Applications of genetic engineering

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The manipulation of the genetic make-up high of organisms by introducing desired DNAs, is known as genetic engineering. By this technology, a novel gene can be transferred to closely related organisms as well as unrelated organisms. This is an advantage over the conventional breeding methods. Many new strains of microbes, plants and animals have been developed by using genetic engineering. The genetically manipulated organisms (GMOs) are known as genetically engineered organisms(GEOs).

•*Genetically manipulated bacteria and yeasts are altogether called genetically manipulated*
microorganism (GMMO). The genetically , manipulated plants are called transgenetic
plants. Genetically manipulated animals are said to be transgenic animals. The GEOs are useful in agriculture, industries, medicine and environment for the betterment
of human life. The important applications are

Transgenic Plants

Plants containing introduced DNA, are known as transgenic plants or genetically engineered plants. They have acquired a new trait from the introduced DNA and inherit the trait for many generations. In some transgenic plants, the introduced DNA blocks the normal functioning of certain original genes of the plants. Scientists have developed transgenic plants having

1. Herbicide resistance
2. Insect resistance
3. Virus resistance
4. Improved storage proteins
5. Improved oils and fats
6. Male sterility
7. Altered flower colours
8. Environmental stress resistance
9. Enhanced photosynthetic efficiency
10. Novel proteins.

1. Herbicide - resistant Plants

Many transgenic plants with herbicide resistance have been developed by using genetic engineering. Such transgenic plants tolerate the herbicides and be safe in the field, when the herbicides are applied in the field. Example: Glyphosate resistant petunia, tobacco, tomato, corn, etc.

Glyphosate is the active ingredient of many commercial herbicides such as Glyphos, Tumbleweed, Roundup, etc. It is a competitive inhibitor of EPSP synthetase*, blocking the biosynthesis of tryptophan and phenyl alanine.

EPSP synthetase gene was isolated from the bacterium Salmonella typhimurium and glyphosate resistant cell line of petunia and introduced into plant cells using Ti Plasmids. Transgenic plants regenerated from the plant cells are resistant to the herbicide glyphosate by over producing the enzyme EPSP synthetase or by producing glyphosate tolerant EPSP synthetase. Eg. Potato, tomato, tobacco, cotton, etc.

2. Insect Resistant Plants

Many transgenic plants with insect resistance have been developed by adopting gene transfer methods. They reduce the use of chemical pesticides in agriculture.

The bacterium Bacillus thuringiensis produces an endotoxin called Bt-toxin. This toxin kills a wide group of insect pests but not harmful to man and domestic animals. The gene for Bt. toxin was isolated from B.thuringiensis, linked with 35S promoter of CaMV and introduced into plant cells using Ti plasmid as vector. The transgenic plants developed from these cells are resistant to many insect pests. Examples

Crop	Resistant to
* *Tomato*	Tobacco hornworm
	Tomato fruitworm
	Tomato pinworm
•Cotton	Tobacco budworm
	Cotton bollworm
	Pink bollworm

Transgenic plants are also developed by introducing serine protease inhibitor gene, cowpea trypsin inhibitor (CPTI) gene, etc.

3. Virus Resistant Plants

Viral infection does'nt take place in plants, if the plants are already infected with certain virus. This principle is called cross protection.

By genetic engineering plants are made to have parts of viral protein coat or virus nucleoproteins. The viral coat protein or nucleoprotein interferes with infection by the related viruses. Transgenic tobacco is developed by introducing *gene coding for capsid protein of tobacco mosaic* virus (TMV). It is resistant to TMV, *tobacco streak virus (TSV) and tobacco etch* virus (TEV).

Some transgenic virus resistant plants are:

crop	*Resistant to*
Tomato	**Tomato spotted wilt virus (TSWV)**
Potato	**Potato virus-X & Y.**
Alfalfa	**Alfalfa mosaic virus (AMV)**
Cucumber	**Cucumber mosaic virus (CUMV)**
Rice	**Rice stripe virus (RSV)**
Papaya	***Papaya ringspot virus***

4. Transgenic Plants with ImprovedStorage Proteins

Nutritional quality of storage proteins can be improved by genetic engineering French bean sterile (Phaseolus vulgaris) contains the storage protein called phaseolin. Phaseolin constitutes about 50% of cotyledonary proteins. It is low in methionine content and is hard to digest as it gets glycosylated. cDNA of phaseolin gene was
isolated from French bean, its glycosylation sequence was deleted and the cDNA was introduced into a phaseolin mutant French bean. The transgenic french bean is rich in methionine and easily digestible.

Potato is deficient in almost all essential amino acids. But the protein AMA-I of grain Amaranthus is rich in all the essential amino acids. cDNA of AMA-I protein was made from mRNA of grain Amaranthus and introduced into potato. The transgenic potato is nutritionally valuable as it is rich in starch and amino acids. These transgenic plants can correct protein deficiency malnutrition in man.

5. Transgenic Plants with Improved Oils and Fats

Genetic engineering is used to improve the quality of oils and fats in plants. Rapeseed is low in stearate level so that it causes cholesterol accumulation in man. An antisense construct for the enzyme A 9-stearoyl ACP desaturase was made and introduced into the embryo of rapeseed. The transgenic rapeseed is rich in stearates & oleic acids. The stability of its oil during frying is high and there is no problem of cholesterol.

`Genes for enzymes responsible for cocoa oil were transformed from cocoa to soybean calli. The transgenic soybean yields cocoa oil that can be used chocolate making.

6. Male Sterile Plants

Male sterile plants help the plant breeders for hybridization, especially to avoid emasculation. A gene for RNase of Aspergillus oryzae *and a gene for RNase of Bacillus amyloliquefaciens are joined together and put* under the control of another specific promoter of tobacco called TA29. The gene construct was introduced into callus tissues. The transgenic plants regenerated from the calli are male sterile. Monsanto company (USA) has developed male sterile rape seed, maize, cotton, pumpkin, snake guard, etc.

7. Transgenic Plants with Attractive Flowers

Attempts have been taken to change the flower colours by introducing certain genes involving in flavonoid metabolism or antisense RNA producing genes. Transgenic petunias with different patterns of flower colours were developed in this way.

8. Stress Tolerant Plants

Genetic engineers have developed new strains of plants with stress tolerance due to esteem cold, heat and drought.

Gene for glycerol-1-phosphate acyl transferase was isolated from Arabidopsis and introduced into tobacco calli. The transgenic tobacco is resistant to chilling as low as 10°C for a long time. It can be grown in cold areas.

Genes for mannitol dehydrogenase and sorbitol dehydrogenase were isolated from E.coli and introduced into tobacco through Ti plasmid. The transgenic tobacco is resistant to drought.

Gene for superoxide dismutase was isolated from a soil bacterium and introduced into tobacco for calli through Ti plasmid. The transgenic tobacco*is resistant to high* light intensity which causes splitting of cellular water.

9.Engineering For Preservation of Fruits

Transgenic plants with bruise resistance and delayed fruit ripening, have been developed an in
genetic engineering. Fruits of the plants can be sent to far away markets. An antisense RNA producing gene for polygalacturonase was constructed and introduced into tomato calli through Tiplasmids. The transgenic tomato retains the fruits for one more day and the fruits are higher in sugar contents. Transgenic tomatoes produce aminocyclopropane carboxylic acid (ACC) for delayed fruit ripening:

10. High Rate of Photosynthesis

Mutant RUBISCO genes with low oxygenase activity was isolated from different plants and introduced into tobacco calli. The transgenic tobacco shows higher rate of photosynthesis. Research is going on to increase photosynthetic efficiency of various crop plants

11. Transgenic Plants As Bioreactors

Transgenic plants are used for the large scale production of some valuable products as the bioreactors are used. So they are known as tra transgenic plant bioreactors. They produce interferons, vaccines, biodegradable plastics, etc.

A gene coding for protein coat of hepatitis B-virus was introduced into banana calli through Ti plasmid. The transgenic banana contains C hepatitis B protein coat. Eating small slices of t its fruits is enough for vaccination against hepatitis B virus. Human interferon is produced in this way in transgenic tobacco Pharmacologically active cyclodextrins are produced from transgenic potato. *Polyhydroxybutyrate (PHB) is a biodegradable plastic-like polymer. It is present in the cell of the bacterium Alcaligenes eutrophus. Two genes coding for acetyl CoA reductase and PHB synthetase were isolated from the bacterium and introduced into Arabidopsis thaliana. The transgenic Arabidopsis accumulates 0.2 to* 0.5 mg PHB/ gram. Now efforts have been taken to increase the expression of the cloned genes in A. thaliana.