

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?

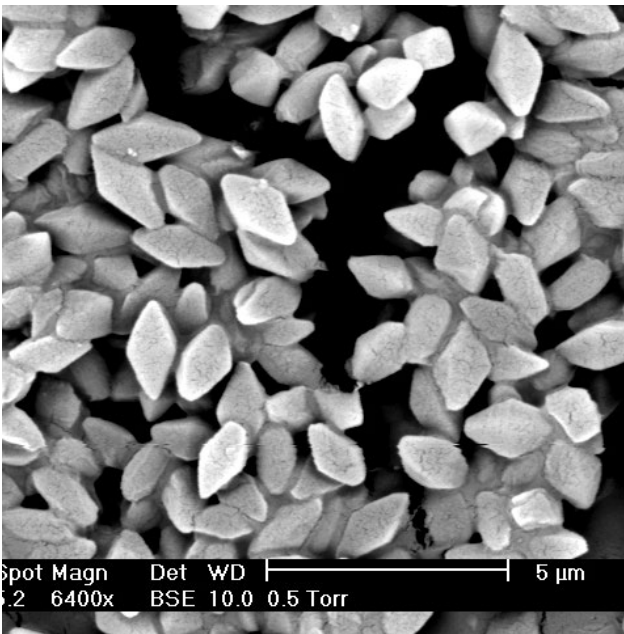
Extension

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>



Name

Bos primigenius
Cattle

DONOR

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.

Name

Agrobacterium sp
C4 strain

DONOR

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.

Name

Phyllomedusa bicolor
Giant Leaf Frog

DONOR

Key gene

DRS B1

Properties of gene product

B1 dermaseptin protein kills bacteria and fungi.

GM use

To prevent blight and bacterial diseases in potato crops.

Name

Bacillus thuringiensis

DONOR

Key gene

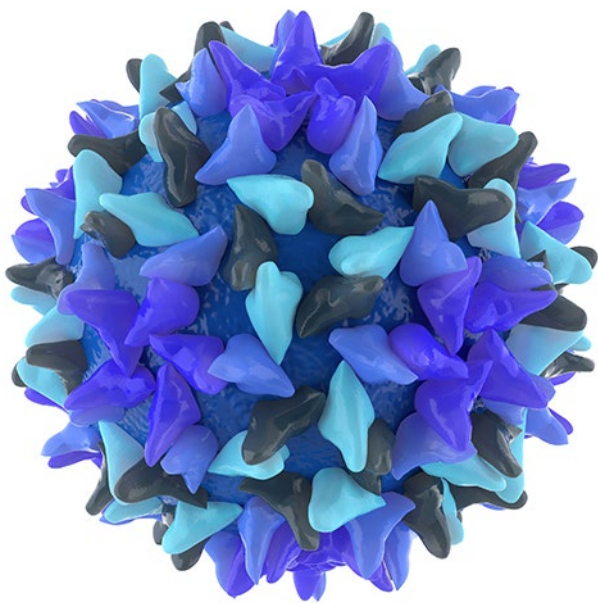
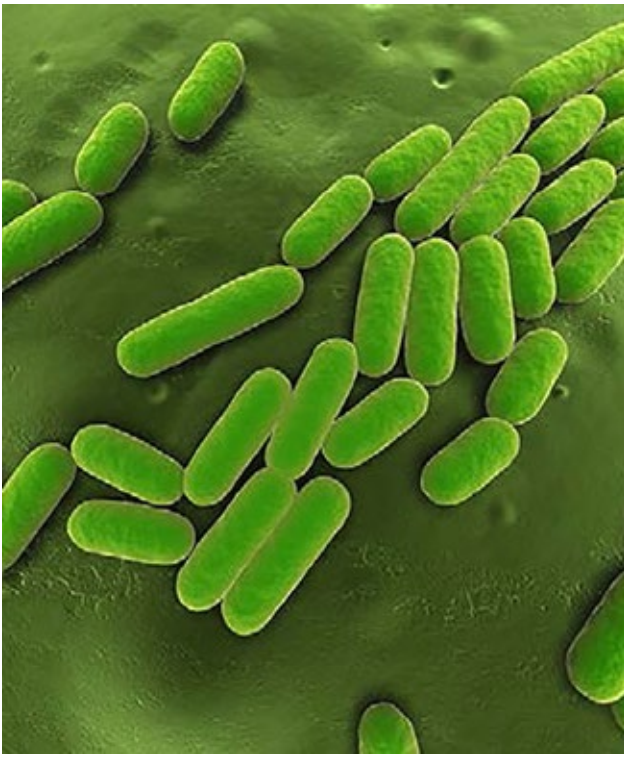
Cry

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.



Name

Nephila clavipes
Golden Orb Weaver

DONOR**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.

Name

Bacillus subtilis

DONOR**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.

Name

Aequorea Victoria
Jellyfish

DONOR**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.

Name

Hepatitis B virus

DONOR**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.



Name

Homo sapiens
Human

DONOR**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.

Name

Androctonus australis hector
Scorpion

DONOR**Key genes**

AaHIT1

Properties of gene products

Toxic to insects but not harmful to mammals.

GM use

To kill insects on GM cotton crops.

Name

Homo sapiens
Human

DONOR**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.

Name

Homo sapiens
Human

DONOR**Key genes**

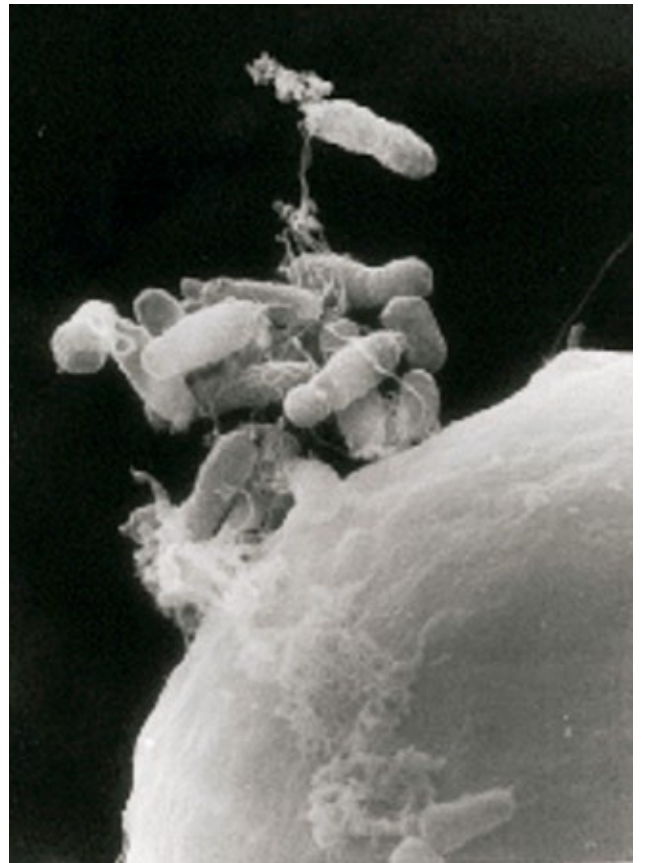
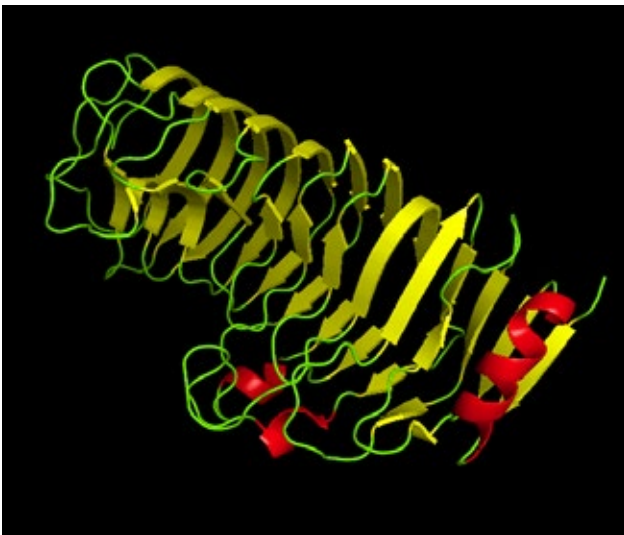
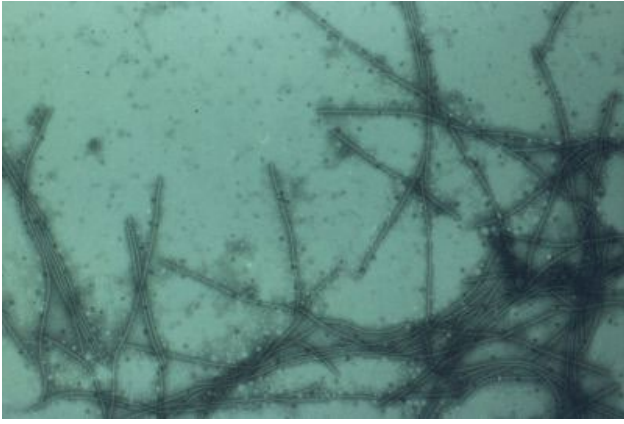
CFTR
RPE65

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.



Name

Zoarcetes americanus
Ocean Pout

DONOR**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.

Name

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

DONOR**Key genes**

PRSV HA 5-7

Properties of gene products

Provide resistance to PRSV

GM use

Confer resistance to PRSV

Name

Agrobacterium tumefaciens

DONOR**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.

Name

Polygalacturonase (PG)

DONOR**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.

Name

Delta-12 oleate desaturase

DONOR**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.

Name

Agrobacterium tumefaciens

DONOR**Key genes**

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

GM use

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

Name

Gossypium hirsutum
Cotton

RECIPIENT**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.

Name

Zea mays
Maize or Sweetcorn

RECIPIENT**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.



Name

Solanum tuberosum

Potato

RECIPIENT**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.

Name

Glycine max

Soybean

RECIPIENT**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.

Name

Oryza sativa

Rice

RECIPIENT**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).

Name

Daucus carota

Carrot

RECIPIENT**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.



Name

Ovis aries

Sheep

RECIPIENT**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.

Name

Capra aegagrus hircus

Goat

RECIPIENT**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.

Name

Homo sapiens

Human

RECIPIENT**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).

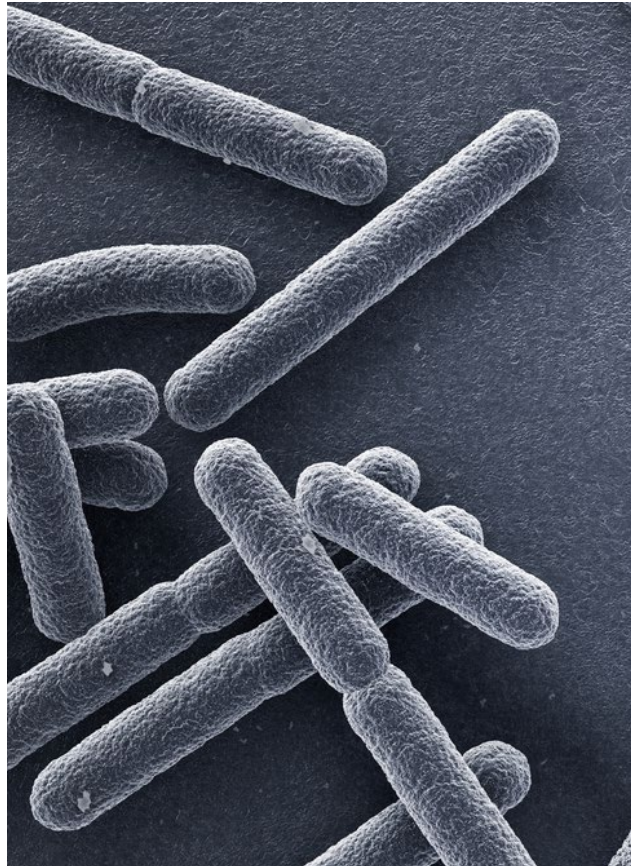
Name

Mus musculus

Mouse

RECIPIENT**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.



Name

Escherichia coli

RECIPIENT**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.

Name

Rerio danio

Zebrafish

RECIPIENT**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™.

Name

Salmo salar

Salmon

RECIPIENT**Suitability as a GM recipient**

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

Name

Carica papaya

Papaya

RECIPIENT**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.



Name

Solanum lycopersicum

Tomato

RECIPIENT**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.

Name

Fragaria × ananassa

Strawberry

RECIPIENT**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.

Name

Glycine max

Soybean

RECIPIENT**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.

Name

Cucurbita pepo

Summer squash

RECIPIENT**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 β -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 |