

# GMO speed dating

## What do you know about GMOs?

Genetic modification is a confounding topic to many people. In reality, humans have been genetically modifying plants and animals for thousands of years. Selective breeding and selective mutagenesis have resulted in many of the different crops and breeds of animals we take for granted today. Teosinte is the most closely related plant to what we call corn or maize today; it is a tall grass that has wide branching lateral leaves and an ear with only 5–12 kernels tightly sealed in a hard casing. This plant still grows in southern Mexico.

There are many methods of genetic modification and more are being utilized every day. They include: selective breeding and hybridization, stacked traits, mutagenesis, transgenesis (transfer of a gene from one to another of a different species), gene silencing and CRISPR.

The most common method of genetic modification up to now, has been transgenesis. Donor genes have given the recipient organisms new traits to add beneficial nutrients, or protection from disease, pests, drought, or flood. This activity is a review of some of those transgenic matches.

### Materials

- Donor cards
- Recipient cards

### Instructions

1. Each participant gets one card. The donor card holders sit around the room. The recipient card holders spend 30 seconds with one donor card holder.
2. After 30 seconds, the recipient card holders move to a new donor card holder. Repeat until all recipients have spoken with all donors.
3. Participants choose their match. Each match stands and shares their match with the large group.

### Reflection

1. Which pairings were hardest to find?
2. What other combinations might you be able to make?

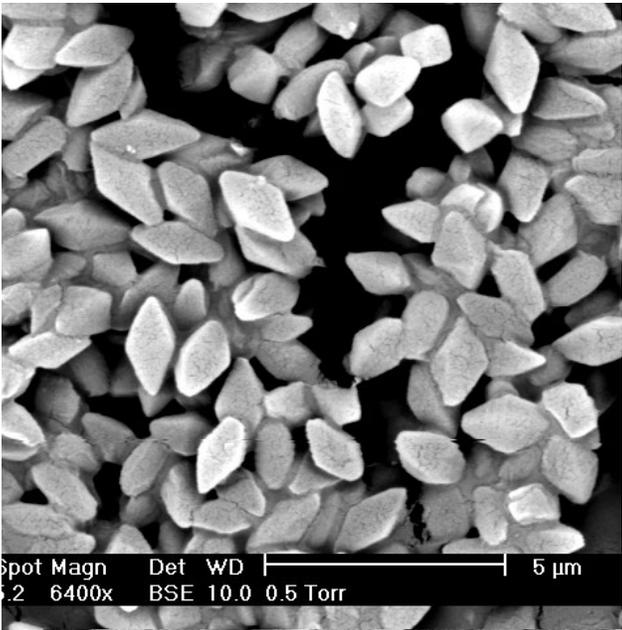
### Extension

What is the future of GMOs? How might GMOs address these issues:  
*Reduce food waste; Increase production; Reduce vulnerability to environmental stresses.*



<http://teosinte.wisc.edu/questions.html>

*This resource has been adapted from an original activity © OCR: <http://www.ocr.org.uk/qualifications/as-a-level-gce-biology-a-h020-h420-from-2015/delivery-guide/Images/123-241420-le-dating-game-learner-activity-v1.doc>*



## DONOR

### Name

*Bos primigenius*  
Cattle

### Key gene

*Cym*

### Properties of gene product

Chymosin is a protease enzyme that curdles milk

### GM use

GM bacteria produce the enzyme which is purified and used to make cheese. Previously chymosin was extracted from the stomachs of calves so cheese made in this way was not acceptable to vegetarians. 80–90% of the cheese sold in Britain is made with GM bovine chymosin.

## DONOR

### Name

*Phyllomedusa bicolor*  
Giant Leaf Frog

### Key gene

*DRS B1*

### Properties of gene product

B1dermaseptin protein kills bacteria and fungi.

### GM use

To prevent blight and bacterial diseases in potato crops.

## DONOR

### Name

*Agrobacterium sp*  
C4 strain

### Key gene

*C4 EPSPS*

### Properties of gene product

EPSP synthase performs a crucial metabolic step in plant chloroplasts. The bacterial version is undamaged by glyphosate.

### GM use

To make crops resistant to glyphosate so it can be used as a weed killer without harming the maize, cotton or soya bean crops.

## DONOR

### Name

*Bacillus thuringensis*

### Key gene

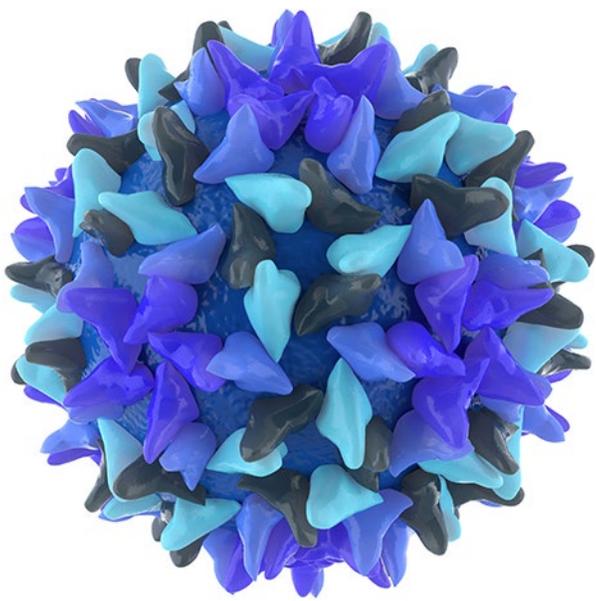
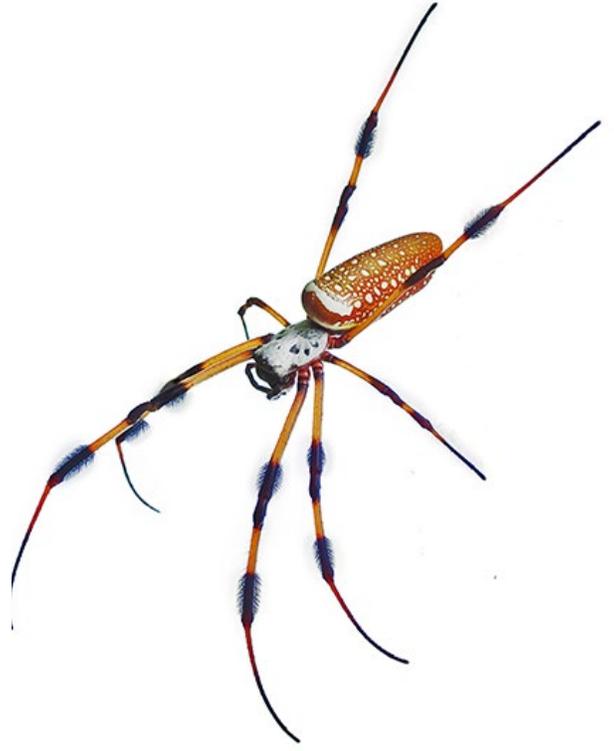
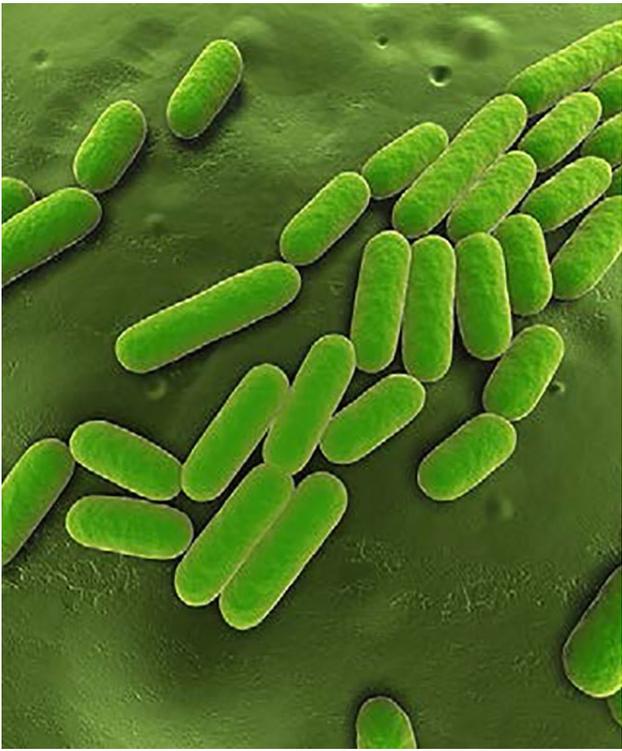
*Cry*

### Properties of gene product

Crystal protein kills caterpillars, maggots and beetles that eat the protein.

### GM use

To make crops such as maize, cotton and soya bean resistant to herbivorous insects.



## DONOR

### Name

*Nephila clavipes*  
Golden Orb Weaver

### Key gene

*MaSp*

### Properties of gene product

High-strength silk fibre for webs.

### GM use

Gene is switched on in mammary glands of GM goats to mass-produce the silk fibre for artificial tendons and ligaments and for bullet-proof vests and parachutes.

## DONOR

### Name

*Bacillus subtilis*

### Key gene

*cspB*

### Properties of gene products

Cold shock protein B helps organisms metabolise normally during abiotic stress.

### GM use

To produce higher yields for maize crops and produce a higher yield under drought conditions.

## DONOR

### Name

*Aequorea Victoria*  
Jellyfish

### Key genes

*GFP*

### Properties of gene products

Green Fluorescent Protein glows under UV light.

### GM use

The gene is extensively used as a marker to reveal which organisms have taken up a foreign gene and in which tissues the gene is switched on. Spin-offs include Glo-Fish™ and NeonMice sold as pets in the USA.

## DONOR

### Name

*Hepatitis B virus*

### Key gene

*HBsAg*

### Properties of gene product

Surface antigen of virus stimulates an immune response in humans if injected or given orally

### GM use

GM potatoes eaten raw in small quantities boost immunity to hepatitis B. This is an inexpensive and efficient way to deliver vaccines in developing countries.



## DONOR

### Name

*Homo sapiens*  
Human

### Key genes

Normal alleles coding for insulin, lactoferrin, Factor IX, anti-thrombin III and glucosidase.

### Properties of gene products

Insulin controls blood glucose concentration.  
Lactoferrin is an antimicrobial found in colostrum and milk.  
Factor IX helps blood clot.  
Anti-thrombin III stops blood clotting.  
Glucosidase in lysosome function.

### GM use

#### *Pharmaceutical drugs*

Insulin from GM bacteria treats diabetics.  
Lactoferrin in GM rice treats diarrhoea in children. Factor IX from GM sheep's milk treats people with haemophilia B.  
Anti-thrombin III from GM goats' milk is used as an anti-coagulant in surgical procedures.  
Glucosidase from GM carrot cells in culture treats people with Gaucher's disease.

## DONOR

### Name

*Homo sapiens*  
Human

### Key genes

Mutated version of *BRCA1* and activated *Ras* oncogene

### Properties of gene products

Cause cancer. The products of the normal versions of the genes repair DNA mutations and suppress tumours.

### GM use

Creating cancer research models  
GM mice engineered to carry the mutant alleles are used to study cancer and treatments for cancer.

## DONOR

### Name

*Androctonus australis hector*  
Scorpion

### Key genes

*AaHIT1*

### Properties of gene products

Toxic to insects but not harmful to mammals.

### GM use

To kill insects on GM cotton crops.

## DONOR

### Name

*Homo sapiens*  
Human

### Key genes

*CFTR*  
*RPE65*

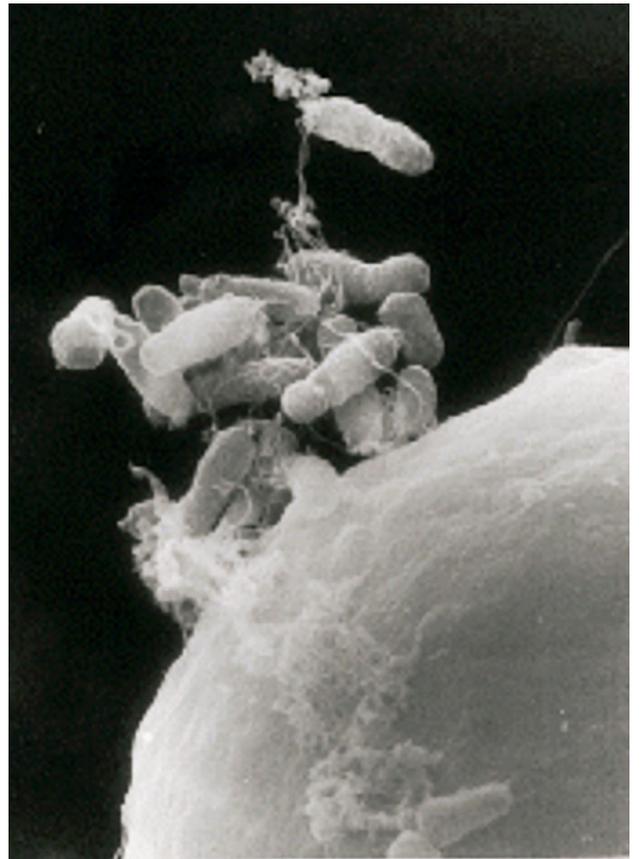
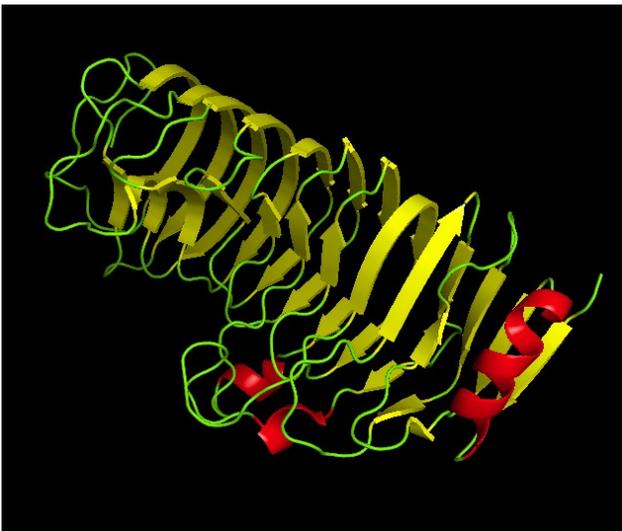
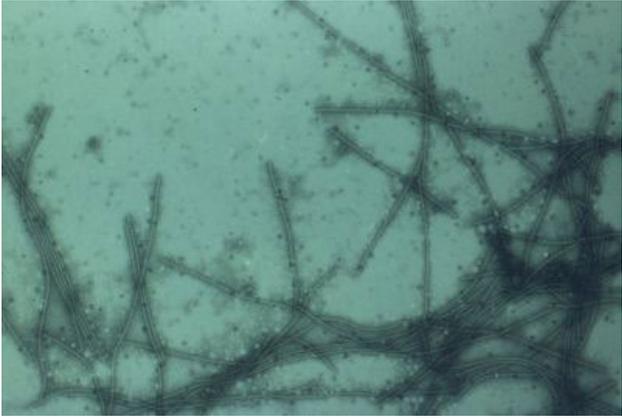
### Properties of gene products

*CFTR* protein allows normal mucus production in lungs and gut.  
*RPE65* protein is needed in rods and cones for normal vision.

### GM use

#### *Gene therapy*

Normal *CFTR* allele is introduced into lung epithelial cells of cystic fibrosis patients.  
*RPE65* inserted into retinal cells of blind patients with Leber's Congenital Amaurosis restored sight.



## DONOR

### Name

*Zoarcetes americanus*  
Ocean Pout

### Key genes

Antifreeze glycoproteins or AFGP gene

### Properties of gene products

Permit survival in subzero environments

### GM use

The promoter for the antifreeze protein gene is used in conjunction with the growth hormone taken from a Chinook salmon, which leads to a higher concentration of the growth hormone in the blood, causing the genetically modified salmon to grow much more rapidly than it would naturally.

## DONOR

### Name

Coat protein (CP) of Papaya Ringspot Virus (PRSV)

### Key genes

*PRSV HA 5-1*

### Properties of gene products

Provide resistance to PRSV

### GM use

Confer resistance to PRSV

## DONOR

### Name

*Agrobacterium tumefaciens*

### Key genes

*CaMV 35S*

### Properties of gene products

Code for the coat protein (CP) encoding sequences from zucchini yellow mosaic virus (ZYMV) and the watermelon mosaic virus (WMV2).

### GM use

Provides protection against these viruses.

## DONOR

### Name

*Polygalacturonase (PG)*

### Properties of gene products

*Antisense* DNA Keeps Polygalacturonase (PG), the major cell wall degrading enzyme of tomato fruit, from forming.

### GM use

By inhibiting the development of PG, the fruit should stay fresher longer.



## DONOR

### Name

Delta-12 oleate desaturase

### Key genes

*gm-fad2-1; FAD2-1*

### Properties of gene products

An antisense RNA strand is created to silence the formation of the enzyme that converts oleic acid into linoleic acid using the omega-6 desaturase encoding gene.

### GM use

Inhibits conversion of oleic acid to linoleic acid, keeps oleic acid levels high for healthier oil.

## DONOR

### Name

*Agrobacterium tumefaciens*

### Key genes

*CP4 EPSPS* (5-enolpyruvylshikimate-3-phosphate synthase) encoding gene.

### GM use

Inhibits action of glyphosate, the key ingredient in RoundUp (Monsanto).

## RECIPIENT

### Name

*Gossypium hirsutum*

Cotton

### Suitability as a GM recipient

Important crop for textile fibres but many insect pests attack it and the crop must be kept free of weeds.

## RECIPIENT

### Name

*Zea mays*

Maize or Sweetcorn

### Suitability as a GM recipient

Major food source for animals and humans and as a source of starch and sugars for processed food. Many insects attack the crop, its yield falls in drought conditions and the crop must be kept free of weeds.



## RECIPIENT

### Name

*Solanum tuberosum*

Potato

### Suitability as a GM recipient

Major carbohydrate food source in Europe and America. Potatoes are easy to grow and can give high yields but suffer from many diseases such as blight, which lower yields. They can be engineered to make vaccines but these must be grown under cover to prevent gene flow to other potatoes and to stop antigenic potatoes accidentally entering the human food chain.

## RECIPIENT

### Name

*Glycine max*

Soybean

### Suitability as a GM recipient

Major food source for animals and for humans as a source of protein in processed food. Many insects attack the crop and the crop must be kept free of weeds.

## RECIPIENT

### Name

*Oryza sativa*

Rice

### Suitability as a GM recipient

Major food source in Asia and a suitable vehicle for therapies like treating children with diarrhea (rice enhanced with human lactoferrin) and preventing vitamin A deficiency (genes from maize or daffodil and a soil bacterium).

## RECIPIENT

### Name

*Daucus carota*

Carrot

### Suitability as a GM recipient

Field-grown crops generally have been found to be unsafe to use as vehicles for production of pharmaceutical drugs, but carrot cells grown in culture in bioreactors are a new 'expression platform' for human proteins that can be used as medical drugs.



## RECIPIENT

### Name

*Ovis aries*

Sheep

### Suitability as a GM recipient

Female sheep produce plenty of milk.

A gene for a pharmaceutical protein is linked to a promoter to switch the gene on in the mammary glands, so that the protein appears in the milk. Sheep have been used to make factor IX to treat sufferers of haemophilia B.

## RECIPIENT

### Name

*Capra aegagrus hircus*

Goat

### Suitability as a GM recipient

Female goats produce plenty of milk.

A gene is linked to a promoter to switch the gene on in the mammary glands, so that the protein product appears in the milk. So-called 'spider-goats' produce silk in their milk for medical and military applications. Other GM goats produce a drug, human anti-thrombin III, used as an anticoagulant in surgery.

## RECIPIENT

### Name

*Homo sapiens*

Human

### Suitability as a GM recipient

People suffering from genetic diseases caused by two recessive non-functional alleles can be treated with gene therapy. The dominant functional allele is inserted into affected somatic cells. Trials have included treatment of cystic fibrosis and Leber's congenital amaurosis. The limitation on treating a human with another human allele is whether the cells that need the foreign DNA are accessible (e.g. lung epithelium) and stable (not replaced every few days).

## RECIPIENT

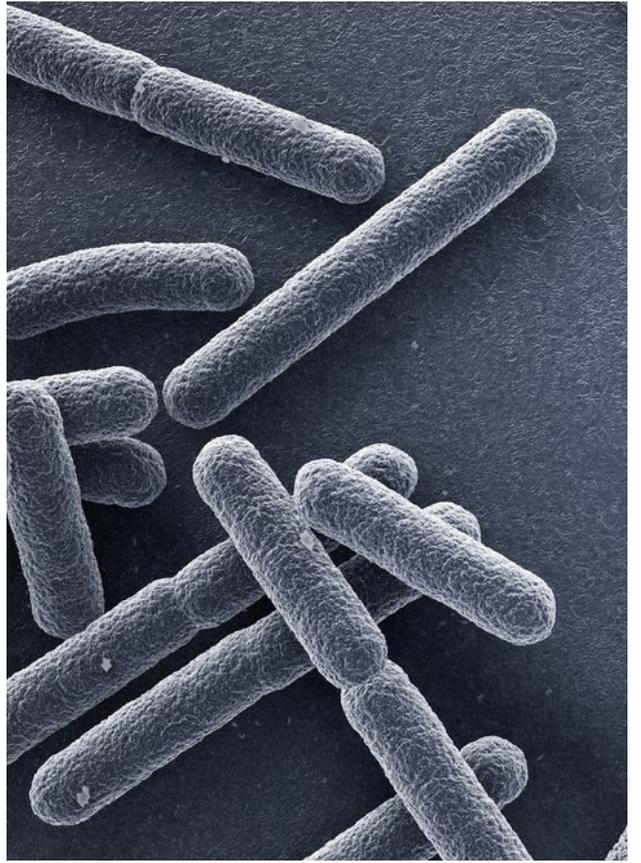
### Name

*Mus musculus*

Mouse

### Suitability as a GM recipient

It is a genetic model organism with a well-known, fully-sequenced genome. As a mammal its genome is very similar to that of humans. Mice are small so are cheap to feed and house. Many GM techniques applicable to humans or farm mammals are first tried on mice. Fluorescent GM NeonMice are sold as pets in the USA.



## RECIPIENT

### Name

*Escherichia coli*

### Suitability as a GM recipient

GM bacteria divide rapidly in a fermenter to produce proteins like human insulin and bovine chymosin for cheese-making. *E. coli* is a genetic model organism with a well-known, fully-sequenced genome. Its plasmids are widely used as vectors. However, some strains of *E. coli* are pathogenic and the GM process may involve inserting antibiotic resistance genes into the bacteria.

## RECIPIENT

### Name

*Rerio danio*

Zebrafish

### Suitability as a GM recipient

It is a genetic model organism with a well-known, fully-sequenced genome. It is a useful, simple vertebrate for research. GM zecubrafish expressing genes for fluorescent proteins are on sale in the pet trade in the USA marketed as Glo-Fish™.

## RECIPIENT

### Name

*Salmo salar*

Salmon

### Suitability as a GM recipient

Wild salmon disappeared from many rivers during the twentieth century due to overfishing and habitat change.

## RECIPIENT

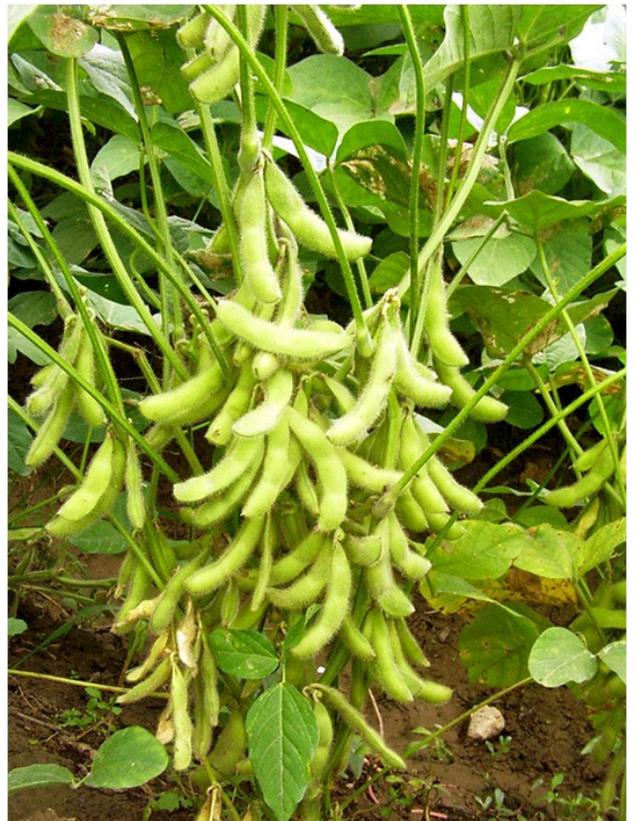
### Name

*Carica papaya*

Papaya

### Suitability as a GM recipient

The papaya is cultivated in most tropical countries. However, it is susceptible to the Papaya Ringspot Virus (PRSV). Since 1992, PRSV has destroyed nearly all non-GMO papaya in Hawaii.



## RECIPIENT

### Name

*Solanum lycopersicum*

Tomato

### Suitability as a GM recipient

Tomatoes are picked as green fruits and artificially ripened by ethylene treatment, which gives a ripe tomato color but not the full vine-ripened tomato flavor.

## RECIPIENT

### Name

*Fragaria × ananassa*

Strawberry

### Suitability as a GM recipient

Strawberries grow in temperate climate regions which are capable of having low temperatures and frost. Spring frosts cause damage to the flowers of the plant leading to poor yields and erratic fruiting. Frost on average causes millions of dollars in damages and drives up the price of the fruit for the consumer.

## RECIPIENT

### Name

*Glycine max*

Soybean

### Suitability as a GM recipient

Soybean oil is hydrogenated as a preservative to extend shelf life. High oleic oil does not need to be hydrogenated.

## RECIPIENT

### Name

*Cucurbita pepo*

Summer squash

### Suitability as a GM recipient

Viral diseases are a limiting factor to squash production, particularly during summer and fall months. Mosaic viruses include the cucumber mosaic cucumovirus (CMV), zucchini yellow mosaic potyvirus (ZYMV) and watermelon mosaic potyvirus (WMV2).



## RECIPIENT

### **Name**

*Glycine max*

Soybean

### **Suitability as a GM recipient**

Soybeans chief rivals in the field are weeds.

If the plant can resist herbicide spraying,  
the control of weeds is much easier.

Gene donor	Recipient organism	Purpose of GMO
Bacillus thuringensis	Maize	insect resistant crop
Agrobacterium sp. C4		herbicide resistant crop
Bacillus subtilis		drought resistant crop
Bacillus thuringensis	Cotton	insect resistant crop
Agrobacterium sp. C4		herbicide resistant crop
Bacillus thuringensis	Soybean	insect resistant crop
Agrobacterium sp. C4		herbicide resistant crop
Giant leaf frog	Potato	disease resistant crop
Hepatitis B virus		vaccine production
Human	Carrot	pharmaceutical product for Gaucher's disease patients
Human	Rice	lactoferrin-containing rice treats children with diarrhoea
<i>Erwinia uredovora</i> Maize		Golden Rice 2 with $\beta$ -carotene to prevent vitamin A deficiency
Golden orb weaver spider	Goat	strong silk fibres for medical and military uses
Human		pharming of anti-thrombin III
Human	Sheep	pharming of factor IX for haemophilia B sufferers
Human	Mouse	mouse cancer models
Jellyfish		NeonMice
Human	Human	gene therapy for recessive genetic disorders like cystic fibrosis and Leber's congenital amaurosis
Jellyfish	Zebrafish	Glo-Fish™
Cow	<i>Escherichia coli</i>	GM rennet (chymosin) for cheese-making
Human		insulin for diabetics
Scorpion	Cotton	insect-resistant crop
<i>Papaya ringspot virus</i>	Papaya	resistance to PRSV
Ocean pout	Salmon	antifreezing compounds
	Strawberry	
<i>Antisense Polygalacturonase (PG) enzyme</i> from tomato	Tomato	stops formation of enzyme that breaks down pectin; keeps fresh longer
<i>Zucchini yellow mosaic virus (ZYMV)</i> and <i>watermelon mosaic virus (WMV2)</i>	Squash	resistance to SMV
<i>Delta-12 oleate desaturase enzyme silencing</i> from soybean	Soybean	stops conversion of oleic acid into linoleic acid; health benefit