AN ETHICAL INQUIRY INTO GENETIC ENGINEERING AND REORDERING OF NATURE

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Abstract

The paper reflects on the use of the medical technology, genetic engineering. It exposes the different forms of the application of this practice and the obvious benefits. Among other things, the paper acknowledges that genetic engineering has contributed enormously to the treatment of many genetic disorders and several deadly diseases. However, polemics have created a problem of blind acceptance or rejection of genetic engineering. This paper is an ethical evaluation and arguments for and against the practices of genetic engineering. Its import lies in provision of ethical guideline as to what should be accepted or rejected of these technological interventions on genes production. Hence, the paper is aimed at exposition of these arguments and drawing their ethical implications. Employing expository and critical methods, the paper argued that genetic engineering is like every other scientific innovations which has both positive and negative effects; and hence it cannot be rejected or abolished since its benefits far outweigh, and compensate for, its shortcomings. This is with the exception of germline genetic engineering which should be rejected because it disrupts nature and the created order in the universe in such a manner that endangers the continuous existence of the human species.

Key words: Engineering, ethics, genetic, nature and reordering

Introduction

Soon after the publication of the short essay by Crick and Watson (1953) on DNA structure, research began to uncover the way by which deoxyribonucleic acid (DNA) molecules can be cut and "spliced" back together. With the discovery of the first restriction endonuclease by Hamilton Smith et al. (1970), the real story of genetic engineering began to unfold. The creation of the first engineered DNA molecule through splicing DNA fragments of two unrelated species together was made public in 1972. Soon followed were a whole array of recombinant DNA molecules, genetically modified bacteria, viruses, fungi, plants and animals.

The first genetically modified organisms (GMOs) were a bacterium generated by Herbert Boyer and Stanley Cohen in 1973. Rudolf Jaenisch created the first GM animal when he inserted foreign DNA into a mouse in 1974. The first company to focus on genetic engineering, Genentech, was founded in 1976 and started the production of human proteins. Genetically engineered human insulin was produced in 1978 and insulin-producing bacteria were commercialised in 1982. Genetically modified food has been sold since 1994, with the release of the Flavr Savr tomato. The Flavr Savr was engineered to have a longer shelf life, but most current GM crops are modified to increase resistance to insects and herbicides. GloFish, the first GMO designed as a pet, was sold in the United States in December 2003. In 2016 salmon modified with a growth hormone were sold.

The debate over the issues of "tinkering with God" heated up and public outcry over genetic engineering was wide-spread. The birth of "Dolly", the first mammal ever from an adult body cell, has elevated the debate over the impact of biological research to a new level. Furthermore, a number of GMOs have been commercially released since 1996. Today, it is estimated that over 70% of US foods contain some ingredients from GMOs. Obviously, genetic engineering holds tremendous promise for medicine and human well-being. Medical applications of genetic engineering include diagnosis for genetic and other diseases; treatment for genetic disorders; regenerative medicine using pluripotent (stem) cells; production of safer and more effective vaccines, and pharmaceuticals; the prospect of curing genetic disorders through gene therapy. The list goes on.

Owing to its potential to give humanity unprecedented power over life itself, the research and application of genetic engineering have generated much debates and controversy. Many human diseases, such as cystic fibrosis, Down syndrome, fragile X syndrome, Huntington's disease, muscular dystrophy, sickle-cell anemia, Tay-Sachs disease, etc. are inherited. There are usually no conventional treatments for these disorders because they do not respond to antibiotics or other conventional drugs. Another area is the commercial production of vaccines and pharmaceuticals through genetic engineering, which has emerged as a rapidly developing field. The potential of embryonic stem cells to become any cell/tissue/organ under adequate conditions holds enormous promise for regenerative medicine.

Despite many benefits of genetic engineering, the debate on its interference on natural order subsists. The wide use of DNA in paternity determinations even in marriages has thrown up more issues. All these combined to give impetus to this work. There is need to bring to limelight issues surrounding genetic engineering once again and give them ethical consideration. The product of this ethical consideration will obviously facilitate decision making in practical life on issues related to gene reconfiguration for medical and reproductive purposes.

This paper intends to achieve its purpose by addressing the following questions. What is genetic engineering? What are the forms or kinds of techniques involved in genetic engineering? What are some of the benefits? Are there ethical concerns surrounding the practice? What are these concerns? Are these concerns sufficient to abolish genetic engineering techniques? These questions embody the ethical controversies this paper seeks to demystify through the study of genetic engineering.

Understanding Genetic Engineering

Technically, genetic engineering is the collection of a wide array of techniques that alter the genetic constitution of cells or individuals by selective removal, insertion, or of individual genes or gene sets. The term genetic engineering is often thought to be rather emotive or even trivial, yet it is probably the label that most people would recognise. However, there are several other terms that can be used to describe the technology, including gene manipulation, gene cloning, recombinant DNA technology, genetic modification, and the new genetics. Genetic Engineering is also called Genetic Modification or Genetic Manipulation. It is a process that uses laboratory based technologies to alter the DNA makeup of an organism. According to Smith, "this may involve changing a single base pai (A-T or C-G), deleting a region of DNA or adding a new segment of DNA" (Smith, 2020:4). For example it may involve adding a gene from one species to an organism from a different species to produce a desired trait. Zheng describes it as "a set of techniques that are used to achieve one or more of three goals: to reveal the complex processes of how genes are inherited and expressed, to provide better understanding and effective treatment for various diseases (particularly genetic disorders) and to generate economic benefits which include improved plants and animals for agriculture, and efficient production of valuable biopharmaceuticals" (Ming, 2008:1). An organism that is generated through genetic engineering is said to be genetically modified (GM) and the resulting entity is described as a genetically modified organism (GMO).

Although there are many diverse and complex techniques involved, the basic principles of genetic manipulation are reasonably simple. Nicholl (2008) points out that

> The premise on which the technology is based is that genetic information, encoded by DNA and arranged in the form of genes, is a resource that can be manipulated in various ways to achieve certain goals in both pure and applied science and medicine. (3)

Nicholl (2008) further explains:

> The mainstay of genetic manipulation is the ability to isolate a single DNA sequence from the genome. This is the essence of gene cloning and can be considered as a series of four steps [namely; generation of DNA fragments, joining to a vector or carrier molecule, introduction into a host cell for amplification and selection of required sequence]. Successful completion of these steps provides the genetic engineer with a specific DNA sequence, which may then be used for a variety of purposes. (3)

Genetic engineering has been applied in numerous fields of study such has research, medicine, industrial biotechnology, agriculture, etc. In research, GMOs are used to study gene function and expression through loss of function, gain of function, tracking and expression experiments. Proponents of genetic modification science believe that by knocking out genes, responsible for certain conditions, it is possible to create animal model organisms of human diseases. Apart from producing hormones, vaccines and other drugs, genetic engineering has the potential to cure genetic diseases through gene therapy.

One aspect of the genetic engineering that has given cause for concern is the debate surrounding the potential applications of the technology. The term genethics has been coined to describe the ethical problems that exist in modern genetics, which are likely to increase in both number and complexity as genetic engineering technology becomes more sophisticated. The use of transgenic plants and animals, investigation of the human genome, gene therapy, and many other topics are of concern not just to the scientist, but to the population as a whole. Recent developments in genetically modified foods have provoked a public backlash against the technology. Additional developments in the cloning of organisms, and in areas such as in vitro fertilisation and xeno-transplantation, raise further questions. Taking all the potential costs and benefits into account, it remains to be seen if we can use genetic engineering for the overall benefit of mankind and avoid the misuse of technology that often accompanies scientific achievement. Some moralists are however worried that as this technology (genetic engineering) unleashes its power to impact our daily life, it will also bring challenges to our ethical system and religious beliefs.

Variants of Genetic Engineering

There are many variants of genetic engineering which cannot be fully discussed here. However, there is need to give a synopsis of some of them. Gene therapy is a technique for correcting or preventing defective genes responsible for disease development. Researchers may use several approaches for correcting faulty genes. Most commonly, a normal gene is inserted into a nonspecific location within the genome to replace a nonfunctional gene (Reiss & Straughan, 1996:12). Related to this is genetic enhancement which refers to the transfer of genetic material intended to modify nonpathological human traits. The term is commonly is used to describe efforts to make someone not just well, but better than well, by optimizing attributes or capabilities; perhaps by raising an individual from standard to peak levels of performance. When the goal is enhancement, the gene may supplement the functioning of normal genes or may be superseded with genes that have been engineered to produce a desired enhancement. The procedure followed is similar to that of therapy.

Gene therapy and enhancement discussed above can be of somatic or germline. Somatic refers to body cells and germline refers to reproductive cells. Changes made to somatic cells are restricted to the individual, while changes made to germline cells are passed on to future generations. Germline genetic enhancement is, not unexpectedly, the most controversial form of genetic intervention.

Organismic cloning is another form of genetic engineering. It refers to the procedure of creating a new multi-cellular organism genetically identical to another. In essence this form of cloning is an asexual method of reproduction, where fertilization or inter-gamete contact does not take place. Dolly, the sheep, was the world's first cloned adult animal (Reiss & Straughan, 1996: 12). The scientists who cloned Dolly were forced to stop experiments involving genetically modifying pigs for human organ transplants because of concerns that deadly new diseases could be passed on to people.

Benefits of Genetic Engineering

There are so many benefits associated with the practice of genetic engineering. Some of these are articulated below. Genetic engineering has enabled production of human proteins from micro-organisms. Microorganisms have been used during the last 50 years to produce medically important drugs such as antibiotics and synthesis of mammalian proteins including human genes were inserted into bacteria. Many human proteins are now being commercially manufactured using the technology in bacteria, yeast and eukaryotic cell nature. These proteins can be used to treat patients that lack these hormones or enzymes. They can also be used to treat other diseases such as cancer. By the year 2000, about 50% of all approved drugs were estimated to have been made using the recombinant DNA technique made possible by genetic engineering (Macer et al. 1991:4).

Similarly, through genetic engineering, animals have been genetically modified to produce desired proteins in their milk. Mice and sheep have successfully been used to make the human blood-clotting factor for the treatment of haemophilia, as well as the protein alpha-1-antitrypsin which can be used to treat emphysema (a lung disorder caused by a deficiency of this protein) (Macer et al, 1991:4). This has ensured greater productivity and less production cost.

On another note, human and animal vaccines are now being made with the aid of genetic engineering via recombinant DNA technique. Vaccines against Hepatitis B, Covid 19 etc made using this procedure is also ready in use across the globe. There are ongoing several researches on the molecular basis of many diseases (Blackford, 2014:23; Sheng, 2023). Genetic engineering has also enabled genetic screening. Every human person has a different set of genes or genotype. Sexual reproduction is a risky business with a relatively high occurrence of abnormality. Many of these are aborted naturally. However about 3% of humans born have some genetic diseases (Macer et al. 1991:5), which are mainly protein abnormality and other gene disorders. Genetic probes can be sequenced and used for screening. Related to this is the use of genetic engineering for gene therapy. Due to recent rapid advances in molecular genetics it is now possible for the initial application of the technique of gene therapy to be undertaken; defective genes are substituted for correct genes. There are two levels at which this can occur, and they differ in the consequences they have for the patient. The genes can be inserted into specific cells of the body where the defect is causing the disease. This is called somatic cell gene therapy (Bungs & Postiglione, 2000:34). The genetic defect is often only noticed in one specific tissue, and the aim of somatic cell therapy is to insert the normal gene in a specific tissue. The other level of gene therapy is germline therapy. This second level is advanced and complicated.

DNA fingerprinting compares people on the basis of their DNA sequences. Each individual has a unique DNA sequence with about half of each DNA fingerprint inherited from each parent. Comparing of the parents' and child's DNA fingerprints can reveal the true genetic relationships. The evidence is accepted in many countries for criminal cases, in disputed paternity cases and for immigration purposes. It can also be used for tissue transplantation matching.

All these and more are made possible by genetic engineering. In all, genetic engineering has made serious inroad in human, animal and plant reproduction and disease control through genetic modifications. However, most of these achievements raise ethical questions.

Ethical Issues Surrounding Genetic Engineering

There are many ethical issues surrounding genetic engineering. In the first place, there is serious fear among many people as to where genetic engineering is heading to. Expressing this fear Ormandy, Dale and Griffin (2011) write:

> Little data has been collected on the net welfare impacts to genetically engineered animals or to those animals required for their creation, and genetic engineering techniques have been described as both unpredictable and inefficient. The latter is due, in part, to the limitations in controlling the integration site of foreign DNA, which is inherent in some genetic engineering techniques (such as pro-nuclear microinjection).

The nature of science is such that total consequences cannot be foreseen. We can guard against the risks that we can foresee; those we cannot foresee we cannot guard against. The more rapidly we make changes to organisms, the less time we have to see the long term consequences of those changes. The ethical question then is whether we have the necessary knowledge and wisdom to alter successfully life-forms without creating long term and catastrophic eco-disasters.

Although of precautionary measures are put in place, these cautionary measures are not sufficient to remove the fear of the unknown regarding the practice of genetic modification because the adequate application of those measures depends on the personal disposition of the scientist to keep to rules and exercise measured restrain, especially with regard to not exceeding stated limits.

Again, genetic engineering is viewed with consternation as playing God. The expression 'Playing God' refers to the tendency to assume the role of a god and hence make critical decisions without reference to God and perhaps even the opinions of other people. This behaviour is seen as a demonstration of pride or arrogance. It is not the use of power and creativity that is wrong, but rather attributing power to our own resources. What is wrong is not the act itself, but the human-centred attitudes that could be involved. All religions condemn this extreme tendency. (see Lacey 2018). However, useful applications of technology are positively advocated in Judeo-Christian tradition (as well as most other religious traditions) as part of good stewardship of the earth's resources.

The expression 'Playing God' usefully suggests that people should be cautious in the use of technology whose potential risks and side-effects we do not fully understand. The idea is that while God may understand all, we do not, so we should only tamper cautiously with things as fundamental as genes. For some, there is a feeling that we should not explore all the secrets of life; that the mystery of life will be gone if we discover too much. However, as many scientists will say, the more we know the more appreciative of the workings of life we become. Discovery itself may not be wrong, but how we use it or abuse it raises ethical questions. The fact that we have practical requirements, such as to feed, house and heal people of the world, are major justifications for the pursuit of practical knowledge in any system of religion or philosophy that places a high value on human life. Although it must be acknowledged that science and technology are value-free, there is need to respect people's feeling in their pursuits.

In a related development, there are also non-theological ethical objections to genetic engineering, as expressed by such statements as "we should not interfere with nature/natural evolution/the natural order of life." This 'meddling' is judged to be morally wrong, although not necessarily on religious grounds (although the same idea is common to people from many religious and cultural backgrounds). These objections were the strongest in the most surveys and were the strongest in relation to plant and human genetic engineering. Underlying the debate is an unease about scientists digging around in the 'very stuff of life,' in the heritable programmes which define us as individual humans (Sagoff, 1988:11). Many people believe that by engaging in genetic engineering we are acquiring powers that humans ought not to have.

Scientists are transferring genes across species barriers that have been erected by millions of years of evolution thereby tampering with the integrity of species. This frightens many people. Concern exists over the involvement of humans with the evolutionary process in a more direct way than is currently occurring. The level of concern on this issue was low in the 1990s and often expressed within the concepts of possibility for disaster or creating mutants. However, modern biologists generally think of species as reproductive communities or populations. The species are limited by an arbitrary limit to variation. One species may exchange little or no genetic material with related or adjacent species, while another may seem to be almost promiscuous, interbreeding frequently with a neighbouring, related species. (See Philips, 2008).

Perhaps, the greatest public concern is over the mixing of human and animal genes. Since much transgenic animal research is aimed at increased understanding of human diseases, the insertion of human genes may become common. The primary reason for this is convenience since a large number of human genes have been cloned. The most convenient, readily available form of a gene will be used for manipulation. Proponents of genetic engineering have responded to this concern by noting that it is unlikely that animal genes will be introduced into humans as therapy at this some stage, and it is unlikely that any will be needed as the appropriate human genes should be available at all times.

Uniform crop varieties are economically useful. Having a field of wheat that grows to the same height, producing good heads of grain that can be harvested at the same time, that is resistant to all known pests and diseases, and has uniform milling properties is an ideal. Improved crop varieties have increased food production; some have however argued that it has contributed to genetic erosion. Old varieties of crops were dropped in favour of new uniform ones over a short time period in developing countries and over a long period in Europe. Genetic variability that has been relied on for plant breeding is being lost as a result of genetic engineering.

There is the objection that cloning or tissue culture plant propagation will reduce the genetic diversity of a species. Landry (2015) haps on this when he avers:

> A major concern of genetically modified organisms is that they will cause reduced genetic diversity of plants and animals in the environment. What this means is that the DNA, which codes for proteins in an organism, will become more similar between individuals of a species.

This would only apply if a significant proportion of the breeding population was developed asexually. We should always try to maintain diverse organisms, as such organisms tend to be better able, as a population, to survive major diseases or environmental changes. Modern breeders should realize the need to maintain stocks of the original species and the importance of maintaining a wide variety of wild species, in seed or germ plasma banks. If this precaution is taken, then there is no danger of losing old varieties - a calamity that has happened in the past for some organisms. Proponents of plant genetic engineering argue that the most powerful influence of genetic engineering will be indirect and should increase biological diversity. Their assumption is that because the efficiency of agriculture is increased, it is possible that large areas of land may be left fallow, allowing wild plants, such as wildflowers, to grow.

Of the many fears about the future abuse of science, the most sensitive areas are the changes that affect the inner constitution of humans. People express most concern about human genetic manipulation. The eugenic excesses of the Nazis and other countries in the first half of this century must not be forgotten. Medical ethics should protect human beings from such blatant abuses, but there are many other trends that we must remain alert to (Geogi, 2020). The ethical question here is to what extent must genetic modification be applied to human beings? This problem emerges not only when we use genetic therapy, but is also found in common practice, such as cosmetic surgery, or in the more serious case, on deciding the limits of growth hormone replacement therapy. The point at which we stop using gene therapy may be when it is no longer a treatment for a disease, but becomes enhancement. When therapy no longer adds to our understanding of human dignity we should stop using it, just as in other applications. The more important question however is: would users or scientists yield to reason and let things be when that red line is reached? Will they be able to exercise restraint?

To examine the alternatives, it is important to look at the goal of genetic engineering. From the parents' perspective, it is aimed at producing a healthy child. At an individual level it is aimed at leading a healthy life, including reproduction. At a societal level, it is aimed at reducing the number of people in the next generation who suffer from genetic disease. There are benefits at all levels. However, these goals must be accomplished without infringing individual rights or casting another person's life or the entire human race to danger.

One unethical use of genetic engineering techniques that is of grave concern is their major use in the military sphere even though biological weapons are outlawed by a Geneva Convention. This research is already a reality; it is difficult to stop but, like a nuclear holocaust, its use can be prevented. The fear of biological warfare is not an argument for stopping research in other areas of genetic engineering, which promise many benefits. On this issue, Aken and Hammond (2003) have this to say:

> By using genetic engineering, biological researchers have already developed new weapons that are much more effective than their natural counterparts. Countless examples from the daily work of molecular biologists could be presented here, not least the introduction of antibiotic resistance into bacterial pathogens, which today is routine work in almost any microbiology laboratory. Indeed, many research projects in basic science show—sometimes unwillingly and unwittingly—how to overcome current scientific and technological limits in the military use of pathogenic agents. Furthermore, genetic engineering is not merely a theoretical possibility for future biowarfare: it has already been applied in past weapons programmes, particularly in the former Soviet Union.

People may make claims about the ethical neutrality of science. This implies that scientists do not have responsibility for the production of knowledge. However, this belief confuses the findings of science, which are ethically neutral, with the activity of science, which is not. Some pursue the neutrality argument by claiming that the moral burden lies with those who choose to implement knowledge for all purposes. We may not be able to predict the abuses of pure knowledge, however, scientists are still moral agents and must think in advance of the possible abuses. They may not be solely responsible but they share responsibility.

Another genetic engineering related issue is abortion. Abortion is a contentious issue, as is human embryo research. They are separate issues to genetic engineering, but overlap in some applications. Genetic engineering techniques have made it possible to detect many genetic diseases, at increasingly earlier times during pregnancy, which is a medical advance that many women and families can take advantage of. It is important to note that after a positive diagnosis, and confirmation of the result (as mistakes occur), the mother may decide to have an abortion or, for some diseases, to commence medical therapy on the foetus. The technique of genetic screening is also recommended for people who do not agree with abortion, as it may be medically advantageous to know the genetic condition of the foetus before it is born, so that therapy, or extra educational, economic, social and emotional preparation for the birth of a child may be arranged.

Privacy of genetic information is yet another major ethical concern regarding genetic engineering. Knowledge of the total human genome sequence raises many questions about the rights of individual privacy. This is a key issue for the future as it will be possible to screen for so many genes. The type of information produced ranges from a predisposition to diseases, or the certainty of knowing that a later acting disease will develop. They may reveal important hints on a person's physical or intellectual potential. The data can play an important role in the life of the individual, affecting the choice of spouse, psychological health, reproductive decisions such as whether to have children, and whether to use pre-natal screening and selective abortion or therapy. Decisions must be made about personal health risks that may be affected by diet, smoking, etc., and the type of work. The genetic information can be of great benefit to the individual person wanting to know about his or her genetic constitution.

There are two different technologies for genetic testing. Genetic screening can be used to identify people who are susceptible to certain illnesses. Genetic monitoring is different; it is aimed at understanding the significance of genetic mutations that occur in groups of people as a result of exposure to chemicals. Gene monitoring is targeted at a group, to determine whether a carcinogen is present in the workplace.

Screening for susceptibility to lung disease if an individual is exposed to asbestos might be an advantage if an alternative job in the company can be found. This has already been used to prevent people from working in some factories. It may become an excuse for companies not to hire susceptible workers, or women of child-bearing age, instead of cleaning up the factory. On the other hand, if a person suffers from haemophilia it would be wrong not to warn them of the risks of becoming a butcher. Decisions regarding insurance schemes and retirement are also involved. It is difficult to prevent insurance companies from genetically screening potential clients to reduce costs. Several recent studies of this issue have agreed that the only ethical, and most practical solution, is to provide nationalized health care, and social security. Society must make decisions as to whether it wishes to adopt this system. If we consider individual human life to be of a high status, then we should protect individuals from discrimination. Some access to personal information will be required for medical emergencies, but otherwise third parties should not have any access. This will mean sharing the cost of health insurance, and disability pensions, as in the past. This issue is very important, more important than some of the other issues that attract our attention away from new genetic technologies. The law must protect privacy of genetic information, as the alternative is widespread discrimination against many people. International law is required, as well as a change in society. The call is for any employer or insurer not to discriminate. Government action to support prohibition of any form of discrimination, whether racial, sexual, religious or genetic, will be required. Knowledge obtained by genetic screening, at gene level or at the level of DNA fingerprinting, will be very powerful. We must be wise in our use of it. Like much offered by science, it has the power to enrich lives as well as to frustrate or destroy them. However, there have been increasing efforts to ensure security of privacy of genetic data (Fair, 2023).

The goal of biomedical research has always been to alleviate human suffering. The technique of gene therapy provides new approaches to achieving this goal. Just because a new technology becomes available it is not necessarily the most rational approach. Gene therapy has been described as a preventative therapy, preventing disease at the fundamental level. We should not forget that other causes of disease, and poor health, such as diet, and lack of health education, need to be focused on. Because of the doubts about success, the immediate prospect of gene therapy is limited to life threatening diseases that do not have any other cure, and are due to a single gene defect whose effects can be corrected by the insertion of the normal gene without the need for precise regulation of gene expression. What is essential is full public review of the results, which will have to be debated further before the techniques are more widely used. The results of gene therapy and comparisons with the alternatives should be made available to allay public anxiety. The patients, or their guardians, must be educated so as to be able to decide if they will submit to the experiments, which will have to include long term follow-up studies of patient progress.

The extension of gene therapy to germline, or inheritable gene therapy, is now possible, but the ethical implications are still being debated. There are many ethical problems to be discussed, and they will require much more public debate before such techniques are ethically possible. In July 1990, a workshop/conference on human genetics and ethics organized by the United Nations CIOMS (Council of International Organizations of Medical Sciences) was held in Japan. Representatives from 30 countries, with expertise in science, law, ethics and public policy debated these issues (Koepsell, 2007:15). The conference called for extensive public discussion over this issue, and for the need for any national ethics committee that considers germline gene therapy to consider the international consequences of such therapy, because people travel between countries and it would affect the entire human race eventually.

A common feature of issues raised by genetic engineering is that we need to consider the effects of technology on future generations to whom we have a responsibility. The beneficiaries and those at risk from the technology may not yet exist. The human genome project raises similar ethical and legal issues to those raised by current genetic screening, including confidentiality of the results. However, screening on a huge scale, for many disease traits and susceptibility to disease is inevitable. It is important that we deal satisfactorily with the test cases, before we are faced with this new information.

Our traditional view of morality only involves short term consequences. Human action is seen as only having a small effective action range. Moral liability is limited by what is unenforceable. If another agent intervenes, or something unexpected happens, it is not considered our fault. Genetic engineering changes our moral horizon. There is a moral imperative to obtain predictive knowledge and data about the wide-ranging possibilities of some action. Secondary consequences may be sufficient to prevent the primal action, even when the primary action may be good. This imposes a restraint on the use of technology. In this respect ethics are important for public policy decisions, beyond the physician’s concerns with each patient, or the scientist’s concerns with increasing yield of a crop.

Researchers may be held accountable for secondary consequences of their research. It may be very difficult to predict what will happen in the future. If social ideas change, then so may the pressures for genetic technology, such as the desire to use genetic enhancement. We need to ensure that future generations retain the same power over their destiny as we do, while benefiting from the culture and technology we have developed. There is a growing realization of the interdependency of the new genetic technology and the conservation of our genetic heritage in gene banks. The erosion of our genetic resource needs to be minimised because of its vital importance for the future development of industries based on plants and animals. The gene banks can also be improved through the use of new genetic techniques for mapping genes as well as the application of tissue culture techniques to negatively propagated plants, etc. Besides, as Friedl (2021) rightly captures:

> This comes from the fact that the eugenics movement was heavily biased against non-white races, lower-class citizens, and the mentally ill. Many mental disabilities aren't even related to genes, and many human behaviors are influenced as much by our environment as our genetic make-up.

What this implies is that the place of nurture in shaping organism especially human beings should not be ignored as if gene determines everything.

There are other ethical concerns of genetic engineering. MedlinePlus (2023) give the summary of other issues thus:

> The ethical questions surrounding gene therapy and genome editing include: How can "good" and "bad" uses of these technologies be distinguished? Who decides which traits are normal and which constitute a disability or disorder? Will the high costs of gene therapy make it available only to the wealthy?

However, the kernel of all these ethical concerns is how to reserve the dignity of human species which is the ultimate recipient of all effects of the activities of genetic engineering whether on human, animal, plant or environment, both positive and negative.

Ethical Evaluation of Genetic Engineering

Efforts to give ethical evaluation of genetic engineering have produced arguments in favour and against. Some of these arguments have been captured in the previous sections of this research. What we intend to achieve in this section is to present the arguments more specifically and distinctively and evaluate them.

Theological arguments against genetic engineering revolve around the notion that such undertaking could amount to 'playing God' and interfering with natural order. The contention is founded on the idea that life is sacred and should not be altered by humans. By 'playing God' we are interfering with the natural process of creation and thus are violating the will of God. It has however been argued that this argument does not have solid grounding since most theologians themselves agree that God expresses himself in every facet of creation by granting humans to freedom to explore and dominate other creatures. Genetic engineering can thus be viewed as an expression of free will (Koepsell 2007:15).

The other argument against genetic engineering that is theologically inclined is that it changes the fundamental nature of an organism in a way that would never occur in nature and hence it is immoral to do so. It other words, genetic engineering goes against the created order of things in nature. This argument too does not have a strong basis, proponents have suggested, since the very definition of technology is to alter nature for the betterment of living (Hon-Ming, 2013:42). Our culture exists solely because of human inventiveness and our ability to change the natural order thrust upon us. Also, we are unclear on the very definition of what is 'natural' and even if genetic engineering is unnatural there is no reason why it should be unethical.

Some arguments against genetic engineering are grouped into secular arguments. The secular argument against genetic engineering is founded on the need to preserve the dignity of the human life which is only possible when the human life is protected in its natural state, i.e., unaltered by human intentions or actions. This argument does not hold good in face of natural 'indignities' that occur in nature. For example, a person suffering from Lesch-Nyhan syndrome (a genetic disorder) has an uncontrollable desire to self-mutilate himself, so for that person, dignity is not in his natural state but rather in overcoming it. Overcoming our natural disadvantages does not violate our inherent dignity (Preston, 2007:42).

Mill (1853) based his theory of liberty on human autonomy and self-determination (34-45). Based on this viewpoint, some have argued that it is our autonomy to dispose ourselves as we please that gives us dignity as human beings, therefore in this sense modifying our genes to get rid of our disabilities is not inherently wrong. However, every other scientific intervention especially in medicine and biology poses the same threat. Legislations and adherence to professional ethics can go a long way to curb practices with negative tendencies to indignity.

From another perspective, opponents to genetic engineering claims that the technology requires that we take a reductionist view of life that sees only genes, not individuals, as important. Rifkin notes,

> From the reductionist perspective, life is merely the aggregate representation of the chemicals that give rise to it and therefore they see no ethical problem whatsoever in transferring even a hundred genes from one species into the heredity blueprint of another species. (Rifkin J. cited in Jaqadish, 2008:4)

But the reductionist is not only pertaining to genetic engineering, the allopathic treatment system itself is based on such a view (Jaqadish, 2008:4). So criticizing genetic engineering on this plane is not very fair, the relaxation allowed to the allopathic medical treatment have to be leveraged to genetic engineering too, proponents have countered.

Similarly, somatic genetic engineering is in principle similar to other established treatment methodologies like blood donation or organ transplant. It is not qualitatively different from these, although quantitative gap from them is enormous, some concerned moralists have argued. The effects of somatic genetic engineering are fast and on a much higher scale (Hon-Ming, 2007:50). Based on this concern, proponents have advocated that greater caution and restraint be employed in the use of genetic engineering procedures to avoid unwarranted harm.

As all forms of genetic engineering will be accessible to more, may be only, to the rich class of society, this will lead to polarization of society, some have argued. It will further expand the inequality between the poor and the rich. So from a justice perspective, genetic engineering is not favoured. This criticism even exists for other medical treatments. The question then is: is it right to abolish critical medical apparatus provided by science and technology simply because of the concern that such would only be accessed the rich and the poor would be left behind? The obvious is negative – no. Even the type of food one eats is still determined by the side of their pockets. Besides, government, non-governmental organizations, privileged individuals and rich countries are trying their best to see that the poor have access to products of genetic engineering especially in health sector.

The decisive position of this seminar is that genetic engineering, in spite of the ethical issues surrounding it, is morally acceptable. The practice should therefore be upheld but extreme caution and preventive measures must be followed while implementing genetic engineering techniques in the treatment of diseases. However, this research is totally against the practice of an aspect of genetic engineering described as germline genetic engineering.

Human germline engineering is the process by which the genome of an individual is edited in such a way that the change is heritable. Stock (2000) describes it as a type of genetic modification that directly manipulates the genome using molecular engineering (5). This is achieved through genetic alterations within the germ cells, or the reproductive cells, such as the egg and sperm. The reasons for the rejection of this strand of genetic engineering are exposed below.

The changes made by germline genetic engineering are permanent and irreversible. This enforces decision that will result in the selection of one and rejection of other gene. As there is no ultimate notion of good, this selection rejection/process is difficult. For example, sickle-cell anaemia allele is more resistant to malaria, so permanent rejection of a particular gene is difficult, and if done the loss might be tremendous. On this ground many have rightly called for a stop or extreme restraint to be exercised in the practice of germline genetic engineering. (See UNESCO, 2015).

Another severe argument against germline genetic engineering is that it kills the variety on earth. As any selection with precision becomes possible, humans will tend to select as per the current trend/fashion. This will lead to the permanent wiping out of some traits like black skin color from the human community. It might end up with the case that, humans will be similar to a batch of cars produced from a factory.

The most severe and controversial argument against germline genetic engineering is that it is unpredictable and could bring unintended results in the future. It has a higher tendency to cast future generations into unforeseen danger. So why engage in a scientific practice that may bring glory today but end up endangering the human race in the future?

Conclusion

Considering the enormous benefits genetic engineering brings to medical science, specifically, the indisputable contributions of this technology to the cure of deadly diseases and hitherto incurable genetic disorders; it would be difficult and very unconventional to argue for the cessation or abolition of the practice. Of course, genetic engineering like every other scientific practice has its drawbacks. These have been rightly acknowledged in the course of this discourse. Nevertheless, it would be illogical and also disastrous to suggest that the practice be abolished due to these obvious inadequacies. Like genetic engineering, no technology is inherently bad; it all depends on the application and usage. If we argue that genetic engineering be aolished due to the negative effects that may follow, we can also argue that other forms of technologies like the use of mobile phones, automobiles, airplanes, etc. should be abolished too because of the probable negative effects that go with their usages.

These having been said, this research acknowledged the irredeemable danger in the practice of germline genetic engineering. This is the only aspect of genetic engineering that the research frowns out. It calls for the abolition of this aspect of the use of the technology because it can obscure or disrupt the natural order in the universe and hence endanger the continuous existence of the human species and some species of plants and animals in the universe.

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