



Ethical Concerns and Risk Perceptions Associated with the Application of Genetic Engineering

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Abstract. Genetics and ethics have had numerous convergences and divergences over time. One major area where genetics and ethics have connection is the application of genetic engineering research. Genetic engineering has increased significantly in recent years. The advocates of this biotechnology portrayed it as a major scientific and technological revolution in the contemporary world. However, the application of genetic engineering brings with it ethical issues. Therefore, this study examines the ethical concerns and risk perceptions associated with the application of genetic engineering with a view to ascertain the dangers and usefulness of this biotechnological advancement to the wellbeing of humanity. Data for this study was generated through secondary sources and subjected to historical, critical, content and constructive analyses. The research discovered that genetic engineering have some major problems relating to technical complexity and ethical dilemma that call for public concerns. The paper maintains that despite the aforementioned problems, there are indications that genetic engineering has the potential to improve the quality of life. However, the application of genetic engineering must be seriously guided by laws and standard ethical systems so that man will not be a victim of his own creations. Therefore, biotechnologists, medical scientists, Legal experts, social and religious ethicists and other relevant stakeholders need to engage in sincere, fruitful and meaningful dialogue to resolve the pending, technical, legal and ethical dilemma inherent in the application of genetic engineering in order to advance the moral and scientific wellbeing of humanity.

Keywords: Genetics, Ethics, Genetic Engineering, Ethical Concerns, Moral and scientific wellbeing

1. Introduction

Genetics and ethics have had numerous convergences and divergences over time. One major area where genetics and ethics have connection is the application of genetic engineering research. Genetic engineering has increased significantly in recent years. The advocates of genetic engineering portrayed it as a major scientific and technological revolution in the contemporary world, which is what makes it legitimate in the eyes of its supporters. However, the use of this biotechnology brings with it ethical issues. These issues need to be considered by all stakeholders to ensure that all parties are aware of the ethical dilemma and can make a valid contribution to the current debate regarding the creation and use of genetically engineered organisms. Also, it is imperative for stakeholders to reflect societal values within the context of scientific practices and emerging biotechnologies that may be deemed ethically contentious. As a result of the ethical challenges and potential risks that genetic engineering bring, some governing bodies have started to develop relevant policies, often calling for increased vigilance and monitoring of potential dangers inherent in the application of this biotechnological advancement (Veerhong 1992.; Larrère, 2003). According to (Glenn, 2013):

Genetic engineering and transgenics continue to present intriguing and difficult challenges for 21st century scientists and ethicists, and education, meaningful and respectful discourse are just the beginning of what is required to tackle such complex ethical issues. Until we as a society or, perhaps, as a global entity can agree on what beings—human or otherwise—are worthy of moral and legal status and respect, we can expect intense cross-disciplinary

debate and discussion as new life forms are created through science and medicine (n.p.). Critical examination of the scientific and ethical controversies and debate on the subject of genetic modification of organisms shows that genetic engineering is sophisticated but nonetheless tinkering with uncertain results, and far from unnaturally meddling with life, it actually has to do with controlling (albeit inefficiently) natural processes. Moreover, exponents of genetic engineering posit that the 'irrational' fears of people concerning this biotechnology stand in the way of progress. They equally observe that the reason members of the public are so scared of consuming genetically modified organisms is because they do not understand what they are all about. Closer scrutiny reveals that they are not so much worried about GMOs, as about the inability of the authorities in charge of monitoring this new technology to resist the powerful interests of multinational corporations. It is believed that public hostility towards genetic engineering of organisms is more the product of reasoned skepticism than of irrational fear (Larrère, 2003).

It is pertinent to note that the characteristics of genetic engineering possess both vast promise and potential threat to human kind. Due to its potential to give humanity unprecedented power over life itself, the research and application of genetic engineering has continued to generate much debate and controversies among scientists, ethicists, and religious adherents in recent times (Zheng, 2003). Therefore, this study examines the ethical concerns and risk perceptions associated with the application of genetic engineering with a view to ascertain the dangers and usefulness of this biotechnological advancement to the wellbeing of humanity. Data for this study was generated through secondary sources and subjected to historical, critical, content and constructive analyses.

2. Understanding Genetic Engineering

Genetic engineering is the designation for a group of techniques used for direct genetic modification of organisms or population of organisms using recombination of DNA. These procedures are used to identify, replicate, modify and transfer the genetic material of cells, tissues or complete organisms (Izquierdo, 2001; Karp, 2002; Montaldo, 2006). Genetic engineering, or genetic modification, uses a variety of tools and techniques from biotechnology and bioengineering to modify an organism's genetic makeup (Glenn, 2013). Coates et.al gives what we may call a functional definition of genetic

engineering to mean 'the alteration of an organism's hereditary material, commonly used to increase plant and animal food production, diagnose diseases, and improve medical treatment'(2008). In this light, Benjamin and Familusi (2020) contend that genetic engineering embraces the deliberate adaptation of an organism's genetic or hereditary material to eliminate undesirable characteristics or to produce desirable new ones. Several terms are used to describe genetically engineered organisms; genetically modified, genetically altered, genetically manipulated, transgenic and biotechnology derived, among others (Hampton, 2016). This technology may be called 'biotechnology,' 'bioengineering,' 'recombinant DNA technology', among others. Most techniques of genetic engineering are related to the direct manipulation of DNA oriented to the expression of particular genes. In a broader sense, genetic engineering involves the incorporation of DNA markers for selection (marker-assisted selection, MAS), to increase the efficiency of the so called 'traditional' methods of breeding based on phenotypic information (Montaldo, 2006; Benjamin and Familusi, 2020).

It is pertinent to state at this point that the term genetic engineering initially referred to various techniques used for the modification or manipulation of organisms through the processes of heredity and reproduction. It is argued that Mother Nature has been carrying out genetic manipulations over the years, long before the primate ancestors of humans were even introduced on earth as distinct species. This argument is used to explain the phenomena of evolution, natural selection and selective breeding. When repeated over several generations, this process led to dramatic changes in the species (Benjamin and Familusi, 2020). In the early stages of genetic engineering, the primary technology used was transgenesis literally meaning the transfer of genetic material from one organism to another (Hampton, 2016). However, over the years, new technologies emerged which did not necessarily require transgenesis. Benjamin and Familusi observe that at a point in time, the term genetic engineering came to refer more specifically to methods of recombinant DNA technology or gene cloning, in which DNA molecules from two or more sources are combined either within cells or in vitro, and are then inserted into host organisms in which they are able to propagate (Encyclopedia Britannica cited in Benjamin and Familusi, 2020).

In recent times, genetic engineering embraces both artificial selection and all the interventions of biomedical techniques, among them are: artificial

insemination, in vitro fertilization, cloning, and gene manipulation. Recent applications allow for the creation of genetically engineered organisms via the deletion of genes, or the manipulation of genes already present. According to Benjamin and Familusi (2020), modern biotechnology has made it easier and faster to target a specific gene for more precise alteration of the organism through genetic engineering. It is imperative to state that the most accepted purpose of genetic engineering is focused on the direct manipulation of DNA sequences. These techniques involve the capacity to isolate, cut and transfer specific DNA pieces, corresponding to specific genes (Lewin, 1999; Klug and Cummings, 2002; Montaldo, 2006). Gene splicing, that is, direct altering of genetic material to form recombinant DNA, and cloning are vital techniques used for recombinant DNA production. Cloning techniques have been applied to both plants and animals. Benjamin and Familusi (2020) note that the copies produced through cloning have identical genetic makeup and are known as clones. Scientists have combined genetic engineering with cloning to quickly and economically produce thousands of plants and animals with preferred qualities. It is important to state here that genetic engineering technology is applied to humans, animals and plants.

3. Ethical Considerations

A lot of social and religious ethical concerns have been expressed with regards to genetic engineering and issues associated with the application of this biotechnological advancement. In this regard, Benjamin and Familusi, (2020) maintain that there is no technology without accompanying challenges provoking moral questions and necessitating ethical considerations. According to them, every novel breakthrough in science requires cross-disciplinary debate and discussion lest man becomes a victim of his own creations. They further observe that as this technology unleashes its power to impact our daily life, it will also bring challenges to our ethical system and core religious beliefs. The hope of human enhancement and selective breeding is not without its social horrors and moral concerns. Some individuals have continued to argue that crossing species boundaries is unnatural, immoral, and in violation of God's laws, which presumes that species boundaries are fixed and readily delineated (Glenn, 2013.). There is also confusion as to the rights and protection to be given to genetically modified organisms. In this light, Glenn raised the following fundamental questions: if the blending of animal and human DNA results, intentionally or not, in chimeric entities possessing degrees of intelligence or sentience never before seen

in nonhuman animals, should these entities be given rights and special protections? In others words, If we create a being that has the ability to speak and perhaps even reason, but looks like a dog or a chimp, should that creation be given all the rights and protection traditionally bestowed upon a person? Will transgenic interventions in humans create physical or behavioral traits that may or may not be readily distinguished from what is usually perceived to be "human"? (Glenn, 2013). As a matter of fact, these questions have raised serious ethical concern with regards to the application of genetic engineering in contemporary times.

One major aspect of genetic engineering that has raised so many ethical and safety concerns among bioethicists and researchers is human genome editing. Bioethicists and researchers generally believe that human genome editing for reproductive purposes, should not be attempted at this time, but that studies that would make gene therapy safe and effective should continue (Hampton, 2016). Most stakeholders agree that it is important to have continuing public deliberation and debate to allow the public to decide whether or not germ-line editing should be permissible. As of 2014, there were about 40 countries that discouraged or banned research on germ-line editing, including 15 nations in Western Europe, because of ethical and safety concerns. There is also an international effort led by the US, UK, and China to harmonize regulation of the application of genome editing technologies. This effort was officially launched in December, 2015 with the international summit on Human Gene Editing in Washington D.C Safety. Due to possibility of off-target effects (edits in the wrong place) and Mosaicism, safety is of primary concern. Researchers and ethicists who have written and spoken about genetic engineering such as those present at the international summit on Human Gene Editing generally agree that until germ-line genome editing is deemed safe through research, it should not be used for clinical reproductive purposes, the risk cannot be justified by the potential benefit. Some researchers argue that there may never be a time when genome editing in embryos will offer a benefit greater than that of existing technologies, such as Pre-Implantation Genetic Diagnosis (PGD) and In vitro Fertilization (IVF) (Araki, and Ishii, 2014).

Moreover, some people worry that it is impossible to obtain informed consent for germ-line therapy because the patients affected by the edits are the embryo and future generations. The counter argument is that parents already make any decisions that affect their future children, including similarly complicated

decisions such as PGD with IVF. Researchers and bioethicists also worry about the possibility of obtaining truly informed consent from prospective parents as long as the risks of germ-line therapy are unknown. Also, there is concern that genome editing will only be accessible to the wealthy and will increase existing disparities in access to health care and other interventions. Some worry that taken to its extreme; germ-line editing could create classes of individuals defined for the quality of their generated genome (National Academics of Sciences, 2017). According to Benjamin and Familusi (2020), what should be kept in mind is to consistently ask if these therapies will finally exclude the disadvantaged and exacerbate already existing domestic and global socio-economic inequalities, especially in very corrupt nations. Man can then anticipate intense cross-disciplinary debate and discussion as new life forms are emanating through science and medicine (Powledge, 2002).

Furthermore, many people have religious ethical objections to the use of human embryos for genetic engineering research (National Academics of Sciences, 2017). Benjamin and Familusi (2020) are of the view that religion still acts as a sure ethical guide to the use of scientific knowledge. To them, science does not have the mechanism to determine what is moral, nor should we expect value judgment from it. Soon after the cloning of the first human embryos, there has been widespread condemnation from several religious quarters. Theologians view some aspects of genetic engineering as thorny issues, an example of the ongoing tension between faith and science. Benjamin and Familusi further contend that:

Every scientific attempt that downgrades the image of God in man to the level of brute beast is an aberration. For man is more than just a being with blood and tissues, but a soul as well. ... Thus, religious people on the basis of value of human life argue against unnecessary genetic intercourse with lower animals and plants. As more human genes are being used in non-human organisms to create new forms of life that are genetically partly human, new ethical questions arise. It is either we are trying to raise animal and plant lives to the level of man or we are lowering ours to the level of non-human species (2020:42-43).

Some religious adherents believe that the principle of the dignity and sanctity of life covers all human life from the embryo stage. Life begins at conception and there is no justification to use embryos even if the research leads to medical breakthroughs. In this religious parlance, research cloning, where embryos

are destroyed is unethical. According to Roman Catholic Church's bioethical teachings in *Dignitas Personae*, 'to create embryos with the intention of destroying them, even with the intention of helping the sick, is completely incompatible with human dignity.' The biomedical interest of procuring embryos must never be allowed to negatively affect the dignity and sanctity of human life (Benjamin and Familusi (2020).

It is pertinent to state at this juncture that playing God has become the strongest religious ethical objection against genetic engineering in recent times. According to Benjamin and Familusi (2020), playing God simply means performing tasks that are reserved for God and God alone. Bohlin (2000) observes that for some religious believers, the notion of playing God carries a pietistic view of God's realm of activity versus that of the human race. Benjamin and Familusi (2020) contend that if the above assertion of Bohlin is what genetic technology does, then the concerns about playing God are justified. They however, raise the following questions and observations:

What if God's intention was to transmit his creative sparks into man in order that man might become co-creators with the divine? If this is accepted, at what point can we say man has voyaged beyond his borderline into the realm of the divine? If concerns about 'playing God' are legitimate, are they meant to protect man from self-destruction or a sympathetic crusade to prevent human usurpation of God's glory? Why is it any more plausible to imagine God erecting electric fences around certain areas of knowledge than to imagine God watching with delight and parental pride as human beings use their divinely designed brains to decipher the code of life? It is therefore likely that this 'playing God' thing is more of saving man from his arrogance rather than saving God from losing his reserved-creator status (Benjamin and Familusi (2020:42).

Different bioethicists, environmentalists, and animal rights activists have continue to contend that it is absolutely wrong to create animals that would suffer as a result of genetic alteration (for example, a pig with no legs) and that such experimentation should be banned. The opponents of genetic engineering express concern that such technologies could be used to create a slave race—that is, a race of sub-humans that could be exploited. They contend that by allowing this genetic manipulation, we run the risk of creating a race of super-humans, changing what it means to be "normal" and increasing the ever-widening gap between the haves and the have-nots (Glenn, 2013).

4. Risks Associated with Genetic Engineering

Several known risks are associated with the application of genetic engineering, especially when it involves the transplantation of cells or organs from animals to humans. For example, there is the risk of the transmission of fatal zoonotic diseases, such as bovine spongiform encephalopathy (aka “mad cow disease”), porcine endogenous retroviruses (PERVs) and Nipah encephalitis. It is said that the introduction of these diseases to the human population could have devastating consequences. The risk of creating new diseases by combining animal DNA or human DNA with plant DNA for which there is no treatment calls for serious concern about genetic engineering technological advancement (Glenn, 2013).

There is the argument that the production of transgenic animals threatens and weakens the genetic diversity of other animals and thereby make them more susceptible to new strains of infectious disease. According to Benjamin and Familusi (2020), a particular disease or virus may wipe off the whole herd sharing the same genetic characteristics. Others argue that transgenic farm animals are far more likely to endure greater suffering than what is already experienced on factory farms. Citing Comstock, Benjamin and Familusi observe that when human growth hormone was implanted into a pig, the unfortunate result was pigs that ended up with bowlegs, cross-eyes, arthritis, and dysfunctional immune systems that made them susceptible to pneumonia. Likewise, dairy cows which are commonly injected with bovine growth hormone to increase their rate of milk production, are much more likely to suffer from udder disease, and it also makes cows more susceptible to infertility and lameness. They further assert that the intercourse between human genes and nonhuman organisms seem to be taken too far even when there may be beneficial outcomes. Obsession with breakthroughs in gene manipulation could lead to a blurred relationship between animals and human beings. Thus, the deliberate germ-line genetic engineering in humans where the DNA changes will be inherited by successive generations is by far the biggest and most profound risk in genetic engineering. Moreover, to force the body to accept foreign organs, doctors administer immunosuppressive drugs which turn out to put patients at greater risks for sickness and tumors in the future. Again, there are cases of infections (Benjamin and Familusi (2020). Some abnormalities that occur in genetically modified animals suggest that more information is required on the

consequences of such practices in both humans and animals, before its routine use (Montaldo 2006). Furthermore, Hagedorn (2000) categorizes risks associated with genetic engineering into two; potential harms to health and potential environmental harms. According to him, potential harms to health include new allergens in the food supply, antibiotic resistance, production of new toxins, concentration of toxic metals, enhancement of the environment for toxic fungi and unknown harms to health. Potential environmental harms according to Hagedorn include cross contamination, increased weediness, gene transfer to wild or weedy relatives, change in herbicide use patterns, squandering of valuable pest susceptibility genes, poisoned wildlife, and creation of new or worse viruses. Similarly, Benjamin and Familusi (2020) declare that new organisms created by genetic engineering could present an ecological problem. One cannot predict the changes that a genetically engineered species would make on the environment. An accident in engineering the genetics of a virus or bacteria for example could result in a stronger type, which could cause a serious epidemic when released. This could be fatal in human genetic engineering creating problems ranging from minor medical problems to death (Mercer et.al, 1999). The release of genetically altered organisms into the environment can increase human suffering when medical measures are concerned, decrease animal welfare in experiments or through the use of recombinant DNA – technique in breeding, and lead to ecological disasters (Harry, 1994). The containment of biotechnological material in laboratories and industrial plants involves two types of risk. The first is the possibility of an accidental release in and by itself. The second layer of risk becomes visible in the case of accidental release, and is the increased probability with which this can produce them. These are matters which have traditionally been dealt with by systematic risk assessment (Thompson, 1986).

A risk that lies between the scientifically controllable dangers of release and containment and the more indirect political hazards of technology is the probability of the inadequate handling and irresponsible use of genetically altered material, prompted by the economic self-interest of research groups and industrial cooperation. The purely social and political dangers of genetic engineering include the possibility of increased economic inequality accompanied by an increase in human suffering and the possibility of large scale eugenic programs and totalitarian control over human lives. The risk in this case is clearly moral rather than technical. If multinational corporations choose to supersede the

national products of third world countries by their own biotechnological substances, millions of workers will in a few years' time be unemployed. If governments decide to develop racial programs and surveillance systems based upon the achievements of genetic engineering, the undesired outcome is certain, not possible or probable. The danger is that the decision makers act immorally, not that they have miscalculated the consequences of their actions (Rachels, 1975). In debates concerning the risks of biotechnology, the social and political dangers are not discussed as often as the hazards of responsible and irresponsible containment and releases. A partial reason for this can be that economic inequality and totalitarian measures are not seen by all as unwanted, undesired, or evil. Another partial explanation could be that the possibility of these outcomes is small, especially in the assessment of particular biotechnological innovations or products. It is difficult to see a connection between, say a technological process designed to produce expensive pharmaceuticals on the one hand and the emergence of an unjust totalitarian political order on the other. The risks at hand can be defined not only by scientific evidence but also in relation to public concern (whether perceived or real) that exists in some people. Some individuals contend that genetic engineering is a dangerous technological adventure and unnatural interference in living processes (Larrère 2003).

5. Benefits of Genetic Engineering

There has been a strong argument that despite the various risks associated with the application of genetic engineering; this biotechnological advancement has the ability to solve a number of agricultural, industrial, environmental and health problems. There is no gainsaying that several works have been done on genetic engineering with major focus on its importance; ranging from increasing plant and animal food production, diagnosing disease condition, medical treatment, improvement, as well as production of vaccines and other useful drugs (Benjamin and Familusi 2020). According to Glenn (2013), transgenic biotechnology presents an exciting range of possibilities, from feeding the hungry to preventing and treating diseases. The advocates of genetic modification argued that many deadly human inherited diseases, such as cystic fibrosis, diabetes, Down syndrome, fragile X syndrome, Huntington's disease, muscular dystrophy, sickle-cell anemia, Tay-Sachs disease, "bubble boy" disease (Severe Combined Immunodeficiency), among others, can be treated with genetic engineering. They further argued that health professionals can now detect, treat and

prevent 4,000 or more genetic diseases that humans are vulnerable to. Somatic cell engineering and germ-line engineering are used in gene therapy for correcting defective genes and for preventing the transmission of hereditary diseases from one generation to subsequent generations (Benjamin and Familusi 2020). Walter (1998) declares that diseases, such as hypertension, AIDS, Alzheimers' disease, high cholesterol, anemia and hepatitis B, are currently being studied through the use of genetically engineered animal models. The use of transgenic animal models for the study of gene regulation and expression has become commonplace in the biological sciences (Montaldo 2006).

Moreover, Majzoub and Muglia (1996) posit that genetically engineered animals such as the 'knockout mouse', in which one specific gene is 'turned off' are used to model genetic diseases in humans and to discover the function of specific sites of the genome. Genetically modified animals such as pigs will probably be used to produce organs for transplant to humans—xenotransplantation (Murray et al. 1999; Prather et al. 2003). This biotechnology is equally beneficial because it is used for the production of specific therapeutic human proteins such as insulin in the mammary gland of genetically modified milking animals like goats (transgenic animals, bioreactors) (Murray et al. 1999; Wall, 1999). According to Montaldo (2006), genetic engineering may be used to increase disease resistance and productivity in agriculturally important animals by increasing the frequency of the desired alleles in the populations used in food production. With regards to the agricultural industry, experts are of the opinion that transgenic farm animals can be created, that are better able to resist disease, grow faster, and more efficiently reproduce than current species of animals. Advocates of genetic engineering technology contend that transgenic animals (animals that have been genetically altered through the introduction of another plant's or animal's genes), may one day help solve many of our modern day problems in life, from starvation and ill health, to environmental degradation and the modern extinction crisis (Benjamin and Familusi 2020). Benjamin and Familusi also observe that:

Genetic engineering can be used to increase growth, shorten gestation and enhance nutritional value. Equally, transgenic animals, sharing the genes of two or more species, may be created to withstand rough environments. Genetically engineered plants are created to resist pests in some ways possible. Genetically modified plants are expected to give higher yields and be more resistant to disease, frost, drought, and stress. They will have higher protein,

lower oil and more efficient photosynthesis rates than ever before. Natural processes such as ripening can also be enhanced and controlled (2020:39).

Furthermore, genetic engineering makes it possible to use human growth hormone for more than its original intent as a treatment for dwarfism. In a similar view, parents deficient in mathematical skills may literally shop for genes that predispose their offspring to mathematical excellence and have these genes inserted into their children during the prenatal or postnatal period. Some other parents may select traits such as artistic ability, musical talent or athletic prowess for their children. Also, with germ-line engineering, scientists would assist parents decide their children's capabilities, eye colours, heights or even genders before birth (Coates et al, 2008; Benjamin and Familusi 2020).

6. Conclusion

This paper has investigated the ethical concerns and risk perceptions associated with the application of genetic engineering in the contemporary society, and it was discovered that this biotechnology have some major problems relating to technical complexity and ethical dilemma that call for public concerns. The authors further observe that despite all the aforementioned problems, there are indications that genetic engineering has the potential to improve the quality of life and allow for longer life span and even transmit quality to successive generations (Benjamin and Familusi 2020). However, the processes involved in the application of genetic engineering must be seriously guided by laws and standard ethical systems so that man will not be a victim of his own creations. There is the need to employ proper safeguards and develop coherent and unified regulations for genetic engineering technology. A reasonable degree of regulation, open information on the issues of genetic modification from the academic world and the involvement of the whole society in the developments of laws and ethical systems concerning genetic engineering, seems to be the best way to avoid or reduce unethical or abusive use of biotechnologies in the contemporary world (Fukuyama and Stock, 2002; Montaldo, 2006). Moreover, there is the need for concern agencies to educate the general public on the perceived dangers and benefits of genetic engineering for proper understanding in order to reduce the impact of conspiracy theories regarding this biotechnology on the members of the public. There is no doubt that genetic engineering will continue to generate serious controversies in the social and religious terrain because of the unresolved ethical dilemma. In this

light, biotechnologists, social and religious ethicists and other relevant stakeholders need to engage in sincere, fruitful and meaningful dialogue to resolve the pending ethical dilemma in order to advance the moral and scientific wellbeing of humanity.

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