Plant biotechnology

Biotechnology: "the application of scientific methods to manipulate living cells or organisms for practical purposes." Nabors; Chapter 14.

"For centuries, humankind has made improvements to crop plants through selective breeding and hybridization — the controlled pollination of plants. Plant biotechnology is an extension of this traditional plant breeding with one very important difference — plant biotechnology allows for the transfer of a greater variety of genetic information in a more precise, controlled manner." From Monsanto web page on biotechnology.

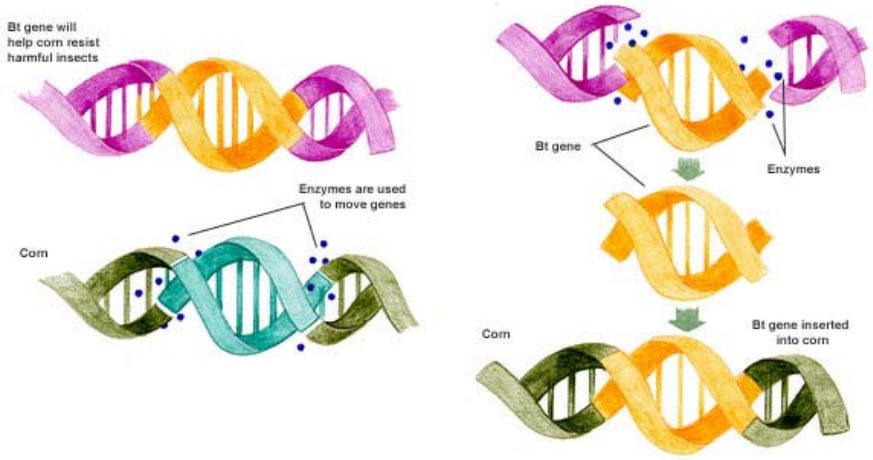
Methods utilized in plant biotechnology:

Genetic engineering: the transfer of specific genes from one organism to another.

- **Gene identification**
- **Isolation of genes**
- **Transfer of genes**

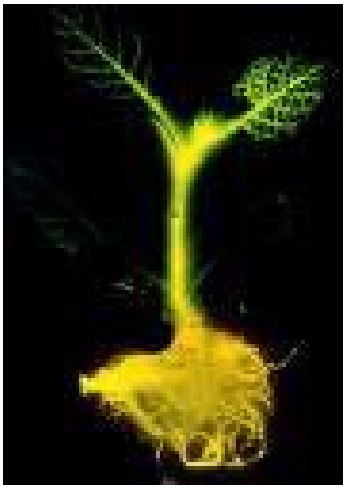
Result: transgenic organism.

Transfer of Bt genes from Bacillus thuringiensis which code for proteins that are converted into toxins in the gut tracts of insects.

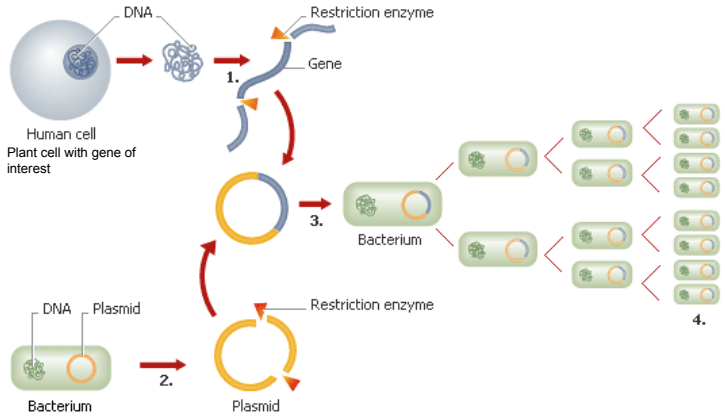


When spliced into the genome of corn, it is hoped that these genes will produce the proteins which will convey insect resistance to this particular strain of corn.

Result from transferring the gene for luciferase enzyme from fireflies into tobacco plant. In the presence of the enzymes substrates (luciferin, ATP, & oxygen), the plant glows with the light of a firefly.

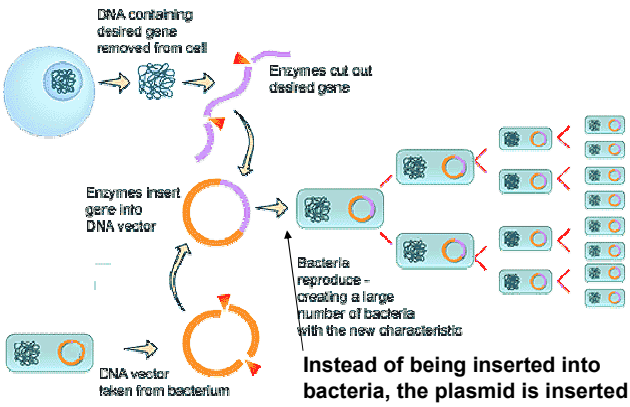


Gene transfer in plants most often utilizes the Ti plasmid from *Agrobacterium tumefaciens*.



Steps involved:

1) Ti plasmids isolated.
2) Gene of interest is isolated (ligase enzymes excise desired gene)
3) Enzymes splice gene of interest into the Ti plasmid.
4) The Ti plasmid is inserted into a plant cell where DNA from the plasmid is incorporated into the DNA (chromosomes) of the plant.
5) Plant grown from these cells all contain the new gene.



Instead of being inserted into bacteria, the plasmid is inserted into plant cells

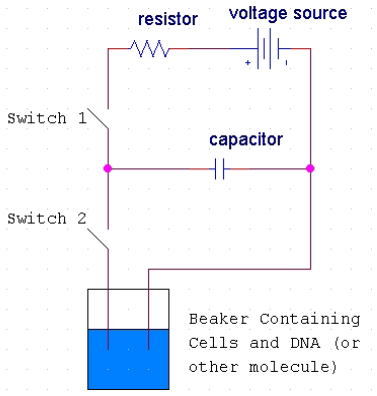
The transference of genes into plant cells can occur via other processes other than Ti plasmids.

In order to get the desired gene (“a transgene”) into as many plant cells as possible tissue culture is used to propagate masses of undifferentiated plant cells called callus. These undifferentiated cells are totipotent (each cell can develop into a complete plant under the correct conditions).

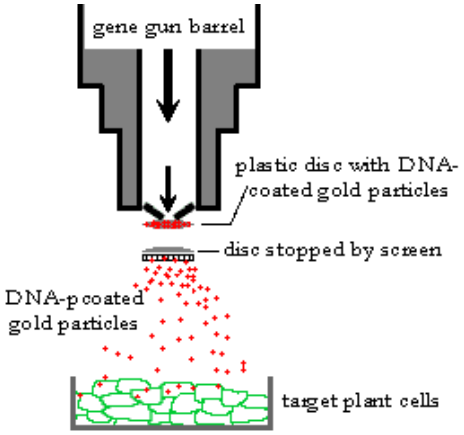
The new gene is inserted into some of the cells using various techniques. Some of the more common methods include the gene gun, agrobacterium, microfibers, and electroporation.

The goal is to insert the transgene into the nucleus of the cells without killing the cell.

Once the gene is inserted into the undifferentiated, callus cells, transgenic plants are grown from them.

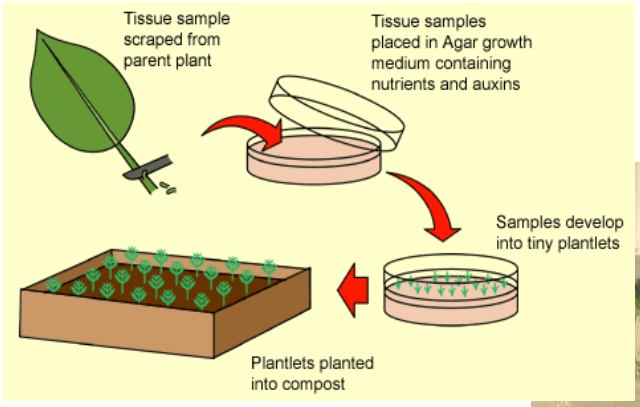


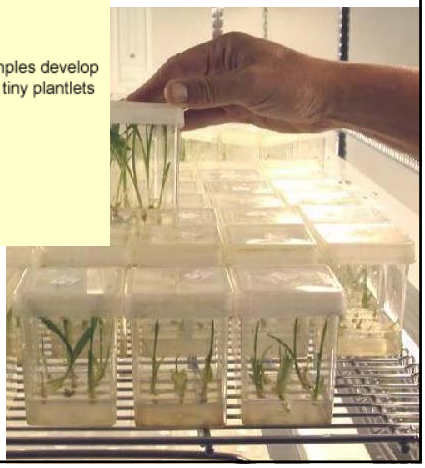
Electroporation method: a very short burst of high voltage disrupts the phospholipid membranes of cells creating short-lived aqueous pores through which molecules of DNA are forced by a change in the electrical potential.



Gene gun method

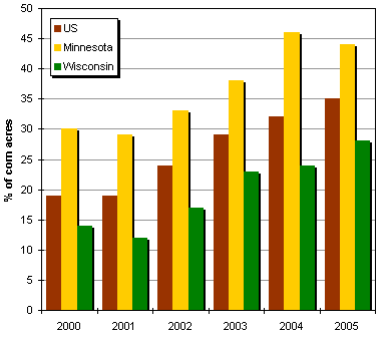
Tissue culture: isolated cells grown on media





Finally, the transgenic plants are backcrossed with the plants having other desired characteristics in order to incorporate the characteristics of this particular strain of crop plant with the transgene.

Using biotechnology methods, plants have been made to be more resistant to viral and bacterial diseases, insects infestations, etc.



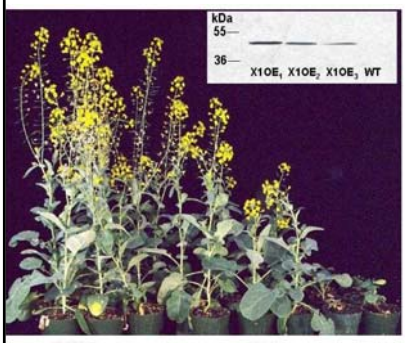
Bt corn adoption trends in US, Minnesota and Wisconsin 2000-2005

Flavr Savr® tomatoes have a gene that reduces the natural production of the enzyme polygalaturonase which breaks down cell walls. Fruits could ripen before being picked without suffering cellular breakdown during transport.

Mechanized harvesting and packing machines damaged the ripe fruit, so it was removed from the market.

It was more prone to diseases, grew poorly in the sandy soils of Florida (a prime tomato growing region) thus produced lower yields than non-transgenic tomatoes.

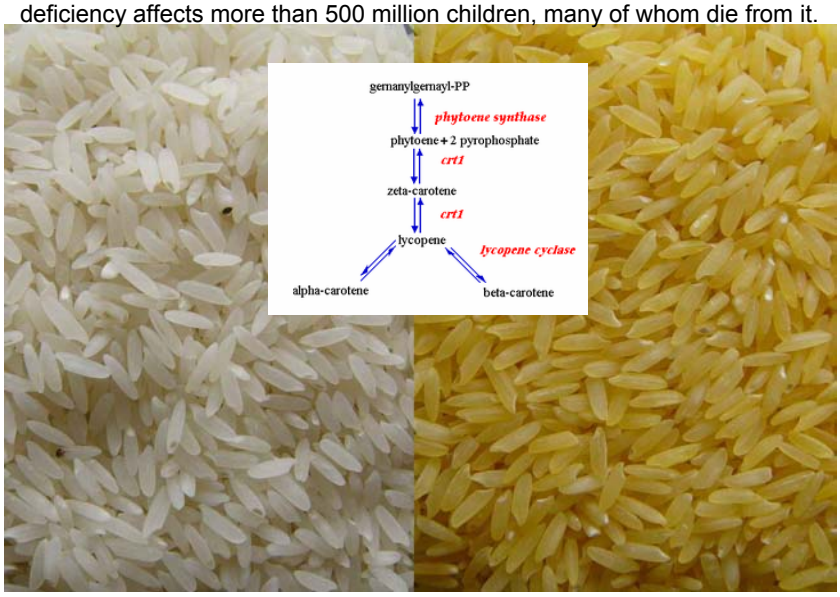
Other crop plants have been engineered to resist drought, withstand exessive soil salinity, and soil acidity, produce more seeds or fruits, be resistant to herbicides used to control weeds, etc…



Salt-tolerant, transgenic Brassica plants

On the left are CMV infected nontransgenic tomato plants, and on the right are CMV resistant transgenic tomato plants. Note the differences in growth and fruiting.

"Golden" rice has been developed with increased vit. A production through the increased production of carotenoids.` Other strains of rice have been modified to increase iron accumulation by three times over normal rice. Iron deficiency affects more than 500 million children, many of whom die from it.



But there are problems…

Golden rice contains antibiotic resistant genes which could possibly be transferred to bacteria that cause diseases in plants and animals.

There is the argument that golden rice could provide too much vitamin A and cause vitamin A toxicity in people who eat rice on a daily basis.

Unpolished rice (containing the vitamin rich aleurone layer) provides sufficient vitamins (without being genetically engineered), but is culturally unpopular in areas where rice is part of the culture. Vitamin A is also widely available in many leafy vegetables.

And there is the cost of the seeds…and fertilizers…and pesticides for “maximum production”.