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Eugenics in the 21st Century

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by

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ABSTRACT

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Eugenics is the science of enhancing the human population through the management of breeding and hereditary traits. This thesis explores the history of eugenics and shows how eugenic practices continue in the 21st century with advancements in technology and positive eugenic goals that can result in adverse effects on the human body and society. When Sir Francis Galton coined the term eugenics in 1883, he intended to improve British society with the use of positive eugenics. Galton used positive eugenics to encourage people with good mental and physical qualities to produce more children. He avoided negative eugenics, which involved sterilization and contraceptive methods.

However, when other countries launched their eugenic movements, many incorporated negative eugenic practices and targeted people who were feeble-minded and physically impaired. Many countries enacted sterilization laws to decrease the likelihood of having mixed-race children and to prevent the spread of undesirable traits to offspring in the interest of improving their population. The eugenics movement in 19th–century Germany is reviewed carefully due to its misuse of eugenics and inclusion of human experimentation. The research performed on human test subjects by Nazi physicians in the Auschwitz concentration camp varied in methods and goals,

but the harmful effects of controlling the human body are evident in testimonies and physical impairment. After Germany's defeat in World War II, eugenics movements declined and became unfavorable because of its negative association with Nazi Germany.

Research to comprehend heredity continued until the discovery of the double helical structure for deoxyribonucleic acid (DNA) and investigation on how genetic information is passed from cell to cell and from parent to offspring. Similar to a specific enzyme's ability to cut DNA at precise points, the Clustered Regularly Interspaced Short Palindromic Repeats-(CRISPR) associated protein 9 (CRISPR-Cas9) device has made it possible to edit the genetic structure of species. With this advancement in technology, Chinese scientist He Jiankui has continued eugenic practices in the 21st century with the birth of twins who are claimed to be immune to human immunodeficiency virus (HIV). However, after an examination of the available data from He's research, it is evident that the experimentation includes unanticipated side effects. The effects noted to date are improved cognitive abilities, quick recovery from a stroke, and the presence of more than one type of cell in one of the twin's genetic structure.

While these after-effects of human experimentation are not as horrific as those experienced by Auschwitz survivors, the human body's response to other viruses is unknown. The twins may be immune to HIV, but without direct exposure to this virus or others such as West Nile, it is unclear what other effects may occur. Additionally, the twins' genetic enhancements may convince parents who can afford gene editing to create designer babies and widen the existing social and economic gap. He Jiankui's gene editing methods to make humans immune to HIV can be associated with eugenics because he has controlled human breeding and inheritance to "improve" the human population. However beneficial his research and goals may seem for human health and the population, the diverse effects are positive, negative, and unknown. Since the publication of He's research, there have been many discussions among scientists and the International Summit on

Human Genome Editing regarding human gene editing and He's work. It is crucial to explore the possible outcomes of human genetic modification before other scientists continue He's studies and human genome editing becomes an acceptable eugenic practice.

This thesis is divided into four chapters to explore the history of eugenics, examine the misuse of eugenics in Nazi Germany, observe the breakthrough research conducted to understand heredity, and view how eugenic methods persist in the 21st century with technologic development. The introduction outlines the progression of this thesis, as it reviews various eugenic methods in the 19th, 20th, and 21st centuries. Chapter one provides a brief overview of the history of eugenics and eugenic movements in a few notable countries. In chapter two, the development and establishment of eugenics in Germany are reviewed, and the inclusion of sterilization and human experimentation are analyzed through the research of a few notorious physicians. Chapter three reviews the studies of multiple scientists in pursuit of comprehending DNA's ability to pass on and inherit genetic information. In chapter four, He Jiankui's research is explained, and the potential effects of human genetic engineering are carefully examined. The conclusion provides an overview of the preceding chapters and compares the effects of human experimentation to improve the human population through the control of breeding and inheritance. Despite the different results of human testing between Nazi physicians and He Jiankui, it is apparent that there is always the potential for adverse, unintended, and even lethal results.

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Introduction

In 1883, British explorer and natural scientist Sir Francis Galton coined the term eugenics in his book *Inquiries in Human Faculty and its Development*. Eugenics is the science of improving the human population through the control of breeding and inheritance of desirable traits. Galton's definition of eugenics focused on positive practices such as encouraging healthy and capable people with above-average intelligence to birth more children, thereby building an "improved" human race. In Britain, he aimed to support the British elite class by encouraging them to have more children, but it did not take hold because scholars showed little interest despite Galton's research, publications, and incentives to encourage early marriage among the British elite class.

The eugenics movement also occurred in other countries such as the United States, Canada, Brazil, Germany, Japan, in addition to others where negative eugenic practices, rather than only positive practices, began. These countries utilized forced sterilization to control the breeding of the feeble-minded, physically disabled, and many other people deemed unfit for procreation. Forced sterilization ensured that traits considered negative by society in each respective country would not pass onto offspring by stopping people who possessed negative traits from having children. When the United States began these eugenic methods of forced sterilizations in the late 19th century, this began the misuse of eugenics in the United States. When scientists in Germany began practicing eugenics in 1933, they incorporated experimentations on living human beings to sterilize large numbers of people efficiently and the term eugenics retained its association with negative practices because of its application in Nazi Germany. After the Second World War, eugenic practices decreased, and the term's usage became less frequent though eugenic practices continue. This thesis argues that eugenic practices

continue in the 21st century through experimentation on human beings and similar to past eugenic methods are harmful and can lead to unintended and unknown results. This thesis is a history of the misuses of eugenics in the 20th century and how, despite measures to ensure history does not repeat itself, negative eugenic experimentation continues today. I argue that the eugenic practices of today, like those in the past, are dangerous with unknown consequences for the individuals experimented on and future generations.

The eugenics movement in Germany is of particular interest for this thesis because it is where negative eugenics experimentation began though it had a long and slow development in the late 19th century. It began with two medical doctors, Wilhelm Shallmayer and Alfred Ploetz, who advocated eugenics and provided the foundation for the future of the eugenics movement in through their writing and publications. When the Nazis came to power, eugenicists, also known as race hygienists, received support for their interest in human heredity and the movement transitioned to include human experimentation. Notable doctors Josef Mengele, Carl Clauberg, and Horst Schumann conducted their negative eugenic practices and experiments in the concentration camp in Auschwitz, Poland. Mengele's research consisted of many topics, but was well known for his twin studies. The exact purpose of twin studies is unknown, but it is possible the research was conducted to improve the German population and birth rate. For Clauberg and Schumann, their research focused on mass sterilization with the intent to maintain a large infertile labor force in the concentration camps. The Nazi party imprisoned people who were deemed "inferior" and used them as a source of labor, but did not want them to reproduce. In the cases of research on twins and mass sterilization, the results were irreversibly harmful to the test subjects' bodies, and not in the interest of improving human health.

However, with the end of World War II approaching and Germany's defeat imminent, in

1945 the eugenics movement declined and human experiments ceased with varying results. After the war, the International Military Tribunal held the Nuremberg Medical Trials, but Mengele, Clauberg, and Schumann never received a trial due to their evasion of arrest, poor health, and death before or during detainment. Despite the inability to place these individuals on trial for their medical crimes, the concept of "racial science," which claims there is a link between race and intelligence, and its medical applications were put on trial (Weinberger 383). To prevent future ethical and legal abuses similar to those committed by the Nazis, the Nuremberg Code was created to act as guidelines for future human experimentation. The eugenics movement in Germany weakened, but the term eugenics maintained a negative association.

After WWII eugenics research continued in new forms of research as milestones in identifying and understanding DNA occurred. In 1953, James Watson and Francis Crick discovered the double helical model of DNA. Their discovery gave other scientists the much-needed understanding of its structure to uncover how various genetic information passes among cells and from parent to offspring. Their discovery prompted several other scientists over the next twenty years to greatly advance understanding of DNA structure. In 1965, Swiss microbiologist Werner Arber discovered restriction enzymes that cleave DNA into pieces during cell replication. American microbiologist Hamilton O. Smith followed in 1969 by revealing the particular restriction enzyme that cut DNA, labeled type II restriction enzyme. From 1970 – 1971, American biologist Daniel Nathan researched and demonstrated the process of type II restriction enzyme's process of cutting DNA with the use of a monkey virus called simian vacuolating virus 40 (SV40). Then, in 1973, American biochemists Stanley Cohen and Herbert Boyer used restriction enzymes to produce a genetically modified organism for the first time. These experiments and discoveries made after Watson and Crick's publication provide important

knowledge on how genetic information is copied, passed on, and edited by type II restriction enzymes. The understanding and ability to modify organisms' DNA leads to the possibility of altering production of food, creating vaccines, and experimenting on animal cloning.

More recent scientific advances include the 2012 development of Clustered Regularly Interspaced Short Palindromic Repeats-(CRISPR) associated protein 9 (CRISPR-Cas9) technology. Established by American biochemist Jennifer Anne Doudna and French professor and researcher in microbiology, biochemistry, and genetics, Emmanuelle Charpentier, CRISPR-Cas9 demonstrates the ability to edit gene sequences as observed by the natural type II restriction enzymes. Similar to the type II restriction enzyme's natural ability to cut DNA at precise points, the CRISPR-Cas9 makes it possible to operate on DNA with the Cas9 enzyme acting as a molecular scissor, which cuts two strands of DNA at a specific point. Scientists' observations of the arrangement and editing of DNA, after the establishment of its structure, contributes to the development of technology capable of similar gene-editing processes.

In 2018, the use of technology to produce genetically edited human babies, a misuse of eugenic practices, was reported by online news sources. Chinese scientist He Jiankui claimed to produce genetically modified twin babies using CRISPR-Cas9. The research and development of CRISPR-Cas9 in combination with concerns about the increasing number of human-immunodeficiency-virus (HIV) positive people in China prompted He's use of CRISPR-Cas9 technology to produce humans claimed to be immune to HIV. Using CRISPR-Cas9 on the embryos from volunteer couples who consisted of husbands with HIV, He gave parents the option to proceed with the pregnancy with either edited or unedited embryos. Among the couples, one had successfully given birth to twin girls, which He claims are immune to HIV. Whether the babies are in fact immune to HIV has yet to be proven, but it is evident after

examining the genetic structure of the twins that they have been genetically edited. The aim and results of He's work is evidence of the misuse of eugenic methods because he has controlled human breeding in aim to produce a desirable trait. This use of technology to edit a specific gene could lead to adverse effects, by opening the possibility of developing new and worse health issues, and impact human society in yet unknown ways.

After reviewing He Jiankui's work in attempting to make humans immune to HIV by disabling the CCR5 gene, it is apparent that his goals and practices are similar to eugenics. He has sought to control the breeding and specific inheritable trait amongst humans to improve the health of the human population that can contract the virus. While He's efforts differ from past actions of eugenicists and the goals of previous eugenic movements, it is clear that the potential for adverse effects when conducting human experiments is likely. For the Auschwitz prisoners that were experimented on in twin studies and sterilization procedures, the adverse effects are physical scars and impairments to their bodies. Although the intention of He's research was for the improvement of the human body's immunity to HIV, there are potential side effects to the body that impact the brain and genetic structure, which in turn can affect human social and economic status. Many questions arise in response to He's eugenic practices, and these questions are difficult to address, but it is essential to reflect on the effects of past eugenic methods and explore the possibilities of gene editing on humans before it becomes an acceptable practice.

This thesis examines the continued misuse of eugenics through experimentation on living human beings. The first chapter briefly reviews the history of eugenics with the use of forced sterilizations in various countries. Chapter two examines the misuse of eugenics in Germany with experiments on human beings in pursuit of scientific knowledge and mass sterilization. Chapter three is a review the significance of Watson and Crick's discovery of the double helical

model and the research of other scientists of how genetic information is passed onto offspring. Chapter four carefully examines the continued misuse of eugenics by human experimentation of gene-editing technology to replicate the way DNA is naturally edited. The conclusion reviews and compares past eugenic practices, with a particular focus on German eugenics, and He Jiankui's research on gene editing to make humans immune to HIV. He has attempted to resolve a health related issue for humans by controlling their breeding and heredity, but a deeper reflection on past eugenic practices, their results, and the effects of gene editing and human experimentation is necessary when deciding the future of human genetic modification.

Chapter 1

When British natural scientist Sir Francis Galton coined the term eugenics in his 1883 book *Inquiries in Human Faculty and its Development*, he defined it as the use of positive practices to promote healthy and intelligent people to have more children, thereby "improving" the human race. People with acceptable hereditary qualities should marry with care and have large numbers of children; this was positive eugenics, while those who possessed hereditary disabilities should be discouraged from having children, was negative eugenics (MacKenzie 499). Galton encouraged the elite class of Britain to marry early and produce more children. Through research, publications, and campaigns, Galton promoted eugenic practices in Britain. However, from the 1880s onward, negative eugenics was gaining interest among the eugenicists in Britain as decreasing fertility rates among lower class citizens became a more important goal than raising the fertility of upper and middle-class people. Although in Galton's work, he approached the subject of negative eugenics with caution and avoided topics such as sterilization and contraception (Mackenzie 512).

In Britain, the acceptance of eugenic practices rose and fell out of favor between the 1880s and 1930s. When the birth rate of upper and middle-class British citizens began to decline the idea of applying eugenics became acceptable among the educated class. Political figures began to express interest in eugenics, and Galton's campaigns and funding to support his research received almost uninterrupted success. However, after 1918, the acceptance of eugenic practices dissipated as it began to lack political credibility, especially within the professional middle-class. The working class' concerns with the unemployment and the elite classes' issues with the larger working class were resolved through communication and reconciliation between the two groups. Political and industrial leadership positions were established and incorporated

into the unions to give the working class authority, and with their concerns addressed the elite class' fear of an uprising by the lower class dissipated. With this resolution, eugenic methods on the lower class were unnecessary, and the movement lost its momentum. When the Nazis were victorious in Germany in 1933 and began rigorous eugenic measures, the negative practices of eugenics were most prominent and linked with fascism. This association of eugenics with fascism in British society led to its decline in Britain.

Although the eugenics movement did not take hold in Britain, in the United States negative practices of eugenics gained acceptance. Marriage laws were the first target of negative eugenics. In 1896 Connecticut deemed it illegal for people with epilepsy or who were "feeble-minded" to marry. In 1910, the Eugenics Record Office (ERO) was established in Cold Spring Harbor, Long Island, New York by the Carnegie Institution of Washington's Station for Experimental Evolution. Functioning as a privately funded research institution that gathered biological and social information on the American population, it had a multitude of missions, which included:

> Serving as the national repository and clearinghouse for eugenics information, compiling an index of traits in American families, training fieldworkers to gather data throughout the United States, supporting investigations into the inheritance patterns of particular human traits and diseases, advising on the eugenic fitness of proposed marriages, and communicating all eugenic findings through a series of publications. (Wilson)

The ERO utilized the data gathered to create pedigree charts of American families. These charts were an attempt to demonstrate the power of heredity by showing that feeble-mindedness was an inheritable attribute, and if an "inferior" trait such as this were passed to offspring, it would affect society. Additionally, fieldworkers used these charts when they interviewed families and identified inheritable family traits, which varied from acceptable to undesirable attributes according to the ERO and society's acceptance. Many of the families considered unfit

were poor, immigrants, and minorities, and the ERO remained steadfast in providing evidence to support the theory that these negative traits were the result of bad genes and not racism, social, or economic views. The families interviewed by the ERO fieldworkers were located in rural and low-income areas, and to create pedigree charts and gain support for eugenics, undesirable traits needed to be identified. It was convenient to associate these poor attributes with poor minority families and portray immigrants in a negative way to deal with the surge of immigration in the United States.

The practice of negative eugenics in the United States continued with the implementation of forced sterilizations by severing or tying women's fallopian tubes to prevent the possibility of producing eggs for fertilization. As immigrant populations in the United States increased, American's concerns and fears of the degradation of American culture also increased. Eugenics offered a convenient, cost effective response to these fears, with the implementation of sterilization of those deemed "unfit." Certain minorities that were abundant in America's prisons and institutions for mental illness were sterilized. Between 1909 and 1979, with California leading the way, about twenty thousand sterilizations took place in mental institutions across the country to protect society from the offspring of people with mental illness ("Eugenics"). In 1927, the United States Supreme Court ruled that forced sterilization of the disabled was not in violation of the United States Constitution as American society's possibility of dealing with generations of people with mental and physical disabilities was unwanted. In 1942, this ruling was overturned, but thousands of people had already been sterilized.

The eugenics movement spread to other countries such as Australia, Canada, Brazil, Germany, and Japan. Within these countries, various methods were established to control the breeding and heredity of people. Some countries sought to control genetic inheritance by

preserving one physical attribute over another, while others focused on removing or preventing the spread of mental illness through forced sterilizations and marriage restrictions. In Australia, from 1909 to 1969, government policies targeted children of mixed descent who possessed both Australian White and Aboriginal genes. The Australian government wanted to preserve and promote White Australians by separating mixed children from their families for monitoring and eventual absorption into the White race. Over time, people of Aboriginal background would be bred out of existence because of their "inferior" genes. The removal and displacement of mixed children resulted in what is known as the "Stolen Generation," and its effects are still felt in many Australian communities today (Leung, "Australia").

Brazil possessed similar goals to increase the White race by encouraging intermarriage between Whites and non-White immigrants to produce mixed children. Through generations of intermarriage with White Brazilians, the preferred physical features of Whites would presumably dominate in children and non-White genes would decrease. Concerns regarding education and mental hygiene also arose, and eugenicists proposed immigration restrictions and sterilizations, but these resolutions were not enforced due to disagreements amongst eugenicists. In the 1930s, eugenic thought continued and influenced discussions regarding changes to immigration. Later, changes in Brazilian leadership altered the people's views on mixed-race children and acceptance of non-White immigrants.

Although Canada as a country considered the idea of eugenics, only two provinces, Alberta and British Columbia, passed laws to control human breeding. These two provinces limited their attention towards institutionalized people with mental disorders and deficiencies. Canadian provinces, such as Ontario, founded eugenic organizations and developed lists of inheritable traits and eugenic methods, but the debates among eugenicists took time. Eventually,

the negative practices of Nazi eugenics were publicized, and World War II had begun, which decreased the support of eugenics. Other Canadian provinces considering eugenic practices had deemed sterilization procedures more risky than beneficial to the health of people and therefore did not pass eugenic laws. Alberta passed its eugenic laws in 1928 and British Columbia in 1933. Both provinces viewed sterilization as the solution to mental illnesses. For Alberta, the Sexual Sterilization Act was established to protect society from the transmission of undesirable traits to children by sterilizing the mentally disabled. When British Columbia created its law to authorize sterilization, the title of the law enacted was "An Act Respecting Sexual Sterilization." By 1937, Alberta revised its Sexual Sterilization Act to remove informed consent as a requirement of people subjected to sterilization, which set it apart from any other North American region that required approval (Dyck). When eugenic practices fell out of favor, the laws supporting sterilization were repealed, Alberta revoked its laws 1972, and British Columbia did so the following year.

German eugenicists also targeted feeble-minded people and involved similar solutions such as sterilization, but their interest in mental hygiene, combined with Adolf Hitler's desire for a superior German race led to severe and inhumane methods that incorporated human experimentation to develop quick and effective mass sterilization. These experiments included the use of x-ray machines, plants, and chemical injections to make people infertile of sterile. In 1933 the eugenics movement arrived in Germany in the form of laws targeting people with psychological and physical disorders. The Nazi government implemented the "Law for the Protection of Genetically Diseased Offspring," which made sterilization of individuals acceptable to prevent the spread of undesirable genetic traits, such as mental and physical disabilities. If the government believed a person possessed or that their offspring could suffer

from a mental or physical disorder, they were subjected to sterilization according to this law. Nazi Germany escalated its eugenic practices by implementing a euthanasia program called Action T4. Rather than stopping people deemed "inferior" based on physical or mental attributes from having children by sterilizing them, the Nazi government changed tactics and began killing people who were incurably ill, elderly, or physically and mentally disabled (Shaw).

Eventually, as Germany's region expanded under Hitler's leadership and with the outbreak of World War II, more German and non-German people were incorporated into the country and its neighboring territories. Many of these people were unwanted by the Nazi government and were deemed "inferior" based on physical, mental, and racial status. Since Germany found these people undesirable and could not relocate them to other neighboring countries, they established labor camps to remove them from German land. These labor camps transformed into death camps and became sites for euthanasia and research on mass sterilization, which included the use of plants, x-ray exposure, and injections to affect the fertility of individuals. After the defeat of Germany in World War II, the eugenics movement declined in Germany, but the term remained associated with negative practices due to these inhumane acts conducted during Nazi German rule.

Japan progressively adopted eugenic methods much like the United States and Germany. Unlike Australia and Canada, Japan wanted to maintain racial purity by prohibiting intermarriage and mixed-race children. Only marriage between those considered "pure-blood" Japanese were encouraged, similar to the positive eugenics Galton had promoted for the British elite class. However, negative eugenic practices were also adopted. In 1940 Japan implemented sterilizations with the National Eugenics Law, which "focused on criminals and people with perceived genetic disorders such as color-blindness, hemophilia, ichthyosis, and mental illnesses

such as manic-depression, epilepsy, and schizophrenia" (Leung, "Japan"). In 1948 Japan revised and reinforced this eugenic law under the title "Eugenic Protection Law." With the discontinuation of eugenic methods in Japan, the Eugenic Protection Law was changed and retitled in 1996 as the "Women's Body Protection Law." Eugenic practices ceased in Japan due to this revised law's intention to protect the life and health of women by performing medical operations for infertility and the prevention of pregnancy only with women's consent. Additionally, Japanese factions began to oppose eugenic practices because human sterilization suggested Japanese people were like animals when there was control over their fertility.

Many countries, in addition to those listed above, have used negative eugenic methods, with few practicing positive eugenics, to prevent the inheritance of physical and mental characteristics. However, in regards to the misuse of eugenics, or utilization of negative methods, in the 21st century, the experimentations on human beings in Auschwitz, Poland are of particular importance. In comparison to the eugenic practice of human genetic engineering discussed in Chapter four, the methods used in Auschwitz to remove undesirable genetic traits and improve a particular ethnicity are similar, utilize humans as test subjects to study and manage human breeding and genetic inheritance. In Chapter three, an in-depth analysis of Nazi practices at the Germany labor camp at Auschwitz shows the types of human experiments that involved x-rays and injections to control the reproduction and inheritable traits of "inferior" people, with the ultimate goal of preserving and strengthening German racial superiority. Examination of the human experiments in Auschwitz serves as an example of how people were used as test subjects to improve the health of other people and society by preventing the spread and inheritance of unwanted genetic traits.

Chapter 2

The German eugenics movement began in the late 19th century in response to two concerns regarding the degeneration of the German race. The first was "because medical care for 'the weak' had begun to destroy the natural struggle for existence; and second, because the poor and misfits of the world were beginning to multiply faster than the talented and fit" (Proctor 15). Two medical doctors who promoted eugenics and provided the foundation for the future of the German eugenics movement were Wilhelm Schallmayer and Alfred Ploetz. Schallmayer was an early advocate with his book, *Über die drohende körperliche Entartung der Kulturmenschheit und die Verstaatlichung des ärztlichen Standes* (The Threatened Degeneration of Civilized Nations and the Proposal to Make Doctors Civil Servants) published in 1891. Schmallmayer's book "touched on the social, economic, and political justifications for eugenics, and it offered such practical proposals as the creation of medical genealogies and health passports and the introduction of marriage restrictions. "[It also] stressed the role of physicians and the importance of education and propaganda as the most effective means of achieving eugenic goals—both hallmarks of German race hygiene policy until 1933" (Weiss 19).

Twelve years later another of Schallmayer's work, *Vererbung und Auslese im Lebenslauf der Völker. Eine Staatswissenschaftliche Studie auf Grund der neueren Biologie* (Heredity and Selection in the Life-Process of Nations: A Social Scientific Study on the Basis of the Newest Biology) appeared in 1903. This essay won first prize in a literary competition and achieved considerable recognition. The central theme of the essay was "the rational management of national efficiency" (Weiss 20). The nation's future depended on the proper management of its human resources, and that responsibility rested on the government. He was also cautious in the area of negative eugenics. "Although Schallmayer clearly believed that marriage restrictions for

the insane, the feebleminded, the chronic alcoholic, and other defectives were in the best interest of the state and the race, he refrained from openly supporting state legislation as a means to this end" (Weiss 21). Until more information on the laws of heredity was known, eugenicists would have to concentrate on voluntary measures. He promoted positive eugenic practices, such as encouraging the "fitter" people in society to increase their fertility rate. Essentially, Schallmayer saw eugenics as a means of improving the general fitness of Germany's population and advancing its cultural superiority, but he did not seem to emphasize any views of Aryan Nordic superiority.

Advancing Aryan Nordic superiority was the goal of Alfred Ploetz, who supported a purist theory of German eugenics. Ploetz coined the term *Rassenhygiene* (Racial Hygiene), which he defined as the measures required to guarantee "the optimal preservation and development of a race" (Weiss 17). Therefore, the term referred to the hereditary improvement of diverse populations, the Germans, Jewish, "Aryans," and all of humanity. Ploetz pushed a racist view of German eugenics, which he promoted in a book published in 1895: *Die Tüchtigkeit unsrer Rasse und der Schutz der Schwachen* (The Excellence of our Race and Protection of the Weak). His book raised the overall biological, social, and ethical issues, and the need for race hygiene. In 1904, he launched a new journal, the *Archiv für Rassen- und Gesellschaftsbiologie* (Archive for Racial and Social Biology), which investigated the principles of the optimal conditions to maintain and develop the race (Proctor 17). A year later, he was among the founders of the Berliner Gesellschaft für Rassenhygiene (Berlin Society for Racial Hygiene).

Ploetz believed in the natural superiority of the Nordic race and placed responsibility on the German government to judge the fitness of its citizens to marry, and the number of children

couples could possibly have. He advocated the prohibition of reproduction by "unfit" people, abortion of abnormal fetuses, and the "elimination" of the weak, sick, and disabled. Ploetz asserted, the more the government could prevent these inferior attributes, the less German people need to struggle for existence to remove them (Weiss 18). When the National Socialists, more commonly known as the Nazi Party, came to power in Germany in 1933, the new Reichs Minister of the Interior, Wilhelm Frick, created an advisory committee of experts on population and racial policy, of which Ploetz was a member.

Thus, before World War I, eugenics already had a solid foundation in Germany for its gradual introduction of increasingly racist views. At first, the movement developed slowly, and due to the decimation of the German population as a result of World War I there was little popular support for eugenics in general. The German government and the German Society for Race Hygiene, founded in 1910, doubted and resisted eugenic ideas. The German eugenicists, who also referred to themselves as race hygienists, wanted to make health certificates a prerequisite for obtaining marriage permits and advocated sterilizing patients with mental illnesses. However, the eugenicists' ideas were unacceptable as they diminished individual rights and went against religious ethics.

In 1912, Julius Wolf, a German economist and demographer, published his book *Der Geburtenrickgang: Die Rationalisierung des Sexuallebens in unserer Zei* (The Decline of the Birthrate: The Rationalization of Sexual Life in Our Time), which focused on the declining birth rate in Germany. Three years later, Wolf founded the German Society for Population Policy in 1915. Its primary concern was increasing and strengthening the German population rather than improving its quality, which was the eugenicists' focus to better the mental and physical attributes of the German people. Ultimately, with the increasing death count due to the war the

need to increase the population took precedence over the need to improve human attributes through marriage and child bearing.

A few goals of the Population Policy Society and the Race Hygiene Society overlapped, and due to political pressure, the Race Hygiene Society adapted to support quantitative population increase. The Race Hygiene Society and race hygienists "had to concede that the available scientific experience was insufficient to achieve 'an improvement of the race' through sterilization" (Weingart 262). "The demand for qualitative rather than purely quantitative population policy, especially the advocation of sterilization, seemed far fetched" (Weingart 261-262). Therefore, the issue of low birth rates and the task of increasing the German population after the war made eugenic ideas acceptable.

In order to address the issue of a reduced German population, an institution concentrated on studying human heredity was needed. In 1922, the Race Hygiene Committee of the Ministry of Public Welfare submitted a report to the Reich Ministry of the Interior. The report justified the necessity for a laboratory dedicated to studies of human heredity and demography. By 1923, the Ministry of the Interior had approved the plan. Two-and-a-half years later Adolf von Harnack, the president of the Kaiser-Wilhelm-Gesellschaft (KWG), sent a proposal to the senate of the KWG arguing the need of a center for scientific research on human heredity, anthropology, and eugenics. The KWG was one of many important German centers devoted to various aspects of race hygiene and eugenics. In response to this suggestion, The Kaiser Wilhelm Institute (KWI) for Anthropology, Human Heredity and Eugenics was founded in 1927, in Berlin. The director of the institution, anthropologist Eugen Fischer, was well known for his 1913 research on racial mixture in Rehoboth, South-West Africa. He stated that race crossing between Europeans and people deemed "inferior" would lead to intellectual and cultural deterioration, though he was

unable to provide evidence of these adverse effects in his studies. Under Fischer's leadership, the KWI was established as a scientific center focused on the fields of study specified by Harnack, namely anthropology, human heredity, and eugenics, and would continue as the leading institution on race hygiene in Germany until 1945.

The KWI had a race hygiene representative acting as head of each department. In particular, Fischer served as both head of the Institute and the Anthropology Department. Fischer, considered a leader in German anthropology because his book on racial crossing, *Die Rehobother Bastards und das Bastardisierungsproblem beim Menschen* (The Rehoboth Bastards and the Problem of Miscegenation among Humans) was a classic in the field. "Fischer was instrumental in bringing about a shift in Germany from physical anthropology, which had focused on measuring techniques, to race anthropology, which pursued research on physical and mental phenomena from a genetic perspective of heredity and selection" (Weingart 266).

Another notable KWI leader was biologist and geneticist Otmar Frieherr von Verschuer, who oversaw the human heredity department. Fischer invited Verschuer to join the KWI based on publications of his research on twins, for which he was awarded his *Habilitation* by the University of Tübingen in 1927. Verschuer's name would become associated with the infamous Nazi physician, Josef Mengele, Verschuer's most notorious student, due to his mentorship and indirect involvement with Mengele's experiments on imprisoned twins in Auschwitz, Poland. Although Verschuer promoted the sterilization of those with mental and physical deficiencies before 1933, it was not until the Nazis came into power would he take the opportunity to become an extreme racial hygienist (Weingart 267).

In 1933 when the Nazis assumed control of the government, they took control of the German Society for Race Hygiene (Eugenics). Previously, in 1931, it was known as the German

Society for Race Hygiene, but was renamed to align with eugenic ideas and distance itself from ideas related to race hygiene. However, when the Nazis took control, they restored its previous name and relocated it from Berlin to Munich. Fischer, Verschuer, and other directors in the KWI were forced to step down from their positions, and the institution was neutralized. The race hygienists excused the changes because, under Nazi leadership, the policies they had hoped for could be realized with radical racial hygiene. Yet the gain of having the new government's support of race hygiene meant the loss of independence from political control. Within the same year that the Nazis came to power they completed a draft of a sterilization law that was created by the previous government, within one day. This sterilization law "entailed changing the provision for voluntary sterilization into a compulsory measure and setting up an elaborate legal apparatus, the 'hereditary health courts'...which were to oversee the legality of sterilization measures and hear appeals" (Weingart 270). Fischer, Verschuer, and other race hygienists were asked to support the implementation of this law. Later both Fischer and Verschuer became members of the hereditary health court in Berlin.

Along with the passing of the first sterilization law, the activities of the KWI of Anthropology also changed. Physicians and medical students had to be educated about current information on heredity and research on race. When the sterilization law, titled "Law for the Protection of Genetically Diseased Offspring," went into effect in 1934, education about heredity and research on race intensified. Before the new government, education in eugenics was encouraged; however, under Nazi rule, it became the dominant activity in the Institute and the eugenic movement. In Fischer's Institute, education was the most crucial activity, and scientific research had to be reduced so that more physicians could be prepared for newly created "health agencies" (Weingart 272). In 1935 Verschuer relocated to Frankfurt at the request of the Institute

for Hereditary Biology and Racial Hygiene at Frankfurt University to become its director. His department for human heredity at the KWI was divided between Fischer and Fritz Lenz, another race hygienist, a supporter of eugenics and student of Fischer, with the plan for Lenz to be Verschuer's successor. The "Law for the Protection of Genetically Diseased Offspring" also gave the race hygienists some professional recognition and increased activities in areas for which they had advocated previously under the former government.

In 1935, two additional laws were established in correlation with race hygiene. The first was the "Law for the Protection of German Blood and German Honor" and the second was the "Law for the Protection of the Hereditary Health of the German People" (Weingart 274). The intention of the "Law for the Protection of German Blood and German Honor" was to protect the purity of the German race and penalize marriage and sexual intercourse between German and Jewish people. The protection of German ancestry had been an earlier goal of racial hygienists, and with this new law, it became a priority. The second law mandated marriage counseling and requires health certificates to obtain marriage permits, a previous desire of the race hygienists. The eugenics movement continued to grow under the Nazi regime, and even the KWI for Anthropology received an increase in funding. The growth of human heredity studies led to its merger with anthropology and race hygiene. Human heredity had overlapping interests with anthropology and similar research methods with race hygiene. "By 1937 the institute had expanded by one third. It was the most prestigious institution of its kind and prided itself on having visitors from Norway, the Netherlands, Switzerland, Italy, Hungary, India, Japan, China, Brazil, and many other countries" (Weingart 275).

As the KWI Institute and race hygiene continued to grow, there was a loss of independence in scientific research. Fischer must have anticipated the separation between the

Nazi's race policies and the development of his scientific studies. Nazi race policy had focused on expanding the information on racial traits. This was executed through research on race crossing within and outside Germany, including the Rheinlands, Chile, Trinidad, and South-West Africa (Weingart 275-276). Fischer's research shifted to phenogenetics, the study of a particular area of genetics involving the mechanisms of development and the differentiation of specific qualities controlled by genes. He believed human inheritance had progressed to a point where it could describe the characteristics of regular and irregular hereditary traits, associate unique appearances of these traits, and provide an estimation of the environment's impact on traits (Weingart 277). However, the difficult question for Fischer was how an inherited attribute developed and functioned to acquire its appearance. Despite the increasing division between the Nazi party's goals and the racial hygienists' goals, Fischer maintained influence in his institute. By 1942, Verschuer returned to Berlin and became Fischer's successor as director.

As director of the KWI, Verschuer redirected the Institute's focus towards the study of the genetic basis of diseases. He shifted towards a primarily medical direction of race hygiene with his ideas of hereditary pathology and the hereditary physician. "In fact, through Verschuer the institute was to become directly connected with the murderous 'experiments on humans' at Auschwitz. Even though this connection was never substantiated in a court of law, evidence accumulated over the years leaves little doubt" (Weingart 278-279). When the Nazis had come to power, he seized the opportunity to become a racial hygienist and identify eugenics with race hygiene. Under Verschuer's leadership, a new department for embryology was created in the KWI and grant funding was approved for "projects on comparative hereditary pathology and on hereditary research on tuberculosis" (Weingart 279). The Reich Research Council through its Research Foundation also tasked Verschuer with nine projects, one of which involved research

on eye color. Josef Mengele, who had written his dissertation under Verschuer while in Frankfurt, in 1938, was also involved with the commissioned projects. Verschuer likely influenced Mengele to request a commission to go to Auschwitz for research on race biology. In 1943, Mengele became the camp physician in Auschwitz, conducting twin studies on those imprisoned. He would regularly send sample collections from twins that perished to Verschuer, who remained at the KWI in Berlin.

In Auschwitz, the Schutzstaffel (SS) or protection squad doctor, Josef Mengele became known as the "Angel of Death" due to his inhumane methods of experimentation and high rate of death and deformities during research. Medical experiments were important to the Nazis, and the ability to use concentration camp prisoners was advantageous to doctors. "The idea of using humans for experiments during (Nazi rule) stemmed from the fact that there was a wide belief that the war would not last long, paired with the sense of having an imminent need for maximum scientific achievements. The fastest way to achieve this goal was seen as simply omitting the first step of animal experiments," and concentration camp prisoners were viewed as expendable beings (Weinberger 54). For Mengele, Auschwitz was an ideal site to conduct his experiments because of the research possibilities it offered. Mengele, like many of the other doctors at Auschwitz, received and performed the tasks requested of them by their superiors; however, Mengele also volunteered for new projects. Some research that Mengele pursued were changes in eye color, the Noma virus, and twin studies (Weinberger 86-87).

Concerning twin research, Mengele initially concentrated on Gypsy twins and then transitioned to Jewish twins. He selected test subjects from various barracks within Auschwitz and from the transports that brought new prisoners. Birkenau, the largest camp in Auschwitz, is where Mengele's twin research took place. Using identical and fraternal twins, and siblings who

looked like twins as test subjects, Mengele's experiments included injecting chemicals and surgically attaching twins together to create Siamese twins in the interest of furthering his knowledge. Testing would often begin with measuring each twin to document their original status and monitor changes as research progressed. According to reports from survivors of Mengele's experiments, his practices included blood draws, blood transfusions, injections of chemicals and viruses, x-rays, and surgery.

The exact purpose of Mengele's twin research is unknown, but he was passionate about conducting his research. In 1935, Verschuer insisted that research on families and twins who were without hereditary defects and selected at random was necessary to obtain a complete and reliable understanding of hereditary influences and the relationships between disease, racial types, and racial crossing (Lifton 348). Even with survivor testimonies and views from people who worked with and observed Mengele, it is difficult to determine the exact purpose of his research on twins. Yet, there is little doubt that Mengele researched twins because of his experiences studying genetic determinism in Frankfurt and Berlin. There is a possibility that twin research could have been in pursuit of a larger goal, such as doubling birth rates by using genetic factors to ensure conception of twins. However, this is unconfirmed and only based on views from survivors and those who worked with Mengele. It is also possible that Mengele conducted twin studies with the hope that his research in Auschwitz and the data he collected would be beneficial for a later scientific career after the war.

By 1944 Mengele foresaw the end of Nazi rule and prepared to leave the concentration camp, and in 1945 he left Auschwitz with his essential scientific documents. For many years, Mengele avoided arrest by American Allies, the German government, and Israeli investigation teams seeking to bring him to justice for his war crimes. Mengele fled to Argentina and never

stood trial. However, in 1985 the Israeli Holocaust Memorial Research Center conducted a mock trial against Mengele where he was charged with murder and torture, even though he was not present. In that same year, the United States Department of Justice joined the German and Israeli investigation teams trying to locate Mengele. In their joint search, they eventually located a grave in Brazil that was confirmed to be Mengele's based on results from a forensic investigation (Weinberger 95-96).

Other medical experiments conducted in Auschwitz involved sterilization research, which was in direct correlation with the Nazi's eugenic goals and interest in heredity. Sterilization renders a person or animal infertile or sterile, thereby depriving them of the ability to produce offspring. This is different from castration, which involves surgical intervention. "It was the Nazis' idea to 'use' the masses of unwanted people as effective manpower, rather than just eliminating them. Nonetheless, measures had to be taken to ensure the sterility of this work force, so as to effectively implement the Nazis' 'negative population policy'" (Weinberger 112). People who the Nazis deemed "inferior" were useful for labor in the concentration camps, but the Nazis did not require an abundant amount of labor, and they did not want "inferior" races and traits to increase with new children being born. Therefore, the negative population policy aimed to maintain a work force that could not reproduce. However, individual sterilization methods were time-consuming and expensive, so a new procedure was needed to sterilize large numbers of people without their knowledge. Henrich Himmler, the commander of the protection squad and leading member of the Nazi Party, was the person who conceived of this unrealistic goal.

A notable physician stationed at Auschwitz who researched mass sterilization was Carl Clauberg, professor of gynecology at Königsberg University. Initially, Clauberg's research in the treatment of infertility began as early as 1933, but the Nazis showed little interest. In 1940,

Clauberg and Himmler met in Himmler's Nazi Berlin office to discuss Clauberg's plan of establishing a research institute for reproductive biology. During the meeting, Clauberg outlined the institute's three main areas of research. Only the development of a sterilization method without surgery was of great interest to Himmler. The other two areas focused on resolving infertility, which was intriguing to Himmler because this might increase the fertility rates of German women, but research on sterilization was the priority because Himmler wanted to maintain a large labor force that could not produce offspring.

Eventually, Clauberg was stationed at Auschwitz in the section labeled Block 10, where he found an opportunity to improve his understanding of fertility issues and advance his scientific career. Clauberg's meeting with Himmler resulted in Clauberg focusing his research on non-surgical sterilization methods while in Auschwitz. His research began with animal test subjects who received chemical injections to sterilize them. By 1942, Clauberg received approval from Himmler to continue his research in Auschwitz and transition to human trials. His research consisted of inserting a chemical irritant into female reproductive organs, which induced inflammation and caused the fallopian tubes to close shut. Clauberg utilized various types of chemical injections, which produced results such as pain, bleeding, ovarian inflammation, and abdominal spasms.

In his 1943 communication to Himmler, Clauberg provided the following report on the status of his research:

> The method I contrived to achieve the sterilization of the female organism without any operation, is as good as perfected. It can be performed by a single injection made from the entrance of the uterus in the course of the usual customary gynecological examination.... If my research continues to have the same results as up to now—and there is no doubt that— then the moment is no longer far off when I can say: By one adequately trained physician in one adequately equipped place with perhaps 10 assistants ...most likely several hundred — if not even 1,000 [women can be sterilized] per day. (Weinberger 139)

Even though Clauberg's method of chemical injections needed refinement, he had accomplished Himmler's goal of developing a suitable eugenic sterilization method for one thousand women. Himmler had tasked other physicians with sterilization research, but Clauberg's method was more promising. It fulfilled Himmler's goal of sterilizing large quantities of people with minimal cost and time, and without the test subject being aware of the experiments' purpose. In 1944, he moved his operation to another block at Birkenau and increased the number of female prisoners for experimentation. Clauberg's research ceased in 1945 when he relocated to the Ravensbrück camp and was captured by Russian troops. Three years later, in 1948, Clauberg was sentenced to twenty-five years of imprisonment in Moscow. In 1955, with changes in the Russian government, Clauberg was released and returned to Germany. That same year, Clauberg was arrested again, and the German Medical Association pressured the Medical Chamber to revoke his medical license. During that process, he suddenly died in 1957 and was never tried for his crimes.

Alongside Clauberg's research in mass sterilization with injections, Himmler also commenced research on the possibility of sterilization with x-rays. This work in x-ray sterilization was taken on at Auschwitz by Horst Schumann, director of the euthanasia center at Sonnenstein and loyal follower of the Nazi movement. In 1941, he was placed in Auschwitz to start experimenting x-ray sterilization, despite his lack of training as either a radiologist or a gynecologist. Within the Birkenau barracks, Schumann practiced sterilization on both men and women through radiation from x-ray machines. Women and men's reproductive areas were exposed to varying levels of radiation to determine the needed amount of radiation to achieve sterilization. Because of prolonged exposure to radiation, many of these individuals developed burns, festering sores that would not heal, and many died due to the effects.

Schumann's findings proved that radiation through x-rays was not an effective method for mass sterilization. One of the initial goals of mass sterilization research was to perform the procedure on the prisoners without their knowledge. However, the x-ray machine in Auschwitz had limited capabilities and strength. To effectively sterilize people, the x-ray machine needed to be applied for an extended period of time because of its low strength. The long term exposure resulted in wounds alerting the victims that the x-ray treatments were harmful. Additionally, Schumann had to test the efficiency of x-ray sterilization, which proved to be time-consuming due the need for surgical operations to collect specimen samples. Ultimately, in 1944, Schumann's x-ray sterilization experiments ended at Auschwitz. The method was less reliable in inducing sterility in comparison to surgical sterilization methods, and it was expensive. In that same year he left Auschwitz and thereafter maintained a relatively low profile.

In 1951 when Schumann attempted to obtain a firearm, his criminal record was exposed and he left Germany to escape arrest. For seven years, he remained undetected in Egypt, Sudan, the Congo, Nigeria, and Ghana until an Auschwitz survivor identified him and he was delivered to representatives of West Germany in Ghana for his arrest. In 1966, Schumann returned to West Germany, and upon arrival was placed in detention to await prosecution (Weinberger 216). The trial against him was opened in 1970 but was delayed until 1971 due to Schumann's poor health. Ultimately, he was released from prison in 1972 due to his deteriorating health and died in 1983 without going to trial.

After 1945, "only about half of all perpetrators who committed medical crimes, medical experiments, or euthanasia during [Nazi rule] were forced to stand trial" (Weinberger 368). Mengele had avoided both arrest and trial while Clauberg and Schumann only evaded trial. Yet it is important to note the intention of the Nuremberg Medical Trial, held by an International

Military Tribunal in 1945–1946, to publicly declare that the medical experiments that took place were factual and that the United States and humanity considered these acts and ideas inhumane and illegal. During the criminal proceedings, some sterilization experiments were discussed, but "the International Military Tribunal moreover marginally explored links between the racial ideology of the [Nazis] and medical abuses of human experiments" (Weinberger 382). As a result, the International Military Tribunals decided that its orders would only allow for the criminalization of certain areas of sterilization that were not associated with the Nazi sterilization law of 1933. "The 1933 law was mainly seen as an internal German law and thus not applicable to proceedings under the aegis of war crimes and crimes against humanity" (Weinberger 382). Therefore, the tribunal only reviewed any medical experiments or medical crimes involving sterilization that occurred and did not fall under the 1933 Nazi sterilization law.

How the tribunal handled the topic of eugenics during the Nuremberg Medical Trials was scrutinized in subsequent years. Critics, lawyers, judges, commentators, and political scientists from various countries, including the United States, argued that the link between sterilization and eugenics could have been explored in greater detail had it not been for the influence of American eugenicists, such as Alexis Carrel from the Rockefeller Institute for Medical Research. During the trials the defense, Robert Servatius claimed that the medical procedures were intended to release test subjects from their suffering and incurable ailments. He affirmed that the purpose was genuine euthanasia, which was no different from the practices advocated in other countries (Weindling 254). Servatius cited various literary justifications of euthanasia, including Carrel's 1935 book, *Man, the Unknown*. In this book, Carrel supported positive eugenics and suggested that "fit" people should focus on reproducing and raising their children properly. For criminals, Carrel recommended execution in small euthanasia centers equipped with gas chambers. The

reference to American evidence of euthanasia and eugenics was supposed to give the impression that the Nazis mercifully euthanized people. However, the defense failed to challenge the euthanasia killings as relentlessly carried out until 1945 (Weindling 254). "Despite its shortcomings in properly addressing the crimes of Clauberg, Schumann, Mengele, and those committed in the name of eugenics, the Nuremberg Medical Trial nonetheless succeeded in putting on trial the concept of 'racial science' and its medical application" (Weinberger 383).

In response to "racial science" and the ethical issues of medical experimentation on human beings, Leo Alexander, Werner Leibbrand, and Andrew Levy formulated guidelines known as the "Nuremberg Code". Alexander was a Viennese-born American neuropsychiatrist, Leibbrand, a German psychiatrist and medical historian, and Levy, a renowned American physiologist. When the Nuremberg Code was created, it was viewed more as a set of guidelines to prevent future ethical and legal abuses similar to those of the Nazis, and were not regarded as general ethical or legal principles. The Nuremberg Code of research ethics in human experimentation consists of ten points:

1. The voluntary consent of the human subject is absolutely essential.
2. The experiment should be such as to yield fruitful results for the good of society, unprocurable by other methods or means of study, and not random and unnecessary in nature.
3. The experiment should be so designed and based on the results of animal experimentation and a knowledge of the natural history of the disease or other problem under study that the anticipated results will justify the performance of the experiment.
4. The experiment should be so conducted as to avoid all unnecessary physical and mental suffering and injury.
5. No experiment should be conducted where there is an a priori reason to believe that death or disabling injury will occur; except, perhaps, in those experiments where the experimental physicians also serve as subjects.
6. The degree of risk to be taken should never exceed that determined by the humanitarian importance of the problem to be solved by the experiment.
7. Proper preparations should be made and adequate facilities provided to protect the experimental subject against even remote possibilities of injury, disability, or death.

8. The experiment should be conducted only by scientifically qualified persons. The highest degree of skill and care should be required through all stages of the experiment of those who conduct or engage in the experiment.
9. During the course of the experiment the human subject should be at liberty to bring the experiment to an end if he has reached the physical or mental state where continuation of the experiment seems to him to be impossible.
10. During the course of the experiment the scientist in charge must be prepared to terminate the experiment at any stage, if he has probably cause to believe, in the exercise of the good faith, superior skill and careful judgement required of him, that a continuation of the experiment is likely to result in injury, disability, or death to the experimental subject. (Weinberger 384–385)

These points were regarded by the judges of the American tribunal as only legal in nature, only intended to assist in establishing and determining criminal responsibility and punishment. Additionally, according to the ten points of the Nuremberg Code, the medical experiments that occurred in the concentration camps and under Nazi rule breached every point because the people imprisoned in the camps were used for experiments without their consent or knowledge before or during the experiment.

After World War II, not only did the eugenics movement decline in Germany, but the term "eugenics" remained linked with negative practices because of the medical crimes and medical experiments on human beings conducted under Nazi German rule. Nevertheless, the search to understand heredity continued, and in 1953, the discovery of the double helical structure of deoxyribonucleic acid (DNA) raised the possibility of manipulating genetic material at very specific points in DNA. The comprehension of DNA's structure and functionality led to the development of technology to select desirable traits and prevent undesirable ones in living organisms, which has led to modern genetic engineering, modification, and manipulation.

Chapter 3

The publication of DNA's three-dimensional double helical structure as a twisted ladder was a significant discovery that led to further research by other scientists. The work of these scientists after the publication of DNA's structure led to understanding how DNA passes on inheritable genetic information from cell to cell and how this information is arranged. The understanding of how genetic information assembles and edits itself influenced another set of scientists to develop tools to control physical traits and breeding. The information gathered from DNA research by biochemists, microbiologists, and biophysicists influenced the development of technology that can genetically modify organisms, used today to genetically modify food, develop vaccines, and research animal cloning. This use of technology to edit the genetic structure of humans and produce genetically modified humans had not been performed until the 21st century.

In 1953, American geneticist and biophysicist James Watson and British biophysicist Francis Crick were credited for their joint research and publication on the double helix model of DNA. Their presentation of a model depicts the arrangement of DNA, which led to other scientists' discoveries on how genetic information passes from cell to cell. This answered one of the essential questions in genetics: what is in DNA that determines traits for inheritance and how is that information transmitted? Through human reproduction, the DNA genome from each parent breaks up into genes, which randomly recombine to create a unique genetic structure for the offspring. Based on this process and the involvement of various genes, it was assumed DNA's simple structure needed to be complex to pass on a multitude of genetic information. Prior to Watson and Crick's achievement, Swiss chemist Johann Friedrich Miescher discovered DNA in 1869. During his study of white blood cells, he "extracted a substance containing

nitrogen and phosphorus from cell nuclei. The substance was originally called nuclein (later changed to nucleic acid), but it is now known as DNA" (Rogers 57). Along with nucleic acids, there were proteins, and the question arose for Miescher and other scientists: was it nucleic acids or proteins that carried genetic information, or was it a combination of the two?

Proteins seemed to be the likely carrier of genetic information because they consisted of twenty different amino acids, while nucleic acids only contained four different building blocks. Because genetic traits are varied, it seemed likely that they would require a carrier of diverse structure, which made proteins seem a more suitable agent (Rogers 57). Later research by American bacteriologist Oswald T. Avery, in 1944, provided evidence that it was the DNA, which enabled the transmission of genetic information, not proteins as hypothesized. Research on DNA proceeded as:

> Avery and his research team obtained mixtures from heat-killed virulent bacteria and inactivated either the proteins, polysaccharides (sugar subunits), lipids, DNA, or RNA and added each type of preparation individually to avirulent cells. The only molecular class whose inactivation prevented transformation to virulence was DNA. Therefore, it seemed that DNA, because it could transform, must be the hereditary material (Rogers 58).

DNA, despite its less varied structure, was the carrier of "chemical messages of inheritance from generation to generation" (Bronowski 390). It demonstrated the ability to transform and therefore was the carrier of inheritable information.

DNA was determined as the messenger, but it was still unclear what parts of it formed the message and how the message was arranged. The double helix model of DNA discovered by Watson and Crick answered this question. Understanding how and where the creation of the message took place in DNA allowed the possibility of deciphering the message and then manipulating it to produce desired results. After determining the contents of the message that passed from cell to cell, scientists could subsequently select parts of the message for alteration to

allow or stop certain inheritable traits from reaching offspring.

Similar to a spiraling staircase or a twisted ladder, the double helix model of DNA consists of two intertwined sugar-phosphate chains. The flat base pairs form the steps between the chains (Rogers 31). “When a cell divides, the two spirals separate. Each base fixes opposite to it the other member of the pair to which it belongs” (Bronowski 393). The part that forms the message, the inheritable traits, is the half of the spiral with its base. When the spiral separates, each half contains the same message in its entirety. Therefore, as a cell divides in two each half contains part of the parent spiral, but the whole genetic message. However, the strands do not remain separate within their respective cells. Every base within the strand links up with its respective base and forms another set of DNA. As cell division continues, the message is carried on throughout the body to form specific organs and tissue relative to each section of the human body.

In a body, every cell carries the complete ability to create the whole living being with the exception of the sperm and egg cells. The sperm and egg are essentially half-cells and are therefore incomplete as they carry half the total number of genes (Bronowski 395). When the sperm fertilizes the egg the half of the spiral, they each contain pair up and create a new set of DNA. The two separate messages combine and create a new message, and this new message is copied and shared to create a new organism. The new message, this new set of DNA, becomes the model for every cell within that body. During the embryo state, the cells begin to differentiate as they take on specific roles to develop the body. “The cells specialize because they have accepted the DNA instructions to make the proteins that are appropriate to the functioning of that cell and no other. This is the DNA in action” (Bronowski 395). DNA is the messenger within cells as it separates and shares the genetic message to determine what is created such as nerves,

muscles, and tissue, how specific areas in the body function, and the physical characteristics within and outside of the body.

The offspring produced from the mixing of two genetic structures is a unique individual with an original arrangement of DNA. Because the child has acquired a mixture of genetic traits from both parents, there is diversity in his or her own genetic structure. “The child is not a prisoner of its inheritance; it holds its inheritance as a new creation which its future actions will unfold” (Bronowski 396). Although the child and parents lack control of selecting inheritable traits and in what quantities, we can estimate what possible characteristics could be passed on in future generations. The health history and physical attributes of an individual’s parents can aid in anticipating characteristics that could appear later in life in future offspring. In turn, its child will pass on his or her genetic message if they create offspring, and he or she will have some idea what genetic traits they are sharing with their future children.

When Watson and Crick provided the model of DNA, they enabled other scientists to perform research in response. Researchers discovered what areas in DNA influenced inheritable traits and which sections of the message were capable of change when DNA from parents split and recombine to create a new genetic message. Watson and Crick’s discovery led to further research and experimentation to understand heredity and later on to control it. After Watson and Crick’s publication, Swiss microbiologist Werner Arber’s discovery of restriction enzymes in the late 1960s introduced the term “genetic engineering” (Anderson 55). “The term *genetic engineering* initially meant any of a wide range of techniques for the modification or manipulation of organisms through the process of heredity and reproduction” (Rogers 123). Presently, the field includes the artificial manipulation, modification, and recombination of DNA in order to change an organism or a group of organisms (Rogers 123). In other words, it is the

deliberate alteration of an organism's genetic structure to produce new traits.

In 1965, Arber's research uncovered restriction enzymes, which cut DNA into pieces during replication. His discovery demonstrated that naturally occurring enzymes segmented the genetic message carried and copied it in the DNA structure. However, while it was clear then that the message was editable, it was still not understood how targeted areas of the message might be changed. American microbiologist, Hamilton O. Smith answered this in 1969 with his findings. He "revealed that one type of restriction enzyme cut DNA at very specific points in the molecule. This enzyme was named type II restriction enzyme to distinguish it from type I and type III enzymes, which cut DNA in a different manner" (Anderson 56). Smith had distinguished the enzyme that could target specific areas of the message for editing. Following Smith's findings, from 1970 to 1971, American biologist Daniel Nathan advanced genetic engineering by demonstrating how type II enzymes could be useful in genetic studies. Nathan's work consisted of cleaving the DNA of a monkey virus called simian vacuolating virus 40 (SV40) with restriction enzymes. He then analyzed the DNA fragments from two additional viruses and then pieced together the fragments from three sources to complete the genetic map of the SV40 DNA.

Miescher discovered the vessel containing genetic code; Watson and Crick found the structure and arrangement of DNA; Arber discovered that the message was capable of change; Smith located the natural "tool" to edit the message; and Nathan showed how the natural "tool" segmented the message. By discovering the type II enzyme to alter the DNA of organisms, scientists were then able to further their research to control species' inheritable traits and breeding. The development of a model for DNA structure continued scientific research and learning to comprehend the process of genetic inheritance in species.

In 1973, American biochemists Stanley Cohen and Herbert Boyer "were the first

scientists to use restriction enzymes to produce a genetically modified organism. In 1973, they used type II enzymes to cut DNA into fragments, recombine the fragments in vitro, and then insert the foreign genes into a common laboratory strain of bacteria. The foreign genes replicated along with the bacteria's genome" (Anderson 57). Cohen and Boyer cleaved the genetic message using type II enzymes, arranged the genetic message as they desired, and reinserted the new genetic message to be passed from cell to cell. As a result, the modified bacteria produced proteins as specified by the genetic message of the foreign DNA.

Further research and testing to control inheritance has included cloning of animals, genetic manipulation of plants, and vaccine development. The findings from scientists like Smith, Nathan, Cohen, and Boyer led to further research and technologic developments to control the inheritance of other organisms, though they were still not including humans in their research. The experiments and discoveries of Miescher, Watson, Crick, Arber, Nathan, Cohen, and Boyer on DNA's role in inheritance enabled later scientists to develop technology to edit the genetic message of living organisms.

Chinese scientist He Jiankui, as explained in more detail in the next chapter, and his manipulation of human genetic structure, has claimed to affect certain inheritable genetic traits. When scientists begin altering genetic structure during development of the embryo there is a change to the genetic message from each parent. The child possesses a new arrangement of DNA, which is new because it is a combination of both parents' genetic information, but it is also different from the parents because the child also possesses traits that did not originate from either parent. The manipulation of a particular genetic trait has the possibility to affect other attributes of the child, whether intended or not, and this is explored further in the next chapter. Sixty-five years after the publication of the double helical DNA structure and the subsequent

research and discussions regarding policies and ethics of genetic engineering on human beings, came the announcement of the first gene-edited babies by He Jiankui.

Chapter 4

The misuse of eugenics is evident in its past practices of forced sterilizations and its negative uses during Nazi Germany, and both the term and its methods have fallen out of favor. However, in the 21st century, it is evident that eugenic practices continue with experimentation and human genetic engineering. Reflecting on genetic engineering's definition as the intentional modification of an organism's genetic structure to produce new traits clearly, its definition is very similar to the definition of eugenics, which is to control human breeding to result in desired inheritable traits. The obvious difference between these definitions is that genetic engineering relates to organisms in general while eugenics is specific to humans. Regarding the latter, Chinese scientist He Jiankui has recently used genetic engineering on human beings and has shown that eugenic practices continue in the interest of presumably improving human health. The concern for human health and longevity is and has been an important subject matter, but the purposeful editing of human DNA can have consequences and negative effects on human beings and society.

On November 25, 2018, the online news media source, MIT Technology Review, reported the birth of genetically modified human baby twin girls. Scientist He Jiankui from the Southern University of Science and Technology in Shenzhen, China, used a gene-editing tool called Clustered Regularly Interspaced Short Palindromic Repeats-(CRISPR) associated protein 9 (CRISPR-Cas9), to modify two embryos by "eliminate[ing] a gene called [C-C chemokine receptor type 5] CCR5 in hopes of rendering the offspring resistant to the [human immunodeficiency virus] HIV, smallpox, and cholera" (Regalado). His main goal was the prevention of the ability to contract HIV, the virus that causes Acquired Immunodeficiency Syndrome (AIDS).

In China, HIV has become increasingly problematic in recent years due to blood transfusions and sexual transmission. Initially, HIV transmission through blood transmission was the most common way of acquiring the virus, but recently, new cases have reported sexual transmission as the most frequent method of contraction. Discrimination of homosexuals continues in China and due to the country's conservative values, men who have sexual relations with other men continue to marry women. According to a study on the potential of bisexual men in China acting as the bridge for HIV transmission to women by Eric P.F. Chow, David P. Wilson, and Lei Zhang, it is estimated that seventy to ninety percent of men who have sexual intercourse with other men will eventually marry women. In 2018, China announced a fourteen-percent increase in the number of citizens living with HIV and AIDS. Chinese people who have contracted HIV experience discrimination based on the health concerns associated with the virus and the recent increase in contraction through male-to-male intercourse, which is considered taboo. It is a growing problem in China because of the social obligation to maintain a heterosexual marriage and lack of protection during intercourse, and it is a health concern that needs a remedy. Medication for HIV and AIDS after contraction of the disease is available, but preventing the contraction of HIV is important and He Jiankui worked to find a solution with the use of CRISPR-Cas9 to edit human DNA.

DNA has an important role in the contraction of HIV, and without certain proteins in DNA, obtaining the virus would not be possible. When HIV enters the body, it requires assistance in replication to spread. Therefore, it must attach to receptors located on the outer surface of cells; these receptors receive and transmit messages to the inner part of the cells. These receptors are also essential for fighting diseases, which is needed for the body's immune system. However, when HIV attaches to these receptors, it destroys the cells and damages the

immune system. HIV is unable to enter the cell and replicate with the cell to spread the virus. The protein CCR5 is needed to work with the receptors and act as a doorway to allow HIV to enter the cell.

In 2012, American biochemist Jennifer Anne Doudna, from the University of California, Berkeley, and French professor and researcher of microbiology, biochemistry, and genetics, Emmanuelle Charpentier, from the University of Umea were the first to study and propose the use of CRISPR-Cas9 to edit the set of genes in an organism. Their research focused on the DNA of viruses and their discovery of this process to edit genes relatively quickly influenced other research groups. Chinese-American biochemist Feng Zhang at MIT-Harvard Broad Institute had also been working on the Cas9 system in human cells as early as 2011, and referenced Doudna and Charpentier's work for comparison. Doudna and Zhang had applied for patents independently for CRISPR-Cas9, and Zhang received the patent first. The University of California, Berkeley filed a lawsuit, but Zhang continues to possess the patent on the basis that his research began before Doudna's and had applied it to human cells whereas Doudna and Charpentier had only suggested its application. Their study and discovery leads us to He Jiankui's use of the CRISPR-Cas9 device on human cells to produce genetically modified human beings.

The process of manipulating DNA has become cheaper and uncomplicated with the CRISPR-Cas9 device. The CRISPR-Cas9 "makes it possible to operate on DNA to supply a needed gene or disable one that's causing problems" (Marchione). It works by using two molecules that produce a change or mutation: an enzyme and a piece of ribonucleic acid (RNA). CRISPR associated protein 9 (Cas9) is the enzyme which acts as a molecular scissor to cut two strand of DNA at a specific spot. Very much like the type II restriction enzyme that cuts DNA at

specific points, a natural process, the Cas9 enzyme performs the same task. Following this, two pieces of DNA can be added or removed. The second molecule, RNA, is a piece of pre-designed RNA sequence found within a longer RNA scaffold. This scaffold binds DNA and the pre-designed sequence "guides" Cas9 to the correct part of the genome, the complete set of genes in an organism. This ensures the Cas9 enzyme cuts at the correct spot of the genome ("What is CRISPR-Cas9"). CCR5 is a protein that resides on the surface of white blood cells and plays a role in the immune system as a receptor of chemokines, which are involved in the migration of immune cells to infected areas. The CCR5 protein was the target for editing in He's research and clinical trials because it acts like a doorway that allows HIV to enter a cell.

According to news publications, He did not have difficulty in finding participants for his clinical trials. Unlike Nazi methods of using imprisoned people, couples were recruited "through a Beijing-based AIDS advocacy group called Baihualin" (Marchione). In total, He had seven couples who participated in what was believed to be fertility treatments. Of these couples, only the men were HIV positive while the women were not.

He's documentation of the clinical trials states that modifications occurred in the embryo state. First, the sperm was separated from the semen, the fluid where HIV can be located. Then the sperm was placed in an egg to create an embryo and the gene-editing tool was added. When the embryo reached three to five days old, a few cells were removed and inspected for evidence of editing. He's data also states that genetic testing had occurred as late as twenty-four weeks, which is six months. According to He, sixteen out of twenty-two embryos were edited, and eleven were used in six implant attempts prior to the birth of the twins (Marchione). The participating couples were able to select edited or unedited embryos to use for pregnancy attempts. However, the status of all the pregnancies is unclear, whether they had been carried to

term, terminated, or are still in progress. These parents were seeking protection for their children by genetically enhancing their children to be immune to HIV. They were imperfect humans looking to create better offspring who could not contract HIV. By genetically modifying human embryos, He was able to control human breeding in order to produce a desirable trait in human offspring.

While He and his team viewed the birth of two genetically modified human babies as a success, which can surpass the achievements of in vitro fertilization (IVF), many people do not concur. Many ethicists, scientists, religious leaders, and even the Chinese government view this scientific and technological milestone as opening Pandora's Box. Geneticist George Church from Harvard University defends He's work by calling the attempt on gene editing for HIV a significant act that addressed HIV as a growing threat to public health, which he believes is justifiable (Marchione). However, HIV treatment is available with medication and prevention is possible with protection and safe sex practices. The greater concern from He's work is the effect his gene editing may have on future generations. Modifications to the sperm, eggs, or embryos are inheritable, the genetic message contributed by the sperm and egg and combined in the embryo state has been edited, and this new altered genetic code will become the basis for every cell in the body that copies and passes on the genetic information. Thereby new types of humans will enter this world and be able to pass on any genetic modifications to their future offspring. The potential to create people without "imperfections" perceived by parents and society alike is possible, and they might be advanced humans, intellectually, physically, or both. Changing the genetic structure of human beings begins to transform the world and society so that eventually everyone is special, whether it be enhancements intellect, physical abilities, or both. While the thought of ideal or designer humans may be pleasing to some, there are still potential health

risks, which can develop directly from manipulating the genetic structure of humans.

The International Summit on Human Genome Editing held on November 27–29, 2018 by the United States National Academy of Sciences and United States National Academy of Medicine, the Royal Society of the United Kingdom, and the Academy of Sciences of Hong Kong at the University of Hong Kong expressed concern for the future of the CRISPR-Cas9 technology. Two days before the summit gathering, November 25, 2018, publication of He Jiankui's work with CRISPR-Cas9 spread across the Internet and news outlets. This conference consisted of experts from around the world who met to discuss scientific, moral, and governance issues regarding human gene editing research. Of the experts who gathered, He was to be a speaker at the summit, but the news of his use of genome editing raised numerous questions about He and his actions. The technology He used not only altered the embryo, but it also affected the future offspring of the genetically modified humans. Because He had altered the genetic structure in the embryonic state, the genetic inheritance was subsequently altered for future generations. This procedure, therefore, has a significant and long-lasting effect, which may affect the person receiving modification and those that follow as biologically related offspring. He has successfully accomplished the goals of eugenics through the control of human breeding. However, rather than increase the occurrence of desirable traits, he has decreased the likelihood of passing on a particular trait deemed negative. He Jiankui has not edited human DNA so that a particular trait would become dominant and increase its likelihood of inheritance by offspring. Instead, he has edited the DNA of human embryos so that a specific gene could not be passed on and thereby decrease the potential of that particular gene's inheritance by offspring.

Genetically modified humans can consist of both modified and unmodified cells, which opens the possibilities for unwanted mutations. It is not yet known what can result between the

intermingling of original and edited cells because such a collection has not occurred previously. While it may not be an immediate concern for He or the modified humans, there could be long-term effects for the future. The possibility of change to human beings and society may include new mental and physical deficiencies or new viruses. There may be unintended consequences for the future of human evolution. When He examined his genetically modified twins his findings "suggest[ed] that one twin had both copies of the intended gene altered while the other twin had just one altered, with no evidence of harm to other genes" (Marchione). Therefore, it is possible that the twin with one edited gene is still capable of contracting HIV. If she were to contract HIV, there is very limited research suggesting her health may decline at a slower rate, compared to people who have the CCR5 gene and have contracted HIV. It is also unconfirmed if the twins are definitely immune to HIV; however, to test the twins' immunity and the success of He's work, the twins would need to be exposed to HIV. While the other twin has had both copies of the gene altered, there is only speculation that she is immune. Unless she is directly exposed to HIV, it is unclear if He's genetic modification has truly been successful. Another prominent concern for those without the CCR5 gene is in susceptibility to other viruses, such as influenza, West Nile, or Japanese encephalitis. The removal of CCR5 reportedly prevents the contraction of HIV, smallpox, and cholera, which are very specific viruses targeted for immunity, but what are the consequences when the body encounters other viruses, and the CCR5 gene is missing or damaged. He has focused on one particular health issue, but there are many other viruses in existence, others that may develop in response to future drug development and the changing of human DNA.

When geneticist Dr. Kiran Musunuru from the University of Pennsylvania reviewed He Jiankui's data, he apparently found evidence of mosaicism in the edited embryos. Mosaicism is

the existence of more than one type of cell in the body. An example of mosaicism is mosaic Down syndrome, which is a rare form of Down syndrome. In some cases, people with mosaic Down syndrome have fewer symptoms of Down syndrome, but intelligence and physical development are affected. In the case of the genetically modified twins, it is unclear if they were born with a mosaic patchwork of cells. However, according to Dr. Musunuru, the data on one of the twin's placenta has evidence of mosaicism, which is not good (Kolata and Belluck). Evidence of mosaicism in the placenta implies one twin may possess more than one type of cell in her body, whether the type of cells are blood or skin cells, the existence of mosaicism was caused by an error in cell division during the embryonic state. The interaction and effect of having more than one cell, which are genetically modified, in one body is unknown because it has not been researched or executed previously. However, based on the example of mosaic Down syndrome, it is probable that both the intellect and physical capabilities of this particular twin may have been affected, but how and to what degree cannot be determined without further research and monitoring her growth and development.

The importance of removing the CCR5 gene in humans addresses health concerns, and the natural adaptation of some human beings' immunity to HIV inspires scientists to force genetic change, but the necessity of removing this particular gene is questionable. Despite He's achievement in editing human genes, it was unnecessary to remove the specific CCR5 gene to create humans that are resistant to a specific virus. The inheritance of HIV by children from their parents is not likely, but it is possible if the mother possesses the virus. In the case of He's clinical trials, only the fathers had the virus and it is unlikely that this virus could be passed onto offspring if only the father is infected. Other than potentially acquiring HIV from the mother, contracting the virus is possible by the sharing of blood between an infected and non-infected

person through cuts or blood transfusions. The DNA of twins that He has changed, absent a specific gene, can be passed on to their children and the children may possess an immunity to HIV, depending on how their children's genetic message is arranged.

Although the CCR5 gene can be inherited, not all humans possess this gene in a functioning capacity. People that naturally do not possess the CCR5 gene primarily reside in parts of Northern Europe, but not in China, which shows how human evolution has progressed without human interference. "The distribution of the genetic trait around the world—in some populations but not in others—highlights how genetic engineering might be used to pick the most useful inventions discovered by evolution over the eons in different locations and bring them together in tomorrow's children" (Regalado). Because there exists a group of people in a specific region, naturally missing of the CCR5 gene means that this particular gene may not be necessary for the body's immune system. It also means people can live without this particular gene. The evolution of people from Northern Europe could be viewed as an influential genetic trait that scientists could research and recreate through genetic engineering to help and improve the health of future generations, as He aimed to do in his work with the CRISPR-Cas9. However, according to Antonio Regalado's report titled "Exclusive: Chinese Scientists are Creating CRISPR Babies," in the *MIT Technology Review*, "in order to mimic the same results in embryos …He's team has been using CRISPR to mutate otherwise normal embryos to damage the CCR5 gene." The passing of damaged genetic structures may prove to be worse than not passing on a specific gene, whether it remains dormant or active. While waiting for natural selection and adaptation to create people immune to HIV seems inadequate and slow, the quick editing of human genetic DNA has the potential of introducing new and more problems related to human health.

Power such as this, while possibly beneficial to humans for health reasons, can also have adverse effects on society. Now that two genetically modified humans exist, this opens the possibility for further variations of genetic augmentation. The potential to create tailored humans affects people of the present and future. People who interact with modified humans can be affected as well. For instance, Chris Reed in his article titled "Commentary: Chinese Scientist's Gen-Edited Babies Have Opened Pandora's Box: Brace Yourselves" speculates that military personnel will desire superhumans to enslave for war and win battles. In time, military personnel could be replaced with super humans who could fight with increased strength and devise battle plans quickly and strategically. People can be altered to be geniuses surpassing the current average human intelligence and potentially be capable of working alongside artificial intelligence.

From the perspective of the average person, this could lead to increased divisions within society where a "genetic gap" could separate genetically modified people who are mentally and physically superior from those who are born only with average intelligence and physical strength and capabilities (Reed). Even today's geniuses and professional athletes could experience a genetic gap if parents wished and could afford to select the traits their children might possess. He stated in a social media post that he "support[s] gene editing for the treatment and prevention of disease…but not for the enhancement or improving [intelligence quotient] I.Q., which is not beneficial to society" (Regalado). However, He's lack of support for improving intelligence or physical attributes cannot stop other scientists or parents from desiring their version of a better human and using the CRISPR technology to realize their own aspirations.

If the use of the CRISPR-Cas9 device or any genetic alteration came into regular practice on human beings, this would surely impact the human race. Either the characteristics of unedited

humans could be deemed “inferior” or genetically modified humans could be viewed as “inferior” or “superior.” For unedited people to be considered “inferior” it would mean their intelligence and/or physical capabilities might be lesser in comparison to edited people who were made to be smarter and stronger. For genetically edited people to be considered “inferior” to unedited people, this might be because they had not acquired their intelligence or strength naturally from their parents or through experience and practice, but rather through a selection of desirable traits and genetic modification. The potential for a genetic gap requires rethinking of human society, where genetic structure is added to the list of determinants of who is “superior” and fit for survival, alongside race, class, gender, and social and economic status. Who is genetically modified and who is not could create a divide in human society, and there is the possibility of the dwindling of unedited people. If the CRISPR-Cas9 becomes more affordable, there is the potential for more parents to desire genetically altered children.

The accessibility and affordability of gene-editing technology also affects society by dividing people based on economic status. The utilization of CRISPR technology may be easier and less expensive in comparison to in vitro fertilization (IVF), but it is still not affordable for people today in poor regions where HIV is prevalent, and if HIV were the only target for genetic alteration. Therefore, there is already a divide based on the economics of who can afford to create modified children and who cannot. The divide in economic status can create a deeper divide by weeding out people of poor economic status and not immune to HIV.

The concerns of creating a genetic gap may already be present with removing or disabling the CCR5 gene to make humans immune to HIV. Neurobiologist Alcino J. Silva from the University of California, Los Angeles, uncovered the significant role the CCR5 gene plays in memory and the brain’s ability to form new connections (Regalado). In Silva’s studies, the test

subjects were mice and the deletion of the CCR5 gene made the mice smarter. His research implies that the same genetic alteration to the twin babies could also improve the human brain's ability to recover after a stroke and could be linked to academic success. Therefore, the aim of modifying genetic structure to address a health issue has likely affected the functionality of the human brain. Although, brain recovery after a stroke, enhancement of the brain's abilities in memory and forming connections, and heightened intelligence are not negative to the human bodies' health, such improvements have the potential of negatively impacting human society. People genetically modified to be born with the CCR5 gene will have higher recovery rates after a stroke but those who possess the gene will have slower recovery or will be unable to recover. This genetic gap in the area of health divides who can and cannot recuperate from a stroke and exemplifies physical enhancement. People who are not genetically modified and are unable to get better after a stroke could be marginalized or pushed out of existence. The enhancement of memory and intelligence in people absent the CCR5 gene may make learning and studying easier compared to those who possess the gene. A genetic gap in intelligence may lead to categorizing who is "superior" and "inferior" based on cognitive capabilities.

With regard to the genetically modified twins, it is likely their brains have been inadvertently affected by CRISPR-Cas9's use to remove the CCR5 gene. The exact effect the removal of the gene will have on the twins' brains is impossible to predict and it is only speculated that their intelligence and health are improved based on the research gathered from mice studies. The link between the gene and intelligence is also suggestive as observation of the connection was only in mice and it is unclear if the same connection exists in humans or other species. However, this unpredictability makes the genetic alteration of humans a subject that should not have been executed quickly and without supervision and thorough exploration of the

consequences.

It appears that under this 21st century version of eugenics all non-genetically modified humans may be deemed "inferior" based on health or lack of attractive physical characteristics. On the other hand, genetically modified people could be deemed "inferior" because they are "unnatural." The current unpredictability of conceiving and bearing a child can be exciting because the child will possess a mix of the parents' genetic codes. However, this unpredictability can also be worrisome to some parents. Through heredity, there is the potential of passing on genetic defects, which could create humans who could experience a poor quality of life. The acquiring of unattractive physical appearances could also be considered a hindrance if one prioritized physical attributes. For instance, inheriting a specific hair color does not affect people's health, but certain hair colors may be undesirable because they are difficult to dye, such as dark pigmented hair that requires a bleaching process to make the hair follicles become a lighter or different color. While the CCR5 gene does not negatively affect humans born with immunity to HIV, it leaves them vulnerable to acquiring other viruses. Additionally, if certain people do not possess genes that make them vulnerable to illness they can believe themselves "superior" and deem unedited people as "inferior," if human genetic modification becomes an acceptable practice in the interest of health and beauty.

Current acceptance of human genetic engineering is minimal. China prohibits human modifications, specifically outlawing human cloning, but not particularly the editing of human genes. In the United States and Europe, this form of eugenics, the genetic engineering of embryos to provide immunity to a virus would be considered illegal. Particularly in the United States, gene editing is allowed, but only for lab research (Regalado). It will take time for scientists, ethicists, and world leaders to discuss the future of human genetic alteration after the

publication of He's work. Current laws need review and possibly change to ensure there is no misuse of the CRISPR-Cas9 technology, and the goal of improving human health does not lead adverse effects on the human body and society. The responses and proposals for solutions in the science community to He's human gene editing are mixed. Some scientists desire a year-long prohibition on creating pregnancies with gene-edited human embryos while other scientists believe this would be too restrictive and enforcement would be difficult. One of the inventors of CRISPR, Feng Zhang, concurs that a global prohibition should be established, specifically a five-year prohibition so that public discussion could take place regarding human gene editing. Jennifer Doudna, also credited as a CRISPR inventor, received direct email communication from He Jiankui regarding the birth of the twins and was displeased with the news. She disagrees with setting a five-year prohibition, as suggested by Zhang, and instead advocates for strict international criteria that all countries must abide by, where national science academies from multiple countries would draft guidelines about what is permissible for human genome editing. In addition, she wants journals to state they will not publish work regarding human genetic modification (Belluck). Despite differing suggestions on how to proceed with work on human gene editing, it is evident that scientists agree, He's use of CRISPR and the birth of humans who are genetically altered is unacceptable in today's society.

As a means to enhance human life by controlling human breeding, which is eugenics, He's results in genetic modification, and the CRISPR-Cas9 device require thorough review and comparison to the effects of past eugenic practices and movements. It is unclear how humans will adapt and evolve in an environment with edited and unedited people. However, genetically modified humans exist in today's society and while it is unproven if they are immune to HIV it is evident that they possess DNA that has been edited with the use of technology and not just the

type II restriction enzyme. Further genetic modification of humans may be stopped or delayed presently due to its likely use for vain desires of designer children, however, other scientists will be influenced by He's work, to support and continue research on human gene editing. This is not a matter of whether science and technology are good or bad, history has shown that it is desire and curiosity that enables scientists like He Jiankui to use the human genetic experimentation, as a form of eugenics, to control human breeding and genetic heredity. Eugenics practices continue in the 21st century with the desire to resolve a health related issue in humans, but the solution to one problem creates concerns for other issues related to human health and society.

Conclusion

After reviewing a brief history of eugenics, its negative practices, and He Jiankui's work to make humans immune to HIV through genetic modification, it is evident that his actions can be associated with eugenics. According to the definition of eugenics, He has attempted to improve the human population through the control of breeding and genetic heredity. With the CRISPR-Cas9 device, He has edited the genetic structure of twins in the embryonic state, so they are, it is claimed, unable to contract HIV, thereby protecting the twins' health, creating an opportunity for the twins to pass on their edited genes to their offspring, and potentially making more humans immune to the virus. It is unverified if the twins are immune to HIV since confirmation requires exposure to the virus. However, after examining the genetic structure of the twins, it is evident that their genetic structure has been altered. The genetic makeup of one twin has shown evidence of mosaicism, which is the existence of more than one type of cell in the body. Additionally, Alcino J. Silva's research on disabling the CCR5 gene, which assists in managing the body's immune system, has shown a linkage between CCR5 and the brain's memory and functions. In the case of He's genetically modified twins, their intelligence and ability to recover from a stroke may have been enhanced with the disabling of this particular gene. Therefore, He may have improved the health of the twins in more than one way.

In comparison to some countries' past eugenic movements, He's research and goals differ because he has targeted a gene that allows a virus to harm the human body, rather than sterilize people to prevent reproduction of presumed negative traits. However, both the German eugenics movement and He Jiankui's research in China have incorporated human experimentation to control human breeding. Concerning He's work and the twins, there are still potentially negative effects with human genetic experimentation. Past eugenic movements primarily emphasized

prohibiting certain marriages and enacting laws allowing the sterilization of people with physical and mental disabilities to prevent the spread of inheritable and undesirable traits. Germany's eugenic movement, with Nazi party support, involved mass sterilization and damaging effects to the human body from research attempting to control human breeding and heredity, or in Nazi Germany's case, restrict people considered "inferior" from having children. Regarding He's research, he sought to improve the human population and health through the use of a gene editing tool to disable the undesirable trait. Rather than prohibit people with an undesirable trait from having children, He has disabled the genetic trait in the offspring, and that disabled gene is now hereditary. Although He is not changing human birth rates or fertility, it is apparent in the twins' genetic structure that their bodies have been affected in an attempt to control the inheritance of the CCR5 gene.

From the 19th to the mid-20th century, many countries and governments that implemented eugenic practices were primarily concerned with interracial marriages, or sought to improve quality of human beings by restricting marriages or sterilizing people who had or were thought to possess undesirable physical or mental characteristics. However, in the 21st century, concerns regarding the enhancement of human health have taken precedence, especially with regard to fighting diseases and viruses.

In both the Nazi Germany human experiments by Mengele, Clauberg, and Schumann, and the human clinical trials by He, there were minimal or no testing on animals before starting human trials. Regarding He's research material, he has not released all of his data; therefore, it is difficult to understand exactly how he proceeded with his clinical trials. However, the results of both German eugenics and He's work with CRISPR-Cas9 have displayed effects to the human body that were not part of the primary goals. In the case of German eugenics during Nazi rule,

evidence of side effects from twin studies and research in mass sterilization is present in testimonies and physical proof of impairment and scaring on Auschwitz survivors. Due to the actions of Mengele, Clauberg, and Schumann, survivors of their experiments have suffered adverse side effects. For the twins in He's research, when the CCR5 gene was removed, the evidence of side effects was not present in their physical appearances, but within their genetic structure. Presently, the effects of disabling the CCR5 gene do not appear to have had any negative effects since the after effects noted previously include the presence of more than one type of cell, enhanced intelligence, and the potential to quickly recovery from a stroke. However, if the twins' or any gene-edited humans with the disabled CCR5 gene are exposed to other viruses, the results are unknown.

Additionally, the improvement of brain functions in the gene-edited twins could lead to adverse effects in society. Either those who are genetically modified could be classified as different and unacceptable, or they could be viewed as superior due to their exceptional intelligence. In either scenario, there is an opposite effect on non-genetically modified humans, if gene-edited humans are regarded as socially "superior" to unedited humans. Another negative result from removing the CCR5 gene may be furthering existing class divisions in human society. Regarding economics and those who want to genetically modify their children, there might be an increase in the economic divide between people who can and cannot afford the medical procedures to modify their embryos with the CRISPR-Cas9 device.

After investigating the medical crimes and human experiments that occurred under German eugenics, the Nuremberg Code was created to provide guidelines to prevent horrific acts perpetrated on human beings. Presently, He's research with gene editing, which can be viewed as eugenics, is still under review and is under discussion by the International Summit on Human

Genome Editing. However, how to address He, his research, and the existence of genetically modified twins is still in progress. There are many challenging factors to consider, but the most significant hindrance is He's missing research data, which he has not released. Many questions arise from learning about He's goals and research. If the majority of humans were to be born immune to HIV over time, will new and more fatal viruses and diseases arise? If humans can select the genetic structure of their offspring and create "better" versions of themselves, more intelligent or physically superior in strength and mortality, will this change the way people think of the human society generally? Will there be new criteria for dividing people as "superior" and "inferior" in addition to their race, social, or economic status? Is there a possibility that scientists will create another version of humans and that the genetic structure of human beings, as known presently, change into a new genus or species, becoming another step in the evolutionary chain? Will a new species surpass or replace sapiens? Answering these questions with the current events and information available today is a difficult task, but it is essential to explore the possibilities before accepting a regular practice of gene editing on human beings.

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