CRISPR: A Futuristic Tool at the Intersection of Promise and Ethical Controversy in Biotechnology

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Abstract
This paper investigates CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) technology, a tool that is revolutionary in the genetic engineering space. It has the power to revolutionize the field of biotechnology, biomedicine, and more. Starting with exploring the history of CRISPR and its power, this paper explores the transition from a simple defensive tool for bacteria to a futuristic biotechnological tool that allows scientists to modify the DNA of organisms precisely. The focus is primarily on the ethical controversy that arose with applying CRISPR to the human genome. The analysis is structured with three main domains of concern: healthcare inequality, "designer babies," and biodiversity impacts. With a thorough examination, this paper provides valuable insights into the debate on CRISPR, questioning the balance between technological advancement and responsible implementation.

Keywords
Ethical, CRISPR, Gene Editing, Inequality, “Designer Babies”, Risks

Introduction
In the spectacular field of genetic science, only a few discoveries have gained as much attention and debate as CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) technology. The development of CRISPR technology has opened new horizons for genetic engineering. CRISPR is a gene editing technology that allows scientists to make precise modifications to the DNA sequence of living organisms (Foley et al., 2022). This technology will enable scientists to easily add, remove, and alter genetic materials in specific locations, leading to widespread use in biomedical research, biotechnology, and medicine (Huang et al., 2022). Manipulating genes in humans raises huge societal and ethical questions that stretch far beyond the laboratory's walls. The power scientists hold with CRISPR, altering the physical and mental attributes of the human race, ignites many ethical dilemmas. Currently, CRISPR is being utilized for therapeutic applications, but the next steps with this technology are incredibly tantalizing (Abd-Elsalam et al., 2021). The possibility of

spreading strong genetic traits across entire populations, eradicating genetic diseases, and solving public health problems may seem like the path to a bright and healthy future. However, many safety and ethical considerations must be thoroughly investigated, which will be discussed throughout this paper. This paper will examine the social and ethical aspects of a new technology like CRISPR.

The History and Power of CRISPR

To understand just how important the debate on CRISPR is, one must grasp the power and gravity of this technology by examining the history of this technology. CRISPR first originated from research on E. Coli strains and was understood to only provide some defense against viruses in 2007 (Barrangou et al., 2007). Apart from this, not much was understood about CRISPR, and it was not seen as an important technology. This only changed when the 'founding mothers' of CRISPR, Jennifer Doudna and Emmanuelle Charpentier, investigated. She was able to apply CRISPR to the human genome to a limited level, and this was when CRISPR started to gain traction in the ethics community (Jinek et al., 2012). Jennifer in 2012 stated that she thought CRISPR was a tool that was widely applicable for targeted gene regulation and modification (Jinek et al., 2012).

Once CRISPR was more public, experimental trials started to ensue with mammals. Most notably, Feng Zhang and colleagues adapted CRISPR for mammalian cells, marking a significant step toward therapeutic applications (Cong et al., 2013). Dr. Zhang in 2013 proved that CRISPR functioned with high efficiency in human and mouse cells and showed potential to be used in mammals (Cong et al., 2013).

CRISPR had proven itself in the test field and was ready to enter usage with humans. Scientists and ethicists were beginning to understand that CRISPR was a strong technology. However, it was not until CRISPR was used on humans successfully that it became controversial. In 2018, the announcement of the birth of the first CRISPR-edited human twins in China by He Jiankui led to an international outcry and called for stricter regulations (Cyranoski and Ledford, 2018). This was the spark that led to the debates on CRISPR. Many people at the time thought that the experiment was exposing children to the unnecessary risks that are associated with gene editing (Cyranoski and Ledford, 2018). These risks stemmed from ethical, scientific, and health-related considerations, including off-target effects, unpredictable long-term consequences, and a negative societal impact.

CRISPR has evolved from a peculiar bacterial feature to an innovative biotechnological tool with immense power. Through research, collaboration, and tests, scientists now can shape the code of life. CRISPR has unmatched power and has proven helpful in humans with the birth of twins. The future of gene editing is right now; the question that needs to be considered is whether it is safe and ethical. The primary considerations

that need to be investigated are inequality, “designer babies”, biodiversity impacts, and how they would be regulated.

Healthcare Inequality

The success of new technology is heavily dependent on how it is implemented and also on who will have access to these therapies. The first roadblock presents itself here: healthcare inequality. Many factors are important to consider, including economic and geographical. There is a major threat for a chasm to deepen between the people who can and cannot access revolutionary technology like CRISPR.

Often with many new introductions of technology in healthcare, the primary social implication is cost. Most healthcare innovations and solutions have extremely high research and development costs, and CRISPR is no different. Bringing gene therapy to the market has been estimated to have a cost of nearly $5 billion (Hernandez et al., 2016). These R&D costs are traditionally passed on for the consumer to bear. Apart from the high initial price of bringing CRISPR, and gene-therapy solutions to the commercial market, CRISPR is an expensive treatment process. There are already examples of this on the market that are available for patients. For example, a gene therapy solution for spinal atrophy has a price of $2.1 million (Mullard, 2019). This already makes CRISPR inaccessible to the average patient. CRISPR is a treatment that ranges in the millions of dollars, and the already existing health disparities would only widen with the introduction of a new and expensive technology. Could insurance provide a solution to fill the economic gap that CRISPR could create? The short answer is no. Insurance has historically not kept up with the advances in gene therapy, and the existing framework of insurance would make it challenging to introduce CRISPR. As of 2023, gene-editing technology is still labeled as an experimental or investigational technology that limits or denies coverage under many insurance plans. Assigning a therapy the name “experimental” is a significant obstacle to improving patient access (McCarthy, 2017). Furthermore, with new technological advances, insurance providers mandate preauthorization requirements which involve extensive documentation and adherence to treatment protocols. These complications can pose major roadblocks for clients and patients (Cohen et al., 2020). Looking to the future where CRISPR moves past the experimental stage, it is still not promising. Even if CRISPR is covered by health insurance, they are infamous for high deductibles and copayments. As gene-editing technology is very expensive, cutting-edge treatments normally are out of reach for average-income families (Sood et al., 2017). Lifetime caps are also offered by some insurances, however, CRISPR would quickly exhaust these caps giving patients a bill they simply can’t pay. Insurance simply does not provide a simple solution, and the high cost of gene editing will only broaden economic inequalities. If CRISPR were to be commercialized, the question of who should bear the cost - the individual,

insurance companies, or the state - is an issue that would require careful policy considerations.

Geographical access is another aspect that can add to healthcare inequality. While the cost of CRISPR is already so high and will mainly be used in first-world countries, the use of CRISPR in third-world countries where geography may present a challenge that needs to be considered. Access to cutting-edge technology is normally limited to urban centers and places of high income. There are major disparities in access to health care as many non-urban countries lack the infrastructure to use gene editing as a treatment. This could create a geographical divide where rural populations or people in low and middle-income countries could be excluded from healthcare advancements. "The geography of innovation often leaves behind those in remote or underprivileged areas, creating a health technology gap" (Chakradhar, 2018).

Healthcare inequality with CRISPR is an extremely multifaceted challenge. CRISPR has the potential to revolutionize medicine but also has the risk of making existing disparities more obvious. Economic, systemic, and geographical factors come together to shape a landscape where CRISPR would be unequally distributed. Policymakers, ethicists, scientists, and society must ensure that CRISPR's benefits are realized equitably to effectively bring CRISPR to the healthcare field.

"Designer Babies"

To examine the controversy of "designer babies" we need to first understand what they are. "Designer babies" in their simplest terms are defined as "an embryo that has been genetically modified for the sake of producing a child with specific traits (New Hope Fertility, 2023)"

This topic has garnered a significant amount of debate and concern due to the scientific, ethical, and social dimensions. This is a debate about implementing CRISPR for new methods in the future. At the current stage, we are at a level of precision and predictability that is far from the level needed for genetic manipulation in embryos. CRISPR has made targeted gene editing accessible; however, the understanding of individual genes' contribution to complex traits including intelligence and appearance is limited. The safety of the individual/embryo is extremely low for new technology. There could be risks and side effects that are unknown, especially when used in human embryos. Off-target effects or unforeseen consequences of genetic modifications might lead to unexpected health issues later in life (Ormond et al., 2017). Furthermore, we are scientifically limited by what CRISPR can accomplish, as the traits are influenced by many environmental factors. The theory that one can customize human traits disregards the complex nature of genetic expression, upbringing, and environment (Parens, 2017).

When one inspects the topic of "designer babies", many ethical questions arise including the idea of playing god and enhancement vs. therapy. When one holds the power to alter the traits of a human, there will

be attempts to create the “perfect offspring”. Ethicists and religious scholars argue that using CRISPR to alter specific attributes crosses an ethical line. Some ethicists believe that we are venturing too far into a space that doesn’t belong to us, as curing disease is a big difference from creating ideal beings (Sandel, 2007). It is considered an extremely “slippery slope argument” due to how quickly the tides can change (Kass, 2002). This controversy has also gained a lot of traction in the religious community as well, people of religion argue that designing specific traits of babies belongs to a higher power. At the Catholic Bishops’ Conference of England & Wales, it was stated that "to determine the characteristics of our children is to assume a control that traditionally belongs to God" (2017). Apart from “playing god” is the argument of enhancement vs therapy. Therapy with gene-editing technology is socially accepted as it aligns with traditional medical goals. Dr. Juengst put it best when he said:

“Therapeutic interventions designed to prevent or heal, to restore patients to the normal functioning typical of their species, do not introduce new ethical problems" (1998).

Once the floodgates of genetically modifying embryos open, there will be efforts to enhance babies and essentially make a superhuman race. The tables of enhancement vs therapy can quickly change at a moment's notice. The question is not *if* the technology will be used for enhancement but *when*. This is a major reason why the impacts of CRISPR need to be heavily investigated as enhancing humans normally creates discomfort, where one contemplates whether or not a moral or natural boundary is being overstepped (Caplan, 2019).

Socially, there are also many issues with “designer babies”. If CRISPR does become commercialized and is allowed to be used on embryos to alter genetic traits, some traits could become more desirable than others. This could change social norms as there could be new cultural or social pressures to align with certain genetic norms. Even more, if the choice to genetically modify children is private, certain social pressures could evolve, making it a socially normal action to pursue genetic interventions. If it does become a norm, genetic modifications could lead to a stigma where children who did not receive genetic modifications would be discriminated against. There would be more social stratification based on genetic characteristics. Certain traits may gain more preference that could provide support for bias and prejudice in society, whether they be related to race, gender, or disability (Sandel, 2007). As discussed earlier, CRISPR is an expensive treatment, and since it would mainly be available to high-class people, it could further exacerbate the existing social inequalities. Also, genetic modifications could blur the lines between individuality and uniqueness. "The drive towards genetic perfection may lead to an erosion of empathy and a narrowing of what it means to be human" (Wright, 2019).

“Designer babies” is an extremely challenging and complex issue that arises with CRISPR. It is at the intersection of science, technology, and

society. While "designer babies" are still highly hypothetical, the controversy is very real. This necessitates thoughtful and considerate conversation.

Biodiversity

CRISPR holds great promise in many fields, but this technology can also have biodiversity impacts. As said earlier, if CRISPR is commercialized, some traits could be preferred. If certain traits become desirable and they become socially accepted, humans would undergo a biodiversity crisis. Certain traits would lead to a human species where there is reduced genetic diversity. This makes the human race extremely vulnerable to diseases and climate change as there is no diverse gene pool that could provide a buffer from calamities (National Academies of Sciences 2016). Furthermore, interfering with the processes of nature, including evolution and adaptation, could have devastating unforeseen consequences. Editing the germline will not protect the human gene pool that is currently distinctively collective heritage.

In an extreme scenario, where only a handful of traits and characteristics are seen as valuable, we could put ourselves in a dystopia. All humans would essentially be copies of each other. The characteristics that make each human unique from the other simply would not be present. Everyone would be a picture-perfect human which would lead to grave social implications.

Conclusion

CRISPR has proven itself to be a revolutionary technology that has the potential to transform multiple domains and aspects of human life. Being a manner of genetic modification, it is a controversial topic that requires social and ethical inspection. CRISPR's possibilities are attractive but also terrifying by equal measure. With this paper, we have looked into the history of CRISPR, its issues with commercializing it, the controversy of "designer babies", and its possible impact on biodiversity. This has shown us how CRISPR is no longer a scientific question but an ethical and social one. The interplay between science, society, and ethics that CRISPR brings represents the complex challenges that arise at the intersection of technological advancement and human values.

Moving forward with CRISPR we have to navigate the landscape with caution and consideration. CRISPR is not just a problem for scientists but for society at large. We need careful contemplation of what it means to be human and how CRISPR will change it. The question has expanded past the walls of the laboratory and is now reaching into the center of our shared and societal landscape. The path ahead is as detailed and meticulous as the very DNA we seek to understand. We need consideration, collaboration, and understanding of what life is to progress.

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