Genetically Engineered Plants

Genetic engineering involves cutting and moving snippets of DNA from one plant to another. Permanently integrating new DNA into a plant's original DNA forms what's known as a transgenic plant or genetically modified organism (GMO).

Major goals of genetic engineering of plants:

- Produce crops with less impact on environment
- Reduce expense of food production
- Produce crops less vulnerable to insects, diseases, weeds and harsh environments
- Develop crops with more nutrients
- Develop crops for production of medicines and vaccines

Major genetically engineered traits in plants:

- Insect resistance
- Herbicide resistance
- Virus resistance
- Delayed fruit ripening
- Altered oil content
- Pollen control

Molecular farming: plants being genetically engineered to produce pharmaceuticals and vaccines.

Health and environmental concerns:

- Farm worker and consumer safety
- Environmental effects on plants, animals and water systems
- Genes moving from genetically engineered crops into wild plants
- Pests eventually developing resistance to pest-resistant crops
- Introduction of allergy-causing compounds in foods

Agricultural Biotechnology

Biotechnology has influenced human life in many ways by invention to make his life more comfortable or easy. It has made advancement in agriculture to increase the yield, increases the value of animals by improving their breed and contributed significantly in the development and design of drugs against infectious diseases.

Biotechnology in plant sciences

Genetic Engineering has allowed us to produce genetically modified plants with diversified properties such as resistance against pest, drought, abiotic stress. These are few selected examples of advancement in the plant sciences due to technological contributions of biotechnology.

- **Insect control**

Insect uses plants for nutrition and reduces the crop yield. There are two ways to control the effect of insects on the crop; reduction in the number of insects in the affected area or generation of plants with insect resistance.

1- Sterile male insects

The mechanism of reducing the number of insects in the affected area through the use of sterile male insect. In a typical insect life-cycle, male and female mate with each other to produce large number of fertilized eggs. Eggs go through a series of development stages to produce large number of baby insects to continue the life-cycle. In this approach, male insects are exposed to the radiation or other treatment in the laboratory to render them infertile. These sterile male insects are spread over the infected area. In the field, female mate with these sterile males but no offspring is produced. As a result over the course of time, the insect population will be reduced. The classicial example of this approach is irradication of boll weevil, an insect responsible for the loss of cotton crop in USA.

2- Insect resistant plants

A genetically altered crop is produced to develop resistantance against insects. One of the approaches is to genetically modify the plant which will express a toxin to kill the insects but will be safe for human consumption. *Bacillus thuringiensis* (Bt) is a bacteria which secretes a insecticidal toxin. Spraying Bt toxin was in circulation to control the insect population. With the use of genetic engineering transgenic plants are produced which express Bt toxin in their somatic cells. When insect feeds on the plant, toxin reach to the stomatch and causes internal bleeding to kill the insect.

- **Herbicide resistant plants**

Weeds grow very fast and they compete for nutrients with the crop plant. Chemical herbicides are used in the agriculture to eradicate weeds from the fields. If weeds need to be removed from the crop, herbicide should do little or no effect on the crop plants. Herbicides are either selective towards a class of plant or non-selective to kill all plants they applied to and used more often to kill all vegetation. **Glyphosate** is one of the first herbicide designed to kill weeds. It interferes biosynthesis of aromatic amino acid tyrosine, phenylalanine and tryptophan by inhibiting enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSP). The enzyme catalyzes the conversion of the shikimate-3-phosphate to the 5-enolpyruvylshikimate-3-phosphate. The treated plant cannot be able to produce these amino acids as well as protein needed and dies. There are two approaches, adopted to develop herbicide resistance in crop plant.

(1) The genetically modified crop plant is designed with an alternate pathway to supply the aromatic amino acid to compensate the inhibition of EPSP.

(2) Few bacterial strains use an alternate form of EPSP that is resistant to the glyphosate inhibition. The modified version of EPSP gene was isolated from the *Agrobacterium strain* CP4 and cloned into the crop plant to provide herbicide resistance.

- **Disease resistant plants**

Plants are under continuous exposure to the pathogenic organism and the environmental conditions. Pathogenic organisms (bacteria, fungi, mycoplasma and virus) attack on plants to gain nutrients for their growth and disturb its metabolism to exhibit pathological symptoms. There are multiple approaches to develop disease resistant plant.

1- **Selection and breeding of natural disease resistant plant species**

Few naturally occurring plant species have acquired resistance against a particular disease. These species are preferred over other species for production. In few cases plant species resistant to the disease are either susceptible to other disease or the yield is low. In both cases, it is preferred that the disease resistant plant species can be cross breeding with a high yield plant species to acquire resistance as well as high yield.

2- **Production of Resistance Protein**

Plants have R gene (resistance gene) which produces R protein and these virulence factors allow acquiring resistance to combat pathogens. Every R gene recognizes pathogen protein in a receptor-ligand fasion and as a result R gene product provides resistance against a particular pathogen or a family of related pathogens. R gene has the ability to modify its product to acquire resistance against new species of pathogen. A good example includes barley MLO against powdery mildew, wheat Lr34 against leaf rust, and wheat Yr36 against stripe rust.

Biotechnology in animal breeding

Biotechnology has greatly facilitates the animal breeding and improving their species with additional traits.

Artificial insemination

The over-all process involves the introduction of male sperm into the reproductive tract of the female animal artificially. The availability of superior breed animal is due to the artificial insemination (AI). There are several advantages of AI compare to the natural breeding.

1. The male of a high breed (commonly known as sires) is very costly in comparison to the semen from them.

2. Through a natural breeding process, many diseases can be transmitted to the female through mating. These possibilities are much reduced in an AI procedure.

3. The high breed animal imported from other countries needs to go through quarantine process to ensure no spreading of disease. This process is costly and time consuming.

Plant Tissue Culture (PTC):

Plant tissue culture is the sterile, in vitro cultivation of plant parts. Plants have the ability for differentiated cells revert to an undifferentiated state called callus. These cells will then divide and then differentiate back to somatic embryo cells that will regenerate the entire plant. Plants cultured in vitro yield thousands of genetically identical plants (clones) from a single plant. This process is called micropropagation and is used to commercially propagate plants asexually.

The rapid multiplication allows breeders and growers to introduce new cultivars much earlier than they could by using conventional propagation techniques, such as cuttings. Through the use of biotechnology, desirable genetic traits can be transferred from one organism to another by transfer of DNA. Many more plants with the desirable DNA can be regenerated from small pieces of the transformed plant tissue. Examples of plants produced using tissue culture include the large variety of ornamental plants; agricultural crops such as strawberry, banana, potato, and tomato; and a variety of medicinal plants.

Commercial tissue culture involves exposing plant tissue to a specific regimen of nutrients, hormones, and light under sterile conditions to produce many new plants over a very short period of time. There are three main steps to the tissue culture process:

STAGE I: initiation phase. A piece of plant tissue is cut from the plant, disinfested, and placed on a medium. A medium typically contains mineral salts, sucrose, and a solidifying agent such as agar. The objective is to achieve an aseptic culture (one without contaminating bacteria or fungi).

STAGE II: multiplication phase. The plant material is re-divided and placed in a medium with plant growth regulators that induce the growth of multiple shoots. This process is repeated many times until the number of plants desired is reached.

STAGE III: root formation phase. Hormones are used to induce rooting and the formation of complete plantlets. The plants are then moved from the laboratory to greenhouses and placed in soil for further development.

Textiles and Biotechnology

Biotechnology has changed the textiles industry through the development of more efficient and environmentally friendly manufacturing processes, as well as through the design of improved textile materials. Some of biotechnology's key roles have involved the production and modification of enzymes used for improving textiles. Biotechnology has also facilitated the production of novel and biodegradable fibers from biomass feedstocks.

- **Enzymes in Textiles**

Through biotechnology, enzymes are used to treat and modify fibers during textile manufacturing, processing, and in caring for the product afterwards. Some applications include:

1- **De-sizing of cotton** – Untreated cotton threads can break easily when being woven into fabrics. To prevent this breakage, they are coated with a jelly-like substance through a process called sizing. Amylase enzymes are widely used in de-sizing, as they do not weaken or affect cotton fibers, nor do they harm the environment.

2- **Retting of flax** – Flax plants are an important source of textile fibers which are often used in biodegradable clothing. Useful flax fibers are separated from the plant's tough stems through a process called retting which requires large quantities of water and energy. Bacteria, which may be bred or genetically engineered to contain necessary enzymes, can be used to make this a more energy efficient process.

3- **Bleaching fibers** – When cotton is bleached, a chemical called hydrogen peroxide, which can react with other dyes, remains on the fabric. Catalase enzymes specifically break down hydrogen peroxide and may be used to remove this reactive chemical before further dyeing

4- **Stonewashing and polishing** – Instead of using abrasive tools like pumice stones to create a stonewashed effect or to remove surface fuzz, cellulase enzymes may be used to effectively stonewash and polish fabrics without abrasively damaging the fibers.

5- **Detergents** – Enzymes allow detergents to effectively clean clothes and remove stains. Without enzymes, a lot of energy would be required to create the high temperatures and strong shaking needed to clean clothes effectively. Enzymes used in laundry detergents must be inexpensive, stable, and safe to use. Currently, only protease and amylase enzymes are incorporated into detergents. Lipase enzymes, which break down easily, are being studied and developed through genetic screening and modification.

Novel Fibers

Synthetic fibers made from renewable sources of biomass are becoming more economically suitable. Biodegradable synthetic polymers include fibers such as polyglycolic acid and polylactic acid, which are made from natural materials.

Not all novel fibers are synthetic; they may also be naturally derived. Some natural biological fibers come from basic materials found in nature, including:

Chitin – a type of sugar polymer found in crustaceans

Collagen – a type of protein found in animal connective tissue

Alginate – a type of sugar polymer found in certain bacteria

An example of a synthetic biomass fiber is Polylactic Acid (PLA), which is made by fermenting cornstarch or glucose into lactic acid, and then chemically transforming it into a polymer fiber. PLA minimizes environmental waste, as it may be fully biodegraded by microorganisms under appropriate conditions into carbon dioxide and water.

Medical Textiles

Biodegradable fibers may be used to make textiles for medical applications. Such textiles may be used in first aid, clinical, and hygienic practices.

Polymer	**Use(s)**
Polylactic Acid and Polyglycolic Acid	Used in sutures, absorbable wound closure products, and fixation devices, as well as in tissue engineering structures
Chitin	Incorporated into wound dressings
Collagen	Uses in cell engineering structures, such as in artificial skin, or even as surgeon's thread
Alginate	Used to protect and interact with wounds