7.23B: Applications of Genetic Engineering

Genetic engineering means the manipulation of organisms to make useful products and it has broad applications.

Learning Objectives

• Describe the major applications of genetic engineering

Key Points

• Genetic engineering has applications in medicine, research, industry and agriculture and can be used on a wide range of plants, animals and microorganisms.

• In medicine, genetic engineering has been used to mass-produce insulin, human growth hormones, follistim (for treating infertility), human albumin, monoclonal antibodies, antihemophilic factors, vaccines, and many other drugs.

• In research, organisms are genetically engineered to discover the functions of certain genes.

• Industrial applications include transforming microorganisms such as bacteria or yeast, or insect mammalian cells with a gene coding for a useful protein. Mass quantities of the protein can be produced by growing the transformed organism in bioreactors using fermentation, then purifying the protein.

• Genetic engineering is also used in agriculture to create genetically-modified crops or genetically-modified organisms.

Key Terms

• **biotechnology**: The use of living organisms (especially microorganisms) in industrial, agricultural, medical, and other technological applications.
• cloning: The production of a cloned embryo by transplanting the nucleus of a somatic cell into an ovum.

Genetic engineering, also called genetic modification, is the direct manipulation of an organism’s genome using biotechnology.

New DNA may be inserted in the host genome by first isolating and copying the genetic material of interest, using molecular-cloning methods to generate a DNA sequence; or by synthesizing the DNA, and then inserting this construct into the host organism. Genes may be removed, or “knocked out”, using a nuclease.

Figure: Genetically manipulated mice: Laboratory mice are genetically manipulated by deleting a gene for use in biomedical research.

Gene targeting is a different technique that uses homologous recombination to change an endogenous gene, and can be used to delete a gene, remove exons, add a gene, or introduce point mutations. Genetic engineering has applications in medicine, research, industry and agriculture and can be used on a wide range of plants, animals and microorganisms.

Genetic engineering has produced a variety of drugs and hormones for medical use. For example, one of its earliest uses in pharmaceuticals was gene splicing to manufacture large amounts of insulin, made using cells of E. coli bacteria. Interferon, which is used to eliminate certain viruses and kill cancer cells, also is a product of genetic engineering, as are tissue plasminogen activator and urokinase, which are used to dissolve blood clots.

Another byproduct is a type of human growth hormone; it’s used to treat dwarfism and is produced through genetically-engineered bacteria and yeasts. The evolving field of gene therapy involves manipulating human genes to treat or cure genetic diseases and disorders. Modified plasmids or viruses often are the messengers to deliver genetic material to the body’s cells, resulting in the production of substances that should correct the illness. Sometimes cells are genetically altered inside the body; other times scientists modify them in the laboratory and return them to the patient’s body.

Since the 1990s, gene therapy has been used in clinical trials to treat diseases and conditions such as AIDS, cystic fibrosis, cancer, and high cholesterol. Drawbacks of gene therapy are that sometimes the person’s immune system destroys the cells that have been genetically altered, and also that it is hard to get the genetic material into enough cells to have the desired effect.