Genetically Modified Organisms

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Introduction

A genetically modified organism (GMO) is any organism whose genetic material has been altered by using genetic engineering techniques. The exact definition of a genetically modified organism and what constitutes genetic engineering varies, with the most common being an organism altered in a way that "does not occur naturally by mating and/or natural recombination". A wide variety of organisms have been genetically modified (GM), from animals to plants and microorganisms. Genes have been transferred within the same species, across species (creating transgenic organisms) and even across kingdoms. New genes can be introduced, or endogenous genes can be enhanced, altered or knocked out. The first genetically modified animal, a mouse, was created in 1974 by Rudolf Jaenisch, and the first plant was produced in 1983. In 1994 the Flavr Savr tomato was released, the first commercialized genetically modified food. Bacteria are the easiest organisms to engineer and have been used for research, food production, industrial protein purification (including drugs), agriculture and art. Many objections have been raised over the development of GMO's, particularly their commercialization. At broadest GMO can include anything that has had its genes altered, including by nature.

Genetically engineered organism (GEO) can be considered a more precise term compared to GMO when describing organisms' genomes that have been directly manipulated with biotechnology. The term GMO originally was not typically used by scientists to describe genetically engineered organisms until after usage of GMO became common in popular media. The United States Department of Agriculture (USDA) considers GMOs to be plants or animals with heritable changes introduced by genetic engineering or traditional methods, while GEO specifically refers to organisms with genes introduced, eliminated or rearranged using molecular biology, particularly recombinant DNA techniques, such as transgenesis.

The definitions focus on the process more than the product, which means there could be GMOS and non-GMOs with very similar genotypes and phenotypes. This has led scientists to label it as a scientifically meaningless category saying that it is impossible to group all the different types of GMOs under one common definition. Bacteria were the first organisms to be genetically modified in the laboratory, due to the relative ease of modifying their chromosomes. This ease made them important tools for the creation of other GMOs. Genes and other genetic information from a wide range of organisms can be added to a plasmid and inserted into bacteria for storage and modification. Bacteria are cheap, easy to grow, clonal, multiply quickly and can be stored at −80 °C almost indefinitely. Once a gene is isolated it can be stored inside the bacteria, providing an unlimited supply for research. A large number of custom plasmids make manipulating DNA extracted from bacteria relatively easy. Genetically modified bacteria are used to produce large amounts of proteins for industrial use. Generally the bacteria are grown to a large volume before the gene encoding the protein is activated. The bacteria are then harvested and the desired protein purified from them.

Production of GMOs

Traditionally the new genetic material was inserted randomly within the host genome. Genes targeting techniques, which creates double-stranded breaks and takes advantage on the cells natural homologous recombination repair systems, have been developed to target insertion to exact locations. Genome editing uses artificially engineered nucleases that create breaks at specific points. There are four families of engineered nucleases: meganucleases, zinc finger nucleases, transcription activator-like effector nucleases and the Cas9-guideRNA system (adapted from CRISPR). TALEN and CRISPR are the two most commonly used and each has its own advantages. TALENs have greater target specificity, while CRISPR is easier to design and more efficient. Creating a genetically modified organism (GMO) is a multi-step process. Genetic engineers must isolate the gene they wish to insert into the host organism. This gene can be taken from a cell or artificially synthesized. If the chosen gene or the donor organism's genome has been well studied it may already be accessible from a genetic library. The gene is then combined with other genetic elements, including a promoter and terminator region and a selectable marker. A number of techniques are available for inserting the isolated gene into the host genome. Bacteria can be induced to take up foreign DNA, usually by exposed heat shock or electroporation. DNA is generally inserted into animal cells using

microinjection, where it can be injected through the cell's nuclear envelope directly into the nucleus, or through the use of viral vectors. In plants the DNA is often inserted using Agrobacterium-mediated recombination, biolistics or electroporation. As only a single cell is transformed with genetic material, the organism must be regenerated from that single cell. In plants this is accomplished through tissue culture. In animals it is necessary to ensure that the inserted DNA is present in the embryonic stem cells. Further testing using PCR, Southern hybridization, and DNA sequencing is conducted to confirm that either the organism contains the new gene or not.

Application of GMO

Examples of GMOs Resulting from Agricultural Biotechnology

Approved Commercial Products

Herbicide tolerance	Soybean	Glyphosate herbicide (Roundup) tolerance conferred by expression of a glyphosate-tolerant form of the plant enzyme 5-enol pyruvyl shikimate-3-phosphate synthase (EPSPS) isolated from the soil bacterium *Agrobacterium tumefaciens*, strain CP4
Insect resistance	Corn	Resistance to insect pests, specifically the European corn borer, through expression of the insecticidal protein Cry1Ab from *Bacillus thuringiensis*
Altered fatty acid composition	Canola	High laurate levels achieved by inserting the gene for ACP thioesterase from the California bay tree *Umbellularia californica*
Virus resistance	Plum	Resistance to plum pox virus conferred by insertion of a coat protein (CP) gene from the virus

The pharmaceutical industry is another frontier for the use of GMOs. In 1986, human growth hormone was the first protein pharmaceutical made in plants and in 1989, the first antibody was produced. Both research groups used tobacco, which has since dominated the industry as the most intensively studied and utilized plant species for the expression of foreign genes. As of 2003, several types of antibodies produced in plants had made it to clinical trials. The use of genetically modified animals has also been indispensible in medical research. Transgenic

animals are routinely bred to carry human genes, or mutations in specific genes, thus allowing the study of the progression and genetic determinants of various diseases.

Conclusions

The prevalence of GM foods varies from country to country around the world based on existing policies and legislation. The long term environmental impacts of GM food production are still not completely known, but research shows that these crops may have negative effects, such as threatening biodiversity and increasing the prevalence of herbicide and pesticide resistant weeds and pests. US is the worldwide leader in GM food production and these foods are readily available on supermarket shelves. If GM foods continue to dominate supermarket shelves in US and consumers continue to buy them, than there may be less pressure for the government to pass GM labeling regulations. Our preliminary research indicates that more non-GM products can be found in higher end supermarkets, but more research needs to be conducted. Future research can study the reasoning behind the differences in the marketing of non-GM foods in the supermarkets.