A Survey on Immune System in Genetic Engineering and their Applications

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Abstract

The increasing number of human diseases has become a major global concern. Researchers have found a novel way to defend against some of the deadliest diseases emerging across the globe. Incorporating a genetic modifications in immune cells can result in producing more powerful antibodies. With this technology, researchers have now successfully defended a potentially fatal lung infection. The similar approach might be effective in treating other human diseases. The integration of immune system in genetic engineering is being studied by combining wide range of techniques and organisms from agriculturally relevant plants to other genetic models such as Drosophila to humans. This initiates the research investigations on the rapid advancement of genetic engineering, including advancements in research and education. This study discusses the concept of genetic engineering in the immune system, as well as various types of genetic engineering and their applications. This work discusses about preserving an endangered species while promoting free market environmentalism.

1. Introduction

1.1. Immune system

The immune system interacts with each organ and emerge as a necessary component of the human body. Cancer, viral diseases, chronic inflammation, and other illnesses will result in an insufficient or excessive immune response. In order to understand the complex processes and create more effective treatments, recent developments in biomedical and immunoengineering field have enabled researchers to modify the immune cells.

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Immune system act as the body's protection against any infection [9]. Without it, the body wouldn't be able to defend itself against any attacks from bacteria, viruses, parasites, and other harmful organisms. There are three main immune system components seen in many species.

* Innate immune system
* Adaptive immune system
* Passive immune system

The innate immune system is the initial line of protection against the entry of germs like virus, bacteria and more. Each and every multicellular organism possesses different components of the innate immune response. It is also called as the non-specific, immune system, which can immediately prevent the spread of non-self-pathogens or foreign pathogens throughout the body. Adaptive immune response is the second line of protection against non-self-infections. It is also referred to as acquired immune system. The passive immune system is a temporary type of immunity, where a trusted source is derived from a different person. The immune system has been developed to fight against some pathogens and even cancer pathogens, but experts point out that having a strong immune system can also make one more vulnerable to autoimmune diseases, which are the rare conditions in which the body turns its immune system negatively by self-attacking the healthy cells. According to experts, genetics appears to control the quantity of adaptive immune system cells that target dangerous bacteria or healthy cells [8]. The amount of one or more particular types of immune system cells were significantly impacted by variations in particular genes.

1.2. Importance of Genetic Engineering

The genetic engineering sector has grown to be a significant economic factor for the country as a result of the recent global economy development. Even though Genetic engineering has enormous economic benefits, the complicated production process and the variety of raw materials and waste products remains as the significant drawbacks. The technology-based modification and manipulation of an organism's genes is known as Genetic engineering, which is also referred to as genetic modification or genetic manipulation. It is a group of technologies used to change the cell's genetic makeup, including the gene transfers within and across species boundaries in order to produce an improved or entirely new creatures [10]. The term "genetic engineering" is typically used to describe the recombinant

DNA technology, which is developed as a result of microbial genetics. The "genes" found in human or other organism cells regulate the chemical processes that cause a cell to develop and operate, and ultimately regulate the growth and performance of an organism. Genetic engineering is a closely related technology that involves altering the genetic framework of organisms. The goal of genetic engineering is to modify the genes in order to increase the organism's capabilities.

Several serious ethical issues are raised by genetic engineering. For instance, in agriculture, ethicists have drawn significant attention to the development and application of genetically engineered crops or cattle to produce a genetically modified food [1]. Numerous studies have been conducted on genetic engineering by mainly focusing on improving the production of plant and animal food, identifying disease conditions, improving medical treatment, and producing vaccines and other helpful medications.

2. Methods of Genetic Engineering

The genetic engineering methods are used to create novel plant, animal, and microbial strains are briefly described below. The genetic engineering method involves transferring DNA from one organism to another. There are four types of genetic engineering as discussed below. Table 1 shows the different types of genetic engineering techniques.

- ❖ Selection
- ❖ Mutagenesis
- ❖ Conjugation
- ❖ Protoplast Fusion

Table 1: Types of Genetic engineering techniques

Types	Definition	Application	Advantages	Disadvantages
Selection	To determine potential genes and further tests then used to identify desired cell type	Selective breeding (Artificial Selection)	∗ Reduce food allergens. ∗ Better target characteristics	∗ Not ensure the integration of the GOI ∗ The long-term

				impacts are unknown
Mutagenesis	An organism's genetic information is changed, causing a mutation.	Recombinant DNA technology	* Cheap * Simple, Quick way to introduce new variety * More efficient in improving oligogenic characters	* Harmful and undesirable * Limited potential for genetic improvement
Conjugation	Transfer the genetic material across bacterial cells to an adjacent bacterium	1.Isolated mammalian mitochondria 2.Antibiotic resistance	* limited target distribution cellular envelope * Long term protection * Improved immune and memory response	* More complex and complicated * Loss of immunogenicity
Protoplast Fusion	Transferring the genes to produce a particular amount and quality of production	Somatic hybridization	* Strain improvement * High-speed transformation * Multi-plasmid delivery with high co transformation rates	* Does not generate seeds that are visible and viable. * Highly genotypic dependent

2.1 Selection

Selection is the process of utilizing the scientific techniques to determine the potential genes and further tests to identify a desired cell type. This gene can be found in lineage-restricted stem cells or terminally differentiated cell types. The genetic selection is also referred to as **genetic screening**. There are two primary types of genetic selection. The first one is natural selection, which is a biological process that favours some physical characteristics. The second type of genetic selection is artificial selection. This is a synthetic, human-made selection procedure, which is carried out on foetuses or embryos.

Focused selection or selective breeding can produce even greater advances in productivity and efficiency in farming environment. Selective breeding is the process of identifying desirable qualities in plants and animals, which then strengthen and pass those traits on to succeeding generations [4]. Selective breeding is also known as the artificial selection. Selective breeding operates in a similar way to natural selection, with the exception that in natural selection, these judgments are made by nature without human intervention.

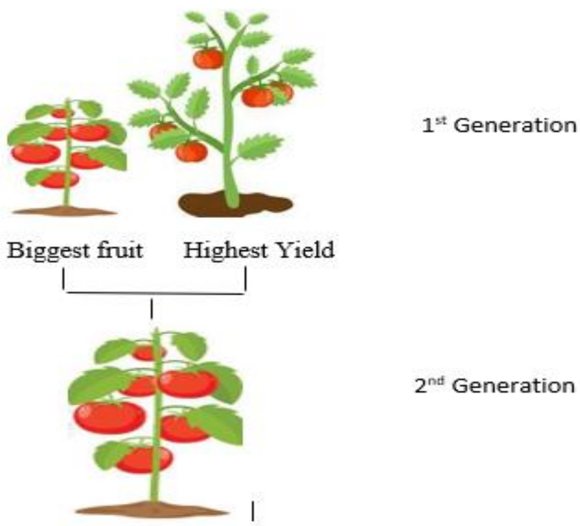

Fig 1: Selective breeding

For instance, through selective breeding, high yield varieties can be produced. It is highly used to reduce the food allergens and also provide better target characteristics. However, the life cycle of plants and the genetic variants that are naturally present limits the process of selective breeding. In selective breeding, the long-term impacts remain unknown. Fig 1 shows the best performing plants in the process of selective breeding.

2.2. Mutagenesis

Mutagenesis is a process by which an organism's genetic information is changed, causing a mutation. It was developed by charlotte Auerbach. It could happen on its own in the natural world or as a result of exposure to mutagens. Using laboratory techniques, it can also be Achieved experimentally [11]. There are several types of mutagenesis, including Random mutagenesis, Directed mutagenesis, PCR mutagenesis, Insertional mutagenesis and so on.

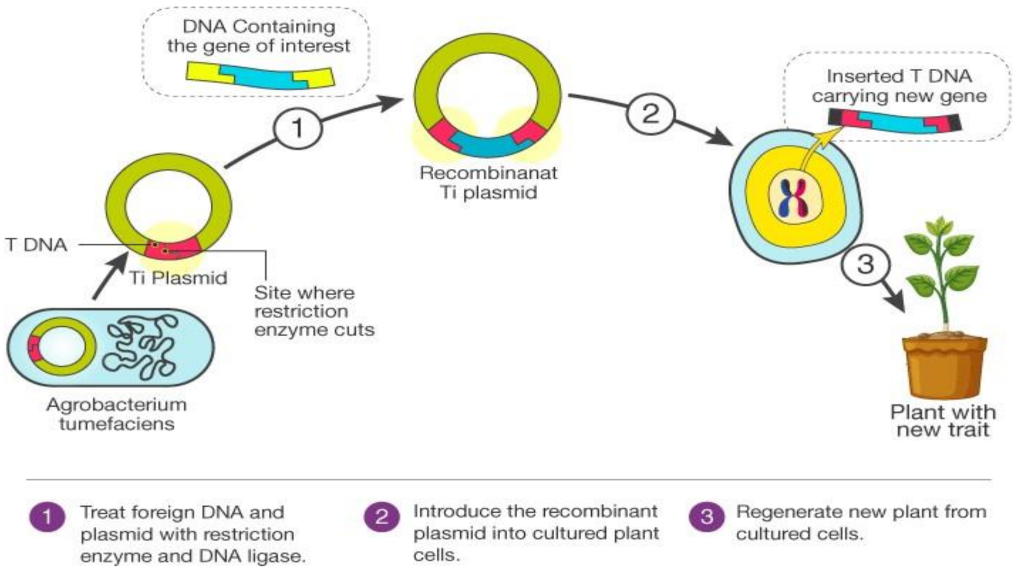

Fig 2: Recombinant DNA technology [2]

Recombinant DNA is DNA that has been formed synthetically by combining elements from different organisms. Recombinant DNA is considered as the one of the applications of mutagenesis. We can isolate and replicate a single copy of a gene or DNA sequence into an infinite number of identical duplicates by using Recombinant DNA technology [12]. Recombinant DNA (rDNA) molecules are the new combinations of genetic material, which are inserted into the host cells, where they multiply and spread. This technique is known as Recombinant DNA technology. Mutagenesis is cheap and rapid method of developing a new variant. It is a simple and quick way to introduce new variety and more efficient in improving the oligogenic characters. It has several negative features as well as most of the mutagenesis are harmful and undesirable. It has limited potential for incorporating a quantitative genetic improvement. Fig 2 shows the Recombinant DNA technology process.

2.3. Conjugation

Transferring the genetic material across bacterial cells to an adjacent bacterium is known as conjugation. It involves two bacteria, where one is considered as donor cell and another one is considered as recipient cell. This takes place through pilus. The majority of time, this DNA is present in the form of plasmid. This DNA is directly transferable and it requires a direct contact between the donor cells and recipient cells by including a conjugation tube [13]. Fig 3 shows the schematic diagram of the conjugation. It includes the A. Donor cell produces pilus, B, which brings the two cells together, pilus attaches to recipient cell, C. A single strand of DNA is then transmitted to the recipient cell when the mobile plasmid is nicked. D. Both cells circularize their plasmids, create second strands, and reproduce the pili.

The major application of conjugation is the transfer of genetic material to different targets. Bacteria to yeast, plants, and human mitochondria have all been successfully transferred in experimental settings. It is also used to enable antibiotic resistance. Conjugation has advantages such as limited target distribution in cellular envelope, long-term protection and improved immune and memory response. It also has a number of drawbacks, such as difficult and complicated preparation process. During the conjugation process, immunogenicity will be lost.

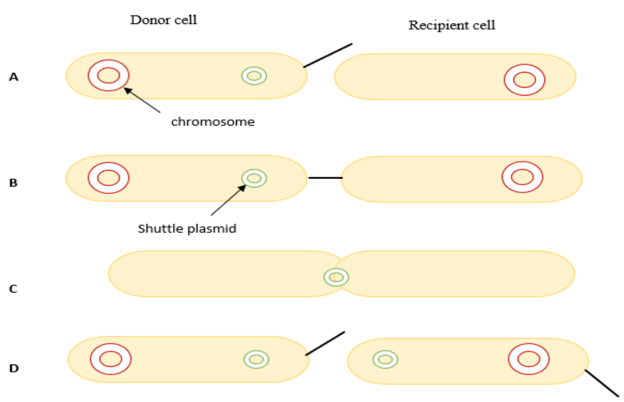

Fig 3: Conjugation schematic diagram [17]

2.4. Protoplast Fusion

Protoplast fusion is a process of transferring the genes to produce a particular amount and quality of production. When two or more protoplasts fuse together, they come into contact and stick together either naturally or with the help of fusion-inducing chemicals.

Protoplast fusion is considered as an important technique in incorporating strain improvements. It has significant potential to enable strain improvements.

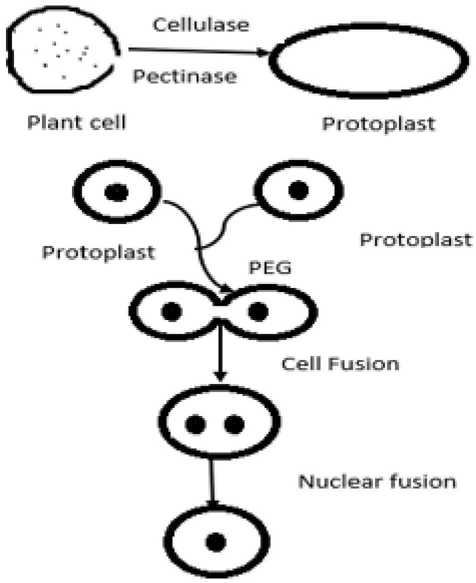

Fig 4. Somatic hybridization [18]

Somatic hybridization has a wide application in developing a protoplast fusion. Fig 4 shows the concept of Somatic hybridization. Somatic hybridization is the process through which two different plant species (somatic protoplasts) combine to form hybrid plants [14]. Advantages of Protoplast Fusion include: high-speed transformation, multi-plasmid delivery with high co transformation rates. A variety of disadvantages are also present, including the fact that it does not produce visible and viable seeds and is highly genotypic dependent.

3. Application of Genetic Engineering

Genetic Engineering (GE) can be used in variety of plants, animals, microorganisms and it has applications in medicine, industry, research and agriculture. As more and more are discovered about various organisms' genomes, the variety of applications for genetic engineering is also increasing. A notable or few interesting application areas shown in the table 2. This section briefly discusses about the application of genetic engineering in medicine, industry, research, plants, animals and agriculture.

Table 2: Application of Genetic Engineering

Sectors	Examples	Description
Medical	1.Gene therapy 2.Production of insulin 3.Human growth hormone 4.Interleukin-2	1. Gene therapy involves inserting healthy alleles into a patient's cells to address genetic disorders. 2. Treatment for diabetes with human hormone 3.HGW used to treat dwarfism 4. Antibiotics, which are used to eradicate germs
Industry	1. Recombinant DNA technology 2.Microorganism	2. Using genetically modified bacteria and other microorganisms, it is possible to manufacture a wide variety of chemicals.
Agriculture	1.Insect resistant plant 2.Golden rice	1. Bactria bacillus thuringiensis gene-modified plants can produce the toxin protein that kills insects that attack them. 2. The body converts extra beta-carotene found in rice treated with daffodil genes into vitamin A.
Animals	1.Transgenic sheep 2.Transgenic fish	1. Florescent protein genes will enable animals to grow in the dark. 2.Salmon modified using growth hormone-regulating genes to reach market sizes in a lot less time.
Food	1.Tomato 2.Corn 3.Soybeans 4.Cotton	1. Tomatoes that have had the genes that cause fruit to soften removed spoil more slowly. 2. Corn that has had a gene for a bacterial insecticide added to it creates insect poison inside of the cells, shielding it from pest species.

Education	1. Gel electrophoresis 2.PCR	1. Proteins or DNA fragments are separated based on size using gel electrophoresis. 2. Small amounts of DNA can be amplified using PCR.
Environmental applications	1.Pest resistant crops	1. Bioremediation through the development and enhancement of bacteria that can break down xenobiotics
Pharmaceutical Industry	1.Regulatory Proteins 2.Monoclonal Antibodies	1. Human insulin and interferon, an antiviral substance that thwarts virus attacks and kills cancer cells 2. It includes certain vivo diagnostics and vitro diagnostics, such as radioactive and chemical diagnostics.

3.1. Genetic Engineering in Medical and Pharmaceutical Industry

3.1.1. Medical

Today, a wide range of medical products are available because of genetic engineering [5]. Genetic engineering enables many advantages in the field of medicine, which includes the gene therapy, insulin production, human growth hormone, Interleukin-2, vaccines and many other drugs.

Gene therapy is a genetic engineering technique, which replaces the defective genes with effective ones. Gene therapy involves inserting healthy alleles into a patient's cells to address genetic disorders. Gene therapy has various drawbacks since the immune system of the patient may sometimes destroy the genetically altered cells. Human hormone and insulin production is used in the treatment of diabetes. . Insulin is a hormone made up of protein. A type of human growth hormone made by genetically modified bacteria and yeasts is used to treat dwarfism [6]. Interleukin-2 is an antibiotic, which is used to eradicate germs.

3.1.2 Pharmaceutical Industry

Pharmaceutical industry is one of the emerging applications of genetic engineering. It is used to produce a large number of low-cost high quality new drugs such as the pharming, human insulin, regulatory Proteins, monoclonal antibodies. "Pharming" is referred to produce pharmaceuticals from transgenic animals. Human insulin and interferon, an antiviral substance that thwarts virus attacks and kills cancer cells. It includes certain in-vivo and in-vitro diagnostics such as radioactive and chemical diagnostics [16].

3.2. Genetic Engineering in Industry

The industrial use of genetic engineering has advanced to a point, where a completely new area can be combined. For example, using recombinant DNA technology, metabolic networks will be restructured by enlisting the proteins from other cells [15]. Microorganisms like bacteria or yeast, as well as insect mammalian cells can be modified to express a gene that codes for a valuable protein for industrial purposes. Using genetically modified bacteria and other microorganisms, it is possible to manufacture a wide variety of chemicals.

3.3. Genetic Engineering in Agriculture and Animals

3.3.1. Agriculture

One of the important applications of genetic engineering is agriculture. To develop genetically modified crops or other genetically altered species, agriculture uses genetic engineering. [1] The major advantages of genetic engineering in agriculture field are higher crop yields, lower costs for food or drug production, a decrease in the need for pesticides, improved nutrient composition and food quality, greater food security, and health advantages for the world's expanding population.

Genetic engineering contributes to overall crop growth and production by increasing medicinal and nutritional value [7]. Numerous applications of genetic engineering are possible in agriculture, they are: crop improvement, herbicide resistance, insect resistance, virus resistance. For example, insect resistant plant is used to bacteria bacillus thuringiensis gene-modified plants, which can produce the toxin protein to kill the insects that attack them [3]. The body converts extra beta-carotene found in golden rice treated with daffodil genes into vitamin A.

3.3.2. Animals

To improve the trait of transgenic animals, transgenes are inserted into the animal during genetic engineering. Transgenesis is the process of integrating a gene or a portion of a gene from one person into the genome of another. For example, transgenic sheep, transgenic fish and transgenic cows. In transgenic sheep, human gene inserted into the sheep chromosomes that allows to produced clotted protein in the sheep’s milk and also florescent protein genes will enable animals to grow in the dark. Similar methods can be used in transgenic cows also. The genetically modified fish or transgenic fish (ex. salmon) are considered as genetically modified organism. Genetic engineering techniques can also be used to change the fish's DNA. Salmon, a particular fish type can be modified by using the growth-regulating genes to reach the increasing market size.

3.4. Application in food industry

Genetic engineering has been envisioned to have a multitude of food industry applications. The food sector uses genetic engineering as a result of the genetic modification incorporated in plants or animals. Today's market is filled with a variety of foods that have been genetically modified (GM) or the ingredients that make them modified.

Foods that are made from genetically modified organisms are referred to as GM foods. For example, Tomato (known as Flavr Savr) enhanced to be more rot-resistant, was the first crop to be genetically engineered [5]. Tomatoes that have had the genes that cause fruit to soften removed spoil more slowly. Next one is corn. The corn that has had a gene for a bacterial insecticide added to it creates insect poison inside of the cells, shielding it from pest species. Researchers and biotechnologists worked on a variety of crops to develop nutritionally superior features that would benefit consumers of genetically modified foods and commodities. They have made an effort to create GM crops that are resistant to specific pesticides and herbicides, such as rapeseed and soybeans.

3.5. Application in Education and Environment

3.5.1. Education

For natural scientists, genetic engineering remains as an important tool. In scientific study, creatures are genetically modified to learn how certain genes operate. In education research, it is possible to transfer genes and other genetic material from a variety of organisms into bacteria for modification and storage, resulting in genetically manipulated bacteria. For instance, Gel electrophoresis and PCR. The Proteins or DNA fragments are separated based on size using gel electrophoresis. The Small amounts of DNA can be amplified using PCR.

3.5.2. Environment

Genetic engineering is exploiting the huge potential of microorganisms, plants, animals for the restoration of the environment [5]. The generation of microorganisms and biocatalysts for the rehabilitation of extreme environments is actively driven by genetic engineering. For example, Pest resistant crop is a bioremediation through which the development and enhancement of bacteria can easily break down the xenobiotics

4. Challenges and Ethical Issues of Genetic Engineering

Genetic Engineering (GE) holds the promise to treat many diseases but they are still in the nascent stage and may have risks. The area of genetic engineering has advanced quickly, yet there are still many obstacles to overcome. One significant challenge is the limitation of genetic engineering based GM food. As GM foods are not independently evaluated before they are permitted, human health is at risk due to its allergic reactions. Other potential challenges of genetic engineering is the genetically modified crops, which can potentially leverage harmful impacts on health. The bioethics of genetic engineering are the hottest topic of research because those opposed to it say that we should have the freedom to alter or shape nature to suit our purposes.

5. Conclusion

The study of genetic engineering has undoubtedly expanded in recent years. In this time, the potential areas of biomedical engineering, immunology, material science, medicine, chemistry, biology, and others have come together to form a new discipline. This study has briefly reviewed the concept and definition of genetic engineering along with an analysis on their advantages. By using genetic engineering, many theoretical and practical aspects of gene function and organisation have improved. This review has provided sufficient information on importance of genetic engineering in immune system by including a brief discussion on various types of genetic engineering. The use of genetic engineering and its potential are also discussed. There is no doubt that this technology will continue to present intriguing and potential challenges for 21st century scientists and ethicists, and education and meaningful, respectful discourse are just the starting point of what is required to overcome the complex ethical challenges.

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Mukil Alagirisamy received her Bachelor degree in Electronics and Communication Engineering, in 2005 and Master of Engineering degree in Communication Systems in 2007 from Anna University, India. She started her career in 2007 as a lecturer at Hindustan Engineering College, India. She was working as an Assistant Professor at B.S. Abdur Rahman University, India until 2011. In later 2011 she joined as a Lecturer at Stamford College, Malaysia. Currently she is working as a Senior Lecturer and Coordinator for Master of Science in Electrical, Electronics and Telecommunication Engineering programs at Lincoln University College, Malaysia. She has 10 years of experience in teaching subjects like Data Communication, Analog and Digital Communications, Digital Signal Processing and Satellite Communications. Currently she is a PhD student at the Faculty of Engineering, University of Malaya. Her research interests are in Sink mobility patterns, Clustering, Modulation, Data Aggregation and Compressive Sensing Techniques for Wireless Sensor Networks.