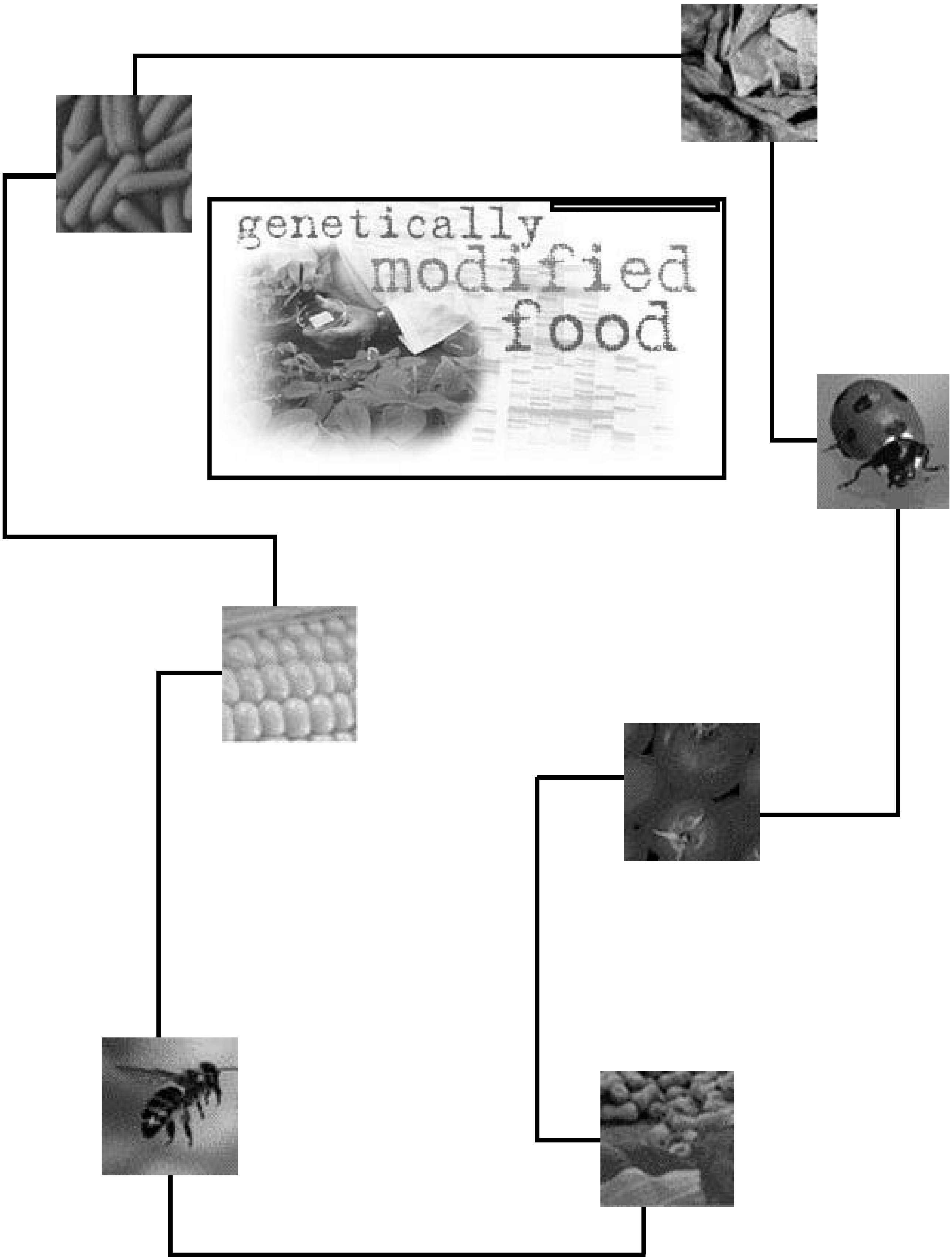
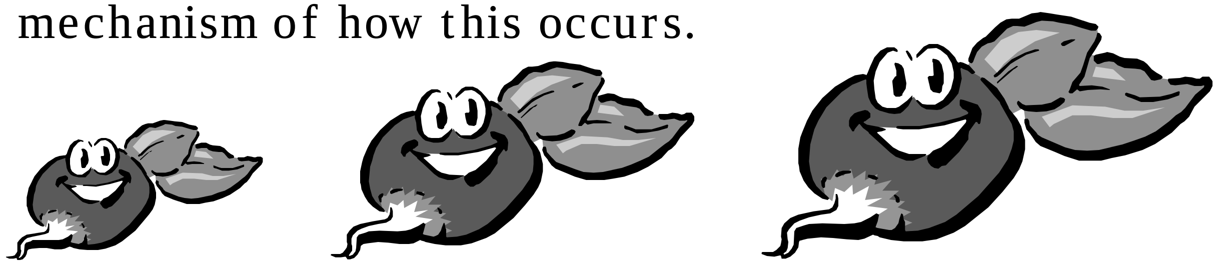


Elaine Law, UBC, 2002

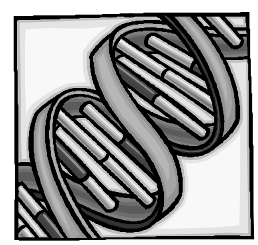
Plant Breeding

For years, framers have been selecting for certain features in crops producing plants that are easier to grow, tastier, and bigger without knowing the exact mechanism of how this occurs.

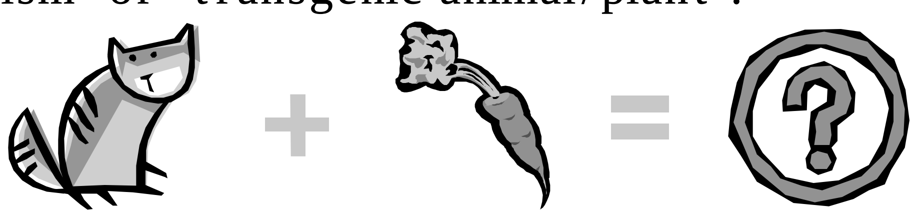


Recognizing valuable traits and incorporating them into future generations is very important in plant breeding

Advances in plant biotechnology has made it possible to identify and modify genes controlling specific characteristics.



Nowadays scientists can transfer genes from one organism to another unrelated organism, producing what is now known as “genetically modified organism” or “transgenic animal/plant”.

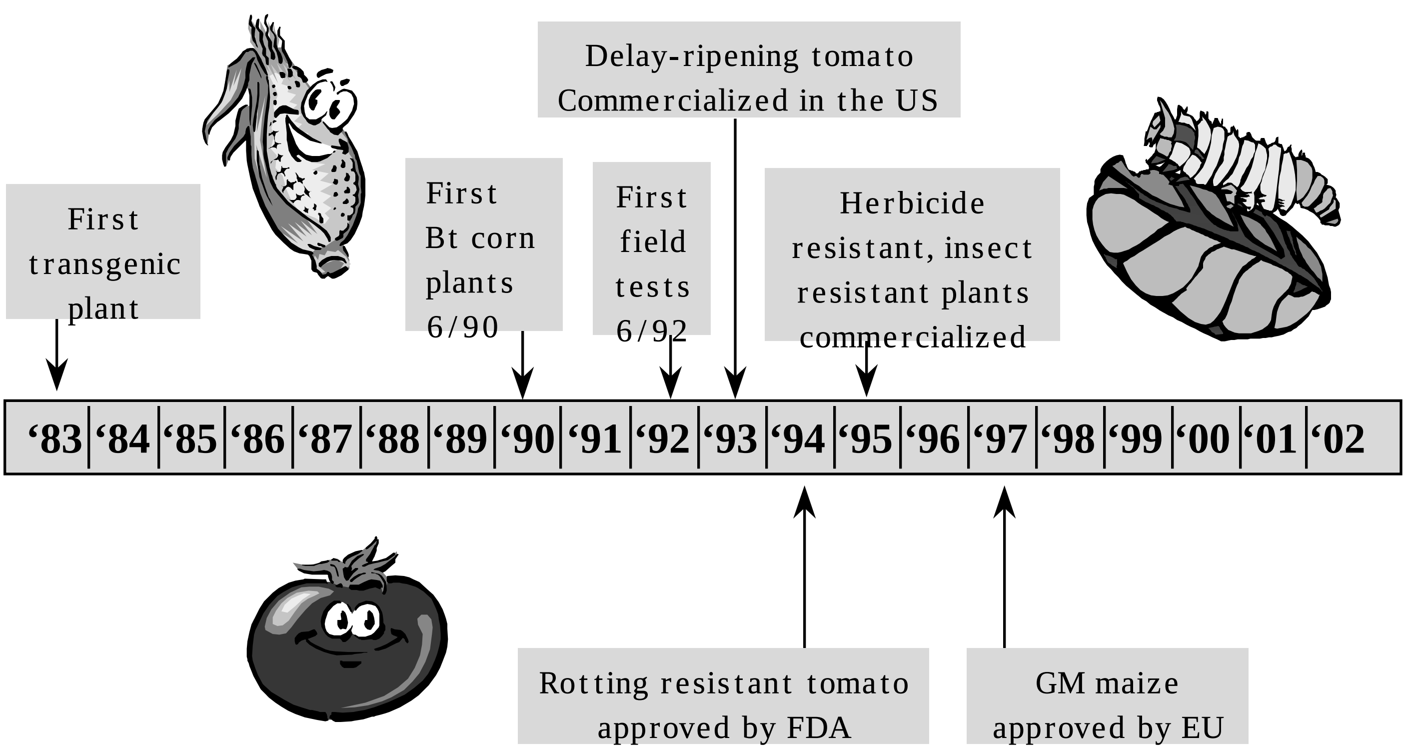


Any food produced this way is called GM food

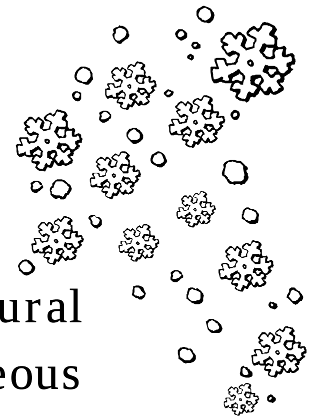
A Little Bit of History......

Transgenic plants were first created in the early 1980s by three groups working independently.

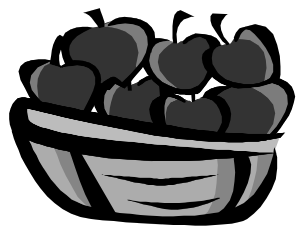
These early transgenic plants were resistant to antibiotics and cancer drug, demonstrating the potential of transgenic plants. Subsequent research has developed transgenic plants with commercially useful traits such as resistance to herbicides, insects, and viruses.



Why Produce GM Food?

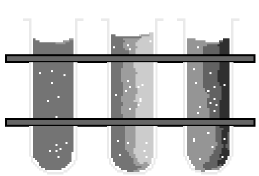


From economical and agricultural standpoints, it is advantageous to grow crops that have higher yield or improved quality, pest or disease resistance, or tolerance to heat, cold and drought.

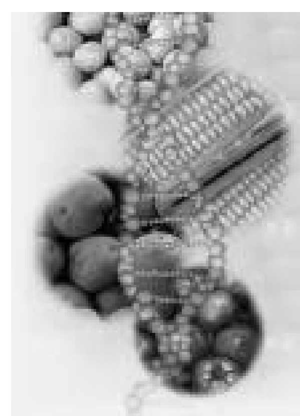


Desirable genes may provide means for plants to combat these conditions.

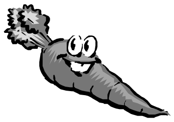
Traditionally, combining the desirable genes in one plant is a long and laborious process, involving crossing one plant to another plant of the same species or related species.



The development of transgenic technology allows useful genes from various living sources to be brought together in a relatively simple manner.

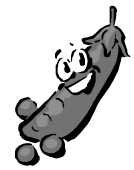


Advantages of GM Food:



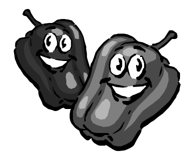
Increase crop yields, e.g. increase the size and number of seed

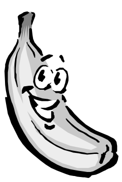
Improve sensory attributes of food, e.g. flavor, texture



Increase the nutritional value of crops, e.g. increase the protein content of rice

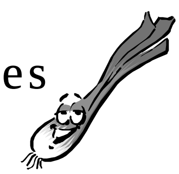
Increase tolerance to adverse growing conditions, e.g. cold/heat/drought





Provide resistance to pests and reduce the use of pesticides

Selectively reduce allergy-causing properties of some foods



The United Nations estimated that with the world population reaching 7.15 billion by 2015, 575 million people will face chronic malnutrition and famine.

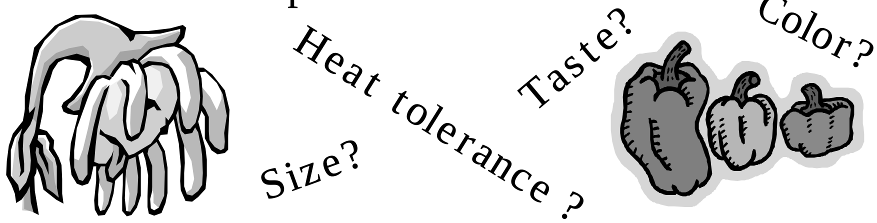
By increasing crop production and nutrient composition, GM food has the potential to reduce hunger, malnutrition, and perhaps alleviates poverty

Making a Transgenic Plant

Identifying a Desirable Gene

> This is currently the rate limiting step of making a transgenic plant.

We know very little about the specific genes that determine plant characteristics.



Effort focused at sequencing and understanding the functions of genes in agriculturally important plant species would accelerate this process immensely.

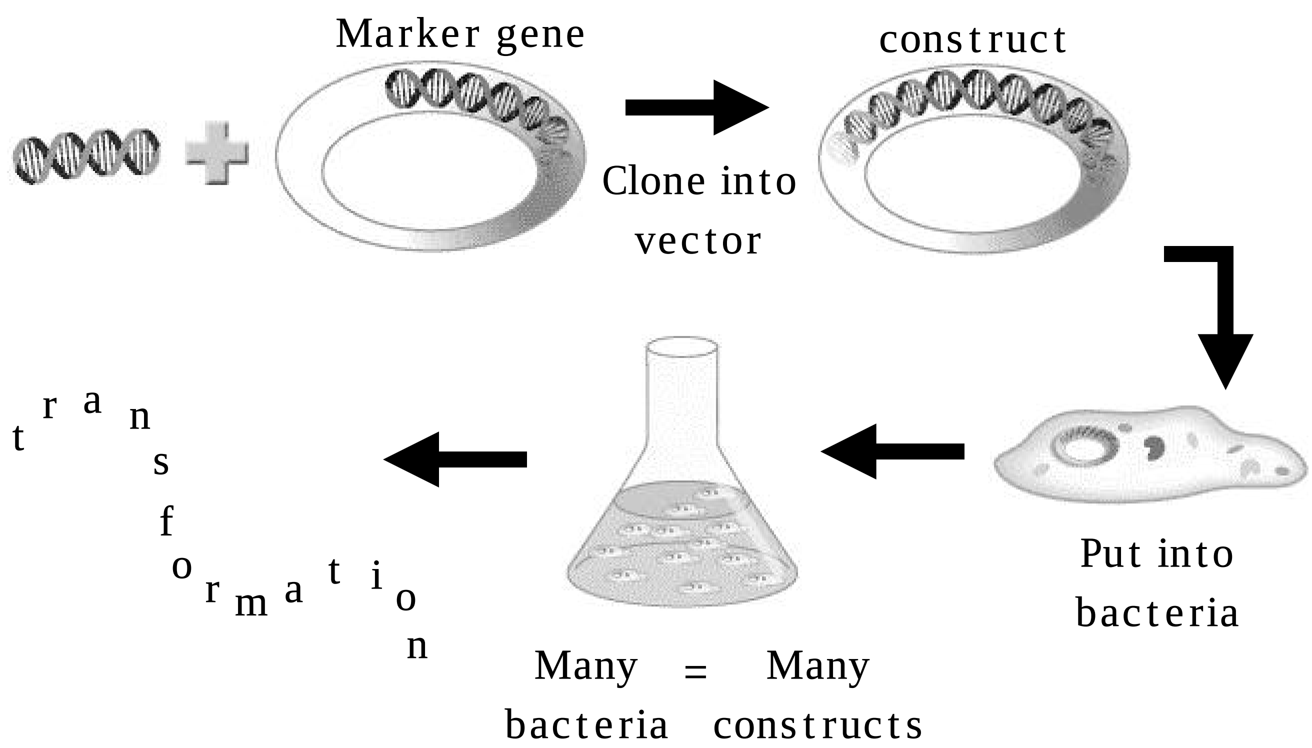
Modifying the Gene

> Certain modifications take place prior to a gene's introduction to a plant host.

To ensure that the gene is expressed (translated into protein product) at the right place and time, a promoter sequence is added.

Changing the sequence of the gene can also optimize resultant protein function.

Successful incorporation of the transgene is a rare event in plants; therefore a marker gene (e.g. drug resistance) is usually added to allow selection

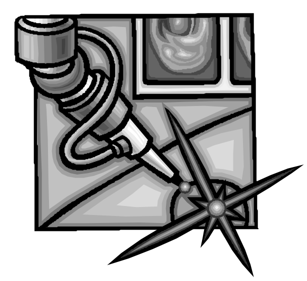


Transformation

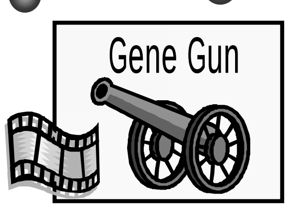
> There are two methods of transformation: Gene Gun and *Agrobacterium* infection

Gene Gun

a.k.a. microprojectile bombardment or biolistics



Gold particle coated with the DNA containing the gene of interest is shot into the nucleus of a plant cell, the DNA will detach and may become incorporated into the plant chromosomes.

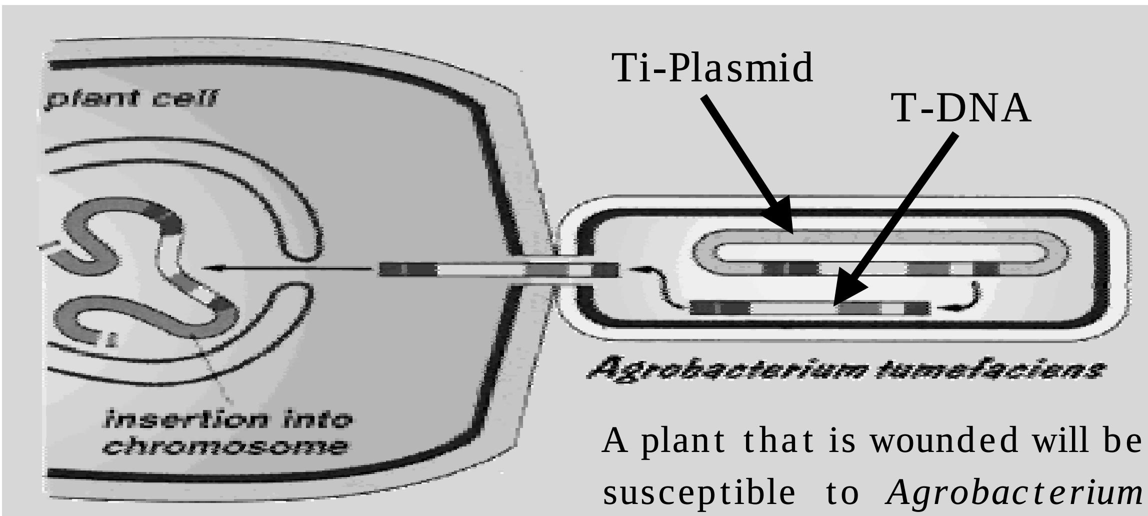


Double click this icon to see a movie prepared by the University of Nebraska describing how gene gun works.

Transformation Con’t

Agrobacterium Infection

Agrobacterium tumefaciens is a species of bacteria commonly found in soil. This bacteria has the amazing ability to infect plant cells with a piece of its own DNA called T-DNA.



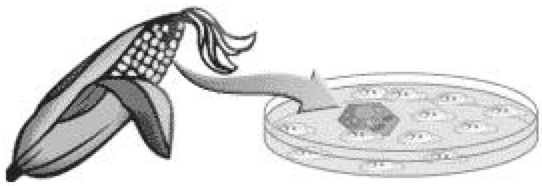
A plant that is wounded will be susceptible to *Agrobacterium* infection and develop tumors.

Upon infection, the T-DNA will integrate into the plant chromosome, takeovers the plant's cellular machinery and uses it to produce more bacteria.

To use *Agrobacterium* as a mean to incorporate transgenes in plant chromosomes, scientists have removed the tumor-causing genes on the T-DNA, but left the bacteria’s abilities to infect a plant and transfer its T-DNA intact.

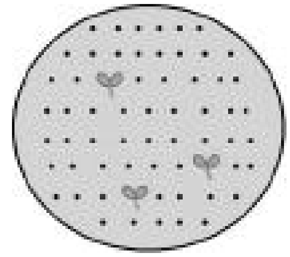
Tumor caused by *Agrobacteria*

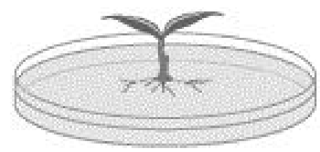
Culture the plant cell with *Agrobacteria* carrying the transgene



The recombinant DNA will be transferred to the plant cell

Selection of transformed cells

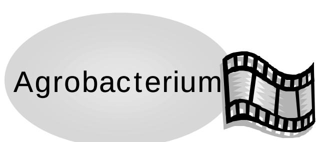




Regeneration of the plant

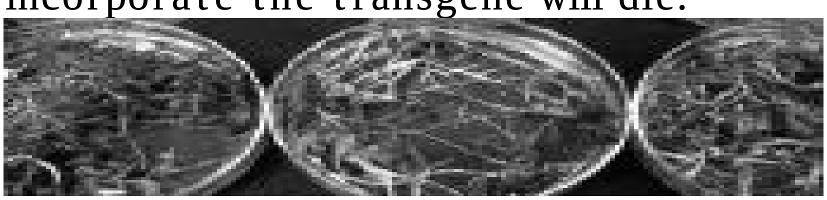
Genetically modified plant

Click the icon below to see the movie "how to make a transgenic plant" made by the Saskatchewan Agricultural Biotechnology Information Centre



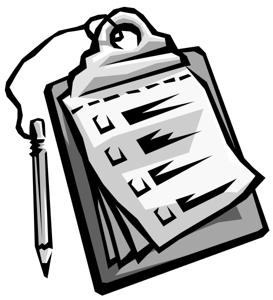
Selection and Regeneration

After the plant cells are infected with *Agrobacteria*, they are transferred to a selective media where cells that did not incorporate the transgene will die.



The cells which harbor the transgene are then regenerated in media containing nutrients and growth hormones.

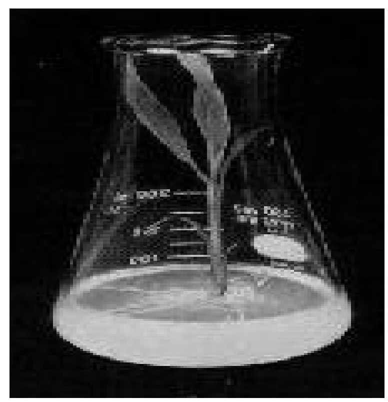
Testing the transgenic plant



Once a transgenic plant is obtained, a set of extensive tests has to be done. Every transgenic plant must be verified for the incorporation of the transgene.

If the transgene is present, the plant is evaluated for any adverse effects imposed by the transgene.

Assays are done to determine the activity of the transgene, whether this gene is passed stably from one generation to the next, and whether there are unforeseen effects on plant growth, yield, and quality.



If a plant passes these tests, it is rarely directly used for crop production, instead it will be crossed with an improved line of the crop.

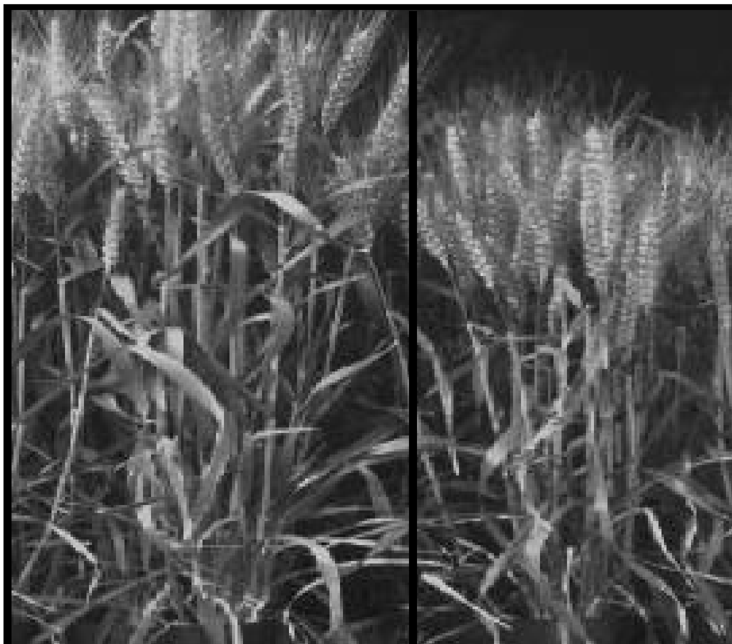
Some Examples of Current Transgenic Plants

Roundup Ready™ Soybeans

A problem in agriculture is the reduced growth of crops imposed by the presence of unwanted weeds. Herbicides such as Roundup™ and Liberty Link™ are able to kill a wide range of weeds and have the advantage of breaking down easily. Development of herbicide resistant crops allows the elimination of surrounding weeds without harm to the crops.

Increase Yields

Crops can be modified to optimize growth conditions: improve nitrogen assimilation, increase oxygen absorption, efficient photosynthetic pathway, and increase starch biosynthesis.



Transgenic plant modified to have increase yield	Unmodified control plant

Insect Resistance

Various insect resistant crops have been produced. Most of these make use of the Cry gene in the bacteria *Bacillus thuringiensis (Bt)*; this gene directs the production of a protein that causes paralysis and death to many insects.

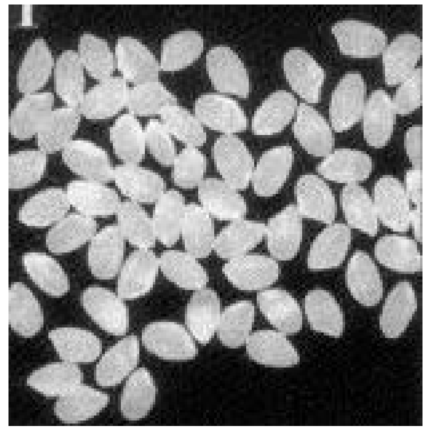
Corn hybrid with a *Bt* gene	Corn hybrid susceptible to European corn borer

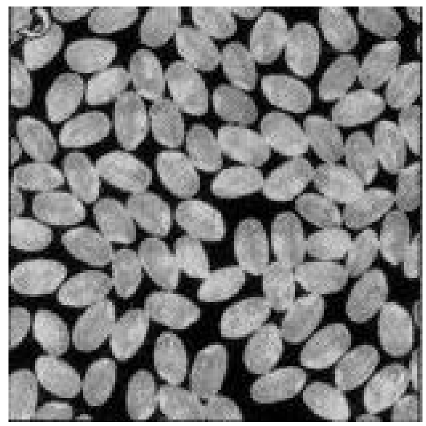
Golden Rice

Transgenic technology produced a type of rice that accumulates beta-carotene in rice grains. Once inside the body, beta-carotene is converted to vitamin A.

More than 120 million children in the world suffers from vitamin A deficiency. Golden Rice has the potential to help prevent the 1 to 2 million deaths each year caused by a deficiency in this vitamin.

Normal rice



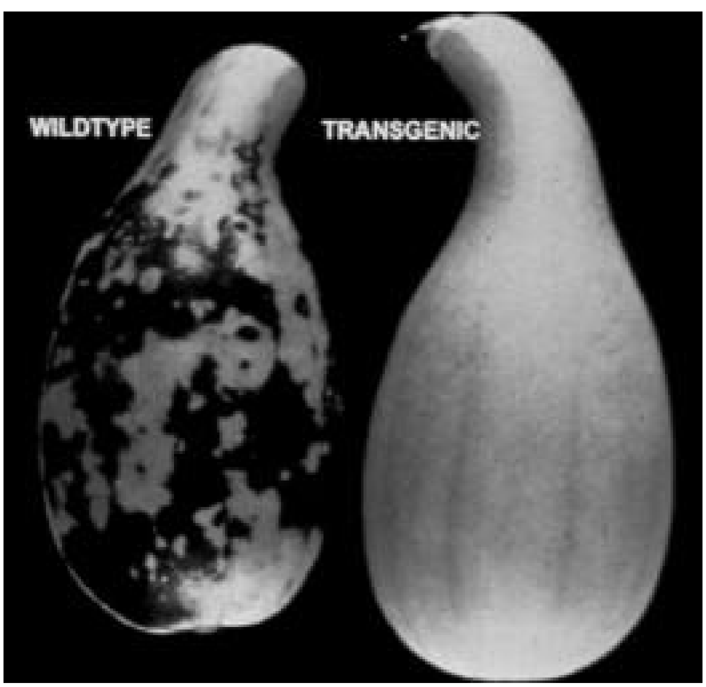


“Golden” rice

Virus Resistant Crops

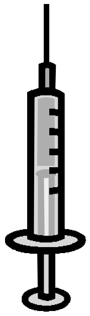
Papaya infected with the papaya ringspot virus

Virus resistance gene introduced



The Freedom II squash has a modified coat protein that confer resistance to zucchini yellows mosaic virus and watermelon mosaic virus II. Scientists are now trying to develop crops with as many as five virus resistance genes

Pharmaceutical Production in Plants



Genetically modified plants have been used as "bioreactors" to produce therapeutic proteins for more than a decade. A recent contribution by transgenic plants is the generation of edible vaccines.

Edible vaccines are vaccines produced in plants that can be administered directly through the ingestion of plant materials containing the vaccine. Eating the plant would then confer immunity against diseases.

Edible vaccines produced by transgenic plants are attractive for many reasons. The cost associated with the production of the vaccine is low, especially since the vaccine can be ingested directly, and vaccine production can be rapidly up scaled should the need arises. Edible vaccine is likely to reach more individuals in developing countries.

The first human clinical trial took place in 1997. Vaccine against the toxin from the bacteria *E.coli* was produced in potato. Ingestion of this transgenic potato resulted in satisfactory vaccinations and no adverse effects.

Edible Vaccines

One focus of current vaccine effort is on hepatitis B, a virus responsible for causing chromic liver disease. Transgenic tobacco and potatoes were engineered to express hepatitis B virus vaccine. During the past two years, vaccines against a *E.coli* toxin, the respiratory syncytial virus, measles virus, and the Norwalk virus have been successfully expressed in plants and delivered orally. These studies have supported the potential of edible vaccines as preventive agents of many diseases.

There is hope to produce edible vaccines in bananas, which are grown extensively throughout the developing world.

GENETIC ENGINEERING NEWS

Cancer Vaccine Made in A Plant-Based System

Vol. 19, No. 3
Feb. 1, 1999

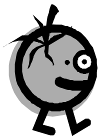
Biosource and Stanford University Achieve a First in An Animal Model

A research team says it has produced a protein-based tumor-specific vaccine for the treatment of malignancies via a plant-based transient expression system.

The collaborative group, led by Daniel Tusé, Ph.D., at **Biosource Technologies, Inc.** (Vacaville, CA), and Ronald Levy, M.D., Ph.D., at Stanford University (Stanford, CA), describe a strategy for individualized treatment of indolent non-Hodgkin's lymphoma (NHL) in a mouse model system. Though

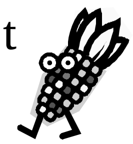
Biosource researchers used tobacco plants as an alternative mechanism for antibody production. The researchers removed malignant B cells from laboratory mice and then isolated the gene for a small piece of the surface markers that are specific to these cells. They inserted this gene into tobacco mosaic virus and then infected tobacco plants.

Concerns of GM Food



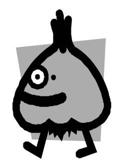
Unintended modification of other species in the neighboring fields due to cross pollination

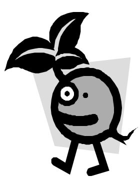
Evolution of super pests that are resistant to all types of herbicides or insecticides



Disturbing the balance of ecosystems by creating species that normally do not exist

Ethics of move genes between plants or animals which do not normally interbreed





Whether it is ethical to eat a food containing a gene from something one would not eat for religious, health or other reasons

The use of modern biotechnology in food has evolve rapidly during the last decade, without a full understanding of this technology and its consequences.

As a safety measure, before any GM foods are released into the market, they are subjected to rigorous safety assessments by the industry and regulatory agencies of the places of origin.

Concerns of GM Food

In the United States, where GM crops are most abundant, they are regulated by three federal agencies: the Environmental Protection Agency, the Food and Drug Administration, and the United States Department of Agriculture. The assessments, including that performed by the manufacturers, may take several years to complete, and the GM food is only released into the market when it meets all the requirements set out by these agencies.

In Canada and the United States, labeling of GM foods is only required when the food is significantly different from its conventional counterpart in composition, nutrition and allergenicity.

Nutrition Facts
Serving Size 2 Cookies (33g)
Servings per container: 6

Amount per serving
Calories 140 Calories from fat 60

Total Fat 6g,	11% Daily Value
Saturated Fat 2.5g	12%
Cholesterol 20 mg	7%
Sodium 65 mg	3%
Total carbohydrate 19g	6%
Protein 1g	
Vitamin A 4%	

PRODUCED WITH GENETICALLY ENGINEERED INGREDIENTS

INGREDIENTS: UNBLEACHED WHEAT FLOUR, CANOLA OIL, EVAPORATED CANE JUICE, BUTTER, STRAWBERRY JAM (APPLE CONCENTRATE, STRAWBERRY CONCENTRATE, WATER, STRAWBERRIES, LOCUST BEAN GUM, PECTIN, CITRIC ACID), EGGS, WHEY, SALT, BAKING SODA

References/Resources

Articles

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Resources on the Web

Transgenic Crops: and introductory and resource guide-very comprehesive web site on transgenic plants http://www.colostate.edu/programs/lifesciences/TransgenicCrops/index.html

UC Davis Biotechnology Program-has a series of PowerPoint presentations on transgenic plant http://www.biotech.ucdavis.edu/

Colorado Agricultural Information http://www.csuag.com/

Environmental News Network GM Food Information-contains introduction to GM food and a quiz on the topic
http://enn.com/indepth/gmfood/index.asp

DNA for Dinner
http://www.gis.net/~peacewp/webquest.htm#Introduction

Food for Our Future http://www.foodfuture.org.uk/

Saskatchewan Agricultural Biotechnology Information Centre Agrobacterium animation:
http://www.agwest.sk.ca/sabic_index_tp.shtml

University of Nebraska geneg gun animation:
http://croptechnology.unl.edu/