

The Ethical Considerations Of Human Genetic Engineering

¹Kalyan Sudarsan

Student

Sri Sankara Senior Secondary School

ABSTRACT

Human genetic engineering, the deliberate modification of an individual's genetic makeup, can revolutionize medicine and enhance human capabilities. However, this emerging field raises profound ethical concerns regarding the boundaries of intervention in human biology, the potential for genetic discrimination, and the implications for future generations. This research paper explores the ethical considerations associated with human genetic engineering by examining the arguments for and against its use, considering its potential impact on society, and analysing the ethical frameworks used to evaluate these interventions. By critically evaluating the ethical implications, we can contribute to a well-informed and balanced discussion surrounding the responsible application of genetic engineering technologies.

Keywords- *Somatic Cells, Germline Cells, Genome Editing, Severe Combined Immunodeficiency (SCID), CRISPR-Cas9, Sickle Cell Anaemia, Huntington disease, Cystic Fibrosis, Molecular Dystrophy, Designer Babies, Genetic Elite, Preimplantation Genetic Diagnosis (PGD)*

1. INTRODUCTION

OVERVIEW OF HUMAN GENETIC ENGINEERING AND CURRENT CAPABILITIES

Human genetic engineering refers to manipulating and modifying the genetic material in human cells to alter or enhance certain traits. It involves using advanced techniques to directly manipulate the DNA sequence in human embryos, somatic cells, or germline cells. Human genetic engineering has made significant progress in recent years, although its capabilities are still somewhat limited.

GENE THERAPY

Gene therapy is one of the most well-established applications of genetic engineering. It involves introducing specific genes into a patient's cells to treat or prevent diseases caused by genetic abnormalities. Gene therapy has successfully

treated certain genetic disorders, such as severe combined immunodeficiency (SCID) and some types of inherited blindness.

GENOME EDITING

The development of genome editing technologies, such as CRISPR-Cas9, has revolutionized the field of genetic engineering. These tools allow scientists to modify specific genes within the human genome precisely. CRISPR-Cas9 can potentially correct disease-causing mutations, eliminate harmful genes, or introduce beneficial traits.

DISEASE PREVENTION

Human genetic engineering holds promise for preventing genetic diseases by editing or replacing faulty genes. For example, correcting mutations

that cause diseases like cystic fibrosis, sickle cell anaemia, or Huntington's disease may be possible.

However, the practical application of these techniques in humans is still under development, and ethical considerations and safety concerns must be addressed.

DESIGNER BABIES

There is an ongoing debate and ethical consideration surrounding the concept of "designer babies", the idea of genetically modifying embryos to enhance desirable traits, such as intelligence, physical appearance, or athletic ability. While this concept has captured public attention, the scientific and ethical complexities associated with such modifications are still being actively discussed.

ETHICAL AND LEGAL CONSIDERATIONS

Human genetic engineering raises various ethical and legal questions. Concerns include the potential for unintended consequences, the creation of genetic inequalities, and the potential for misuse or abuse of these technologies. Many countries have established guidelines and regulations to oversee the use of genetic engineering techniques in humans.

It is important to note that while there have been significant advancements in human genetic engineering, many technical challenges and ethical considerations must be addressed before widespread implementation in humans. The field continues to evolve, and ongoing research and discussions aim to balance scientific progress and ethical responsibility.

2. IMPORTANCE OF ETHICAL CONSIDERATIONS IN GUIDING THE DEVELOPMENT AND USE OF THIS TECHNOLOGY

Ethical considerations are crucial in guiding the development and use of human genetic engineering technology.

Here are some key reasons why ethics is of utmost importance in this field:

I. RESPECT FOR AUTONOMY

Ethical considerations ensure that individuals have the right to make informed choices regarding their genetic makeup and reproductive decisions.

Human genetic engineering raises questions about the extent to which individuals should have control over modifying their own or their children's genetic traits.

Ethical guidelines help protect an individual's autonomy and ensure that decisions regarding genetic modifications are made with complete understanding and consent.

II. AVOIDANCE OF HARM

Ethical considerations help mitigate the risks associated with human genetic engineering. This technology can potentially bring unintended consequences at the individual and societal levels.

Ethical frameworks promote a cautious approach, emphasizing the need for rigorous safety testing and risk assessment before any clinical applications. This focus on avoiding harm ensures that potential benefits are weighed against potential risks.

III. EQUALITY AND JUSTICE

Human genetic engineering can exacerbate existing social inequalities and create new disparities. Access to these technologies and their potential benefits could be limited to those with financial

resources, leading to a genetic divide between the affluent and the disadvantaged.

Ethical considerations emphasize the importance of ensuring equitable access to genetic engineering technologies, preventing the creation of genetic inequalities, and addressing concerns related to distributive justice.

IV. UNINTENDED CONSEQUENCES

Genetic modifications can have unforeseen effects that may be transmitted across generations.

Ethical considerations urge a thorough evaluation of the long-term consequences of genetic engineering interventions, including assessing potential impacts on biodiversity, ecosystem dynamics, and social dynamics, among other factors.

Ethical frameworks advocate for comprehensive research, transparency, and ongoing monitoring to minimize and address unforeseen risks.

V. PUBLIC TRUST AND ENGAGEMENT

Ethical considerations foster public trust in scientific research and technological advancements. Open dialogue, public engagement, and transparency regarding the development and use of human genetic engineering technology are essential.

Ethical guidelines promote inclusive and participatory approaches, allowing diverse perspectives to be heard and considered, thus ensuring that societal values and concerns are adequately addressed.

In summary, ethical considerations are vital in guiding the development and use of human genetic engineering technology. They safeguard individual autonomy, mitigate risks, promote equality, address unintended consequences, and foster public trust.

By integrating ethics into the framework of human genetic engineering, we can strike a balance

between scientific progress and responsible innovation, ensuring that this technology benefits humanity while upholding fundamental moral principles.

3. ARGUMENTS FOR HUMAN GENETIC ENGINEERING

I. POTENTIAL MEDICAL BENEFITS, INCLUDING THE PREVENTION OF GENETIC DISEASES AND DISABILITIES

Human genetic engineering holds significant potential for medical benefits, particularly in preventing genetic diseases and disabilities.

Here are some key ways in which this technology can contribute:

A. DISEASE PREVENTION

Genetic engineering techniques offer the possibility of preventing genetic diseases at their root cause. Identifying disease-causing mutations and using genome editing tools like CRISPR-Cas9, correcting or replacing faulty genes responsible for genetic diseases like cystic fibrosis, sickle cell anaemia, muscular dystrophy, and Huntington's disease may be feasible, thus eliminating the transmission of these diseases to future.

B. ENHANCED PRECISION AND EFFICACY

Human genetic engineering allows for precise modifications at the genetic level. It enables scientists to target specific genes or genetic sequences with high accuracy.

This precision offers the potential for more effective treatments and therapies, resulting in improved outcomes for individuals affected by genetic diseases or disabilities.

C. PERSONALIZED MEDICINE

Genetic engineering technologies can help in developing personalized medicine approaches.

Analysing an individual's genetic makeup makes it possible to identify their predisposition to certain diseases and design personalized treatment plans based on their genetic profile, thus leading to more targeted interventions, increased treatment effectiveness, and reduced adverse reactions to medication.

D. GENE THERAPY ADVANCEMENTS

Human genetic engineering has already shown promise in gene therapy. Gene therapy aims to address genetic disorders at the cellular level by introducing therapeutic genes into the body.

Recent advancements in gene therapy techniques have successfully treated disorders such as inherited blindness, certain types of cancer, and immune deficiencies. With further research and refinement, gene therapy could become viable for a broader range of genetic diseases.

E. IMPROVED QUALITY OF LIFE

Preventing genetic diseases and disabilities through genetic engineering can improve the quality of life for affected individuals. Addressing the underlying genetic causes may prevent the onset or progression of debilitating conditions, resulting in reduced healthcare burdens, enhanced independence, and improved overall well-being for individuals and their families.

While these potential medical benefits are promising, it is essential to approach human genetic engineering cautiously, considering the ethical implications, safety concerns, and the need for rigorous scientific evaluation.

Continued research, responsible application, and open discussions are crucial to ensure that the potential medical benefits of genetic engineering are realized while upholding ethical principles and

prioritizing the well-being of individuals and society.

II. ENHANCEMENT OF HUMAN TRAITS AND CAPABILITIES, SUCH AS INTELLIGENCE OR PHYSICAL PERFORMANCE

Human genetic engineering also raises the possibility of enhancing human traits and capabilities, such as intelligence or physical performance.

While the ethical implications and societal impacts of such enhancements are still subject to debate, here are some considerations related to this aspect:

A. COGNITIVE ENHANCEMENT

Genetic engineering could enhance cognitive abilities like intelligence or memory. However, intelligence is complex, multifaceted, and not solely determined by genetics. Moreover, understanding the genetic basis of intelligence still needs to be improved.

Ethical concerns arise regarding the potential for creating a genetic elite and exacerbating societal inequalities if access to cognitive enhancements is limited.

B. PHYSICAL PERFORMANCE ENHANCEMENT

Genetic modifications can enhance physical traits like strength, endurance, or speed.

However, the ethical considerations are similar to those of cognitive enhancements.

Questions arise about fairness in competitive sports, potential risks to individual's health and well-being due to extreme physical enhancements, and the implications of a level playing field.

C. UNINTENDED CONSEQUENCES

Genetic enhancements for specific traits or capabilities may have unintended consequences on

other aspects of an individual's health or well-being.

The complex interactions between genes and the environment make it challenging to accurately predict all the potential outcomes and risks associated with genetic enhancements.

Comprehensive research and long-term safety assessments are necessary to understand and mitigate these unintended consequences.

III. SOCIAL AND PSYCHOLOGICAL IMPLICATIONS

Widespread genetic enhancements could lead to a society divided along genetic lines, where individuals with enhanced traits are privileged over others, creating social divisions, discrimination, and societal pressure to conform to specific genetically determined standards.

Additionally, the psychological impact on individuals who undergo genetic enhancements and the potential for altering concepts of human identity should be carefully considered.

IV. ETHICAL BOUNDARIES AND THE "SLIPPERY SLOPE":

Determining the ethical boundaries of human genetic enhancement is challenging. The notion of taking the "slippery slope" argues that accepting specific enhancements may lead to a gradual acceptance of more extreme and potentially ethically problematic interventions.

Defining clear ethical guidelines and engaging in broad societal discussions are essential to navigate this complex territory.

It is crucial to approach the enhancement of human traits and capabilities carefully, considering the ethical implications, long-term consequences, and societal impacts. Open dialogue, robust ethical frameworks, and regulatory oversight are necessary to ensure the responsible and equitable use of

genetic engineering technologies while preserving individual autonomy, promoting fairness, and addressing potential harms and ethical concerns.

V. PROMOTING EQUALITY BY PROVIDING ACCESS TO GENETIC INTERVENTIONS FOR ALL

Promoting equality in the context of genetic interventions is critical to ensure fair and equitable access for all individuals.

Here are some key points on how this can be achieved:

A. ACCESSIBLE HEALTHCARE

Ensuring equal access to genetic interventions starts with providing accessible healthcare systems. Universal healthcare coverage and policies prioritizing genetic interventions for medically necessary cases can help reduce disparities and ensure all individuals have equal opportunities to benefit from these technologies.

B. AFFORDABILITY

Genetic interventions should be affordable and accessible to individuals from all socioeconomic backgrounds. High costs can create a barrier, limiting access to those who can afford it, thereby exacerbating inequalities.

Implementing measures to reduce costs, such as government subsidies, insurance coverage, or research funding, can help promote equality in accessing genetic interventions.

C. EDUCATION AND AWARENESS

Promoting education and awareness about genetic interventions is crucial. Individuals must understand these technologies' potential benefits, risks, and ethical considerations.

Providing comprehensive information and resources to diverse communities can empower

individuals to make informed decisions and ensure equal participation in decision-making.

D. RESEARCH AND INNOVATION

Encouraging research and innovation in genetic interventions is essential for advancing knowledge, improving techniques, and expanding the range of conditions that can be addressed.

Supporting diverse research initiatives and fostering collaboration among researchers from different backgrounds can help address health disparities and ensure that genetic interventions cater to a broad range of genetic conditions.

E. ETHICAL AND REGULATORY FRAMEWORKS

Establishing robust ethical and regulatory frameworks is vital to prevent the misuse and abuse of genetic interventions.

Regulations should prioritize safety, efficacy, and ethical considerations while ensuring equal access.

Transparent governance, informed consent, and public engagement mechanisms can help build trust and ensure the decision-making process is inclusive and representative of diverse perspectives.

F. SOCIAL JUSTICE PERSPECTIVE

Approaching genetic interventions from a social justice perspective is crucial.

It addresses broader structural inequalities, such as socioeconomic disparities, discrimination, and systemic biases.

Understanding and addressing the root causes of health disparities can help create a more equitable healthcare system that ensures equal access to genetic interventions for all.

By addressing these aspects, policymakers, healthcare providers, and society as a whole can strive towards a more equitable approach to genetic interventions, ensuring that they are accessible,

affordable, and beneficial for all individuals, regardless of their socioeconomic status, race, or other factors that could contribute to existing health disparities.

4. ARGUMENTS AGAINST HUMAN GENETIC ENGINEERING

I. VIOLATION OF THE PRINCIPLES OF HUMAN DIGNITY AND AUTONOMY

The field of human genetic engineering raises concerns regarding the potential violation of human dignity and autonomy principles.

Here are some key points related to these ethical considerations:

A. INFORMED CONSENT

Human genetic engineering interventions often involve modifying the genetic makeup of individuals, including embryos or germline cells, raising questions about informed consent, as the decisions made regarding genetic modifications can have long-lasting effects on individuals and future generations. Respecting individual autonomy requires ensuring that individuals are fully informed about the risks, benefits, and potential consequences of genetic interventions and that their consent is obtained without coercion or undue influence.

B. HUMAN DIGNITY

Human dignity is based on each individual's worth and value. Genetic engineering interventions that aim to enhance certain traits, such as intelligence or physical abilities, may raise concerns about the commodification of human life or the creation of a "genetic elite."

Treating individuals as mere means to achieve desired traits or societal ideals may undermine the principle of human dignity.

C. UNINTENDED CONSEQUENCES

The potential for unintended consequences in genetic engineering interventions can threaten human dignity and autonomy.

Genetic modifications may have unpredictable effects on individuals' health, well-being, and identity. The long-term consequences, both for individuals and for future generations, still need to be fully understood. Proceeding with genetic interventions with adequate knowledge and consideration of these potential impacts can uphold the principles of human dignity and autonomy.

D. EQUITY AND EQUALITY

Human genetic engineering can raise concerns about equity and equality. If access to genetic interventions is limited to a select few due to financial or societal barriers, it could create genetic disparities and exacerbate existing inequalities, undermining the principle of equal treatment and equal opportunities for all individuals, irrespective of their genetic makeup.

E. SOCIAL AND CULTURAL DIVERSITY

Human genetic engineering interventions that aim to homogenize or standardize certain traits can erode the diversity of human characteristics and cultural identities.

Preserving and valuing the richness of human diversity is crucial for respecting human dignity and promoting autonomy.

Genetic interventions disregarding or devaluing cultural and individual differences may violate these principles.

For upholding the principles of human dignity and autonomy, engaging in open and inclusive discussions, establishing robust ethical frameworks, ensuring that decision-making

processes involve diverse perspectives and respecting individual choices are essential.

Balancing scientific advancements with ethical considerations and promoting the responsible use of genetic engineering technologies can mitigate the risks of violating these principles and ensure that human dignity and autonomy are respected in pursuing genetic interventions.

II. CREATION OF A GENETIC DIVIDE BETWEEN THE "HAVES" AND THE "HAVE-NOTS."

One of the ethical concerns associated with human genetic engineering is the potential creation of a genetic divide between the "haves" and "have-nots." Here are some key points related to this issue:

A. SOCIOECONOMIC DISPARITIES

Genetic engineering interventions can be costly, including the expenses associated with research, development, and implementation.

Suppose access to these interventions is limited to those with financial resources. In that case, it can perpetuate existing socioeconomic disparities, resulting in a genetic divide where only specific privileged individuals or groups can access genetic enhancements, exacerbating societal inequalities.

B. REINFORCEMENT OF PRIVILEGE

Creating a genetic divide could reinforce existing privileges based on socioeconomic status, perpetuating advantages enjoyed by those who already have access to resources and opportunities.

Genetic enhancements that enhance certain traits, such as intelligence or physical abilities, may further widen the gap between those who can afford the enhancements and those who cannot, perpetuating social and economic inequalities.

C. REINFORCEMENT OF DISCRIMINATION

The genetic divide may also lead to discrimination against individuals who do not have access to genetic interventions.

Those not genetically enhanced could face stigmatization or exclusion from specific opportunities, further marginalizing them within society.

This discrimination based on genetic status can undermine fairness, equal opportunity, and social cohesion.

D. ETHICAL IMPLICATIONS OF INEQUALITY

The creation of a genetic divide raises ethical questions about fairness and justice.

Genetic enhancements exacerbate social inequalities, potentially leading to a society where advantages and disadvantages are inherited through genetic manipulation rather than earned through individual efforts that challenge the principles of equal treatment, fairness, and opportunity for all individuals.

E. SOCIAL COHESION AND SOLIDARITY

A genetic divide can undermine social cohesion and solidarity. It may lead to a fragmented society with heightened divisions and tensions between the genetically enhanced and non-enhanced populations.

Fostering a sense of shared humanity and collective responsibility requires addressing the potential consequences of genetic divisions and working towards inclusive and equitable access to genetic interventions.

Promoting equitable access to genetic interventions is crucial, as developing policies prioritizing public welfare over individual preferences and ensuring

that decisions regarding genetic enhancements consider the broader societal impacts, thus mitigating the creation of a genetic divide.

Ethical frameworks, regulatory oversight, and public engagement can contribute to the responsible and equitable use of genetic engineering technologies, ensuring that the benefits of genetic interventions are accessible to all individuals, irrespective of their socioeconomic status.

III. UNFORESEEN CONSEQUENCES AND RISKS TO INDIVIDUAL AND SOCIETAL WELL-BEING

Human genetic engineering carries inherent risks and potentially unforeseen consequences that can impact individual and societal well-being.

Here are some key points related to these concerns:

A. LONG-TERM EFFECTS

Genetic modifications, especially those targeting germline cells or embryos, can have long-lasting effects that may be passed on to future generations.

These modifications' full extent and implications may not be fully understood at the time of intervention, potentially leading to unintended consequences for individuals and their descendants.

Long-term monitoring and research are necessary to identify and address any unforeseen risks.

B. HEALTH RISKS

Genetic engineering interventions can introduce new health risks. Alterations made to an individual's genetic code may disrupt normal biological processes, potentially leading to unforeseen health complications or increased susceptibility to certain diseases.

Rigorous safety assessments, thorough preclinical and clinical testing, and ongoing monitoring are

crucial to minimize risks and ensure the well-being of individuals undergoing genetic interventions.

C. SOCIAL AND ETHICAL IMPLICATIONS

The societal and ethical implications of human genetic engineering can be complex and far-reaching. Genetic modifications may raise concerns about creating a society that prioritizes certain traits or characteristics over others, potentially leading to discrimination or the devaluation of inherent human diversity. Unforeseen consequences in this context can disrupt social norms, relationships, and cultural dynamics, affecting societal well-being and cohesion.

D. ECOSYSTEM AND BIODIVERSITY

Alterations made at the genetic level can impact ecosystems and biodiversity.

Introducing genetically modified organisms into the environment may have ecological consequences, disrupting natural processes and potentially leading to unintended environmental harm.

Comprehensive risk assessments and ethical considerations should be undertaken to ensure that genetic interventions do not compromise the well-being of ecosystems and biodiversity.

E. PSYCHOLOGICAL AND IDENTITY IMPACTS

Genetic interventions that modify traits or characteristics may impact individuals psychologically and identity.

Altering fundamental aspects of a person's genetic makeup can raise questions about personal identity, autonomy, and the potential loss of unique individuality.

Understanding and addressing the psychological and emotional well-being of individuals undergoing genetic interventions is crucial to ensure their overall well-being.

Addressing the unforeseen consequences and risks of human genetic engineering requires a cautious and responsible approach.

Comprehensive research, transparent reporting, robust regulatory frameworks, and ongoing evaluation are necessary to minimize risks, identify potential long-term effects, and address ethical concerns.

Engaging in multidisciplinary discussions involving scientists, ethicists, policymakers, and the public can help navigate the complex landscape of genetic engineering while safeguarding individual and societal well-being.

5. IMPLICATIONS FOR SOCIETY

I. POTENTIAL FOR GENETIC DISCRIMINATION IN AREAS SUCH AS EMPLOYMENT OR INSURANCE

The field of human genetic engineering raises concerns about the potential for genetic discrimination in various domains, including employment and insurance.

Here are some key points related to this issue:

A. EMPLOYMENT DISCRIMINATION

Employers could use genetic information obtained through genetic testing or profiling to discriminate against individuals during hiring or employment decisions.

Depending on genetic information, employers may make assumptions about an individual's future health risks or capabilities, leading to unfair treatment, denial of job opportunities, or biased decision-making.

B. INSURANCE DISCRIMINATION

Insurance companies can also use genetic information to discriminate against individuals when assessing coverage or determining premiums. Insurers may use genetic data to predict an individual's risk for developing certain diseases or conditions, leading to a denial of coverage or significantly higher premiums, which can disproportionately affect individuals with genetic predispositions, creating barriers to obtaining adequate insurance coverage.

II. PRIVACY CONCERNS

Genetic discrimination raises concerns about the privacy and confidentiality of genetic information. Suppose individuals fear their genetic information may be used against them. In that case, they may be reluctant to undergo genetic testing or share their genetic data with healthcare providers, which could hinder the progress of medical research and personalized medicine advancements and limit individuals' access to appropriate healthcare.

III. REINFORCEMENT OF SOCIAL INEQUALITIES

Genetic discrimination can potentially reinforce existing social inequalities. Individuals from marginalized communities or groups disproportionately affected by certain health conditions may face further discrimination based on their genetic information, perpetuating existing disparities in access to employment opportunities, insurance coverage, and healthcare.

IV. LEGAL AND ETHICAL CONSIDERATIONS

Addressing genetic discrimination requires robust legal and ethical frameworks.

Laws and regulations should be in place to prohibit genetic discrimination and protect individuals from unfair treatment based on genetic information.

Educating individuals about their rights, promoting awareness among employers and insurers, and

fostering a non-discrimination culture is crucial to preventing genetic discrimination and promoting equal treatment for all individuals.

Efforts should be made to establish comprehensive legal protections against genetic discrimination, promote public awareness and education about the importance of genetic privacy, and ensure that individuals have control over their genetic information.

By addressing the potential for genetic discrimination, society can work towards fostering inclusivity, equal opportunities, and fair treatment for all individuals, regardless of their genetic makeup.

V. SHIFTS IN SOCIETAL NORMS AND THE CONCEPT OF NATURAL HUMAN VARIATION

Genetic engineering can disrupt societal norms and challenge our understanding of natural human variation.

Here are some key points related to this aspect:

A. REDEFINITION OF "NATURAL"

Genetic engineering interventions can blur the lines between "natural" and "artificial" human traits and characteristics.

By manipulating genetic makeup, interventions can modify traits that would not naturally occur through genetic recombination alone, challenging the traditional notions of natural human variation and raising questions about how we define and value diversity.

B. CHANGING PERCEPTIONS OF NORMALCY

Genetic engineering interventions can alter perceptions of what is considered normal or desirable regarding human traits and capabilities.

As enhancements become accessible, societal expectations and standards may shift, normalizing

particular traits or characteristics which can pressure individuals to conform to these new expectations, potentially marginalizing those who do not possess or desire such enhancements.

VI. ETHICAL IMPLICATIONS OF GENETIC ENHANCEMENT

The ability to enhance human traits raises ethical considerations regarding the pursuit of perfection and the potential devaluation of inherent human diversity.

Genetic engineering prioritizes certain traits, such as intelligence or physical abilities, which may imply that individuals without these enhancements are somehow inferior.

Challenging, embracing and valuing the range of natural human variation is essential.

VII. IMPACT ON PERSONAL IDENTITY

Genetic modifications can raise questions about personal identity and authenticity.

Altering fundamental aspects of one's genetic makeup may lead individuals to question their sense of self and whether their achievements and abilities are indeed their own, which has implications for how we understand and value personal identity, individual agency, and the concept of self-determination.

VIII. REDEFINING SOCIAL NORMS

As genetic engineering becomes more advanced and accessible, it can redefine social norms and expectations.

Society may grapple with whether specific genetic enhancements should be mandatory or how they may affect societal dynamics, including relationships, cultural practices, and social structures. Exploring these shifts' ethical and social implications is crucial to navigating the changing landscape of human genetic engineering.

Engaging in open and inclusive discussions, involving diverse perspectives, and considering the long-term societal impacts are essential to navigate the potential shifts in societal norms and the concept of natural human variation brought about by genetic engineering.

Balancing scientific advancements with ethical considerations and fostering dialogue can ensure that our understanding of human diversity and values are thoughtfully considered and respected in the context of genetic interventions.

6. IMPACT ON NOTIONS OF IDENTITY, PERSONAL RESPONSIBILITY AND HUMAN RELATIONSHIPS

Genetic engineering has significant implications for identity, personal responsibility, and human relationships.

Here are some key points related to these impacts:

I. IDENTITY AND AUTHENTICITY

Genetic engineering interventions can raise questions about personal identity and authenticity.

Modifying one's genetic makeup challenges the concept of "natural" traits and abilities.

It raises concerns about how individuals can truly claim ownership of their enhanced characteristics that may lead to a reevaluation of what it means to be authentic and genetics' role in shaping one's identity.

II. SENSE OF PERSONAL RESPONSIBILITY

With the ability to manipulate genetic traits, questions arise regarding personal responsibility for one's genetic endowment.

Genetic enhancements raise debates about the extent to which individuals should be held accountable for their genetically influenced traits or abilities.

Balancing personal responsibility with recognizing external factors, such as genetics, may become more complex in light of genetic engineering.

III. ALTERED HUMAN RELATIONSHIPS

Human genetic engineering has the potential to reshape human relationships in various ways. Enhanced individuals may face new challenges in interpersonal relationships, such as navigating power dynamics or addressing concerns of superiority or inequality.

Additionally, genetic modifications in reproductive contexts may raise ethical questions about the parent-child relationship, as genetic choices may influence the perception of parental responsibility or the unique bond between individuals.

IV. REDEFINITION OF NORMS AND SOCIAL EXPECTATIONS

The availability of genetic enhancements can lead to redefining societal norms and expectations. As genetic modifications become widespread, the criteria for what is considered "normal" or desirable may shift, which may pressure individuals to conform to these new expectations, potentially affecting self-esteem, body image, and social acceptance.

V. ETHICAL CONSIDERATIONS OF AUTONOMY AND CONSENT

Genetic engineering interventions raise essential ethical considerations regarding individual autonomy and informed consent.

The decision to undergo genetic enhancements or modify the genetic traits of future generations involves complex choices with long-term implications.

Ensuring that individuals have sufficient knowledge, agency, and the ability to provide informed consent is crucial for upholding ethical principles and respecting individual autonomy.

Navigating the impact of human genetic engineering on identity, personal responsibility, and human relationships requires ongoing reflection, dialogue, and ethical deliberation.

It is essential to consider these technologies' potential consequences and societal implications while respecting the values of personal autonomy, informed consent, and the preservation of meaningful human relationships.

7. ETHICAL FRAMEWORKS FOR EVALUATING HUMAN GENETIC ENGINEERING

I. UTILITARIANISM BALANCING BENEFITS AND HARMS FOR THE MOST SIGNIFICANT OVERALL WELFARE

Utilitarianism is a moral framework that emphasizes the importance of maximizing overall welfare and minimizing harm to the most significant number of people.

When applied to the context of human genetic engineering, utilitarianism considers the potential benefits and harms associated with this technology. Here are some key points related to utilitarianism in the context of human genetic engineering:

A. MAXIMIZING BENEFITS

Utilitarianism prioritizes maximizing overall benefits, including preventing genetic diseases and disabilities through genetic interventions.

Using genetic engineering techniques may eliminate or reduce the occurrence of certain genetic disorders, improving the quality of life for affected individuals and their families.

This approach focuses on promoting well-being and enhancing the overall welfare of society.

B. BALANCING RISKS AND HARMS

Utilitarianism also requires weighing potential risks and harms associated with human genetic engineering.

Ethical considerations should be given to unintended consequences, health risks, and potential discrimination or social inequalities.

Careful analysis and risk assessment are necessary to minimize adverse outcomes and ensure that the benefits of genetic engineering outweigh the potential harms.

C. EQUAL DISTRIBUTION OF BENEFITS

Utilitarianism promotes fair benefits across society.

It emphasizes the importance of providing access to genetic interventions for all individuals, irrespective of their socioeconomic-background or genetic makeup.

By ensuring equitable access, utilitarianism seeks to maximize overall welfare by preventing the creation of genetic disparities between different groups in society.

D. CONSIDERATION OF LONG-TERM IMPACTS

Utilitarianism also encourages considering long-term impacts on future generations, which includes evaluating the potential consequences of genetic modifications on the well-being and autonomy of individuals in the future.

Ethical frameworks should consider the potential effects on personal identity, social dynamics, and the preservation of human diversity.

E. ETHICAL TRADE-OFFS

Utilitarianism acknowledges that difficult ethical trade-offs may arise in balancing benefits and harms.

It requires evaluating the overall welfare and considering the potential trade-offs between individuals or groups, including considering the

interests of those who might be negatively affected by genetic interventions and ensuring that the benefits derived from these interventions outweigh any negative consequences.

Utilitarianism offers a consequentialist approach that aims to optimize overall welfare when considering the development and use of human genetic engineering.

By considering the potential benefits, minimizing harms, promoting fairness, and evaluating long-term impacts, utilitarianism provides a framework for ethical decision-making in this complex and evolving field.

However, it is essential to acknowledge and address the diverse perspectives and values that exist when applying utilitarian principles to ensure ethical and inclusive outcomes.

II. DEONTOLOGICAL ETHICS: CONSIDERING INHERENT RIGHTS AND DUTIES

Deontological ethics is a moral framework emphasizing individuals' inherent rights and duties, focusing on the moral principles and rules guiding our actions.

When applied to the context of human genetic engineering, deontological ethics considers the ethical implications based on principles and duties rather than solely focusing on the consequences.

Here are some key points related to deontological ethics in the context of human genetic engineering:

A. RESPECT FOR AUTONOMY

Deontological ethics strongly emphasize respecting individual autonomy and self-determination. This perspective recognizes the inherent right of individuals to make decisions about their genetic

makeup and the right to choose whether or not to undergo genetic interventions.

It emphasizes the importance of informed consent and ensuring that individuals can control their genetic information and the interventions they undergo.

B. DUTY TO PROTECT HUMAN DIGNITY

Deontological ethics emphasizes every individual's inherent worth and dignity.

In human genetic engineering, this perspective highlights the duty to protect human dignity by ensuring that genetic interventions are conducted respecting human values and fundamental rights. It calls for carefully considering the ethical implications and potential risks associated with genetic modifications and potential consequences for individual identity, societal norms, and equality.

C. ETHICAL DUTIES TOWARDS FUTURE GENERATIONS

Deontological ethics also recognize our ethical duties towards future generations, including considering the long-term consequences of genetic interventions and the potential impact on the well-being and autonomy of individuals affected by these interventions in the future.

It emphasizes the importance of acting responsibly and preserving the interests and rights of future generations when making decisions about genetic engineering.

D. DUTY TO MINIMIZE HARM AND ENSURE JUSTICE

Deontological ethics highlights the duty to minimize harm and ensure justice in the context of human genetic engineering.

This perspective requires considering the potential risks and unintended consequences associated with genetic interventions and taking necessary precautions to mitigate these risks.

It emphasizes the importance of fair distribution of benefits and access to genetic interventions to prevent the exacerbation of social inequalities.

E. ETHICAL PROHIBITIONS

Deontological ethics may also involve specific ethical prohibitions.

For example, it may argue against using genetic engineering for non-medical enhancements or interventions that violate fundamental human rights.

It calls for adherence to ethical principles and rules that protect the intrinsic value of human life and the integrity of the human species.

Deontological ethics provides a framework for considering the inherent rights, duties, and moral principles that guide decisions in human genetic engineering.

By emphasizing respect for autonomy, protection of human dignity, ethical duties towards future generations, minimizing harms, and ensuring justice, this approach offers a principled basis for ethical decision-making and responsible use of genetic interventions.

However, engaging in nuanced discussions and considering the diverse perspectives and values within deontological frameworks is vital to ensure a comprehensive and ethical approach to human genetic engineering.

III. VIRTUE ETHICS: EVALUATING THE CHARACTER TRAITS FOSTERED BY GENETIC INTERVENTIONS

Virtue ethics is a moral framework that cultivates virtuous character traits and values as a foundation for ethical decision-making.

When applied to the context of human genetic engineering, virtue ethics examines the character

traits that may be fostered or compromised by genetic interventions.

Here are some key points related to virtue ethics in the context of human genetic engineering:

A. CULTIVATION OF VIRTUOUS TRAITS

Virtue ethics emphasizes cultivating virtues such as compassion, fairness, and empathy.

In the context of genetic interventions, virtue ethics encourages reflection on how these interventions may affect the development of these traits.

It raises questions about the impact on our moral character and whether genetic enhancements might compromise virtues' natural development and cultivation.

B. BALANCE OF NATURAL TALENTS AND EFFORT

Virtue ethics recognizes the value of natural talents and our effort to develop our abilities.

Genetic interventions that enhance specific traits, such as intelligence or physical capabilities, may raise concerns about balancing natural endowments and personal growth through effort and perseverance.

This ethical framework encourages considering the potential effects of genetic interventions on the development of virtues such as resilience, determination, and self-improvement.

C. FLOURISHING AND EUDAIMONIA

Virtue ethics focuses on human flourishing and eudaimonia, which refers to fulfilling and meaningful lives.

It encourages reflection on how genetic interventions may contribute to or hinder individuals' well-being and fulfillment.

The ethical evaluation of genetic interventions within a virtue ethics framework considers aligning these interventions with the pursuit of human flourishing and cultivating virtues that lead to a meaningful life.

D. ETHICAL REFLECTION AND SELF-EXAMINATION

Virtue ethics emphasizes self-reflection and self-examination as essential for developing virtuous character traits.

In genetic engineering, this perspective calls for critically examining the motivations and intentions behind pursuing genetic interventions.

It encourages individuals and society to reflect on whether these interventions are driven by genuine ethical considerations, such as compassion and promoting human well-being, self-interest, vanity, or societal pressures.

E. SOCIAL IMPLICATIONS AND THE COMMON GOOD

Virtue ethics recognizes the social dimension of ethics and the importance of considering the impact of genetic interventions on the common good.

This perspective encourages evaluating how genetic interventions may affect social relationships, justice, and the overall flourishing of communities.

It raises questions about the potential consequences of genetic enhancements for social cohesion, equality, and the cultivation of virtues within communities.

Virtue ethics offers a framework for ethical evaluation that focuses on character development, flourishing, and pursuing virtues.

By considering the impact of genetic interventions on character traits, the balance between natural endowments and personal effort, the promotion of human flourishing, and the social implications of these interventions, virtue ethics provides insights into the ethical dimensions of human genetic engineering.

Engaging in thoughtful reflection and considering the broader implications for individual and societal

virtue can contribute to responsible and ethical decision-making in this field.

8. REGULATION AND GOVERNANCE: CURRENT REGULATIONS AND GUIDELINES SURROUNDING HUMAN GENETIC ENGINEERING

The regulations and guidelines surrounding human genetic engineering vary across countries and jurisdictions.

Here are some critical aspects of the current regulatory landscape:

I. INTERNATIONAL GUIDELINES

The Universal Declaration on the Human Genome and Human Rights, adopted by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1997, provides a framework for the ethical and legal aspects of human genetic engineering.

It emphasizes the importance of respecting human dignity, ensuring the well-being of individuals, and protecting the human genome against misuse.

II. NATIONAL LEGISLATION

Many countries have enacted specific legislation to regulate human genetic engineering. These laws vary in scope and stringency, addressing research, clinical applications, and reproductive technologies.

For example, countries like the United States, the United Kingdom, and Canada have specific regulations and guidelines governing genetic research, clinical trials, and testing.

III. ETHICAL REVIEW BOARDS AND INSTITUTIONAL OVERSIGHT

Human genetic engineering research requires ethical review and oversight by institutional review boards or ethics committees.

These bodies assess the scientific validity, ethical implications, and potential risks and benefits of proposed research or interventions.

They ensure compliance with ethical guidelines and legal requirements, safeguarding the rights and well-being of individuals involved in the research.

IV. GENE THERAPY REGULATIONS

Human genetic engineering for therapeutic purposes, such as gene therapy, is subject to specific regulations.

Regulatory agencies, such as the U.S. Food and Drug Administration (FDA) and the European Medicines Agency (EMA), evaluate and approve gene therapies based on their safety, efficacy, and ethical considerations. These agencies require extensive preclinical and clinical data to ensure the quality and safety of genetic interventions.

V. REPRODUCTIVE TECHNOLOGIES AND EMBRYO RESEARCH

Genetic interventions in the context of reproductive technologies, such as in vitro fertilization (IVF), embryo selection, and preimplantation genetic diagnosis (PGD), are subject to specific regulations.

These regulations often address embryo screening, genetic modifications, and assisted reproductive technologies.

VI. ETHICAL GUIDELINES FOR RESEARCH AND PRACTICE

Professional organizations, such as the American Society of Human Genetics (ASHG) and the European Society of Human Genetics (ESHG), have developed ethical guidelines for genetic research and clinical practice.

These guidelines provide recommendations for informed consent, privacy and confidentiality, genetic counselling, and the responsible use of genetic technologies.

It is important to note that the regulatory landscape evolves as scientific advancements and ethical considerations progress. The field of human genetic engineering raises complex ethical, legal, and social questions, and ongoing dialogue and international collaboration are necessary to ensure responsible and ethically sound practices in this rapidly evolving field.

VII. EVALUATING THE ADEQUACY OF EXISTING FRAMEWORKS IN ADDRESSING ETHICAL CONCERNS

Evaluating the adequacy of existing frameworks in addressing ethical concerns related to human genetic engineering is a complex task.

While existing frameworks provide a foundation for ethical considerations, they may face challenges in keeping pace with the rapid advancements and unique ethical dilemmas presented by genetic engineering.

Here are some key points to consider when evaluating the adequacy of existing frameworks:

A. ETHICAL SCOPE AND ADAPTABILITY

Existing frameworks should encompass a broad range of ethical concerns, including individual rights, social justice, and the preservation of human dignity.

They should be adaptable enough to address emerging ethical issues as new genetic technologies and interventions develop.

Evaluating the comprehensiveness and flexibility of existing frameworks can help determine their adequacy in addressing evolving ethical concerns.

B. CONSIDERATION OF FUTURE IMPLICATIONS

Genetic engineering has long-term implications for individuals, families, and society.

Adequate frameworks should consider genetic interventions' potential consequences and risks,

including unforeseen long-term effects, societal impact, and intergenerational equity.

Assessing whether existing frameworks adequately account for these future implications is crucial.

C. INCLUSIVITY AND EQUITY

Ethical frameworks should promote inclusivity and address equity and justice concerns.

They should ensure that access to genetic interventions is wider than specific populations or exacerbate existing social disparities.

Evaluating the extent to which existing frameworks address the promotion of equity and fair distribution of benefits can help determine their adequacy in addressing ethical concerns related to genetic engineering.

D. PUBLIC ENGAGEMENT AND DELIBERATION

Adequate frameworks should facilitate public engagement and deliberation in decision-making processes related to genetic engineering. They should ensure that diverse perspectives, values, and concerns are considered.

Evaluating the level of public engagement and inclusivity within existing frameworks can shed light on their adequacy in addressing ethical concerns in a democratic and participatory manner.

E. INTERNATIONAL COLLABORATION AND HARMONIZATION

Genetic engineering is a global issue, and ethical concerns transcend national boundaries.

Adequate frameworks should promote international collaboration, exchange of best practices, and harmonization of ethical standards. Assessing the extent to which existing frameworks facilitate international cooperation and coordination can help evaluate their adequacy in addressing global ethical concerns.

F. ONGOING EVALUATION AND ADAPTATION

Ethical frameworks should be subject to ongoing evaluation and adaptation to keep pace with scientific advancements, societal changes, and evolving ethical dilemmas.

They should incorporate mechanisms for regular review, incorporating input from experts, stakeholders, and affected communities.

Evaluating the responsiveness and adaptability of existing frameworks to changing circumstances is essential to ensure their adequacy over time.

Evaluating the adequacy of existing frameworks requires a comprehensive analysis of their scope, adaptability, inclusivity, consideration of future implications, public engagement, international collaboration, and ongoing evaluation.

Identifying gaps and areas for improvement can guide the development of more robust and comprehensive frameworks that effectively address the ethical concerns raised by human genetic engineering.

9. PROPOSALS FOR RESPONSIBLE GOVERNANCE AND PUBLIC ENGAGEMENT

Several proposals can be considered to ensure responsible governance and public engagement in human genetic engineering.

These proposals promote ethical decision-making, inclusivity, transparency, and accountability.

Here are some essential suggestions:

I. MULTIDISCIPLINARY ADVISORY COMMITTEES

Establish multidisciplinary advisory committees comprising experts from various fields, including genetics, ethics, law, philosophy, and social sciences.

These committees can provide independent advice and guidance to policymakers, ensuring a comprehensive and balanced approach to decision-making.

II. PUBLIC CONSULTATION AND DELIBERATION

Implement public consultation and deliberation mechanisms to involve diverse perspectives and values in decision-making processes, including public hearings, citizen panels, or participatory workshops, allowing citizens, patient groups, and affected communities to express their views, concerns, and aspirations.

III. ETHICAL IMPACT ASSESSMENTS

Conduct assessments for new genetic interventions and technologies. These assessments should evaluate the potential ethical, social, and cultural implications of proposed interventions, including considerations of human dignity, justice, equity, and the long-term consequences for individuals and society.

IV. TRANSPARENCY AND ACCESSIBILITY OF INFORMATION

Ensure transparency and accessibility of information related to genetic interventions, including providing clear and understandable information about the benefits, risks, limitations, and uncertainties associated with genetic engineering, enabling informed decision-making by individuals, promoting trust, and fostering public engagement.

V. INTERNATIONAL COLLABORATION AND HARMONIZATION

Foster international collaboration and harmonize ethical standards and regulations, which can be achieved through collaborations between governments, international organizations, and

scientific communities to share best practices, exchange knowledge, and promote consistency in ethical decision-making.

VI. EDUCATION AND PUBLIC AWARENESS

Promote education and public awareness programs to enhance understanding and knowledge about genetic engineering that can involve educational campaigns, public forums, and media initiatives that provide accurate and balanced information, empowering individuals to make informed decisions and engage in meaningful discussions.

VII. ETHICAL GUIDELINES FOR RESEARCH AND PRACTICE

Continuously update and strengthen ethical guidelines for research and clinical practice in genetic engineering.

These guidelines should reflect evolving ethical considerations, emerging technologies, and societal values.

They should be developed through inclusive processes involving experts, stakeholders, and affected communities.

VIII. INDEPENDENT OVERSIGHT AND REGULATORY BODIES

Establish independent oversight and regulatory bodies to monitor and enforce ethical standards in genetic engineering.

These bodies should ensure compliance with regulations, conduct ethical research proposal reviews, and investigate ethical violations or misconduct.

IX. LONG-TERM MONITORING AND EVALUATION

Implement mechanisms for long-term monitoring and evaluation of genetic interventions and their societal impact, which includes ongoing assessment of the safety, efficacy, and ethical implications of genetic interventions and their impact on social dynamics, equality, and the preservation of human diversity.

By implementing these proposals, responsible governance and public engagement can be promoted in human genetic engineering.

These measures aim to uphold ethical principles, protect individual and societal well-being, and foster inclusive and transparent decision-making processes that reflect the values and aspirations of diverse stakeholders.

10. CONCLUSION:

RECAPITULATION OF CRITICAL ETHICAL CONSIDERATIONS RELATED TO HUMAN GENETIC ENGINEERING

In recapitulation, key ethical considerations related to human genetic engineering include:

I. ETHICAL DILEMMAS

Human genetic engineering raises complex ethical dilemmas regarding the limits of intervention in the genetic makeup of individuals.

Balancing the potential benefits with the potential harms and considering the potential long-term consequences is essential.

II. HUMAN DIGNITY AND AUTONOMY

Genetic engineering should respect individuals' inherent dignity and autonomy, ensuring that choices related to genetic interventions are voluntary, informed, and free from coercion or discrimination.

III. EQUALTY AND ACCESS

Ensuring equal access to genetic interventions is crucial to prevent the creation of a genetic divide between those who can afford genetic enhancements and those who cannot.

Promoting equitable distribution of benefits and avoiding exacerbation of social disparities is essential.

IV. UNINTENDED CONSEQUENCES AND RISKS

Genetic engineering may have unforeseen consequences and risks at the individual and societal levels.

A thorough evaluation of potential risks, long-term effects, and unintended consequences is necessary to mitigate potential harm.

V. SOCIAL AND CULTURAL IMPLICATIONS

Genetic engineering has significant social and cultural implications, including its impact on notions of natural human variation, identity, and personal responsibility.

Considering the broader social, cultural, and philosophical implications of genetic interventions is essential.

VI. ETHICAL FRAMEWORKS AND GUIDELINES

Existing ethical frameworks and guidelines provide a foundation for addressing ethical concerns related to genetic engineering.

It is essential to evaluate the adequacy of these frameworks and continuously update them to keep pace with scientific advancements and societal changes.

VII. RESPONSIBLE GOVERNANCE AND PUBLIC ENGAGEMENT

Responsible governance and public engagement are crucial in shaping the ethical trajectory of genetic engineering.

With an inclusive decision-making process, transparency, accountability, and public participation, genetic engineering can foster trust, legitimacy, and democratic values among people.

Considering these critical ethical considerations, stakeholders can navigate the complex ethical landscape of human genetic engineering and work towards the responsible development, deployment, and regulation of genetic interventions that prioritize the well-being and dignity of individuals and society.

Call for continued dialogue, ethical reflection, and responsible application of this technology.

In conclusion, the complex nature of human genetic engineering calls for continued dialogue, ethical reflection, and responsible application of this technology. Engaging in ongoing discussions involving scientists, ethicists, policymakers, and the public is essential to address the ethical concerns and dilemmas associated with genetic engineering. This dialogue should be inclusive, accommodating diverse perspectives and values, and promote active stakeholder engagement.

Ethical reflection is crucial in navigating the ethical considerations raised by human genetic engineering. It requires a thoughtful examination of genetic interventions' potential risks, benefits, and long-term consequences, considering principles such as human dignity, autonomy, justice, and the common good.

Ethical reflection should be grounded in a deep understanding of the scientific advancements, societal impact, and implications for individuals and communities.

Responsible application of human genetic engineering requires robust governance frameworks that balance scientific progress with ethical considerations. Regulations, guidelines, and oversight mechanisms should be continuously evaluated, updated, and enforced to ensure transparency, accountability, and the protection of individual rights and well-being.

Ethical guidelines for research, clinical practice, and the use of genetic interventions should be developed and adhered to by professionals in the field.

Moreover, the responsible application of genetic engineering demands a commitment to the equitable distribution of benefits and access to interventions.

Efforts should be made to prevent genetic discrimination, mitigate social disparities, and ensure that the benefits of genetic interventions are accessible to all segments of society.

In summary, continued dialogue, ethical reflection, and responsible application of human genetic engineering are essential to navigate this technology's ethical complexities and societal implications. By engaging in open discussions, reflecting on ethical considerations, and implementing appropriate governance measures, we can strive towards harnessing the potential of genetic engineering while upholding fundamental ethical principles and safeguarding the well-being of individuals and communities.

This research paper aims to contribute to a balanced understanding of the topic by thoroughly examining the ethical implications of human genetic engineering. It encourages policymakers, scientists, and society to carefully consider the ethical considerations involved in harnessing the potential of genetic engineering while upholding

principles of justice, fairness, and respect for human dignity.

Citations:

1. *More than Gender Selection: PGD Can Decrease the Risk of Genetic Problems in Babies -Fertility Solutions* NE.

<https://fertilitysolutionsne.com/blog/more-than-gender-selection-pgd-can-decreasethethe-risk-of-genetic-problems-in-babies/>

2. *Family-based gene-environment interaction using sequence kernel association test (FGE-SKAT) for complex quantitative traits — 國立陽明交通大學研發優勢分析平台*

<https://scholar.nycu.edu.tw/zh/publications/family-based-gene-environment-interaction-usingsequence-kernel-a>

3. *Can art inspire responsible actions? | UNESCO Chair in Bioethics and Human Rights.*
<https://www.unescobiochair.org/2022/08/26/can-art-inspire-responsible-actions/>

4. *CRISPR-Cas9 gene editing | CRISPR technology | QIAGEN.*
<https://www.qiagen.com/us/applications/crispr>

5. Alexander DR (May 2003). "Uses and abuses of genetic engineering". *Postgraduate Medical Journal*. **79** (931): 249–51.

6. Filipp, F. *Is science killing sport?* *European Molecular Biology Organization Reports* **8**, 433–435 (2007)

7. Woolridge, E. Q., & Murray, R. *The health orientation scale: A measure of feeling about sickle cell trait.* *Social Biology* **35**, 123–136 (1988)

8. Taylor, C. A., & Myers, R. *Long-term impact of Huntington disease linkage testing.* *American Journal of Medical Genetics* **70**, 365–370 (1997)

9. Friedmann T, Roblin R: *Gene therapy for human genetic disease?* *Science* **175**: 949–955, 1972

10. Zischewski J, Fischer R, Bortesi L: *Detection of on-target and off-target mutations generated by CRISPR/Cas9 and other sequence-specific nucleases. Biotechnol Adv* 35: 95–104, 2017

11. *President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioural Research: Splicing life: a report on the social and ethical issues of genetic engineering with human beings. US Government Printing Office, Washington, 1982.*

