What are GMOs?

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GMO = Genetically Modified Organism

A GMO is created when genes from one organism are forcefully inserted into the DNA of another organism - usually an unrelated species

OTHER TERMS

Genetic modification (GM)	=	Genetic Engineering (GE)
Transgenic organisms	=	Genetically Modified Organisms (GMOs)
Traditional plant breeding	≠	Genetic engineering

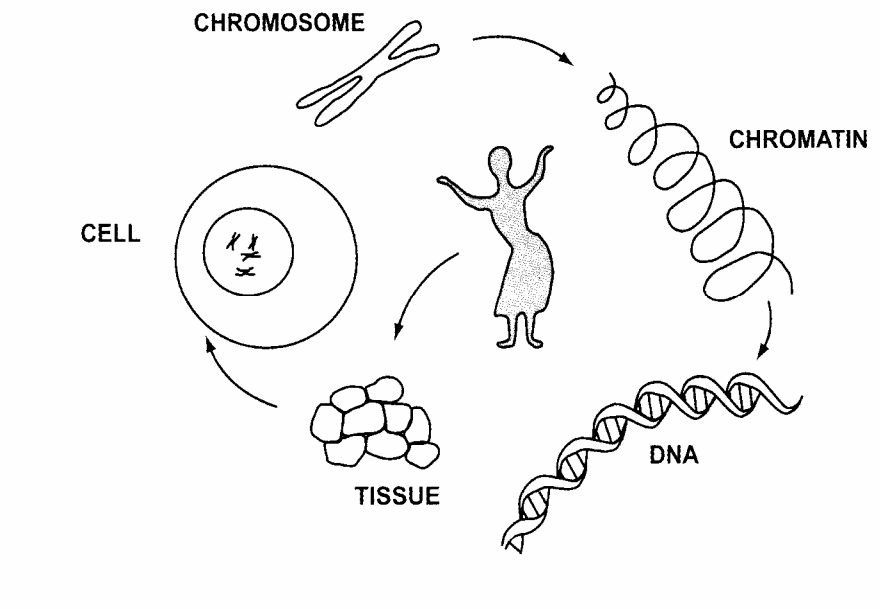
SOME BASIC BIOLOGY AND GENE JARGON

Our body functions in a particular way or looks like it does because we have inherited a genetic 'blueprint' from our parents. This genetic material is contained in each cell of our body.

The cell is the smallest living unit of any organism – the basic structural and functional unit of all living matter. Micro-organisms have only one cell whereas plants and larger animals have many cells that are stacked together to make up their tissues, organs or structures e.g. brain, bones, fruit etc. Each cell consists of:

- a membrane enclosing the contents of the cell
- organelles which perform functions like digestion, excretion or storage within the cell
- the nucleus which is a round structure containing all the vital instructions needed by the cell and the whole organism to function, grow and reproduce. This information is stored in the form of a genetic code on long thread-like structures called *chromosomes*.

All the genetic material within the chromosomes is called the *genome* of the organism. Each species of plant or animal is different. For example the human genome consists of 23 pairs of chromosomes – one half of the pair from the mother and the other from the father. Each chromosome is a very long molecule of *DNA (deoxyribonucleic acid)*, which is made of 2 strands wound around each other in a double helix that is joined so that the DNA looks like a twisted ladder. Each strand of DNA can exactly replicate the other strand ensuring that when the organism reproduces the full genetic instructions are passed on exactly to the offspring.



From 'Living with the Fluid Genome'. Mae-Wan Ho. 2003

Sections of the DNA are also responsible for providing the codes for the structure of *proteins*. These functional strands within the DNA are called *genes*. When the gene is active – called *expressing* - the gene code is translated into the *amino acids* that make up proteins. Proteins are responsible for almost everything that keeps an organism alive from building up cells and tissues to regulating how it grows, functions and reproduces. Most proteins are *enzymes* that start chemical reactions in the organism. There about 30 000 genes in the human genome but only about 3 % of our DNA consists of genes. Surprisingly a rice plant has about 50 000 genes! Scientists don't yet know what the function of the rest of the DNA is.

GENETICALLY MODIFIED ORGANISMS (GMOs)

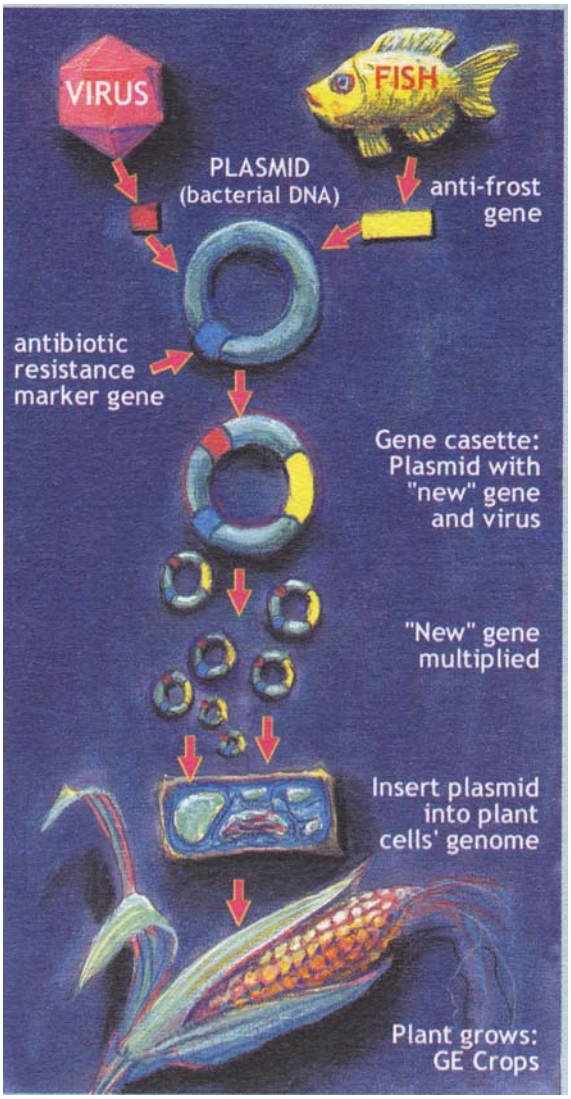
Genetically modified organisms (GMOs) are animals, plants and microbes that result from a process of genetic engineering (also called genetic modification) where foreign genes or fragments of genetic material are forcefully inserted into the DNA of the organism. GMOs are also called 'transgenic' organisms because they contain genes that have been 'transferred' from another organism.

Most genetic engineering results in new types of organisms that could never occur naturally. In nature a fish mates with a fish and a tomato with a tomato. But in genetic engineering a gene from a fish can be inserted into a tomato. This transfers genes across the natural barriers that have separated species over millions of years of evolution. GMOs are made in the laboratory!

This is very different from selective breeding where the same types of organisms are mated in the hope that their offspring will inherit the best qualities of both parents. Farmers have used selective breeding over thousands of years to slowly adapt plants and animals to suit local conditions and culture. Even more modern hybrids use techniques to cross-breed organisms of the same or closely related species.

HOW A GMO IS MADE?

To make a GMO a genetic engineer identifies a particular trait they think will benefit the organism that they are trying to engineer. For example, certain bacteria produce a toxin that kills insects and scientists thought that it would be a good idea for crop plants to also produce this toxin to prevent damage by insects. The scientists identify the gene in the bacteria that produces the toxin and cut this particular gene sequence out of the bacteria. This must then be inserted into DNA of the plant the scientist is trying to change in a way that ensures the inserted gene makes the protein to express the trait one is expecting. But this is not a simple process...



From Biowatch briefings: GE in South Africa:
Barren harvest or fields of plenty

The gene cassette

In order for the trait gene to be active and make proteins it needs a section of DNA called a *promoter* attached to one end to 'switch' the gene on. However, the host plant wouldn't normally recognise the foreign promoter from the bacteria. Viruses on the other hand have the ability to force their genetic information into a host cell and reproduce the virus because they have evolved very powerful promoters which trick the host cell into reading the viral genes to make viral proteins. Genetic engineers use this ability by joining viral promoters to the trait gene get the plant to accept the alien genes as part of its own DNA so that transgene proteins will be made anywhere in the plant. Without the promoter, the gene with the new traits would probably be dormant in the DNA. Most of the GM crops grown today have a promoter that comes from the cauliflower mosaic virus (CaMV 35S) which attacks the cabbage family. Scientists use the CaMV because it is aggressive causing a high level of transgene proteins to be expressed (made) and works in the DNA of all types of plants. However the plant no longer has control over this foreign promoter and can't stop or control the expression of the transgene proteins.

As we shall see the process of getting the foreign genes into the host plant is also difficult and unpredictable. Scientists need some way of telling which plants cells have accepted the foreign genes into their DNA. Usually they do this by joining an

antibiotic resistant marker gene to the foreign trait gene. When all the cells that have been a part of the genetic experiments are exposed to this antibiotic those that remain alive are the ones that have successfully combined with the foreign genes.

All of these pieces of foreign genetic material are joined together in what is called the *gene cassette.*

Invading the cell

There are a few ways in which genetic engineers force the foreign gene cassette into the host plant cell:

1. Certain bacteria (*Agrobacterium tumefaciens*) normally infect plants by inserting a portion of its own DNA into a plant, which causes the plant to grow tumours. Gene scientists swop the tumour causing section of the bacteria's DNA with the transgenes so that the bacteria 'infects' the plant's DNA with these foreign genes.

2. Millions of particles of tungsten or gold are coated with gene cassettes and then blasted into millions of plant cells using a gene gun. A handful of these incorporate the foreign gene.

After insertion the cells that survive the antibiotic are multiplied using tissue culture and developed into plants. These are tested to find ones that have the traits the scientists were looking for. Suitable plants are further multiplied through seeds or by making more clones through tissue culture of the plant's cells.

Both of these insertion methods result in the transgenes being taken into the cell in a random way. There is no way to predict where the transgenes will land along the host DNA and what might happen in the future as a result of this position. Thus each successful gene insertion is unique, and all the plants that are further reproduced from this are collectively called an 'event' and each is given an individual name e.g. MON863

In summary: "*Genetic engineering takes artificial combinations of genes that have never existed together, forcibly inserts them into random locations in the host genome and then clones the results; it is clear this process differs from natural breeding*." (Jeffrey Smith, 2007)

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