

# LMOs, GMOs, and Plant Breeding Advances

Modern innovative plant breeding tools allow for genetic modifications ranging from small changes (or edits) to existing genes, to the introduction of new genes. Some of the resulting plants may be defined as Living Modified Organisms (LMOs) or Genetically Modified Organisms (GMOs). Uses of GMOs/LMOs is highly regulated globally.

Plants created from traditional plant breeding practices are generally not regulated in the same way as GMOs/LMOs. The following are descriptors of the different approaches.

## ① Traditional Breeding

Through the process of combining beneficial genes via crossing and selecting, the selected genes, along with many others, will be present in the offspring.

## ② Transgenesis

The process of inserting specific beneficial gene(s) into the plant genome at random location. The resulting plants are transgenic (or GMO/LMO).

## ③ Genome Editing

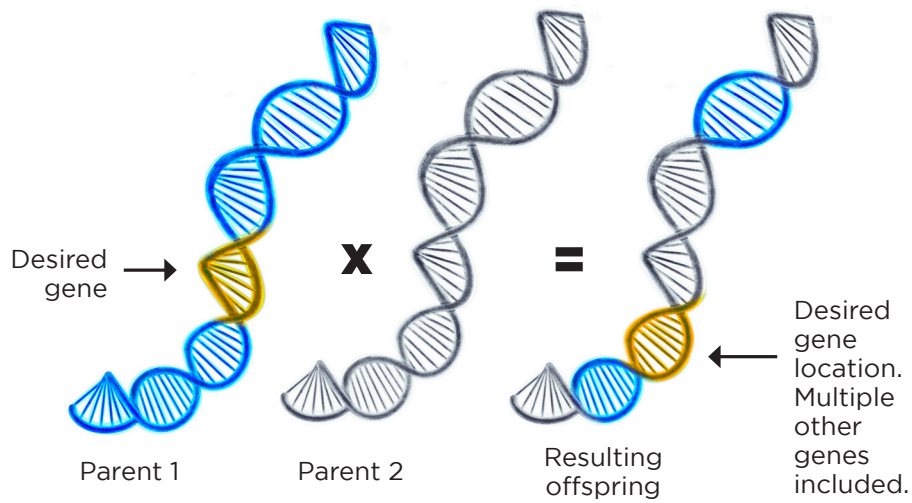
The process of making targeted genetic modifications in the plant genome resulting in a range of genetic changes and plants that may be comparable to either traditionally bred or transgenic plants.

## ④ Synthetic Biology

A multidisciplinary approach to engineering biological pathways and systems. Synthetic biology may utilize the tools of transgenesis and genome editing.

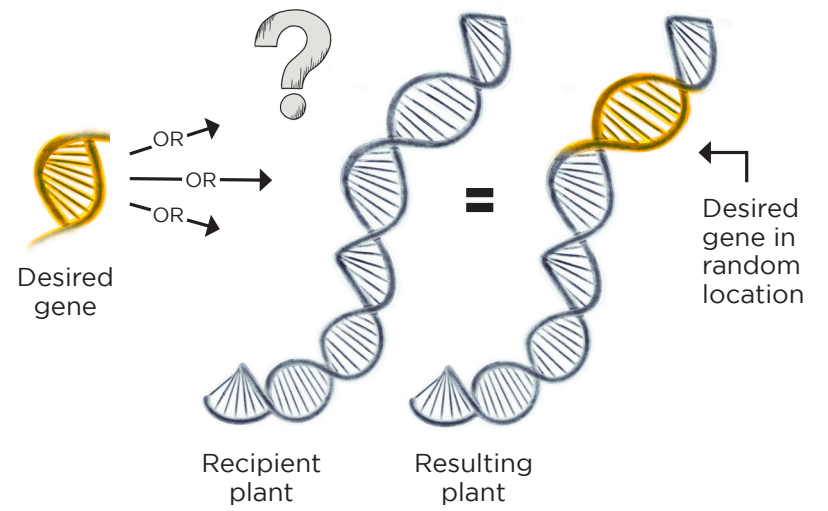
## ⑤ Gene Drive

A genetic mechanism that enhances the inheritance of a specific genetic trait in a species.



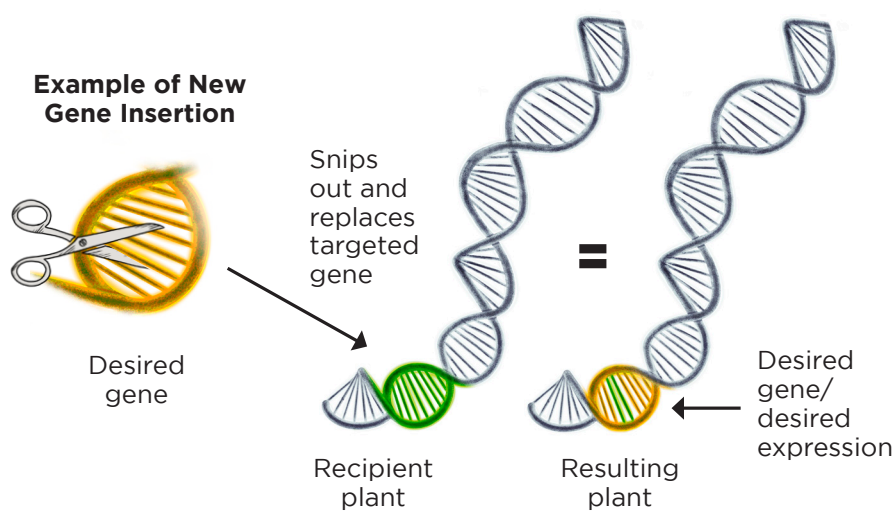
## Traditional Breeding

In **traditional breeding**, related plants are crossed to generate offspring with positive traits such as higher yield and disease resistance. Plant breeders have limited control over the other genes that might also be transferred so it can take many years of breeding to get the desired combination. Advances such as cell culture and marker-assisted breeding are improving the success rates for traditional crosses.



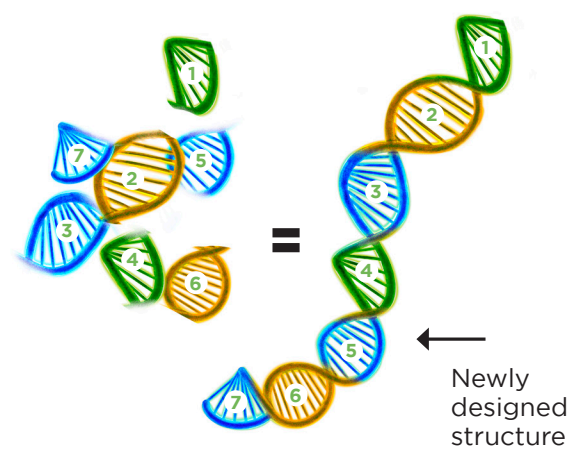
## Transgenesis

**Transgenesis** involves identifying a desired gene with known function, such as one responsible for drought tolerance, and inserting it into the genome of the targeted plant, creating a GMO (or LMO). Physical methods, or a modified virus or bacterium, are used to insert the gene, limiting scientists' control over where the gene will be inserted or if it will be successfully expressed, i.e., the resulting plant is more drought-tolerant.



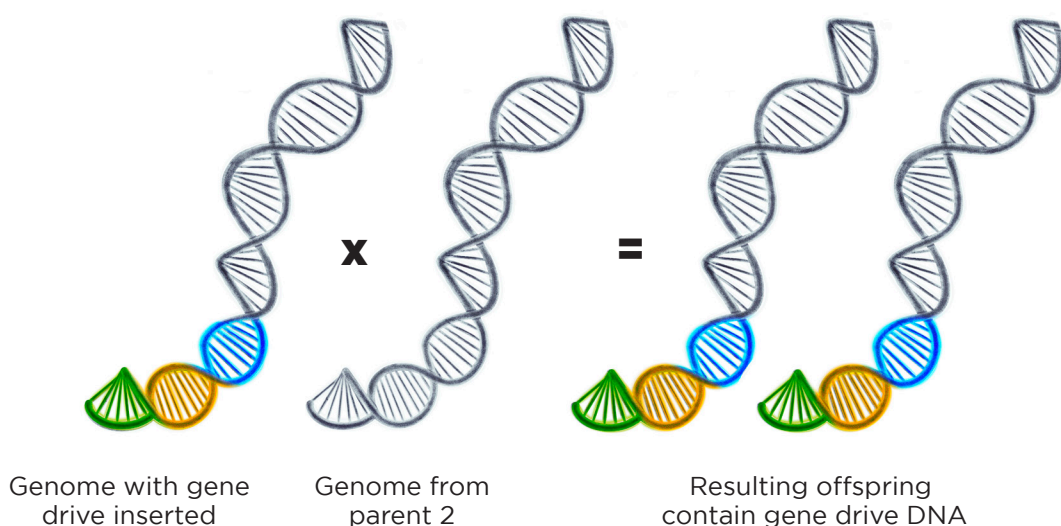
## Genome Editing

Precision and flexibility are the major advantages of **genome editing** over previous tools. Based on information scientists have learned about plant genes, genomes, and traits, plant breeders can now use genome editing tools (like CRISPR) to delete, edit, or add genetic sequences to more rapidly and predictably achieve desired plant characteristics. The range of possible genetic modifications achievable through genome editing can be comparable to those resulting from traditional breeding or to transgenesis, depending on how the editing tools are used.



## Synthetic Biology

**Synthetic biology** combines the tools of biotechnology with engineering principles and computer science to design new biological systems or redesign existing systems for useful functions, such as engineered cells for the production of biofuels, food ingredients, pharmaceuticals, or industrial chemicals. Scientists may use the suite of tools available to them, including transgenesis and genome editing, in synthetic biology applications, and the living organisms developed are regulated as GMOs/LMOs.



## Gene Drive

A **gene drive** is a long-known naturally occurring phenomenon, but genetic modification tools have enabled the potential for engineered gene drives. An engineered gene drive can, in theory, drive a gene (and the associated trait) through a population at a faster rate than normal inheritance rates. To date, research with engineered gene drives remains laboratory-based, with successful demonstrations of the concept in a small number of insect species. The use of engineered gene drives in mammalian systems remains under investigation, and potential applications in plants remain speculative. Organisms containing engineered gene drives are GMO/LMOs and are regulated as such.

