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WELCOMING THE GAME CHANGER OF HUMAN SOCIETY: A DEFENSE OF THE MORAL PERMISSIBILITY AND OBLIGATIONS OF HUMAN GENETIC ENGINEERING

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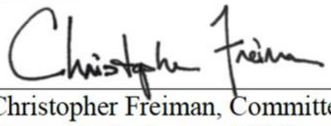

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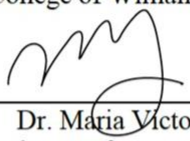

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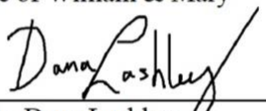

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ABSTRACT

In 2018, a Chinese scientist, Jiankun He, announced the birth of two HIV-resistant babies through his experiment of human genetic engineering. This incidence has soon shocked the entire scientific community and invoked public outrage towards He's corrupt moral integrity.

However, this event should also act as a harbinger to the human society that the technique of human genetic engineering is rapidly approaching maturity. In that case, how should we respond?

This thesis focuses on the moral issues surrounding human genetic engineering and advertises an accepting moral attitude to this booming technology. This thesis will first discuss the types of human genetic engineering that bioethicists usually make and reject their moral significance. This thesis will then proceed to defend human genetic engineering against seven types of moral objections and establish the moral permissibility of human genetic engineering. Finally, this thesis contends that in the future society which guarantees the safety and accessibility of human genetic engineering, parents have the moral obligation to use human genetic engineering for the betterment of their children.

1. AN INTRODUCTION TO THE MORAL DEBATE OF HUMAN GENETIC ENGINEERING

1.1. INTRODUCTION TO HUMAN GENETIC ENGINEERING

The scientific enthusiasm of genetic study began with the rediscovery of Gregor Mendel's theory of genetic inheritance in the early 20th century. With the DNA structure clarified by James Watson and Francis Crick, geneticists took full advantage of the structural knowledge of DNA and started to pioneer DNA cloning that signaled the start of genetic engineering.

Genetic engineering, also known as recombinant DNA technology, refers to intentional manipulations of genetic information through chemical splicing of selected DNA fragments from different species and introducing the resulting DNA into the target organism. In 1972, Stanford University succeeded in creating the first recombinant DNA and, in the subsequent year, inserted the DNA into the plasmid of *Escherichia coli* bacterium (Nicholl, 2002). Since then, the development of genetically modified organisms (GMOs) has been unstoppable and spreads its products to every aspect of our life. For example, genetically engineered food is prevalent in today's supermarkets, as altered genes help the crops and livestock resist diseases and give the food a better taste and more nutritional content (U.S. National Library of Medicines, 2021). Modern medicines like antibiotics and insulin also find their sources in genetically engineered *E. coli* and yeast that produce high-quality yield with minimal cost (Baeshen et al., 2014). With the completion of Human Genome Project that reveals the full sequence of human genomes and the invention of the CRISPR-Cas 9 technique that allows scientists to manipulate genetic materials with unprecedentedly high precision, efficiency, and

flexibility, genetic technology has advanced to the step where scientists can readily edit human genes and make improvements to the human race. This artificial manipulation of human DNA has been known as Human Genetic Engineering (HGE).

1.2. INTRODUCTION TO THE CONTEMPORARY DEBATE OF HUMAN GENETIC ENGINEERING

In 2018, Chinese biophysicists, Jiankun He, announced the birth of two genetically engineered babies, Lulu and Nana, with genes naturally resistant to HIV disease. He used the CRISPR-Cas 9 to modify the CCR5 gene of the two babies at their embryonic stage and implanted them for pregnancy. This news of genetically engineered babies shocked the global scientific community and incited overwhelming criticism, as He has "defied scientific conventions, ignored basic rules for research on human subjects, and violated multiple norms of medical practice" (van Beers, 2020). The HGE technique employed in He's research was still at the very experimental stage and guarantees no safety for the two babies. Besides, there is no sure proof that the mutated CCR gene would effectively induce HIV resistance without causing any harm. Even his own research data suggests that his effort to modify the CCR gene is only partially successful as his experiment did not entirely alter all CCR genes in the embryos and resulted in off-target altered genes (Kolata & Belluck, 2018). Overall, given He's immature experimentation, his HGE attempt on two babies is certainly an irresponsible and morally reprehensible act.

Nevertheless, this incident of genetically engineered babies invokes reflection among the entire society on future HGE. Suppose He had progressed his research in a more responsible manner and achieved complication-free HIV resistance as he promised. In that case, he might

have “single-handedly brought humankind a significant step closer to taking genetic fate into its own hands” (van Beers, 2020). When HGE technology finally comes to maturity and wide application, how should we morally respond to the changes in the human race and our society? How should we organize and distribute this technology? Can we practically handle the consequences of HGE?

Indeed, in the face of this alien yet rapidly advancing technology, we often find ourselves in a myriad of worries and doubts. This thesis first attempts to dismiss common ethical distinctions that separate HGE into morally different categories in section 2. The thesis then categorizes objections towards HGE into three types—deontic, consequentialist, and miscellaneous—to establish the moral permissibility of HGE in section 3. Although some objections may not be as clear cut as to one category or the other, roughly speaking, deontic objections discuss whether HGE is inherently good as an enhancement practice, while consequentialist objections question whether the results brought by HGE are beneficial. After establishing the moral permissibility of HGE from both deontological and consequentialist positions, in section 4, this thesis will elevate the moral status of HGE and argue that HGE is not only morally permissible but morally obligated given parental obligations to better their children’s life. Finally, the thesis will conclude with support towards HGE and discuss potential future works in this area.

2. TYPES OF HUMAN GENETIC ENGINEERING

2.1. INTRODUCTION TO TYPES OF HUMAN GENETIC ENGINEERING

Before discussing the objections towards HGE, it is worthwhile to discuss some distinctions of HGE recognized by some bioethicists, as they believe different types of HGE requires separate deontic and consequentialist evaluations. The main two distinctions commonly discussed are between negative and positive enhancements and between regular and radical enhancements. This thesis will argue that despite attempts to separate HGE into morally and practically different types, these distinctions are unnecessary, and there is no rational foundation to treat some types of HGE differently than others.

2.2. NEGATIVE VERSUS POSITIVE ENHANCEMENT

2.2.1. Introduction to Negative and Positive Enhancement

Negative enhancement, also known as gene therapy or cures, aims to correct genetic defects, while positive enhancement intends to make improvements to normal humans (Glover, 1984). In other words, negative enhancement is to raise individuals to the norm, while positive enhancement is to raise them above the norm (Freiman, 2018). According to this distinction, HGE therapy that eliminates the extra 21st chromosome of children inflicted with Down's syndrome and brings their mental and physical abilities to the level of normal individuals is a negative enhancement. On the other hand, HGE practice that raises the intelligence of a normal child by 40 will be categorized as a positive enhancement.

People can usually well accept the practices of negative enhancement, as allowing normal life to individuals who would otherwise have a genetically damaged life seems hardly morally objectionable. Suppose it is possible to salvage a baby from mentally decapacitating Down's syndrome through HGE. In that case, it is unlikely to see anyone sympathetic to the baby's condition would object, if the parents hope to adopt the HGE treatment.

On the other hand, philosophers show various concerns about the positive enhancement that endows individuals with abilities surpassing the norm. They worry that children surpassing the human norm would infringe the divinity of God, denigrate humanity to something artificial and manipulatable, interfere with the regular human evolution, fundamentally change the social and family structure, and even result in an apocalypse of the human race (these objections and more will be discussed in detail in Chapter 3 and 4). Ultimately, separating HGE into negative and positive enhancements pushes positive enhancement into the spotlight of criticism and permits the negative enhancement to fade out of the discussion.

2.2.2. Response to Positive and Negative Distinction: The Blurry Norms

As the philosophers attempt to demarcate positive enhancement from the negative enhancement, one standard is always mentioned: the normal individual. Yet it does not seem obvious how to consistently define the norm in many cases.

2.2.2.1. Statistical Norm

Let's first consider the norm to be the statistical average. Francis Fukuyama has extensively discussed that many traits of one population will present itself as a normal distribution

(Fukuyama, 2002). Fukuyama uses heights of male and female in the United States in 2000 as an example in the following figure (Figure 1).

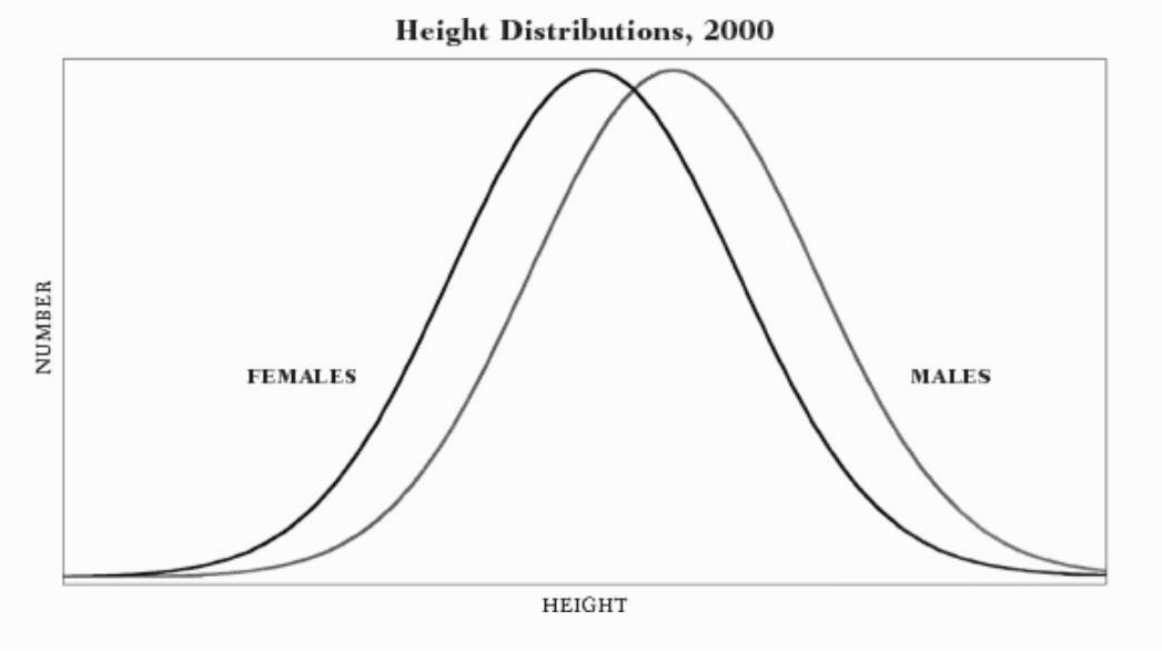

Figure 1: Heights Distribution of Males and Females in the United States of America in 2000 (Fukuyama, 2002)

He argues that the "normal" heights present themselves as statistical features in a bell-curve distribution, such as means, median, and variances. While a population means or median may be considered "normal" in some stringent definitions, a "normal" height is generally within two standard deviations of the population. Besides general features like heights and weights, the statistical normal is especially useful in the medical field (Fukuyama, 2002). Consider a report card from a medical examination. The card will usually tell one whether one's blood pressure, blood sugar, and cholesterol level fall into the normal level. If any of these indicators on one's report card goes below or above the normal range, it may be necessary for some medical intervention for the benefits of one's health.

However, there are several problems with this statistical definition of norm. Firstly, many features of a human population are impossible to be quantified. For example, some people have a better sense of music that allows them to understand and play music better than others. However, it would be an impossible task to measure one's musical sensibility, as these features are essentially abstract. Another example would be personality traits. Although there are many available personalities tests, such as the famous Myers & Briggs 16 personality test, these tests do not generate quantitative results (although there are numbers used for calculations purpose, test takers are suggested to take these numerical results as a grain of salt) (The Myers & Briggs Foundation, 2021). Therefore, it would be difficult to find a norm for these unquantifiable traits since they are inherently subjective and abstract,

Furthermore, these unquantifiable features do not restrict themselves to aesthetic abilities or abstract constitutions since the measuring methods of some seemingly quantifiable traits are controversial. A good example would be intelligence. The most standardized method to measure individual intelligence is through an IQ test. Nevertheless, since the invention of the IQ test by Alfred Binet in 1905, the testing methodology has always been in the center of psychologists' frictions and was once notoriously applied in the eugenic programs to determine whether some individuals were "feebly minded" (Beit-Hallahmi, 1994). One major problem of IQ testing is that individuals' intelligence manifests in various forms that are difficult to compare through numerical measurements. For instance, Matthew is very good at understanding mathematical concepts and solving geometrical problems. On the other hand, Philip can learn a series of gymnastic moves with a quick glance. Say if Philip has trouble in his math classes, it would be unfair to test IQ purely through math and doubt Philip's mental capability. Similarly, if it takes months for Matthew to learn a gymnastic trick, it does not mean

Matthew is less intelligent than Philip. Overall, Matthew and Philip are both undeniably intelligent, but their intelligence manifests in different aspects. Therefore, it would be prudent to think twice before announcing norms for these seemingly quantifiable population features, as quantification of some inherently unquantifiable traits would lead to misrepresentation and sometimes dire consequences.

Moreover, a statistical model of "normal" is contingent on the selection of the population, which only complicates the matter rather than delivering an accurate, consistent "norm." Because an infinite population would be impossible to measure, and the measurement will yield less relevant results, statisticans always confine their data to a particular population at a given time. Take the following analogy: Randy is considering renting an apartment in New York City and hopes to get the best deal by comparing the listings. It would certainly be imprudent if Randy were to check all rental listings worldwide, as the task is quite impossible to perform and does not give Randy useful results. Therefore, Randy should constrain his search to New York City (and probably to a specific borough of New York City) so that it becomes probable for him to perform the task and obtain helpful results in the end.

Nevertheless, population selection would become a problem to define the "normal," since what is "normal" is always relative to the population that one selects. For example, Ibrahim has a perfectly normal height of an Indonesian male. Yet when he travels to the Netherlands, he suddenly finds his height way below the statistical normal range in the world's tallest country. Does Ibrahim become not normal during his trip to the Netherlands? It certainly is unreasonable to determine whether one is normal merely based on the definition of "normal" at his surrounding environment. How about using racial or ethnic groups as statistically meaningful units? In this case, Ibrahim should use the Indonesian standard as he is an

Indonesian and identifies himself as Indonesian. But this criteria for population selection complicates the matter even more, as it involves too much subjectivity. The racial distinction is considered merely subjective (and often discriminative) separation as there is no scientific support for any biological racial difference. Ethnical categorization gives an even more blurred distinction as it usually involves subjective self-identification (Rattansi, 2007). After all, a population selection by racial and ethnic groups defeats the purpose of statistical normality, as this supposedly objective normality becomes a subjective, personal standard. Overall, because the generation of statistical normality necessarily relies on population selection, the statistical normal becomes quite undependable as it cannot yield relevant results without introducing obscuring subjectivity.

Finally, statistical norms always suffer the Sorties Paradox. A Sorties Paradox is an ancient paradox that questions the transition from quantitative changes to qualitative change due to linguistic vagueness (Stanford Encyclopedia of Philosophy, 2018). Suppose Harry plucks out one single strand of hair from his lushly hairy head. Harry is certainly not bald. Harry then plucks out the second strand of hair. He is still not bald. Harry keeps plucking out his hair. Every time he plucks out a single strand of hair, he looks at his head and confirms that he is not bald. Nonetheless, Harry eventually becomes bald despite that he is not bald every time he plucks out a hair. Philosophers consider the absurdity arises because of the vagueness in the definition of "bald." Baldness is not something that we can assign a numerical value to hair number; thus, it is tough to pinpoint a specific number of hair when Harry transitions from "hairy" to "bald."

Jonathan Glover uses the Sorties Paradox to respond to the statistical normal of emotional status (Glover, 1984). Glover presents the example that emotional state is often associated with

the enzyme level in one's body. When one's enzyme level gets below a certain level, one becomes depressed, a sub-normal or abnormal state. But there does not seem to be a definite enzyme level threshold when one can sharply feel that one's emotion drops from normal to depressed (Glover, 1984). Even though Fukuyama gives us a strict statistical standard of normal (i.e., the median or means plus or minus two standard variations), this standard is still susceptible to the Sorites Paradox. Say, in today's America, the male height that is two standard deviations below the means is 5.3 feet. Therefore, by Fukuyama's definition, 5.3 feet would be right on the edge of normality. Then what about 5.299 feet? Fukuyama may say that is abnormal. Yet it is only 0.001 feet, or 0.012 inches, below 5.3 feet. The difference is not even discernible by naked eyes! It would certainly be absurd to call one person normal and the other not normal based on some imperceptible differences. Then what about 5.298 feet… There goes the Sorites Paradox again.

Why does the statistical standard of the norm fail in the face of Sorites Paradox? The answer is something familiar: "normal" is not a quantifiable concept. Quantifying normality is like quantifying one's musical sense or personality, as the sense of "normal" used in our daily language is inherently abstract and vague.

Ultimately, it is futile to implement statistical models to justify what is normal because of the prevalence of inherently unquantifiable human traits, subjectivity in statistical population selection, and the abstract, unquantifiable nature of our sense of normality.

2.2.2.2. Intuitional Norms

Aside from the statistical norm, one other norm that people usually apply in judgment is the intuitional norm. Intuitional norm describes what is self-evidently "normal" judged by

one's "spontaneous unreflected judgment" (Huemer, 2005). If one's intuition says something is normal, it is then normal; if one's intuition kicks in and shouts not normal, by the standard of the intuitional norm, that thing is not normal. For example, when Sally sees a man with three eyes, she immediately knows that this man is not normal since her instinct unwaveringly tells her so. (This intuitional standard of normality also reminds me of a warning that my study abroad consultant often tells me: "if something does not feel right, it is likely not right.")

The theoretical support for intuitional norm roots in *the Principle of Conservatism*. *The Principle of Conservatism* states that "without further objections, other things being equal, it is reasonable to assume that things are the way they appear" (Huemer, 2005). For example, since the sky appears to be blue to my eyes, without further evidence denying the blueness of the sky, it is reasonable for me to assume that the sky is blue. Likewise, *the Principle of Conservatism* justifies the institutional norm since, without further objections, it is reasonable to judge whether something is normal by the way it presents itself to the judging subject. Back to the previous example, according to *the Principle of Conservatism*, since the three-eyed man seems abnormal to Sally, without further objection, it is reasonable for Sally to assume that the three-eyed man is abnormal.

One prominent advantage of the intuitional norm is that it can eschew the problem of Sorites Paradox. How can we tell when the hair-plucking Harry is going bald? By intuition. Even though we cannot identify a specific point where Harry goes from hairy to bald, at each stage, we can intuitively know whether Harry is hairy or bald. Similarly, in Glover's example, individuals can tell whether they are happy or depressed by intuitively interacting with their own feelings. Sir William D. Ross compares intuitional norms to the apprehension of beauty, where he writes that "the judgment as to the rightness of a particular act is just like the judgment

as to the beauty of a particular natural object or work of art" (Ross, 1930). In other words, Ross suggests individuals' intuitions, analogous to their beauty apprehension, provides a ballpark estimation for what is normal and is perfectly sufficient for daily-life judgments.

In the context of genetic enhancement, Steven Rose uses "a considerable unease reflected in custom and law" to justify his objection towards biochemical enhancements that are beyond the ordinary comprehension of normality (Rose, 2002). Leon Kass extensively discusses the "wisdom of repugnance":

> In crucial cases, however, repugnance is the emotional expression of deep wisdom, beyond reason's power fully to articulate it. Can anyone really give an argument fully adequate to the horror which is father-daughter incest (even with consent), or having sex with animals, or mutilating a corpse, or eating human flesh, or even just (just!) raping or murdering another human being? Would anybody's failure to give full rational justification for his or her revulsion at these practices make that revulsion ethically suspect? Not at all. […] Repugnance, here as elsewhere, revolts against the excesses of human willfulness, warning us not to transgress what is unspeakably profound. Indeed, in this age in which everything is held to be permissible so long as it is freely done, in which our given human nature no longer commands respect, in which our bodies are regarded as mere instruments of our autonomous rational wills, repugnance may be the only voice left that speaks up to defend the central core of our humanity. Shallow are the souls that have forgotten how to shudder (Kass, 1998).

Nonetheless, there is a fundamental problem with the intuitional norm. Even though philosophers argue that intuitions are inherent and have the status as "the emotional expression of deep wisdom," they are, in fact, quite malleable through environmental conditioning. To show how easily individuals' instincts can be swayed, moral philosopher, Kwame Appiah, presents a psychology experiment where a little hypnotic priming significantly shapes participants' moral intuitions. In this experiment, psychologists firstly prime participants to feel disgusted whenever encountering an emotionally neutral word, such as "take" or "often."

Then, psychologists present participants with morally neutral scenarios containing the word "take" and "often" and ask participants to judge these scenarios based on their moral intuitions. For example, they present participants with a scenario where a student-council representative "often" attempts to choose topics that would appeal to both professors and students for academic discussions. Although this student-council representative conducts no morally troubling actions, participants harshly judge this representative, giving moral condemnation like "it just seems like he's up to something" (Appiah, 2008). Through this psychological experiment, it is evident that individual intuitions are pliable under conditioning. Therefore, the intuitional norm is an unreliable and inconsistent measure of normality rather than, as Kass promotes, the "unspeakable profound."

Moreover, there are many examples that yesterday's repugnance often becomes today's normal. For example, in 1890, the conspicuous psychologist, William James, declared homosexual activities as "an instinctively repulsive sexual act" in the monumental psychology textbook of that era, *The Principle of Psychology* (James, 1890). This "instinct" that stigmatizes homosexual activities as visceral and nauseating incites prevalent violent hate crimes against gay people and notably led to the prosecution of Alan Turing under the crime of "gross indecency" (Doan, 2017). However, as scientific research and the humanist movement slowly pushed the society towards understanding and inclusivity, the public gradually opened its arms to the LGBTQ+ community and began to question the validity of instinct that first repelled homosexuality. Eventually, the LGBTQ+ population became accepted as a normal and regular part of many communities in the U.S.

Besides, during this year of "new normal," the entire human society adopted a series of updated intuitions. We now find it normal to see the street full of people wearing masks, queue

with 6 feet between each person, or refrain from personal interactions. After all, with society constantly developing, human intuitions are constantly changing and adapting to the environment. As a result, it would be unfair to impose our current intuitions of normality onto the future, where the intuitions could be drastically different.

In all, intuitional normal is overrated: this normal is manipulatable under even slight conditioning and limited to the current circumstances. Thus, it would be an unsuccessful strategy to adopt the intuitional norm as a standard to judge what is normal.

In conclusion of 2.2, after close investigation, neither statistical norm nor intuitional norm could constitute a reliable standard of normality. Given the difficulty of identifying normality, it does not seem that one can demarcate negative enhancement and positive enhancement. Therefore, the ethical difference that permits negative enhancement yet forbids positive enhancement boils down to arbitrary decisions based on inconsistent, unreliable standards of normality. Ultimately, it is not ethically meaningful to categorize human genetic engineering into positive or negative enhancements.

2.3. RADICAL VERSUS REGULAR ENHANCEMENT

2.3.1. Introduction to Radical and Regular Enhancement

The other types of genetic enhancement that bioethicists usually distinguish between are radical and regular enhancements. There are many definitions of radical enhancement in different pieces of literature. This thesis adopts Nicholas Agar's definition of radical enhancement, that is, enhancement techniques that turn individuals into fundamentally

different kinds of beings that “no longer deserve to be called human” (Agar, 2008). The most central idea in this distinction is human nature. If the enhancement transgresses human nature, it is radical; otherwise, it is regular. Examples of radical enhancement include immortality, ever-happiness, and dramatic extension of human features (such as intelligence, heights, or vision).

Philosophers argue that since radical enhancement pushes individuals too far away from human nature, it will degrade humanity and bring dire consequences to society. Take immortality as an example. Philosophers across eras, such as Bernard Williams and Martin Heidegger, advocate that death is an essential and necessary part of a human being. In other words, an individual deprived of death does not constitute a human life (Williams, 1973; Heidegger, 1927). Agar endorses the statements from earlier philosophers and adds that human without death will live in infinite boredom, involve in risky behaviors, and rarely give appreciations to things that current human do (Agar, 2008). Fukuyama also imagines an ominous future where an infinite life expectancy leads to a meager fertility rate, unproductive workforce, and moral chaos (Fukuyama, 2002). George Annas further exacerbates this fear that since genetically engineered human possess power and ability way superior to the current human, they are very unlikely to treat the current humans equal and will see the current human as an inferior species and target of slavery and slaughter (Annas, 2002). Indeed, an element of immortality or the like seems to be an unbearable load that humanity and human society cannot possibly undertake. Therefore, these bioethicists suggest that human society should always avoid the development of radical enhancement to maintain the integrity of human nature and avert devastating consequences.

2.3.2. Response to Radical and Regular Enhancement Distinction and Consequences: Into the Unknown

In response to the radical and regular enhancement distinction and consequences that radical enhancement might bring, this thesis will discuss the flexibility of human nature and promote an attitude of acceptance towards a new future that the radical enhancement might bring. After all, because no enhancement could infringe human nature and is destined to incur disastrous consequences, radical enhancement is nothing more than regular enhancement subjectively aggravated by irrational fears.

2.3.2.1. What Is Human Nature and How Much Can We Change It?

Among bioethicists, there are two contradicting attitudes towards human nature: bioconservatists and transhumanists. Bioconservatists argue that human nature is not infinitely plastic and hence cautions towards radical enhancement. It is worth noting that bioconservatists do not argue that human nature is perfectly static; instead, they admit that human nature attains a certain degree of flexibility. Kass describes his accepted range of enhancement in an analogy that one can teach young birds to fly but not teach an elephant to tap dance (Kass, 2003). Fukuyama puts the limits of human nature into the term of species variance, where every species has its specific maximum and minimum. For instance, a chihuahua cannot grow as big as a polar bear because its being the species of chihuahua gives a limit of how much it can grow. Similarly, individuals' being the species *homo sapiens* gives them certain limits to their constitutions fundamental to their species identity (Fukuyama, 2002). Following their ideas of human nature, bioconservatists contend that the radical enhancement that overly stretches

human nature is disrespectful towards human dignity and would eventually turn future humans into a different species.

On the other hand, transhumanists deny the existence of a limit to human capabilities or any confinement to the definition of human nature. They argue that if there is anything essential to human nature, it will be the tireless striving to improve humans themselves (Bostrom, 2005). This view echoes in the philosophy of Aristotle that advocates indefinable potentiality, that of Fredrich Nietzsche that promotes creativity as an authentic way of living, or that of Jean-Paul Sartre that encourages liberation from our facticity (Stanford Encyclopedia, 2020; Nietzsche, 1882; Sartre, 1943). These philosophers would hesitate to set a restricted essence to human beings because they observe that existence always precedes the essence. In Sartre's words, "man exists, turns up, appears on the scene, and only afterwards, defines himself" (Sartre, 1957). In other words, the process to define human nature is retrospective, where we make and remake the definition of human nature *only after* our constant explorations into and novel realizations of our new potentials. If they were to put their ideas into Kass's analogy, they would contend the following: nothing is denigrating about teaching tap dance to elephant's nature since the fact that *the elephant can do the tap dance* shows that tap dance is merely a formerly unrevealed part of the elephant's nature. Therefore, transhumanists believe that the radical enhancement that the bioconservatists dread is ultimately a part of our nature previously undiscovered (or yet to become), and that we should never wince in front of a self-discovering journey, no matter how crazy that might be.

The comparison between the views of bioconservatists and transhumanists reveals the limitedness and exclusivity of bioconservatists' perspectives on human nature. Nevertheless, bioconservatists could hardly rationalize these constraints except through faulty strategies

mentioned in 2.2.2., such as statistical studies that show the range of human abilities or intuitional disgust towards things out of their natures. Therefore, instead of sweating like a bioconservatist to define human nature and ending up with numerous failures, why don't we accept the all-is-welcomed transhumanist idea and embrace our infinite possibilities as part of who we are. There is no limit to human nature, not even the sky.

2.3.2.2. How Should We Face the Consequences of Enhancements?

Even though some bioconservatists accept that human nature can be infinitely extended, they still defend that some enhancements would still bring more severe consequences than others. These changes include fundamental shifts in individuals' perception and ideology and substantial upheavals in social structures. In addition to immortality, another example would be strengthening an individual's strength by 10% versus strengthening by 100,000 times. An individual with a ten percent increase of strength would certainly have some benefits in his or her life, such as the ease to open a stubborn jar, but this change could bring nothing significant. By contrast, if an individual strengthens his or her strength by 100,000 times, this Herculean gift would significantly alter his or her way of living—he or she could crack steel in a light touch, lift mountains, and become a demolition to any enemy. It is unimaginable how this individual could ever lead the same life as he or she used to have. It would be even more challenging for him or her to transition into this life of incredible strength. His or her strength will likely turn into the Midas touch that brings ultimate misfortunes. Consequently, bioconservatists identify radical enhancement as one that brings fundamental changes and suggest against it because most changes it provokes are catastrophic to both individuals and society.

However, there are two problems with this consequentialist distinction. Firstly, the magnitude of enhancement does not necessarily correspond to the significance of its consequence; therefore, the consequences of an enhancement are not always predictable. For instance, Connie increased her intelligence by 20% while Simon increased his intelligence by 400,000 times. Simon with his unfathomable intelligence transcended worldly values and decided to sit in his armchair to think about philosophy for the rest of his life. Yet, surprisingly, Connie utilized her enhanced intelligence and schemed a worldwide disaster. In this case, even though Connie had a much slighter enhancement than Simon, she left an enormous scar on the world while Simon did almost nothing. Therefore, given its unpredictability, the consequences of a certain enhancement are not always apparent in foresight.

One response to the unpredictability is that instead of assessing the consequences of enhancement prospectively, we could evaluate the consequences empirically to judge whether the enhancement is radical and catastrophic. For example, if 90% of individuals with the 100,000-time enhanced strength became a major threat to society, this enhancement is empirically proven to be radical and dangerous. Therefore, through empirical evidence, one can decide whether an enhancement is radical by the evaluating the consequences of what has happened.

However, this response has a prominent weakness, that is, blending the principle with practical factors. In other words, the enhancement itself could be harmless, but the practical way that the enhancement is performed along with other external factors precipitates the horrendous results. Consider the following analogy: Vivian keeps getting sick from eating vegetables on an industrially polluted farm. Indeed, the result is that Vivian keeps getting sick. Yet, it does not mean the act of eating vegetables is sickening; instead, the culprit is the external

circumstance that the vegetable that she eats grows out of an industrially polluted land. Similarly, if we see the results that individuals with colossal strength often become a threat to society, it does not necessarily mean the enhancement itself is culpable for the results, as the fault could lie in the practice or external factors. Hence, it would be even more complex to use empirical results to decide whether an enhancement is radical due to the entanglement of practical and external elements.

Furthermore, a subversive consequence that an enhancement could bring is not always catastrophic. Throughout human history, the fear towards unknown reveals itself most prominently during the revolutionary movement. Industrialization in the 19th century has substantially restructured human society. Aside from material improvements, such as railroads, electricity, and machinery, industrialization significantly changed the population structure and even incited multiple worldwide revolutions. In the eyes of preindustrial society, industrialization is undoubtedly a threatening upheaval that roots up their concepts of human society and produces terrifyingly overpowered posthumans who transport themselves in cars, use machines to perform tasks and communicate remotely. Nevertheless, when we look at life today with fruits accumulated from generations of technology development, we would be stunned by how irrational these fears are. Similarly, why should we believe bioconservatists' overblown fantasies and let our ignorance hijack our progress towards HGE and a better life for the next generation?

In sum, bioconservatists fail to establish the definition of radical enhancement through its consequences due to its unpredictability and demonstrate unreasonable fear and reservation towards changes that could dramatically improve human society.

2.4. CONCLUISON

In the closing of section 2, this section has established that it is irrational and meaningless to establish distinctions of negative versus positive or of radical versus regular in the practice of HGE. Some arguments in this section will be referred to in later sections, given their undeniable similarity. In the following discussion, HGE will be discussed as a general whole that carries consistent moral weight.

3. MORAL PERMISSIBILITY OF HUMAN GENETIC ENGINEERING

3.1. INTRODUCTION TO MORAL PERMISSIBILITY OF HUMAN GENETIC ENGINEERING

Moral permissibility indicates a moral status of mere allowance. In other words, one can perform a morally permissible practice without inciting any criticism towards one's ethical integrity. However, if the action is merely morally permissible, it is in no way morally encouraged. That is to say, one who performs a merely morally permissible action also deserves no praise. An example of a merely morally permissible act would be sleeping, which brings neither moral blame nor acclaim to the action-performing subject. This section intends to establish that HGE is at least a merely morally permissible practice by responding to various objections and pointing out their futility in attacking HGE.

For clarity, this thesis roughly divides these objections into three categories: deontic objections, consequentialist objections, and miscellaneous objections. Deontic objections focus on HGE's inherent moral value regardless of the results that HGE creates. Consequentialist objections emphasize the evaluations of HGE's consequences and possible solutions to potential problems. Miscellaneous objections are the ones that discuss relevant problems of HGE that do not necessarily belong to the first two categories. The groupings of these objections only serve to deliver a more transparent structure to the overall argument and should contain no indication of different ethical treatment.

3.2. DEONTIC OBJECTIONS

This section of deontic objections to HGE consists of investigations towards the legitimacy for two objections that attack HGE as an inherently faulty practice regardless of its consequences. The thesis will discredit both of these objections and establish the deontological moral permissibility of HGE.

3.2.1. Defying the Divinity of God

This objection appeals to the authority of God and claims that HGE demonstrates a Promethean arrogance, that is, a prideful presumption of intervening in the natural order and violating the wills of God. Outside the realm of bioethics, it is not surprising that this objection is overwhelmingly supported by religious population. Catholic Churches and some conservative Protestant groups have taken an especially strong stance to guard the natural integrity of human being as a respect to God's plan. They argue that since human genomes, as a natural part of God's image, are divinely designed by God, artificial alteration of human genomes is a blasphemous practice that violates God's divine plan (Glover, 1984; Kass, 2003).

To tackle this objection convincingly, this thesis proceeds with recognition of the validity of these religious beliefs, even though many beliefs, including the divine existence, are still under philosophical debates. In other words, this thesis will produce a response that is respectful of opponents' religious belief. However, this acceptance of religious belief also brings a challenge: how to deal with religious groups that oppose all kinds of biomedical interventions, including medicines and reproductive technologies (Evans, 2002). In that case, this response to establish the moral permissibility of HGE would fundamentally infringe their religious beliefs and would not be at all successful in any sense. Therefore, the thesis concedes

its position in front of these particular beliefs and will only target religious resistance that has fully or partially accepted modern biomedical technologies.

To begin with, the main problem of this type of objection is that it encourages a subservient attitude towards natural phenomena or processes under the belief that their integrity should be protected as part of God's design. This equation between natural phenomena and God's divine plan would require humans to adopt unreasonable conditions for living. For example, since it is humans' natural inclination to fall ill because of bacterial or viral infection, medicines would be an artificial alteration of nature and consequently a violation of God's plan. Aside from how ridiculous this might sound to secular ears, most religious texts themselves do not preclude the use of medicines. In Isaiah 38:21, Isaiah gives specific directions on how to cook a medicine to cure illness; alternatively, Luke 10:34 describes how to deal with infected wounds. Therefore, the absurdity of this objection not only comes from its potential anti-medicine attitude but also its contradiction with religious texts. Ultimately, there is no secular nor religious support that individuals should adopt absolute servitude towards natural processes and evade artificial interventions, such as medicines and HGE.

Moreover, this objection sometimes falsely overemphasizes the integrity of human genomes and considers human genes to be a static concept that does not change at all. However, a closer look at the study of human genetics will show us that human genomes are constantly varying. One major source of genetic variations happens through the human reproduction where each biological parent gives the offspring a random half of his or her genetic materials. This mixing of these genetic materials introduces plasticity into human genomes to resist environmental changes. This genetic variation also explains why a child will inherit traits from both of his or her parents instead of being identical to one of his or her biological parents.

Besides reproduction, cellular genetic replication never conforms to perfect fidelity, because benign mutations would propel the species' natural evolution. Some other genetic changes may involve an invasion of virus that inserts its genetic material into the human DNA or an exposure to Ultraviolet (UV) radiation that damages the DNA. Overall, human genetic information has been constantly changing without apparent harm to God's divinity. Therefore, the idea that God's divine plan necessarily relies on the perfect integrity of the human genome is obviously misguided.

Therefore, the objection that HGE would defy God's divine plan does not stand due to its irrational servitude towards natural processes and its misunderstanding of genetic mechanisms.

3.2.2. Degrading Children as Products and Conditional Parental Love

This objection is a derivational argument of Elizabeth Anderson's objection towards commercial surrogacy. Anderson points out that as commercial surrogacy would inappropriately treat children with lower modes of valuations than they deserve, children would ultimately become mere commodities in the scheme of commercial surrogacy and receive only conditional parental love based on their traits (Anderson, 1990). Burley and Harris apply Anderson's argument onto HGE and argue in similar lines that children would become mere products under the practice of HGE and only receive parental love contingent on their desirable traits (Burley & Harris, 1999). As (potential) persons, children have their inalienable interests and deserve to be respected. However, in the practice of HGE, children seem to become the mere products of HGE and are alienated from their deserved interests and respect. Besides, since parents could handpick the traits of their children through HGE, their love becomes contingent on the traits their children have instead of on the children themselves.

However, this objection has a couple of weaknesses. First, the process of HGE does not necessarily denigrate children into mere products. Analogously, surgery (or most medical interventions) will produce children with improved health status, but no one would claim that surgery lowers the status of children from people to products of the surgery. Ultimately, the purpose of HGE is to give children a better life with enhanced capabilities instead of downgrading children into objects. Therefore, it is mistaken to assume that the process of HGE would undermine the modes of valuations towards children, given its benign intentions and similarity to medical interventions.

Additionally, this objection exaggerates the necessity of unconditional love for children. Indeed, we often hear parents say that they love their children unconditionally, but that speech can hardly establish sufficient proof that parental love is always unconditional. There are many cases to support that parental love is often conditional even without HGE. For example, many parents love their children only because of their biological connections. There are numerous cases that once a parent finds out a child is not his or her biological offspring, their parental love significantly diminishes. In addition to biological connections, parental love could be contingent upon children's appearance, achievements, social status, choice of spouse, sexual orientations, and many other factors. Therefore, it is questionable to object to HGE by stating that children necessarily deserve unconditional parental love when it is often not the case even in a world without HGE.

Moreover, even if some parental loves are unconditional, it is unlikely that the trait-picking process in HGE would taint this love. Trait-picking is not a process exclusive to HGE and has empirically proven to be compatible with unconditional parental love. In Darwinian theory, sexual selection is an already process that includes picking the trait for one's children. When

one selects a spouse for procreational purposes, he or she also unconsciously (or sometimes consciously) selects traits for his or her children whose half of the gene will come from one's spouse. In some matchmaking clubs, this consideration even becomes the primary concern for the participants. Not to mention in sperm or egg banks, handpicking donor is an unavoidable step. Nevertheless, among these conscious or unconscious handpicking processes, some parental loves remain unconditional. Hence, it is unfair to judge the handpicking process in HGE differently when handpicking children's traits can be perfectly compatible with unconditional parental love in other scenarios.

In sum, the objections that contend HGE would degrade children as mere products or deprive children of unconditional parental love cannot overthrow the moral legitimacy of HGE, because these objections misunderstand the intention of HGE, exaggerate the necessity of unconditional parental love, and overlook the compatibility of handpicking with unconditional parental love.

3.3. CONSEQUENTIALIST OBJECTIONS

This section of consequentialist objections comprises of three objections that concern about the consequences of HGE development. This section intends to dismiss fears of these consequences and provide possible solutions to potential problems that HGE might lead.

3.3.1. Widening Social Gap between Rich and Poor

Philosophers like Sandel and Fukuyama concern that even if HGE can bring conducive effects to individuals, it may aggravate existing disparities in society (Sandel, 2003; Fukuyama, 2002). They argue that if HGE cannot be available to all people, it will incur an unfair

advantage to individuals who possess this technology (likely among the wealthy population). Children with engineered genes are more intelligent, athletic, creative, musical. They will likely have a competitive advantage in school, career, or just any aspect of life choices. Therefore, wealthy people become wealthier because of their genetic advantages, while poor people become only more impoverished. Eventually, the rich and the poor will be not only different in social status but also different in genetic makeups. Therefore, because the HGE is likely to exacerbate the social division between the rich and poor, the development of HGE should be put on hold.

There are a couple of vulnerabilities of this objection. Firstly, one thing can be good in two different ways: positional good and absolute good. Positional good indicates an advantage over others, while absolute good means to give oneself "the best chance for a long and healthy life" (Harris, 2003). This objection only considers HGE as a positional good to compete with others but neglects its potential to be an absolute good to improve oneself. For example, if Larry uses HGE to lengthen his life expectancy for ten years, he obtains some positional good compared to others who live a shorter life. However, the primary purpose of his life extension is never the positional good—he hopes to have more time with his grandchildren, visit more places, and witness how the world will change in the next ten years. This extension of life would allow Larry much more joyful moments and valuable experiences. If we postpone the research on HGE merely because its positional good to the rich will likely induce inequality, we sacrifice all the absolute good for people to have a better life. Thus, this objection ignores the benefits from the absolute good, which is usually the primary concern in HGE practice.

Admittedly, sometimes the positional good will be the dominant consideration when people use HGE. However, a focus on positional good alone cannot undermine the moral

integrity of HGE. Consider the following analogy: parents may give their children a healthy diet to win them some advantages in the swimming team tryouts. But the act of giving children a healthy diet is not morally corrupt merely because of its competitive purpose. Then what about students who use Adderall in SATs or athletes who use steroids in competitions? Aren't those practices to increase one's positional good considered cheating and immoral? To answer these questions, we must first understand why organizations like the College Board or the International Olympic Committee prohibit the use of these substances. The main reason is that these performance-enhancing medications are addictive and dangerous to use without prescriptions. Adderall is neurotoxic, while steroid users are exposed to a significantly higher risk of cardiovascular diseases and hormonal dysfunctions (National Institute on Drug Abuse, 2020; Berman et al., 2009). Suppose the College Board or the International Olympic Committee had not banned the use of these substances. Using these substances would become a prerequisite to enter SATs or Olympic games because not using them would leave one in a disadvantageous position. In that case, any SAT or Olympic game would endanger thousands of lives, and the College Board or the International Olympic Committee would be liable for these harms. In brief, the primary reason that College Board and International Olympic Committee ban performance-enhancing drugs is their harmful effects on individuals instead of the unfair positional good that these drugs can bring. Suppose Adderall and steroids were to be harmless in all aspects, long-term or short-term. If that would be the case, Adderall and steroids would become part of the healthy diet to prepare students or athletes before the test or the game that the College Board or the International Olympic Committee would likely even encourage to see better performance. We would see smarter students and stronger athletes

under safe conditions. Why wouldn't we like that? Similarly, if HGE can be perfectly safe, its use on positional good would not sabotage its moral coherence.

After all, this objection recognizes HGE is good but concerns that HGE may not be fairly distributed. The obvious solution is to open HGE's access to everybody. However, it may not be evident to the supporters of this objection that the first step to widespread access is to allow HGE to develop. The development of technology tends to follow the trend from expensive to cheap and from exclusive to widely available. Harris nicely describes the journey that technologies have to follow towards fair access:

> No one can be ignorant of the fact that procedures which start expensive, rare (even elitist), and risky often become widely available, if not universal, cheap, relatively safe (safe enough given the balance of risk and benefit), and widely accessible. […] There is of course reason to fear the escalating costs of high-tech medicine, but the point for the present argument is that products and procedures need to start somewhere if they are to get anywhere. This means that unless we permit and possibly fund the development, we never benefit from the product or procedure ad wide (if not universal) access could never occur. If we banned innovations unless and until they could be made available to all, it is probable that they would never be (have been) developed (Harris, 2010).

If we want HGE to distribute its benefits to all, we should allow its very first step and every step towards final distributional equity. Sometimes the initial inequity will even stimulate faster progress towards equality, as the rich individuals who first receive the benefits of the HGE can subsidize further research to make it cheaper in the long term (Freiman, 2018). Therefore, it would be irrational to forsake the whole progress of HGE merely because, at one stage of its development, it will incite inequalities.

In conclusion, this objection cannot undermine the moral integrity of HGE practice because it neglects that the primary focus of HGE is its absolute good on individuals, mistakes

intentions for positional good as morally corrupt, and ignores that inequity is an inevitable step towards technological equality.

3.3.2. Eugenic Consequences

Some philosophers worry that the development of HGE that eliminates undesirable traits would put people who currently have these traits into a disadvantageous position, as the population that they identify with becomes increasingly smaller (Kitcher, 1996; Powell, 2012). They even worry that these HGE attempts may be consciously or unconsciously implemented to reach a homogenized population and result in possible eugenic consequences (Powell, 2012; Fukuyama, 2002).

For example, with HGE, parents would likely select against autism. As fewer and fewer autistic children were born, the community of autism would shrink significantly. In a world where autism is selected against and where the autistic population dwindles by day, the remaining population with autism would live on a smaller and smaller margin of the society until they are entirely wiped out from this planet. Similar situations may happen to people with disabilities, genetic defects, and even undesirable traits like shortness. How would those people walk into a new era of HGE where they face public denial of themselves and possible extinction?

The first response to this objection hinges on the scientific evaluations on the physical harms of these genetic traits. In other words, we need to evaluate whether those undesirable traits are physically neutral or harmful to the individuals. If those traits are physically harmful, passing on harmful genes to children for the purpose to enlarge their community is evidently unethical and should be prohibited. Analogously, HIV/AIDS patients are prohibited to intentionally spread their diseases because it can severely harm others. Premarital screening is

another existing mean to defer individuals with serious inheritable genetic defects, such as sickle cell anemia and Huntington chorea, from reproduction in order to alleviate future suffering of their children. Therefore, in these cases, HGE would be justified to correct these physically harmful genes and could potentially give the population with harmful genetic defects unprecedented hopes to have their own children who would not go through the same suffering as they do.

This objection becomes more challenging to resolve if parents use HGE to select against physically neutral yet socially unfavored traits, such as shortness. However, techniques that can correct socially unfavored features are nothing new. Plastic surgery is a similar biomedical technique that people use to change their physically harmless yet socially unfavored traits. But even at the age where plastic surgeries have become quite accessible, we do not and will not likely see a widespread phenomenon of artificial appearances. Why? Because people have a diverse range of aesthetics and social values. Some groups prefer tall stature while others like short. Some groups love blonde hair, while others like brunette hair. Among various groups, people can find their niches where they, as their authentic self, can be accepted and appreciated.

As Fukuyama illustrates, instead of being a necessary outcome of HGE, eugenic policies and homogenization result from political monopoly and authoritarianism, where one group's interests triumph over all others (Fukuyama, 2002). Therefore, the solution is not to stop HGE but to consider applying HGE in a democratic fashion, such as Nozick's genetic supermarket (Nozick, 2013). Overall, even though parents would make the final decision about their children's traits based on the social preference of groups they are in, it is unlikely that traits that some groups do not prefer would be exterminated in a democratic world.

In all, worries about eugenic consequences and homogenizing society cannot contribute to a sufficient objection to the practice of HGE because some eugenic processes are necessary to reduce harm to subsequent generations. Meanwhile, a democratic method of HGE should be advocated to significantly reduce the likelihood that HGE will be used as a eugenic practice for monopolistic interests.

3.3.3. Limitations on Next General's Freedom

James Hughes argues that designer children can hardly be free for all of their traits are selected by their parents before their birth (Hughes, 2019). As genes act as determining factors for many human traits, it will be extremely difficult for children to change or deviate from their genetically chosen path. For example, Fred's parents decide that they want Fred to be a very talented pianist, so they alter his genes so that he has better appreciation and mastery of the piano. Fortunately, Fred turns out to be a great pianist and loves playing the piano. However, the problem is that it is unlikely for Fred to freely choose not to like piano since his genes are already altered to be so. In other words, Fred cannot physically or even intentionally opt-out the path that his parents have set for him and are ultimately unfree. In all, since HGE deprives children of their entitled freedom, it is unjust for parents to practice HGE (Sandel, 2003).

However, these philosophers ignore that parenting, in general, has a deterministic effect. In reality, besides HGE, many of our parents' decisions in our childhood have profoundly influenced us, and all these decisions accumulate and eventually build the individuals whom we turn out to be. Parents can make lasting decision for us since our childhood: they decide what food we eat, what books we read, which schools we go to, what language(s) we speak, what instrument(s) we play. Besides, parents can decide on permanent changes for their

children just like designing their genes. For example, parents can decide whether their children receive circumcision, appendectomy, or ligament replacement, which are all permanent changes yet less questionable. After all, even if Fred's parents do not choose HGE, they can still create various conditions (such as giving Fred a very musical environment) to make Fred love the piano and an excellent pianist in numerous ways.

However, one can still object that HGE is more deterministic than parenting because one still can change his or her inclinations through rebelling at later stages of one's life but is much less likely to change with genetic dispositions. Nevertheless, this objection would still inculpate parents even without HGE since their genes are the only genetic materials that their children will receive. In simpler words, children will have deterministic genes with or without HGE. It is the *fate* of children to have genes and traits decided by their parents. Even without HGE, children are still destined to look like their biological parents. Even without HGE, children born of athletes are likely to be athletic and love sports. Children are bound to be restricted by their parents. Then why do we frown upon HGE when it brings no different consequences than regular parenting?

They may reply again, indicating an element of random chance in natural reproduction that HGE lacks. Because parents would not know exactly how their children would look like, how exactly they would behave, or what exactly their personalities are, this seemingly blissful ignorance gives room for surprises and free development. Nevertheless, this reply is absurd as it supports that leaving children's dispositions to random chances is better than to a careful control with good intentions. Analogously, if one's child tears his ligament, there is a non-zero but slight chance that his ligament will heal by itself. In this case, should this person leave his child out of surgery just because he hopes for surprises and free development? As absurd as

this case sounds, so are parents who leave their children out of HGE just because they want to see how random chances play out in their children's genes.

Some philosophers still worry that parents would use HGE to micromanage their children through fine-tuning their children's genetic make-ups. For example, Phoebe may use HGE to set her daughter's hair color to be blonde at the age of ten and brunette at the age of twenty. Freiman cites the case of Todd Marinovich to illustrate the harm of parental micromanagement:

> He has never eaten a Big Mac or an Oreo or a Ding Dong. When he went to birthday parties as a kid, he would take his own cake and ice cream to avoid sugar and refined white flour. He would eat homemade catsup, prepared with honey. He did consume beef but not the kind injected with hormones. He ate only unprocessed dairy products. He teethed on frozen kidney. When Todd was one month old, Marv was already working on his son's physical conditioning. He stretched his hamstrings. Pushups were next. Marv invented a game in which Todd would try to lift a medicine ball onto a kitchen counter. Marv also put him on a balance beam. Both activities grew easier when Todd learned to walk. There was a football in Todd's crib from day one. "Not a real NFL ball," says Marv. "That would be sick; it was a stuffed ball." (Freiman, 2018; Looney, 1988)

Todd subsequently led a tragic adult life, struggling with drug addictions. Given Todd's case, Freiman argues that micromanaging one's children through HGE is unhealthy and exemplifies bad parenting. Therefore, parents should only use HGE to "wisely manage" their children instead of micromanaging them (Freiman, 2018).

In response, it is first worth noting that every parent has distinct method of parenting and their own prospect for the children. Besides, parents generally are the ones who have the best knowledge for their children; therefore, some seemingly unreasonable parenting could actually be beneficial for their children. Then who is it to decide whether parents are harming their children because of their distinct parenting style that they consider to be the best for the

children? Who is it to tell that micromanaging children does not exemplify wise parenting when some parents can use micromanagement so skillfully to benefit their children the most? Consider the controversial "Tiger Mom" parenting style demonstrated in Amy Chua's book, *Battle Hymn of the Tiger Mother*:

> I hauled Lulu's dollhouse to the car and told her I'd donate it to the Salvation Army piece by piece if she didn't have 'The Little White Donkey' [a piano piece] perfect by the next day. When Lulu said, 'I thought you were going to the Salvation Army, why are you still here?' I threatened her with no lunch, no dinner, no Christmas or Hanukkah presents, no birthday parties for two, three, four years. When she still kept playing it wrong, I told her she was purposely working herself into a frenzy because she was secretly afraid she couldn't do it. I told her to stop being lazy, cowardly, self-indulgent and pathetic (Chua, 2012).

Critics consider that Chua's parenting method is unduly ruthless and insensitive, and some even accuse Chua's parenting as borderline child abuse. Nevertheless, in 2011, an open letter from Chua's daughter, Sophia, was published in *New York Post*. Sophia defended her mother's parenting strategy and ended her letter saying that "If I died tomorrow, I would die feeling I've lived my whole life at 110 percent. And for that, Tiger Mom, thank you" (Chua-Rubenfeld, 2011). In this case, it would be presumptuous to declare that Chua had an awful parenting method just because of how it looks to strangers. After all, the parent-child relationship is one of the most intimate relationships in the world, and, generally, we should leave the parents to decide what is best for their children. If micromanaging children's DNA is a necessary step in their parenting style, so be it. (Nevertheless, this is not to say there is no bad parenting, whose prominent features and solutions will be illustrated in section 4.3.2.)

Therefore, the objections and worries mentioned in this section is largely unfounded, as parenting has profound, permanent effects on children with or without HGE, and the exact way

how parents hope to use HGE for their kids' benefits should be a decision within their own discretion.

3.4. MISCELLANEOUS OBJECTIONS

This section will briefly discuss the objections about unearned achievements and complexity in HGE and will ultimately defend HGE and question the legitimacy of these two objections

3.4.1. Unearned Achievements

Leon Kass raises another objection that the enhancements brought by HGE is unqualified good and diminishes human efforts. Consider the following example. Cathy and Diane both participate in a marathon race and cross the finish line at the same time. However, the only difference between Cathy and Diane is that Cathy is genetically engineered to run long distance while Diane is not. All things being equal, it seems that Diane's effort in this race is more praiseworthy than Cathy's since she is unassisted by external factors and achieves her success through struggles and difficulties. Indeed, if one attains achievements through HGE, it looks to be "cheating" or "cheap" as one's efforts are detached from the achievements (Kass, 2003). In other words, in order to ensure one's achievement to be acknowledged appropriately, one needs to manifest the "alert, self-experiencing agent" who does voluntary deeds (Kass, 2003). Overall, Kass contends that HGE creates a lack of authenticity in achievements and disrespects genuine human efforts.

Nonetheless, Kass's objection is insufficient to deny the moral legitimacy of HGE because his objection ignores the existing genetic disparities between abilities and the fact that HGE

will become an integral part of human nature and identity. To illustrate the first idea, consider the following example. Usain Bolt has a genetic disposition that equips him with long ligaments and strong muscles to run incredibly fast. This genetic disposition is unique to Bolt and not available to anyone else in the world. However, it does not seem that Bolt's outstanding genetic disposition renders his achievements less valuable. Then why would we object to the achievements of people with artificially enhanced genes but not to those of people with naturally enhanced genes. Therefore, the existing genetic disparities has proven the unnecessity of Kass's objections as genetic advantages do not necessarily diminish our achievements.

Additionally, as discussed in 2.3.2.1, human nature should be treated as all-encompassing and ever-evolving. As human society gradually adapts to the technology of HGE, we would eventually see HGE as an inalienable part of ourselves. Even today, people have embraced some biomedical enhancements, such as ACL reconstructions, as an integral part of human beings and have no problem recognizing the achievements of athletes with these enhancements. Therefore, HGE would not separate our achievements from ourselves as it would eventually become part of who we are.

Therefore, since existing genetic disparities and enhancement procedures have not dampened our achievements in the way that Kass describes, we should instead hold an open attitude towards HGE and accept it as part of who we are.

3.4.2. Devil's Bargain

Some philosophers express their anxiety towards HGE, worrying that changing human genes will ultimately be a devil's bargain, where one benefits will be traded for equivalent curses. Fukuyama presents that the relationship between genes and traits, or phenotypes, is

complicated as in some cases, one gene can control multiple traits, while in others, multiple genes control only one trait. Besides, genes' advantages are relative. For example, the sickle cell anemia gene can protect people from malaria in Africa but presents themselves as genetic defects in Western societies where malaria is never a threat. Therefore, he argues that manipulating genes to yield desirable outcomes will be extremely difficult given these complexities (Fukuyama, 2002).

Nevertheless, Fukuyama's pessimism is more of a concern about our scientific knowledge rather than a principal objection to HGE. Indeed, it would be reckless and irresponsible to practice HGE before we fully understand the functions of specific genes. However, it does not mean HGE is a practice that would inevitably bring side effects because of the complexity of genes. As our scientific knowledge progresses, there is no reason to believe that scientists will never approach a clear understanding of genetic mechanisms and improve the safety of HGE. After all, we should always have hope that scientific progress would eventually bring safe, widely accessible HGE to reality.

3.5. CONCLUSION

In this section, we have explored seven objections to HGE in the category of deontic, consequentialist, and miscellaneous. After close investigation, it is evident that none of these objections can refute HGE's moral legitimacy. Therefore, HGE should be established at least as a morally permissible practice where parents who use its service would not be morally blameworthy in any respect.

4. MORAL OBLIGATIONS TO HUMAN GENETIC ENGINEERING

4.1. INTRODUCTION TO MORAL OBLIGATIONS TO HUMAN GENETIC ENGINEERING

After establishing the moral permissibility of HGE, this thesis intends to take a step further and endorse the moral obligations of HGE. Moral obligations describe actions that would not necessarily receive moral praise, but the failure to perform these actions would incite moral blame. For example, once we made a promise, it would be morally obligated to keep the promise without extenuating circumstances. If one keeps the promise, one will not necessarily receive any praise as the action is what he or she supposed to do. However, if one breaks the promise, one will be morally blameworthy.

This section intends to establish that HGE aligns with parental obligations to give their children a better life. Therefore, if beneficial HGE becomes easily accessible to family and the society in general, failure to use HGE would incur moral blames to the parents because they fail to fulfill their duties.

4.2. PARENTAL OBLIGATION TO BETTERMENT OF CHILDREN

4.2.1. Introduction to Parental Obligation to Betterment of Children

Parental obligation has always been a relatively incontrovertible subject in moral philosophy, as even philosophers who take children as mere properties of parents endorse

parental ob-ligation (Naverson, 1988). Parental obligations could find their theoretical support in many forms, such as genetic and gestational connections to children, the social agreement between prospective parents and the moral community, and the causation of new existence (Austin, 2020). Although it could be discussed extensively which model best describes the parental obligation to the children, that would be unnecessary for the purpose of this thesis. But to avoid controversy, this thesis takes parental obligations in the most basic sense: parents have the *prima facie* obligation to provide resources that support the children's potential betterment, *ceteris paribus* (Freiman, 2018).

The parental obligation is *prima facie* because in no way should parents take their obligations as an absolute, unquestionable duty before everything else. It certainly is reasonable for parents to spend some time with their friends at a marginal cost to their children's happiness. Parents should also exercise their obligations with respect to others' deontic rights. For instance, a mother cannot attack another skater to improve her daughter's chance in the Olympics. Besides, the obligation is placed in conditionals (i.e., *ceteris paribus*) because practical concerns are not primary considerations here. Although there are a million ways that an HGE practice could be misused (will be discussed in 4.3.2.) or go wrong in practical scenarios (discussed in section 2.3.2.2.), these empirical consequences are not inherent defects of HGE and are thus not included in this section's discussion (Freiman, 2018)

To illustrate the parental obligations to children's betterment, consider the following examples. George's family moves to a neighborhood with two schools. School A provides low-quality education with unqualified teachers and poorly furnished facilities, while School B offers excellent education with well-educated teachers and newly refurbished infrastructures. Children would generally learn more, make more valuable friendships, and have a better

experience at School B than School A. School B can also better prepare children for college and future job market than School A. Given these conditions, which school should George's parents choose? All else being equal, it is only reasonable and morally required for George's parents to send George to School B. Similarly, George's parents were to choose between two diet plans that they would offer George. Diet A consists of exclusively junk food that offers minimal health benefits to George. Meanwhile, Diet B comprises healthy food whose nutrition will substantially support George's growth and health. All else being equal, which diet plan should George's parents choose? There is no doubt that the right diet that George's parents should choose is Diet B. In sum, parents have a defeasible obligation to improve their children's welfare, all else being equal.

4.3. PARENTAL OBLIGATIONS TO HUMAN GENETIC ENGINEERING

4.3.1. Introduction to Parental Obligations to Human Genetic Engineering

So far it has been established that parents have a defeasible obligation to allow a better life to their children, all things being equal. Therefore, if HGE ever becomes safe and accessible with proper restrictions mentioned in section 3 (such that excludes physically harmful genes), there is no reason to stop parents to make their children better and give them a better life.

Let's take George's family as an example again. Suppose George's parents are presented with the HGE option to increase their child's intelligence by 40%. The technology is proven safe with approvals from the entire scientific community and guarantees to leave no harm to George. Additionally, in many previous cases of this HGE practice, this increase of intelligence by 40% not only gives the enhanced children a leg up in educational opportunities and job

placement but also allows them an overall better life experience, given a clearer comprehension of everything presented to them. In this case, if everything else is equal, it would be morally required for George's parents to use the HGE as the failure to do so would violate their parental obligations to the betterment of their child.

4.3.2. Concerns of Parental Obligations to Human Genetic Engineering and Responses

Nevertheless, there are some concerns about this parental obligation to HGE. To begin with, some people would likely worry that since parents have different standards of what is better for their children (as discussed in 3.3.3.), it might lead to potential harm to the children because of parents' poor decision or bad values. For example, since Daisy believes that depression is a necessary part of life experience and would help her child to appreciate happiness more, she engineers her child's genes and makes depression a frequent part of his childhood.

There are three scenarios to demonstrate Daisy's possible intentions.

(1) She intentionally hopes to improve her child through HGE, but she is misinformed.

(2) She intentionally wants to harm her child and disguises her true intentions.

(3) She knows clearly what is best for her child and uses HGE to do so.

The purpose of laying out three scenarios is to distinguish between righteous use, misuse, and malicious use of HGE. Correspondingly, (1) is an example of misuse; (2) is an example of malicious use; (3) is an example of justified use, despite that her action seems unreasonable. The misuse and malicious use of HGE do not undermine HGE's claim on moral obligation. As an analogy, one can huff the glue (i.e., misuse) or use the glue to poison someone (i.e., malicious use), but these inappropriate uses of glue will not constitute an indictment of glue (Freiman, 2018). To guard against these misuses and malicious uses, the distributors of HGE

should therefore ascertain the intentions and knowledge of parents about a specific type of HGE before granting them permission. Prevention measures may include a HGE licensing test for prospective parents or the requirement for a formal application and careful review if irregular enhancements would be needed. Yet ultimately, these practical concerns should not obstruct parents' moral obligation to use HGE.

What about the scenario (3)? Is Daisy justified to engineer her children to be depressed if she has good knowledge and a benign intention? As mentioned in 3.3.3., we should recognize that every parent has his or her distinct method of parenting and the best knowledge for their children; therefore, some seemingly unreasonable parental styles could be ultimately beneficial for their children. Therefore, if Daisy's parenting method will yield what is the best for her child after balancing its harm and benefits, her use of HGE should be permitted and obligatory no matter how crazy that might look to others.

Another worry that people usually have is that when genetic enhancement becomes a parental obligation, there would be an "arms race" between parents as no one wants their children to lose at the starting line (Harris, 2003). Eventually, despite enormous resources devoted into HGE, the positional good will be canceled out as every child has gone through similar HGE and obtained similar enhancements.

In 3.3.1., the thesis has established that positional intentions are not morally corrupt, and that we should solve the inequality by opening up the access. Moreover, if done right, the "arms race" will be beneficial to all children as it would raise their absolute good. As the entire generation becomes smarter, stronger, more creative, and more musical, the "arms race" will undoubtedly make our society a better place with better teachers, doctors, athletes, engineers, and artists. Why wouldn't we welcome that?

4.4. CONCLUSION

In section 4, the parental obligation to human genetic engineering emerges from the prima facie parental obligation to allow children a better life. We should not confuse the parental obligation to righteous uses of HGE with misuses and malicious uses, both of which should be prevented. Finally, we should welcome the “arms race” between parents that would help the construction of a better society.

5. CONCLUSION

5.1. CONCLUSION AND FUTURE WORKS

To sum up, this thesis has introduced the practice of HGE and relevant contemporary debates in section 1. This thesis then established that categorizing HGE into negative versus positive enhancements or radical versus regular enhancements is not morally meaningful and that HGE should be treated as a coherent moral entity in section 2. The thesis then defends HGE against seven moral objects and establishes HGE's moral permissibility. Finally, this thesis elevates HGE to be morally obligatory because of its alignment with parental obligations to children's betterment.

As the HGE technique constantly develops, it would be interesting to see how its future advancement will influence our moral decisions and even our recognitions about normality, human nature, religious divinity, social justice, and the parent-child relationship. However, with an inclusive attitude towards changes, this thesis will unlikely shift its position regardless of HGE's future development but will strive to defend HGE against more challenges.

5.2. BIBLIOGRAPHY

Agar, N. (2008). *Liberal eugenics: In defense of human enhancement*. Oxford: Blackwell.

Albert, B. (2001). Genetics: Promising cure or delivering elimination? *Consumer Policy Review, 11*, 166-71.

Annas, G., Andrews, L. B., & Isasi, R. (2002). Protecting the endangered human: Toward an international treaty prohibiting cloning and inheritable alterations. *American Journal of Law and Medicine, 28*, 151-78.

Appiah, K. A. (2008). *Experiments in ethics.* Bryn Mawr College.

Austin, M. W. (2020). Rights and obligations of parents. Retrieved from https://iep.utm.edu/parentri/#H5

Ayres, E. (1955). Social attitude toward invention. *American Scientist, 43*(4), 521-40.

Baeshen, N. A., Baeshen, M. N., Sheikh, A., Bora, R. S., Ahmed, M. M. M., Ramadan, H. A. I., . . . Redwan, E. M. (2014). Cell factories for insulin production. *Microbial Cell Factories, 13*, 141. doi:10.1186/s12934-014-0141-0

Beit-Hallahmi, B. (1994). Science, ideology, and ideals: The social history of IQ testing. *The Centennial Review, 38*(2), 341-360. Retrieved from http://www.jstor.org/stable/23740148

BERMAN, S. M., KUCZENSKI, R., MCCRACKEN, J. T., & LONDON, E. D. (2009). Potential adverse effects of amphetamine treatment on brain and behavior: A review. *Molecular Psychiatry, 14*(2), 123-142. doi:10.1038/mp.2008.90

Blank, R. H. (2019). *The political implications of human genetic technology*. New York: Routledge.

Bono, R., Blanca, M. J., Arnau, J., & Gómez-Benito, J. (2017). Non-normal distributions commonly used in health, education, and social sciences: A systematic review. *Frontiers in Psychology, 8,* 1602. doi:10.3389/fpsyg.2017.01602

Bostrom, N. (2005). In defense of posthuman dignity. *Bioethics, 19*(3), 202-214. doi:10.1111/j.1467-8519.2005.00437.x

Burley, J., & Harris., J. (1999). Human cloning and child welfare. *Journal of Medical Ethics, 25,* 108-13.

Chua, A. (2012). *Battle hymn of the tiger mother*. London: Bloomsbury Publishing Plc. Retrieved from https://ebookcentral.proquest.com/lib/[SITE_ID]/detail.action?docID=5238344

Chua-Rubenfeld, S. (2011). Why I love my strict chinese mom. *New York Post,*

Cong, L., Ran, F. A., Cox, D., Lin, S., Barretto, R., Habib, N., . . . Zhang, F. (2013). Multiplex genome engineering using CRISPR/cas systems. *Science, 339*(6121), 819-823. doi:10.1126/science.1231143

Cyranoski, D. (2018). CRISPR-baby scientist fails to satisfy critics. *Nature, 564*(7734), 13.

Daniel, N. (2000). Normal functioning and the treatment/enhancement distinction. *Cambridge Quarterly of Healthcare Ethics, 9,* 309-22.

Daniels, N. (2007). Can anyone really be talking about ethically modifying human nature? In J. Savulescu, & N. Bostrom (Eds.), *Human enhancement* (). Oxford: Oxford University Press.

Devolder, K., & Ward, C. (2007). Rescuing human embryonic stem cell research: The possibility of embryo reconstitution after stem cell derivation
. *Metaphilosophy, 38,* 245-63.

Doan, L. (2017). Queer history queer memory: The case of alan turing. *GLQ: A Journal of Lesbian and Gay Studies, 23*(1), 113-136. doi:10.1215/10642684-3672321

Elizabeth S. Anderson. (1990). Is women's labor a commodity? *Philosophy & Public Affairs, 19*(1), 71-92. Retrieved from https://www.jstor.org/stable/2265363

Evans, J. H. (2002). *Playing god?: Human genetic engineering and the rationalization of public bioethics debate*. London: The University of Chicago Press.

Frieman, C. (2018). Why parents should enhance their children . *The ethics of ability and enhancement* (pp. 155-71)

Fukuyama, F. (2002). *Our posthuman future: Consequences of the biotechnology revolution*. New York: Farrar, Straus and Giroux.

Glannon, W. (2002). Identity, prudential concern and extended lives. *Bioethics, 16*, 266-83.

Glover, J. (1984). What sort of people should there be? *Philosophical Explorations,* , 31-56.

Harris, J. (2000). Intimations of immortality. *Science, 288*(288), 59.

Harris, J. (2004). Immortal ethics . *Cambridge Quarterly of Healthcare Ethics, 13*, 75-90.

Harris, J., & Sulston, J. (2004). Genetic equity. *Nature Reviews Genetics, 5*, 796-8000.

Harris, J. (2010). Enhancements are A moral obligation. In Julian Savulescu, & Nick Bostrom (Eds.), *Human enhancement* () Oxford University Press.

Harris., J. (2002). Human beings, persons and conjoined twins: An ethical analysis of the judgement . *Medical Law Review, 9*, 221-36.

Heidegger, M. (1927). *Being and time*

Huemer, M. (2005). *Ethical intuitionism* . New York: Palgrave Macmillan.

HUGHES, J. J. (2019). A defense of limited regulation of human genetic therapies. *Cambridge Quarterly of Healthcare Ethics, 28*(1), 112-120. doi:10.1017/S0963180118000440

JEAN-PAUL SARTRE. (1957). *Existentialism is a humanism*. New Haven: Yale University Press. doi:10.2307/j.ctv15vwkgx Retrieved from https://www.jstor.org/stable/j.ctv15vwkgx

Kass, L. R. (1998). The wisdom of repugnance: Why we should ban the cloning of humans. *Valparasio University Law Review, 32*(2), 679-705.

Kass, L. R. (2001). L'chaim and its limits: Why no immortality? . *The New Republic, 113*, 17-24.

Kass, L. R. (2003). Ageless bodies, happy souls: Biotechnology and the pursuit of perfection. *The New Atlantis, ,* 9-28.

Kenney, A. (2008). Philosophy in the modern world: A new history of western philosophy. (). Oxford: Clarendon Press.

Kierkegaard, S. (1843). *Fear and trembling*

Kitcher, P. (1996). *The lives to come: The genetic revolution and human possibilities*. London: Simon & Schuster.

Kolata, G., & Belluck, P. (2018). Why are scientists so upset about the first CRISPR babies? *New York Times,*

Lanigan, T. M., Kopera, H. C., & Saunders, T. L. (2020). Principles of genetic engineering. *Genes, 11*, 291.

Lee, C., Scheufele, D. A., & Lewenstein, B. V. (2005). Public attitudes toward emerging technologies: Examining the interactive effects of cognitions and affect on public attitudes toward nanotechnology. *Science Communication, 27*(2), 240-267. doi:10.1177/1075547005281474

Makarova, K. S., Haft, D. H., Barrangou, R., Brouns, S. J. J., Charpentier, E., Horvath, P., . . . Koonin, E. V. (2011). Evolution and classification of the CRISPR–Cas systems. *Nature Reviews Microbiology, 9*(6), 467-477. doi:10.1038/nrmicro2577

Narveson, J. (1988). *Theœ libertarian idea*. Philadelphia: Temple Univ. Press.

National Academies of Sciences, Engineering, and Medicine, National Academy of Medicine, National Academy of Sciences, & Committee on Human Gene Editing: Scientific, Medical, and Ethical Considerations. (2017). *Human genome editing: Science, ethics, and governance*. (2nd ed.)

National Institute on Drug Abuse. (2020). What are the side effects of anabolic steroid misuse? Retrieved from https://www.drugabuse.gov/publications/research-reports/steroids-other-appearance-performance-enhancing-drugs-apeds/what-are-side-effects-anabolic-steroid-misuse

Nicholl, D. (2008). *Introduction to genetic engineering* (3rd ed.). New York: Cambridge University Press.

Nietzsche, F. (1882). *The gay science*. Newburyport: Dover Publications. Retrieved from https://ebookcentral.proquest.com/lib/[SITE_ID]/detail.action?docID=6199120

Nozick, R. (2013). *Anarchy, state, and utopia*. New York: Basic Books, a member of the Perseus Books Group.

POWELL, R. (2012). The evolutionary biological implications of human genetic engineering. *The Journal of Medicine and Philosophy, 37*(3), 204-225. doi:10.1093/jmp/jhq004

Ran, F. A., Hsu, P. D., Wright, J., Agarwala, V., Scott, D. A., & Zhang, F. (2013). Genome engineering using the CRISPR-Cas9 system. *Nature Protocols, 8*(11), 2281-2308. doi:10.1038/nprot.2013.143

Rattansi, A. (2007). *Racism: A very short introduction* Oxford University Press.

Reiss, M. J., & Straughan, R. (1996). *Improving nature? the science and ethics of genetic engineering*. Cambridge, U.K.: Cambridge University Press.

Rose, S. P. R. (2002). 'Smart drugs': Do they work? are they ethical? will they be legal? *Nature Reviews. Neuroscience; Nat Rev Neurosci, 3*(12), 975-979. doi:10.1038/nrn984

Ross, W. D. (1930). What makes right acts right? *The right and the good* ()

Russell, B. (1961). *Has man a future?*. Harmondsworth: Penguin.

Sadler, T. D., & Zeidler, D. L. (2004). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education, 88*(1), 4-27. doi:10.1002/sce.10101

Sandel, M. J. (2004). The case against perfection. *The Atlantic,*

Sartre, J. (1943). *Being and nothingness*. New York: Philos. Libr.

Sartre, J., & Richmond, S. (2018). *Being and nothingness*. London: Routledge.

Shalem, O., Sanjana, N. E., Hartenian, E., Shi, X., Scott, D. A., Mikkelsen, T. S., . . . Zhang, F. (2014). Genome-scale CRISPR-Cas9 knockout screening in human cells. *Science, 343*(6166), 84-87. doi:10.1126/science.1247005

Singer, P. (2003). Shopping at the genetic supermarket. *Asian Bioethics in the 21st Century,* , 143-156.

Smith., J. M. (1982). *Evolution and the theory of games*. Cambridge: Cambridge University Press.

Stanford Encyclopedia. (2020). Aristotle's metaphysics. Retrieved from https://plato.stanford.edu/entries/aristotle-metaphysics/#ActuPote

Stock, G. (2002). *Redesigning humans*. London: Profile Books.

The Myers & Briggs Company. Reliability and validity. Retrieved from https://www.myersbriggs.org/my-mbti-personality-type/mbti-basics/reliability-and-validity.htm

U.S. National Library of Medicine. (2021). Genetically engineered foods. Retrieved from https://medlineplus.gov/ency/article/002432.htm

UNESCO. (1997). *Universal declaration on the human genome and human rights*

van Beers, B.,C. (2020). Rewriting the human genome, rewriting human rights law? human rights, human dignity, and human germline modification in the CRISPR era. *Journal of Law and the Biosciences,* doi:10.1093/jlb/lsaa006

Wilkinson, R. H. (2010). Genetic information: Important but not exceptional. *Identity in the Information Society*, *3*(3), 457-472. doi:10.1007/s12394-010-0070-y

Williams, B. (1973). The makropulos case: Reflections on the tedium of immortality. *Problems of the self* (). Cambridge: Cambridge University Press.