

# Genetically Modified Organisms

## What are GMOs?

Genetically modified organisms (GMOs) are organisms that have had genes added, enhanced, or deleted using laboratory techniques, typically providing them with new or improved qualities.

GMOs can include plants, animals, and microorganisms. Some GMOs have been approved by regulatory agencies for commercial production and consumption, while others are currently undergoing regulatory evaluation. Still other GMOs are in experimental stages and confined to scientific laboratory research. According to the United States Department of Agriculture (USDA) by 2023, 97% of cotton, 95% of soybeans, and 93% of corn grown in the U.S. were genetically modified.

## What are some things GMOs are modified to do?

**Pest Resistance** (Example: Bt corn): The genome of Bt corn has been modified to include a gene from the soil bacterium *Bacillus thuringiensis* which produces a protein poisonous to the European corn borer, an insect that damages corn crops.

**Virus Resistance** (Example: GM papaya): Developed at the University of Hawaii, the genetically modified papaya is resistant to Papaya Ringspot Virus (PRSV) a plant virus spread predominantly by aphids. The Rainbow papaya variety was produced by introducing the gene encoding a PRSV protein into plant tissue, which confers resistance to the virus.

**Herbicide Tolerance** (Example: RoundupReady soybean): Glyphosate is an herbicide widely used to kill weeds. Tolerance to the herbicide was genetically engineered into agricultural crops, such as soybeans, allowing farmers to broadly spray their fields without killing the crops.

**Fortification** (Example: Golden rice): Engineered to include beta-carotene biosynthesis genes, Golden rice was developed to address dietary vitamin A shortages in the developing world. Rice does not usually produce beta-carotene, a precursor of vitamin A, in the edible portion of the grain.

**Cosmetic Preservation** (Example: Arctic Apple): Arctic Apples are genetically engineered to silence the apple gene responsible for browning due to superficial damage, a measure intended to reduce food waste. After more than a decade of research, the Federal Drug Administration and US Department of Agriculture approved Arctic apples as safe for human consumption in 2018.



**Increased Growth Rate** (Example: *AquAdvantage* salmon) Genetically modified with genetic material from the ocean pout (a bottom-dwelling, eel-like fish) and Pacific Chinook salmon, the *AquAdvantage* Atlantic salmon is designed to decrease the time it takes for this farmed salmon to grow to market size. The FDA approved this genetically engineered fish for sale in the United States in 2015.

## Who are the stakeholders?

Stakeholders are the individuals, organizations, communities, agencies and governments with a vested interest in the issue. Stakeholders in the debate over GMO foods include the global community, sovereign Tribal nations, municipalities, local communities, industry, biotechnology firms, organic and conventional farmers, farm workers, fishermen, religious groups, ecologists, engineers, toxicologists, risk analysts, doctors, politicians, parents, children, non-governmental organizations, and advocacy organizations.

Stakeholders also include non-human entities such as the environment itself, or specific environmental resources. In short, everyone who has a vested interest in the food supply may be a stakeholder, although in practice not every stakeholder group is likely to get equal say in the debate due to power structures, economics, access to information, etc.

## What government agencies regulate GMOs in the US?

The Coordinated Framework for the Regulation of Biotechnology (1986) provides a “comprehensive federal regulatory policy for ensuring the safety of biotechnology research and products.” Though not legally binding, it forms the foundation of U.S. biotechnology regulation, specifying that genetically engineered products are not inherently riskier than their counterparts and can therefore be regulated under pre-existing regulatory structures. The Coordinated

Framework delegates regulatory responsibility to three agencies: the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA).

The USDA oversees the regulation of GMOs as they relate to agriculture. The FDA evaluates food safety from the standpoint of human consumption, and the EPA regulates environmental risks resulting from genetically engineered crops. Each agency must interpret their existing regulatory authority in light of the potential impact of the technology. Delegating regulatory responsibility to existing agencies, however, might not be adequate in the long-term given the rapidly evolving nature and complexity of the technology.

## How do you know whether your food contains GMOs?

Prior to 2022, U.S. food producers were not required to state on their packaging that their products contained GMOs.

In 2022, a new regulation went into effect requiring that most foods sold in the U.S. be labeled as a “bioengineered food” if they contain genetic material that has been modified through a laboratory process rather than through conventional breeding. This regulation is known as the National Bioengineered Food Disclosure Standard.



## Who produces the most GMOs?

The **U.S.** is the largest producer of GMOs, followed by **Brazil, Argentina, and India**. These four countries combined contain 83% of the world's GMO cropland.

## Some food for thought

Food is integrally entwined with place, culture, environment, and ethics. While the use of biotechnology tools for genetic engineering is at least 50 years old, the application of these tools is rapidly evolving. As the science and the tools evolve, so do our perceptions and understanding of both the tools themselves, and the products they produce.

Many fields such as medicine, industrial research, and agriculture utilize the techniques of genetic engineering, but the most heated debates have centered on the use of GMOs in the human food supply and the how these GMOs are regulated. Several questions arise in relation to this complex issue, such as:

- *What are the possible positive and negative environmental impacts of GMOs on agricultural systems?*

- *What are the risks and (unintended) consequences of GMOs on ecological systems?*
- *Moral and ethical questions related to food, such as: How do we best feed a growing global population? What role should traditional food production systems play? Who controls the food supply? Who has access to the safest and most nutritious foods?*
- *What are the legal and economic impacts of GMOs on intellectual property rights and innovation?*
- *How do national and international regulatory frameworks (including labeling requirements) influence world trade and food distribution?*
- *What are some of the benefits and ethical issues that might arise from public/private research partnerships?*
- *How can the voices of all the stakeholders be heard and everyone's values be taken into account?*
- *How can we protect consumer choice and ensure public trust in food systems?*
- *What are the limitations of science and how much uncertainty is acceptable to consumers? Who decides?*



## Where to go to learn more

- Adoption of Genetically Engineered Crops in the U.S., USDA Economic Research Service June Agricultural Survey (2023). <https://bit.ly/3HOuPTx>
- Coordinated Framework for the Regulation of Biotechnology, 51 Fed. Reg. 23,302 (June 26, 1986). <https://bit.ly/3HSO4LX>
- GMOs, Start-ups & Food Security Between the Promises of the Future and the Fears of Today, Genetics and Biodiversity Journal (2022). <https://bit.ly/3SwrHk9>
- “Same Science, Different Policies: Regulating Genetically Modified Foods in the U.S. and Europe” Harvard University Blog Special Edition on GMOs (2015). <https://bit.ly/4buw4VS>
- Case studies: A hard look at GM crops, Nature (2013). <https://www.nature.com/articles/497024a>
- GMOs and the Environment, U.S. Food & Drug Administration <https://bit.ly/3urIkqA>