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Microbes and Genetic Engineering

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Abstract

Genetic Engineering is the operation of micro and macro-organisms to yield useful products for mankind from its diverse applications. Managing desired gene expression outcomes successfully in microbial or higher cells other than its origin cell, is the skill of Genetic engineer. Genetic engineering has applications in various domains such as, agriculture, bioscience, healthcare, life sciences and research and development. It's a commanding tool to further unravel the secrets of evolution, understanding gene expression, biosimilar manufacture, organ formation and regeneration research. In the current article we explained role of microorganisms as such in this Genetic engineering.

Keywords: Microbes; Genetic Engineering

Genetic Engineering and its scope

Genetic Engineering is the manipulation of micro and macro-organisms to yield useful products for mankind from its extensive applications. Genetic Engineering is a technology that has been taken from its concept to effective execution and is very attractive to aspiring biotechnologists. This branch of engineering holds several miraculous promises, mainly due to the resounding success it has enjoyed since the discovery and commercialization of bacterial derived human insulin (Humulin) in 1982. This pioneering example demonstrated the strong potential of genetic engineering, especially to develop a cure for several diseases including cancer. The horizons of this technology are ever-expanding at a pace comparable with advancements in electronics and silico-technology.

Deoxy-ribose nucleic acid (DNA) in living cells of different organisms is unique with respect to the sequence and number of base pairs in its make-up. Essentially, DNA is a bunch of genes which are distinctive sequences in DNA, coding specific proteins. Gene expression in its original host cell yields certain products as a natural process. However, managing desired gene expression outcomes successfully in microbial or higher cells other than its origin cell, is the skill of Genetic engineering. It primarily involves appending foreign DNA or synthetic genes into an organism to produce the molecule of interest. In Genetic engineering the targeted modulation of genetic material, and non-targeted, non-transgenic methods—including chemical mutagenesis and breeding—are various methods of genetic modification used to alter the genetic composition of plants, animals, and microorganisms. Genetic engineering has applications in various domains such as, agriculture, bioscience, healthcare, life sciences and research and development. It's a powerful tool to further unravel the secrets of evolution, understanding gene expression, biosimilar manufacture, organ formation and regeneration research. It can be practiced on a wide range of life forms such as plants, animals and microorganisms.

Genetic engineering and market potential

The Indian biotech industry based on products of Genetic engineering has around 2% share in the global biotech industry and comprises around 800 companies valued at a whooping US$ 11 billion growing at a Compound Annual Growth Rate (CAGR) of 20%. Institutions such as the Department of Biotechnology (DBT) India, and National Biotechnology Board (NBTB) and other autonomous organizations representing the biotechnology industry promote funding to support R and D and product development activities relevant to the field of Genetic engineering. At the heart of this strong biotech industry are the ubiquitous microorganisms, the tiny workers modulated for specialty functions through genetic engineering.

Figure 1

Why do scientists consider microbes for genetic engineering studies?

Microorganisms such as certain bacteria and yeasts have been used extensively in genetic engineering. The reasons are obvious; these life-systems are comparatively simple, genome sizes are smaller (but complicated enough to be challenging to work with), generation times are very small (which means they grow faster), supported rapid studies of several generations, and are scalable to the required extent. Moreover, investigation of a variety of microorganisms have demonstrated existence of tremendous metabolic diversity, which gives them extreme levels of environmental adaptability with respect to temperature, pH, pressure, minerals and nutrient un-availability.

The general principle of steps in genetic engineering in microbes

Universally microbes are used for two purposes - Primarily for use as vectors (carriers) and hosts in gene transmission for expression of the desired gene and secondly, microbes themselves are modified to function as producers or tools in the genetic engineering process.

The key steps in genetic engineering are as follows:

1. Isolation of the gene (target DNA) to be cloned (for adding to producer organism).
2. Insertion of the gene into another piece of DNA called a vector (Carrier) which allows it to be taken up by the recipient cell and replicated.
3. Transfer of the recombinant vectors into microbes, either by transformation or infection using viruses.
4. Selection of microbial cells containing the desired recombinant vectors.
5. Growth of the transformed microorganisms.
6. Expression of the gene to obtain the desired product.

Display of applications of microbes through genetic modifications

Some key microbes currently used in genetic engineering in healthcare and research institutes are précised herewith.

Since the birth of molecular cloning, the bacterium *Escherichia coli* (*E. coli*) has been used as a host for introduced DNA sequences. In 1973, Herbert Boyer and Stanley Cohen showed for the first time that two short pieces of bacterial DNA could be ‘cut and pasted’ together and returned to *E. coli*. They went on to show that DNA from other species, such as frogs, could also be introduced in *E. coli*. Their experiments dramatically demonstrated the potential impact of DNA recombinant engineering on medicine and pharmacology, industry and agriculture.

Genetic engineering had made the leap from the laboratory to the boardroom, as corporations made small fortunes inserting genes into *E. coli* to produce insulin, growth hormones, and other valuable molecules. Moreover, scientists still feel that genetic engineering hadn’t been harnessed to its full potential. This also means that we can expect to produce larger molecules from this process.

Researchers at the University of California, Davis-Genome Centre and Department of Computer Science are attempting just that, by building a computer model that predicts the behaviour of a single cell of the bacterium *E. coli*.

Production of the antimalarial drug precursor Artemisinic Acid in engineered yeast to produce high titres (upto 100 mg/L) of Artemisinic Acid using an engineered mevalonate pathway has been successfully achieved by Berkeley researchers. The drug artemisinin is reported to be effective for treating malaria, but is also expensive, resulting in the African and South American countries that need it most, being unable to afford it. The microbe *Saccharomyces cerevisiae* is a saviour in this case.

Lactobacillus strain has been genetically enhanced to manufacture proteins that target and attack HIV, by Osel Inc, a bacterial therapeutics company.

By modifying some genes in adenoviruses, scientists at Introgen Therapeutics are engineering weapons against cancer. Special strains of the adenovirus have been altered to deploy anti-cancer genes within tumours, killing cancer cells while leaving healthy ones safe.

Researchers at McMaster University have developed a novel new gel made entirely from bacteria killing viruses (Phages). The anti-bacterial gel, which can be targeted to attack specific forms of bacteria, holds promise for numerous beneficial applications in medicine and environmental protection. Phage's can kill bacteria that are resistant to antibiotics. The DNA of phage's can be easily modified to target specific cells, including cancer cells. Through a Nobel Prize-winning technology called "*Phage Display*", it is even possible to identify phage's that can target plastics or environmental pollutants.

Scientists have employed Agrobacteria to deliver genomic ability to provide resistance to insects or pathogens in higher crop plants. This is an amazing way to utilize the potential of bacteria in farming, resulting in saving millions in revenue for farmers across the globe.

People suffering from phenylketonuria must adhere to a strict diet to prevent the toxic build-up of phenylalanine (Phe), a key constituent of proteins, which can lead to severe neurological and cognitive impairments. Researchers at Synlogic, a Massachusetts-based biotech reported that a genetically modified *E. coli Nissle* can has showed great promise in removing Phe from blood in preclinical trials.

Empowerment of microbes for genetic engineering augments its applications

Clearly, genetic engineering is a complex process with a need for higher technical skills and interpretations and multiple methods have been developed to achieve desired results. The potential applications of genetically engineered microbes are even more diverse as they have tremendous natural diversity with respect to metabolism, extreme environment tolerance, and substrate utilization. Genetic engineering tools can be used to employ these abilities of microbes to make them more beneficial for humankind.

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