

Genetic Engineering and Biotechnology: An Overview of The Principles That Define Genetic Engineering

Orhan Uluçay¹

Nurcan Koç²

Abstract

Genetic engineering and biotechnology intersect in many ways. All of these areas have been used, albeit unconsciously, since ancient times. For example, between 8000-1000 BC, people of that period crossbred animals such as horses, camels, and various plants such as corn and wheat for agriculture. People have tried to crossbreed animals and plants to get better yields. For example, they crossed a high milk yielding cow with a high hardiness cow and got more milk producing and stronger breeds. Similarly, by crossing high yielding wheat with drought tolerant wheat, more productive plant breeds that can withstand drought were obtained. Not only the ancient Romans or Greeks, but also the Indians began to conduct similar experiments. As a result of these studies, the concept of genetics emerged in the 1st century AD. Later scientific research revealed that humans are made up of sperm. In the 19th century, Mendel made important contributions and firmly established the concepts of genes and genetics. From the 19th century to the present, many studies have been conducted to develop genetic engineering and biotechnology, and it has taken its current form.

Genetic engineering has recently been studied by many scientists by blending it with other sciences. These studies include the organization of genetic material to modify many genetic characteristics that do not exist in living things or to create completely differentiated living things. In this paper, we provide a general overview of the principles that define genetic engineering, focusing on its core concepts, techniques, and applications.

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- 1 Dr. Öğr. Üyesi, Kafkas Üniversitesi, Mühendislik Mimarlık Fakültesi, Biyomühendislik Bölümü, Orcid: 0000-0002-0820-5372
 - 2 Kafkas Üniversitesi, Mühendislik Mimarlık Fakültesi, Biyomühendislik Bölümü, Orcid: 0009-0003-1660-8168

1. Genetic Engineering and Its Principles

Genetic engineering is a branch of science that modifies the hereditary traits of an organism's genetic material through natural means or laboratory cloning (Uzogara, 2000). Its goal is to introduce new functions to the genetic material found in organisms, such as transferring, replicating, or correcting genes (Uluçay, Gormez, & Ozic, 2022). Genetic engineering allows the production of GMO products. For example, some plants can be developed to be resistant to salt or cold. Similarly, the same studies can be applied to animals. In order to get more products, various genetic modifications are applied to living things through genetic engineering (Khoo et al., 2023). Again, genetic engineering can be applied to many animal and plant species, allowing for more efficient crops to be obtained (Kumar, Srivastava, & Prasad, 2023).

1.1. Types of Genetic Modifications

There are several types of genetic modifications that can be made in genomes. Changes can be made to living things at the genetic level. Here, certain targeted regions can be made possible by adding or deleting some unwanted parts on the DNA or by replacing these parts with other sequences (Sufyan et al., 2023). Some regions of chromosomes can be targeted and gene expression can be blocked. Some short chromosome parts can be suppressed and gene expression can be blocked. In addition, some genes that are not working can be activated and some can be silenced. By using genetic engineering, some gene sequences can be changed and the structure and function of proteins can be changed. It has become possible to intervene in living beings in many ways by making various changes on DNA with genetic engineering (Fraser, Davis, & Hynes, 2001). The antibody DNA of creatures such as mice and pigs, which have chromosomes similar to humans, can be changed to match humans. These changes are possible with stem cell technology, and can be used in modeling for some mutations along with such genetic engineering studies.

1.2. Genetic Engineering with CRISPR/Cas9

There are popular and advanced genome editing tools in genetic engineering. One of them is the CRISPR-Cas9 genome editing option (Bhatt & Challa, 2018). Here, with this method, DNA strands can be cut and reconnected in the desired region. The target region is determined, there is a Cas 9 enzyme that is specific for this region (Ma, Zhang, & Huang, 2014). This enzyme contributes to the division in the DNA Target DNA region. In short, this method is a Genome editing tool and is one of the most advanced

methods among genetic manipulation methods. This genetic modification method is used quite frequently in bacteria. Studies have shown that this study gives good results in human and animal cells such as mice. The system works by first determining the target gene and then the alleles related to this target. In this system, it is very important to reach the target completely. Therefore, the determined concentrations must be worked on correctly. (Hajiahmadi et al., 2019).

2. Biotechnology and Its Applications

Biotechnology is the techniques used to follow and, if necessary, modify the processes of living organisms, namely microorganisms, humans and plants (Holzinger, Keiblinger, Holub, Zatloukal, & Müller, 2023). Microbiology is the totality of technologies used to understand, change the functions of all or part of living beings (plants, animals or microorganisms) and to obtain products that do not exist or are rare, by utilizing natural sciences such as genetics, molecular biology, biochemistry and physiology as well as technology and engineering. Genetic Engineering and Biotechnology can work together. Biotechnology aims to benefit living beings by using the products of Genetic Engineering (Santomartino et al., 2023).

2.1. Agricultural Biotechnology

Agricultural biotechnology is related to many fields of science. One of these is agricultural biotechnology. The aim here is to make plants that cannot adapt to extreme conditions resistant through various biotechnological methods (Sakiroglu et al., 2011). Here, GMO products, that is, genetically modified organisms, are given features that they do not have. As a result, living things can better adapt to extreme conditions for their development. Bt cotton is the best example of this. The product now has a gene sequence that does not belong to it, and this creature, which is sensitive to many insects in the field, can easily reproduce without the need for chemicals with the genes/characteristics it has acquired (Kedisso et al., 2023).

2.2. Medical Biotechnology

Biotechnology covers many sub-branches. One of the most important of these, medical biotechnology, has a very important place in vaccine production, treatment and diagnosis of various diseases (Sanvicens & Marco, 2008). With the development of medical biotechnology, especially in the diagnosis and treatment of some diseases, an era has been leapt. Insulin production for diabetes, which is still a big problem today and disrupts the quality of life of many people, has become quite simple with

the development of biotechnology. Again, in the production of many similar drugs and vaccines, biotechnology is with many scientists together with genetic engineering (Khan et al., 2016). With medical biotechnology, treatment and diagnosis can be applied specifically to individuals (Petersen, 2009).

2.3. Industrial Biotechnology

Another sub-unit of biotechnology is industrial biotechnology. Especially with industrial biotechnology, building a world free of chemicals has become a very easy process (Erickson & Winters, 2012). Microorganisms are frequently used in industrial biotechnology processes. The biggest reason why microorganisms are preferred is the enzymes they produce. These enzymes often replace chemicals and play a role in many complex details, especially waste removal. At the same time, many biologically based products can be produced with industrial microbiology. Further development of the enzymes of these microorganisms and increasing their effectiveness is possible through genetic engineering (Quintana, Van der Kooy, Van de Rhee, Voshol, & Verpoorte, 2011).

2.4. Environmental Biotechnology

Another sub-unit of biotechnology, environmental technology, is a known scientific field for supporting environmental problems. (Kalogerakis et al., 2015). Here, many factors such as bioremediation play a role in the elimination of various wastes. Microorganisms developed through genetic engineering are of critical importance. Microorganisms are preferred by using targeted improvements. Microbiology-based energy sources can also be obtained with microorganisms and their enzymes (Ulucay, Gormez, & Ozic, 2021).

3. Ethical Considerations

Biotechnology is a very important issue and scientists should pay attention to ethical factors while doing biotechnological studies. Some ethical factors:

3.1. Safety

Genetically modified organisms are one of the biggest concerns in biotechnology. They need to be regulated to a degree that will not harm human health. They also need to be environmentally friendly. Therefore, it is important to correctly evaluate the analysis results of the studies conducted here (Premanandh, 2011).

3.2. Environmental Impact

When the environmental impacts of GMO individuals or seeds are evaluated, their release into natural habitats may cause the population balance to be disrupted. Therefore, strict measures must be taken to minimize these risks. It is essential that all organizations are under control and balanced (Prakash, Verma, Bhatia, & Tiwary, 2011).

3.3. Social and Economic Implications

With biotechnology, people can obtain more products per unit area, and with the decrease in agricultural areas, food problems are experienced with the rise of reinforced concrete buildings. Biotechnology can affect many areas such as medicine, agriculture, industry and industry (Tyczewska, Twardowski, & Woźniak-Gientka, 2023). Especially with biotechnology, solutions are provided to these problems through genetically modified organisms. With the development of biotechnology, the balances in the socio-economic conditions in the environment are changing positively. If access to biotechnology is provided equally and fairly throughout the world, the problem of hunger in the world will also be overcome.

3.4. Informed Consent and Labeling

Although it divides the scientific community into two, when we look at the world today, genetically modified organisms have become essential, especially for herbal products to be sufficient for the world population. However, in addition to all this, consumers also need to be informed about the content of the product they choose. When GMO products meet their buyers in the market, there must be explanations that describe them in detail (Jin, Li, Naab, Coles, & Frewer, 2023; Mohan, 2023).

3.5. Genetic Engineering and Human Enhancement

Changes that will be made to the genetic structures of individuals raise ethical questions (Sandler, 2020). Genetically modified organisms do not remain only at the plant level. Today, some changes can be made even on the human genome. However, ethical morality comes to the fore here. The possibility of a physically or genetically advanced being will increase society's concerns about the concepts of justice and equality.

3.6. Privacy and Genetic Information

Today, many researchers around the world are conducting unlimited research using genetic information. However, the confidentiality of genetic information belonging to individuals is very important. If this information

is open to use, it can be used with malicious intent. Therefore, it is necessary to have various laws to ensure that the stored data is not publicly available and is confidential (Clayton, Evans, Hazel, & Rothstein, 2019).

3.7. Access and Equity

Biotechnology and its benefits should be accessible to all humanity. If there is inequality in society, social balance will be disrupted and crises will occur. Therefore, everyone should have technological tools that are equally available.

3.8. Environmental Impacts

It should not be forgotten that biotechnology and genetically modified organisms, one of its blessings, can sometimes lead to unexpected results for society. Namely, before releasing genetically modified organisms into nature, various risk analyses should be conducted and their controls should be regularly ensured (Maghari & Ardekani, 2011).

3.9. Informed Consent

In genetic engineering, human studies are also frequently conducted in addition to plant and animal studies. Here, in human studies, the possible risks and benefits for the participants should be clearly stated (Rossfeld, Cloyd, Palmer, & Pawlik, 2020). As a result of these statements, approval should be obtained and the studies should proceed. Ethical issues should not be neglected in the steps taken while these studies are progressing.

After all, genetic engineering is very important for all living things. However, and only here, the ethical issue for all living things should never be relaxed (Bruce & Bruce, 2014).

4. Current Trends in Biotechnology

4.1. CRISPR-Cas9 Technology

The CRISPR cas 9 technology as a doctor intervening in DNA. It is a method of genome editing and organizing. It is a tremendous technology that allows scientists to delete, remove, add or edit genes on DNA in biotechnology studies. Here, the target organism has its own sequences that recognize the DNA CRISPR locus. These sequences consist of Cas genes and a series of spacer sequences that follow them. With this method, very successful results are obtained in the diagnosis and treatment of many diseases (Rissberger, 2021).

4.2. Synthetic Biology

One of the important sub-branches of biotechnology is synthetic biotechnology. It is a branch of science that brings together synthetic biotechnology and products that cannot be obtained naturally by blending engineering and biotechnology. (Andrianantoandro, Basu, Karig, & Weiss, 2006). The aim here is to obtain the desired element by genetic engineering. Again, with this method, it is aimed to eliminate waste by creating positive effects on the environment and ecosystem or to produce environmentally friendly products such as biofuels (Tong & Zhang, 2023).

4.3. Personalized Medicine

Personalized medicine is an approach that aims to tailor healthcare based on an individual's genetic makeup, lifestyle, and environmental factors. This field of medicine seeks to determine the most effective treatment methods and preventive health strategies by utilizing each patient's unique profile. Advances in genetic engineering have also improved the treatment routes of individuals. As a result of genetic analysis of individuals, how to make the most effective treatment and how to get better results are analyzed and the possible negative effects are minimized. This has been a very important step in the field of health (Liao, Xiao, & Wang, 2023).

4.4. Bioinformatics

Bioinformatics, which has a very important place in biotechnology, includes the computer and mathematical interpretation and application of genetic data. With bioinformatics, very complex genetic sequences are analyzed and as a result of these analyzes, it is predicted what kind of changes structures such as proteins will show. This sheds light on how drugs or treatment methods will progress for researchers (Rawat et al., 2023; Varshney, Bharti, Sundram, Malviya, & Fuloria, 2023).

4.5. Nanobiotechnology

Nanobiotechnology is a branch of science that is applied especially for the development of small-scale biotechnological tools. It develops very small-scale materials and enables them to reach their targets at the molecular level. It allows treatment and research to progress easily while minimizing the margin of error in some sensitive diagnostic methods (Maurya, Mukherjee, & Ranjan, 2023; Soni et al., 2023).

5. Future Prospects

As the years go by, the importance of biotechnology increases and biotechnological studies are carried to more advanced levels. There are promising areas for the future within this:

5.1. Gene Therapy

In gene therapy, many methods such as deletion, re-addition or editing of various genes can be applied with the CRISPR method. These include effective gene transfer or editing of defective genes. This has made gene therapy quite remarkable (Arabi, Mansouri, & Ahmadbeigi, 2022).

5.2. Stem Cell Research

Stem cells are one of the rare cells that have the ability to transform into other cells. These cells can differentiate over time and transform into different tissues and organs. At the same time, stem cells affect damage in the area where they are located, help organs such as tissues to re-develop and thus help treat many diseases (Mimeault, Hauke, & Batra, 2007).

5.3. Sustainable Biotechnology

Today, sustainable energy and resources are doomed to decrease in the world. Therefore, it is important to work on biotechnology-based products. (Hatti-Kaul, Törnvall, Gustafsson, & Börjesson, 2007). Biotechnology should be used to produce biologically derived materials and microbial-based removers should be preferred for waste disposal. This should be preferred as an environmentally friendly approach (Uluçay, 2023).

5.4. Neurobiotechnology

Neurobiology is a sub-branch of biotechnology. It is formed by the blending of biotechnology. Neurological structures and disorders of the human brain are being treated and promising steps are being taken for the future. Advances in this technique offer promising paths for potential treatment methods and are also constantly advancing with biotechnology (Fitzgerald, 2017).

7. Conclusion

Biotechnology is a very comprehensive branch of science that includes genetic engineering, mathematics, computer engineering, chemical engineering, environmental engineering and all other multidisciplinary fields. Biotechnology provides important contributions to our lives from health to agriculture. As biotechnological studies progress, the convenience of life continues to increase.

However, these advances should not exceed ethical elements. Biological and biotechnological research and the benefits they provide should be provided equally to societies. Scientists continue to work on animal, plant and microbial origins in order to ensure the well-being of people. It is hoped that the challenges awaiting our societies will be overcome thanks to advances in biotechnology.

By balancing scientific progress with ethical considerations, we can harness the full potential of biotechnology to improve human well-being, address societal challenges, and create a sustainable future.

ACKNOWLEDGEMENT

In the compilation of this article, the authors have been assisted by some programmes to improve spelling and readability. These are grammarly, AI, deepl, google translate and quillbot. The authors reviewed and edited the content after using these tools.

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