

Plant Breeding 101

Humans have been modifying plants for millennia. From early farmers saving seeds to scientists manipulating genes to create new plants, plant breeders have played a vital role in the development and improvement of edible and ornamental plants. The study of plant breeding begins with an understanding of how plants grow and reproduce, and builds on topics covered in elementary through high school science curricula.



Learning about how the characteristics of organisms contribute to their survival, how the environment can impact physical attributes, and how they inherit those traits from their parents are life science topics that span a range of grade levels. Beginning in first grade, these topics are taught in progressively more complex terms until the end of high school (or beyond for those specializing in the life sciences for advanced degrees). Studying the history and mechanics behind plant breeding can be an interesting way to explore connections between plant genetics and the human world.

A History of Plant Breeding

Every year, the horticulture industry introduces new varieties — a tomato that matures extra-early, a “single serving” melon, a perennial with foliage in unique hues, a spruce that grows just 3’ tall. Where do these new varieties come from? Here are some of the ways new plants are brought to us.

Selective Breeding

Since prehistoric times and the dawn of agriculture, people have been sowing seeds and growing crops, and then saving some of the seeds for replanting. Farmers learned that if they saved seeds from the best plants — the ones that produced the biggest or tastiest crop or had fewer pest problems — and planted them, the next generation of plants often displayed the same desirable attributes. Thus, over many generations, farmers slowly improved the production, taste, hardiness, pest resistance, and other characteristics of their crop plants. These farmers can be considered the first plant breeders, and they used a process we now call *artificial selection* or *selective breeding*.

In contrast to the evolutionary process that we call *natural selection* where the “fittest” survive and go on to reproduce, selective breeding allows growers to nurture the qualities they deem the most important. Some of these qualities don’t make the plant any more “fit” in evolutionary terms, but rather they suit human desires. Throughout much of the long history of agriculture, this was the only method of improving plants. Crops that have been changed from their wild forebears through selective breeding are sometimes called *domesticated* crops; notable examples are wheat and corn. Selective breeding continues today.

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Hybridization

In the 1700s, scientists began to understand the fundamentals of plant reproduction. When Gregor Mendel's experiments in the mid-1800s led to an understanding of the laws of inheritance, the doors to the world of plant breeding were thrown open. Scientists were able to identify desirable characteristics in different plant specimens and then cross-pollinate them in hopes of merging those characteristics into one plant. A hybrid is the offspring of two different parent plants, usually of the same or very similar species.

This exciting discovery was a slow process that required patience. Imagine the time and effort required to try to create a squash plant that produces larger fruits with thicker rinds that last longer in storage. Breeders might use the pollen from flowers of plants with large fruits to pollinate a plant with thick-rind fruits. They'd grow the plants to maturity, harvest the fruits, and then plant the seeds from those fruits and grow them out to see if any of the resulting plants display the desired combined traits. It can take years to develop a new variety, and additional years to produce enough seed for practical use.

Now imagine using this process to develop new varieties of trees that might take a decade or longer to produce seeds!

Mutations

Genetic "Accidents"

Sometimes, a plant displays unique traits not normally found in the species. For example, a plant might be unusually tall, or short, or the flowers, fruit, or foliage might be different in size, color, etc. These traits can be caused by environmental conditions, such as soil chemistry, or as a reaction to infection by a microbe. They can also be caused by a mutation — a genetic "accident" that results from an error in chromosome replication during cell division.

In scientific terms, a plant that differs from the norm because of a genetic accident is called a mutant. Plant breeders have been taking advantage of mutations long before they understood genetics and the concept of chromosome replication. When an entire plant showed unique characteristics, it was called a *sport*. When just one branch of a plant differed, it was called a *bud sport*. These terms are still used by horticulturists.

Sometimes, errors in cell division result in plants having more than two sets of chromosomes, a trait called polyploidy. Polyploid plants often have larger flowers and fruit, more intensely colored flowers, bigger or thicker leaves, or larger tubers.

Human-induced Mutations

In the early 1900s, plant breeders discovered they could induce genetic mutations by subjecting plant parts — usually seeds — to various treatments. By exposing them to different chemicals, biological agents like bacteria, or radiation, breeders can induce mutations. This is called *mutation breeding*. Certain types of red grapefruit, rice, and bananas are the result of mutation breeding.

Many plants discovered or developed via mutations must be reproduced through cuttings or other forms of asexual

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propagation, rather than through seed production. Some plants are even patented and it's illegal to propagate them — even for home gardeners! — without permission or payment to the plant breeders.

Learn more: [Make New Plants and Keep the Old: Asexual Propagation](#)

Genetic Engineering

For millennia, plant breeding went on with little or no controversy. That changed with the introduction of genetic engineering, a discovery that has revolutionized the development of new plant varieties. Some argue that genetic engineering is simply another tool in the plant breeder's toolkit and should be considered a logical development in the science of plant breeding. However, there's a significant difference:

With conventional plant breeding, plants of the same or similar species are crossed to create new varieties.

In contrast, genetic engineering allows scientists to take genetic material from virtually any living organism and insert it into the cell of another, totally unrelated organism — even from animal to plant!

Plants (and animals) created using genetic engineering technology are called genetically modified organisms (GMOs); they're also described as bioengineered, transgenic, or genetically engineered (GE). Most of the commercially grown soybeans, corn, sugar beets, canola, and cotton grown in the U.S. are GMOs and were developed to resist insect pests and/or tolerate certain herbicides. As of this writing, there are no GMOs currently sold for planting in home or school gardens.

For some, genetic engineering offers endless possibilities for benefiting humanity, including improved yields and enhanced nutritional value of food crops. For others, the risks of tinkering with what might be considered the very essence of life — the genetic code — outweigh the benefits, and they cite the evolution of "superweeds" (plants resistant to herbicides) and the potential for hidden allergens, to name a few. The debate will surely continue.

The Future of Plant Breeding

And as evidenced by the influx of new varieties each year, plant breeding is an ever-evolving pursuit that offers important career opportunities, now and in the future. Plant breeders will be busy finding ways to grow enough food for an increasing population while decreasing our footprint on the natural world, growing crops in more turbulent climates, and devising ways to grow crops in untraditional systems like hydroponics and aquaponics. Perhaps the next generation of plant breeders will even develop plants to grow on Mars!

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