo, R.; Church, G.; … Yamamoto, K. A Prudent Path Forward for Genomic Engineering and Germline Gene Modification. *Science* 2015, *348*, 36–38, https://doi.org/10.1126/science.aab1028.
5. Wiley, L. The Ethics of Human Embryo Editing via CRISPR-Cas9 Technology: A Systematic Review of Ethical Arguments, Reasons, and Concerns. *Hec Forum* 2024, https://doi.org/10.1007/s10730-024-09538-1.
6. Frangoul, H.; Bobruff, Y.; Cappellini, M.; Corbacioglu, S.; Fernandez, C.; Fuente, J.; … Wall, D. Safety and Efficacy of CTX001 in Patients with Transfusion-Dependent β-Thalassemia and Sickle Cell Disease: Early Results from the CLIMB THAL-111 and CLIMB SCD-121 Studies of Autologous CRISPR-Cas9-Modified CD34+ Hematopoietic Stem and Progenitor Cells. *Blood* 2020, *136* (Suppl 1), 3–4, https://doi.org/10.1182/blood-2020-139575.
7. Seok, H.; Deng, R.; Cowan, D.; Wang, D. Application of CRISPR-Cas9 Gene Editing for Congenital Heart Disease. *Clin. Exp. Pediatr.* 2021, *64*, 269–279, https://doi.org/10.3345/cep.2020.02096.
8. Howell, E.; Wirz, C.; Scheufele, D.; Brossard, D.; Xenos, M. Deference and Decision-Making in Science and Society: How Deference to Scientific Authority Goes Beyond Confidence in Science and Scientists to Become Authoritarianism. *Public Underst. Sci.* 2020, *29*, 800–818, https://doi.org/10.1177/0963662520962741.
9. Subic, A. CRISPR in Public Health: The Health Equity Implications and Role of Community in Gene-Editing Research and Applications. *Am. J. Public Health* 2023, *113*, 874–882, https://doi.org/10.2105/ajph.2023.307315.
10. Wert, G.; Pennings, G.; Eichenlaub-Ritter, U.; El, C.; Forzano, F.; Goddijn, M.; … Cornel, M. Human Germline Gene Editing: Recommendations of ESHG and ESHRE. *Eur. J. Hum. Genet.* 2018, *26*, 445–449, https://doi.org/10.1038/s41431-017-0076-0.
11. Boni, A.; York, J.; Boyette, N.; Im, D. Seeking Life Science Innovation Opportunities and Beyond: The Art of Blending Science, Medicine, and Business. *Med. Res. Arch.* 2023, *11*, 3443, https://doi.org/10.18103/mra.v11i2.3443.