Food and Agriculture Organization of the United Nations

Information toolkit on food biotechnologies with a focus on food safety

2

Fundamentals

This “Information toolkit on food biotechnologies with a focus on food safety” is a publication consisting of one handbook and ten booklets, referred to as tools. It is strongly recommended to read through the whole set before using the information it contains.

Contents of the information toolkit on food biotechnologies with a focus on food safety

Handbook - Using the information toolkit

Tool 1: Background and guidance

Tool 2: Fundamentals

Tool 3: Rationale for potential benefits

Tool 4: GM food safety assessment

Tool 5: Regulations

Tool 6: Human health

Tool 7: The environment

Tool 8: Practical uses and applications

Tool 9: Current innovations

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Introduction

Tool 2 provides some fundamental information on food biotechnologies by addressing some frequently asked questions and providing examples. This tool aims to help the users of the toolkit to define technical terms, which may differ from one country to another, such as genetically modified organism (GMO), living modified organism (LMO) and genetically engineered organism (GEO). The terms used in the toolkit are based on the terminology used by the Food and Agriculture Organization of the United Nations (FAO, 2001; FAO, 2020a). Six basic questions are addressed in this tool:

1. What is deoxyribonucleic acid (DNA)?
2. What is a gene?
3. What is genetic modification?
4. What is a GMO?
5. What is the main difference between genetic modification and conventional breeding?
6. How long have people been using food biotechnologies?

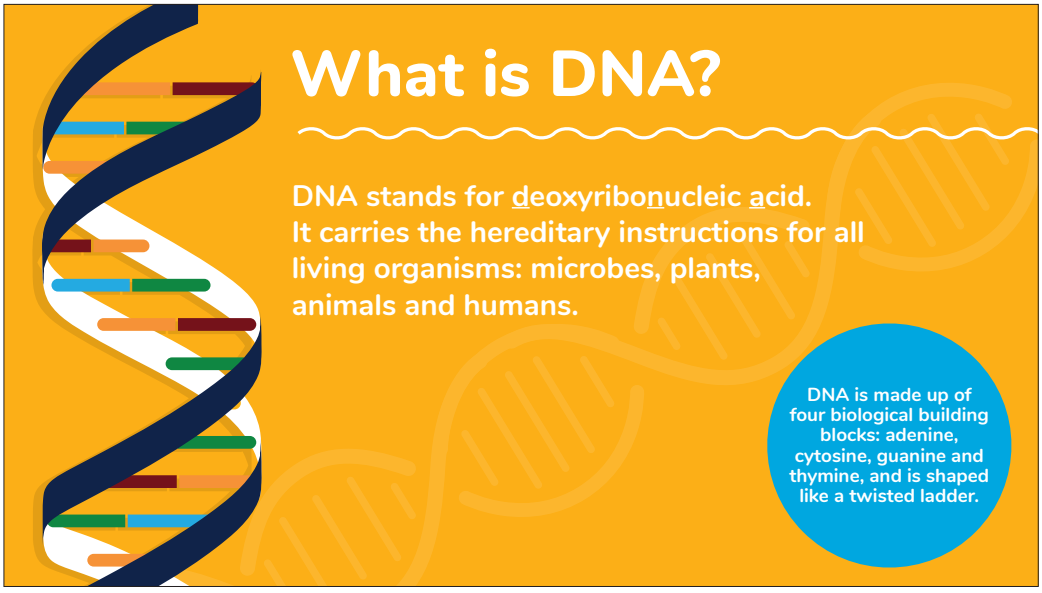
Introducing this information could be beneficial to help increasing the understanding of the science behind biotechnologies: in particular, experts' consultations found that introducing the topic of genetic modification to produce GMOs could help clarifying common misconceptions among the general public. Therefore, the information and the examples provided in this tool focus on genetic modification and GM food. Other important scientific information may also need to be introduced, which is not included in this tool but mentioned in the definition of "modern biotechnology" (FAO, 2001). This includes ribonucleic acid (RNA), protein, chromosome, mutagenesis, tissue culture and cell fusion. For these and other biotechnologies, it is suggested to use factual information alongside the information and the examples here provided.

Six examples

What is DNA?

A way to answer such question is provided in the example below, which illustrates how DNA looks like and which explains its function in an easy-to-understand manner. DNA is a molecule composed of nucleotides. Each nucleotide consists of three elements: a sugar moiety, a phosphate group, and one of four nitrogenous bases in DNA, i.e. adenine, cytosine, guanine or thymine. The nucleotides form a polymer (strand) and two of these strands stay together because of hydrogen bonds that occur between complementary nucleotide base pairs: the adenosine and the thymine base pairs; and the cytosine and the guanine base pairs. The two strands form a 3-D structure called a double helix, which looks like a ladder that has been twisted into a spiral form. DNA is present in every cell of living organisms, and contains the hereditary material for all those organisms, including people, animals, plants and all of our food, except for some viruses. DNA makes up a gene, which is introduced in the next example.

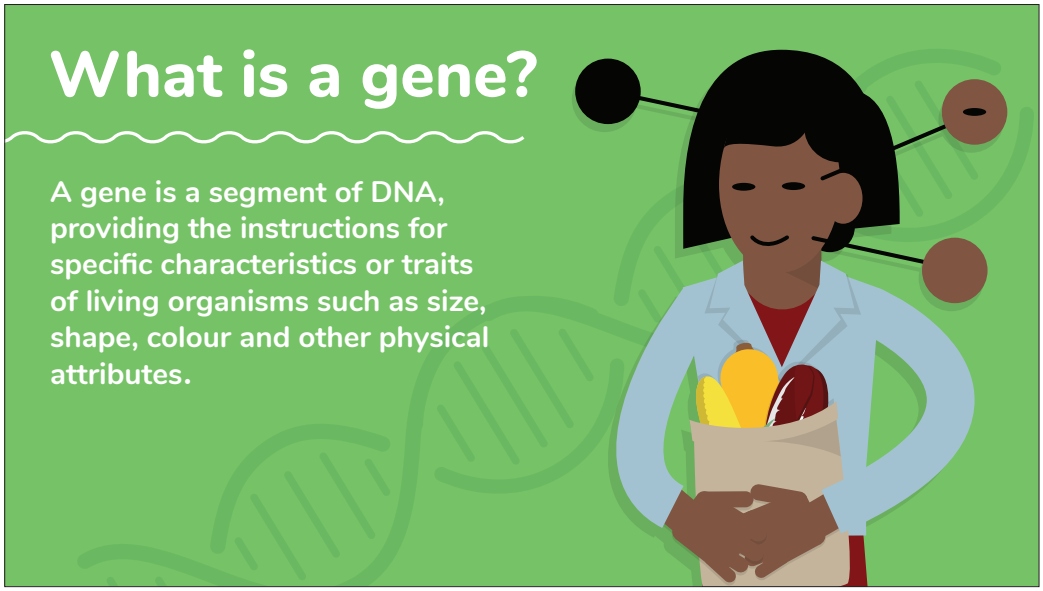
When illustrating scientific information such as that related to the structure and the function of DNA, RNA and protein, clear messages are required and scientific jargon should be avoided as much as possible. A text that looks clear to a scientist or government official may not be easy for non-scientists to understand. Users of this toolkit may like to consider what factual information the audience needs to know in order to convey a certain message, or in order to build up to explaining another concept.



What is a gene?

A gene can be considered as a segment of DNA containing the code for a specific protein that functions in one or more types of cells in the body. Genes vary in size, depending on the size of the proteins for which they code. Humans have over 20 000 genes in their body. Each gene can be thought of as a "recipe" similar to those that could be found in a cookbook. Some are recipes for creating physical features, like brown eyes or black hair. Others are recipes that the body follows to produce important chemicals called enzymes that help control chemical reactions in the body. Such recipes are passed on from parents to their offspring. For instance, if both parents have green eyes, their children may inherit the trait for green eyes. The process of creating such physical features or producing enzymes from the recipes involves two major steps called transcription and translation (Clancy and Brown, 2008).

The example represents a woman with her physical features. It is possible for users to change the illustration by adding or substituting another living organism, for instance a plant and animal can be selected. It's also possible to highlight traits other than the eye colour, hair colour and skin colour that are currently featured in the example.

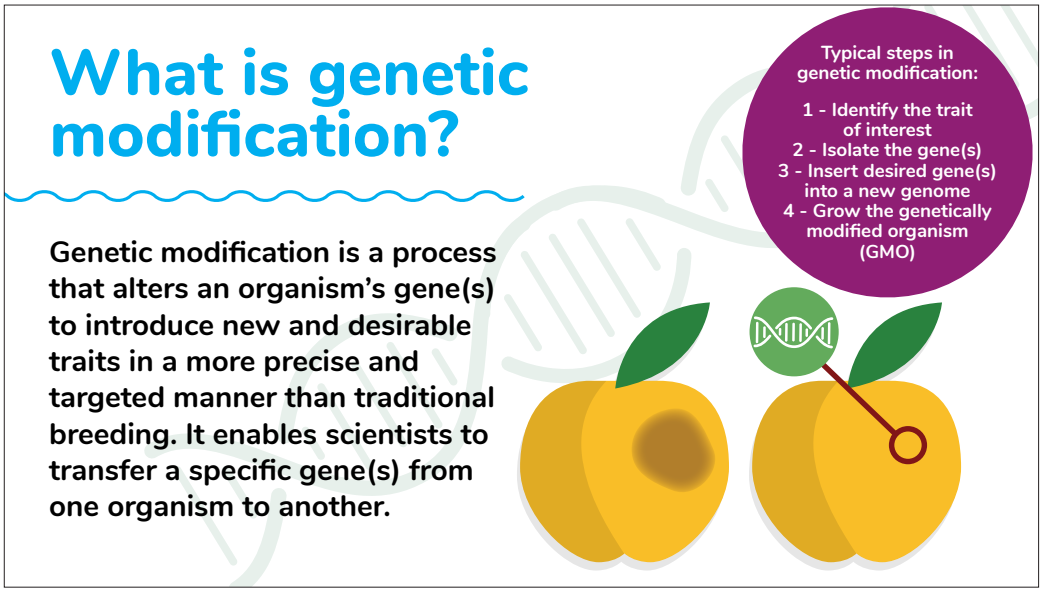


What is genetic modification?

A way to answer this question is illustrated in the example below. This example explains what genetic modification is and it demonstrates how the technique is used to create a GMO. Users of this toolkit can produce materials using the technical terminology used in their own country. For instance, the definition of "genetic modification" may differ from one country to another. In some countries, it means a technology to produce GMOs, whereas in other countries it encompasses all types of biotechnologies.

As a standard method, genetic modification to create a GMO is usually explained to occur in four steps: (1) a trait of interest is identified, (2) the gene(s) of interest is isolated, (3) the desired gene(s) are deleted or inserted into a new genome, and (4) the GMO is grown (Harvard University, 2015). It should be noted that while it is necessary to obtain the approval of government before growing GMOs in general, this is not considered as a step for creating a GMO, but it is a regulatory requirement. Therefore, it does not belong to the texts covering scientific terms, genetic modification and process.

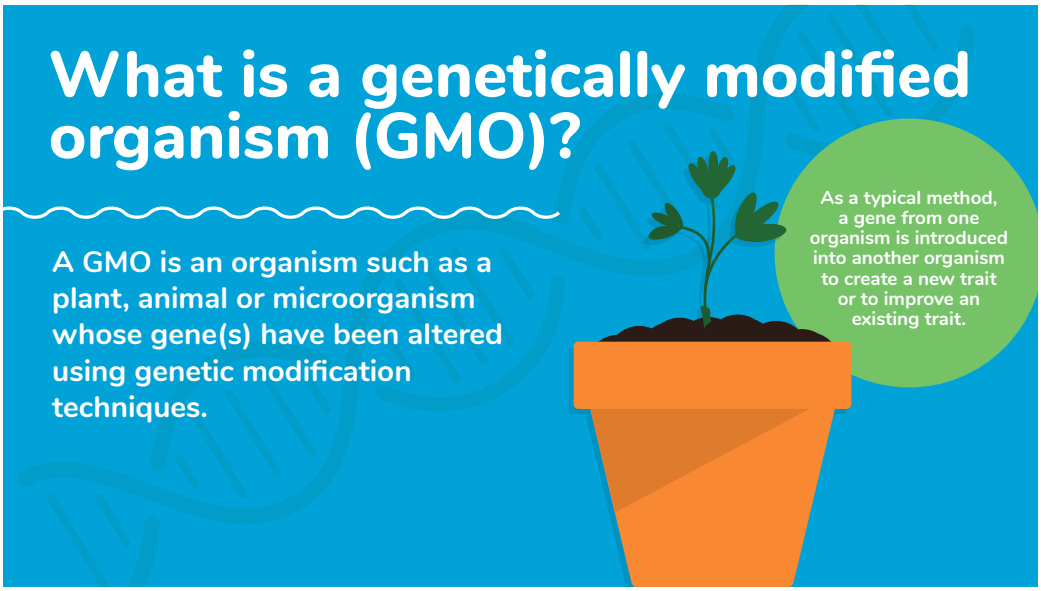
When producing a material starting from this example, it is possible to show DNA in a GM apple and a non-GM apple to indicate that DNA exists in both apples. An additional genetic segment can be shown in the GM apple with an explanation that this makes the apple less prone to browning.



What is a genetically modified organism (GMO)?

There are several ways of referring to a GMO worldwide, such as LMO and GEO. There also may be other ways for describing a GMO. A gene from an organism can be introduced into a different organism to create a new trait or to change existing traits. In addition to gene transfer, gene silencing may also be used within the target organism for the same purpose.

It is advisable that when providing information related to this topic, terms are introduced with the correct definitions or explanations specific to the geographic area and target audience. The example provided here shows that a GMO is a plant, animal or microorganism whose genetic material has been altered using genetic modification. Since the concept of gene silencing may be difficult for a non-specialist audience to understand, it is not included in the example below.



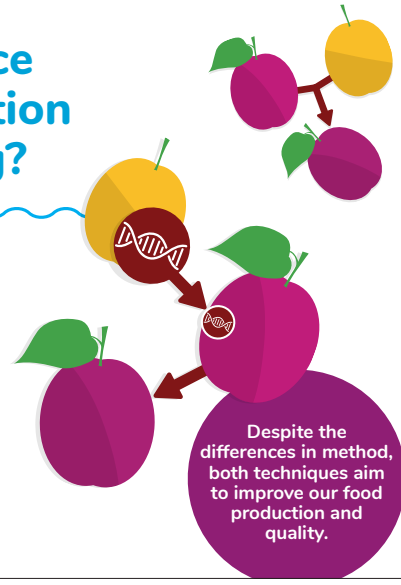
What is the main difference between genetic modification and conventional breeding?

Conventional breeding develops new varieties by crossing together living organisms such as plants and animals with relevant characteristics and selecting the offspring with the desired combination of characteristics. It employs processes that occur in nature, such as sexual and asexual reproduction. Genetic modification works primarily through inserting genetic material, which does not occur without human intervention. The genes could come from diverse sources, and not only closely related species, unlike in conventional breeding.

The example below presents the main differences between genetic modification and conventional breeding, and it can be used as a starting point to introduce the difference with the general public. Other aspects can be added to it, for example, the difference in the time required to obtain a desired trait, which is generally shorter in genetic modification because conventional breeding depends on a process of natural selection.

What is the main difference between genetic modification and conventional breeding?

In genetic modification, genes can come from sources with which the organism cannot breed. Conventional breeding is generally limited to genetic material which is already present within a species or closely related species.



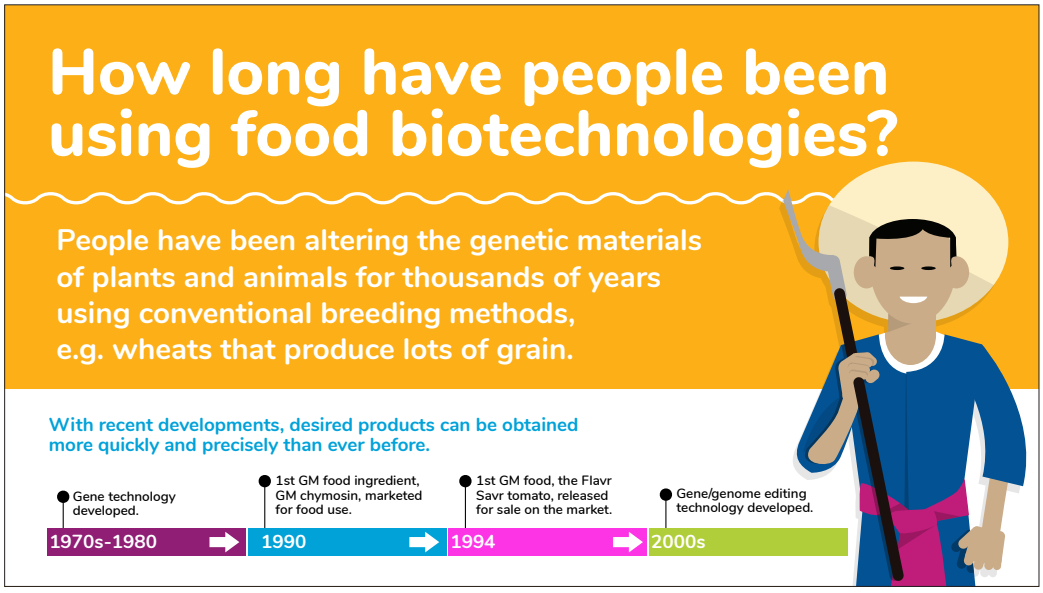
Experts' consultations suggested that many people may think that the food products derived from conventional breeding are safe for human health and the environment, whereas foods produced by modern biotechnologies may be potentially unsafe. No difference exists between the techniques in terms of the safety of the food they produce, because in both cases, foods are subject to food safety assessments (as discussed in Tool 4 of this toolkit). Together with

examples available in Tool 9, regarding the difference between genome editing and genetic modification, this example can help inform the audience that all breeding techniques are employed with the aim of improving food production and the quality of what we eat. Tool 4 of this toolkit can also be referred to complement the information that all foods, including those produced through biotechnologies, are subject to the same food safety assessments (FAO, 2021c).

How long have people been using food biotechnologies?

A way to answer this question is provided in the example below, which displays the history of use of food biotechnologies on a timeline that begins thousands of years ago and stretches to today, showing recent developments. The example contains major historical events, including the discovery of gene technology in the 1970s and 1980s, the release of the first GM food, the Flavr-Savr tomato in 1994, and the development of genome editing technology in the 2000s.

Users of this toolkit may take inspiration from this example to introduce their general public with some country-specific events relevant to food biotechnologies, such as their countries' participation in Codex, the establishment of national legislations or the first cultivation of a GM plant. It is also possible to start from the same example to develop a new infographic highlighting recent regulatory events in a particular country.



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Terminology

Biosafety	Set of measures or actions addressing the safely aspects related to the application of biotechnologies and to the release into the environment of transgenic plants and other organisms, particularly microorganisms, that could negatively affect plant genetic resources, plant, animal or human health, or the environment (FAO, 2001).
Biotechnology	Any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for a specific use. In this document, the words "food biotechnology" are used when biotechnology is applied to make or modify foods for human consumption (FAO, 2001).
Conventional counterpart	A related organism/variety, its components and/or products for which there is experience of establishing safety based on common use as food (FAO and WHO, 2009).
Deoxyribonucleic acid	Deoxyribonucleic acid (DNA) is a long chain polymer of deoxyribonucleotides. DNA constitutes the genetic material of most known organisms and organelles, and is usually in the form of a double helix, although some viral genomes consist of a single strand of DNA, and others of a single- or a double-stranded ribonucleic acid (RNA) (FAO, 2001).
Gene	The unit of heredity transmitted from generation to generation during sexual or asexual reproduction. More generally, the term is used in relation to the transmission and inheritance of particular identifiable traits. The simplest gene consists of a segment of nucleic acid that encodes an individual protein or RNA (FAO, 2001).
Genome editing	Techniques utilized by scientists to correct or to introduce specific mutations at a particular site (locus) within the DNA of an organism. The techniques used to accomplish these site-specific corrections or directed mutations (base substitution, addition or deletion) include living modified organism (LMO) genome editing and transcription activator-like effector nucleases (TALEN). The term gene editing may be used interchangeably (FAO, 2019).
Genetic modification	Altering the genetic material of cells or organisms with the intention of making them capable of producing new substances or performing new functions (FAO, 2020a). The term genetic engineering may be used interchangeably.
Genetically modified food	Food produced for human consumption and derived from organisms whose genetic material (DNA) has been modified in a way that does not occur naturally, e.g. through introducing a gene from a different organism (FAO, 2020a).
Genetically modified organism	An organism that has been transformed by inserting one or more transgenes (FAO, 2001).
Living modified organism	A living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology. It is a synonym of GMO, but is restricted to organisms that can endanger biological diversity (FAO, 2001).
Modern biotechnology	Application of: i) *In vitro* nucleic acid techniques, including r-DNA and direct injection of nucleic acid into cells or organelles, or ii) fusion of cells beyond the taxonomic family that overcome natural physiological reproductive or recombinant barriers and that are not techniques used in traditional breeding and selection (FAO, 2001).

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