Natural & Artificial Selection

What do we do to improve crops over time?

Introduction (~5 minutes)

There are plants all around us! There are trees, flowers, grasses, bushes, crops, succulents, ferns, and many more! In this module, we will explore how plants change over generations. We will also learn how we ended up with so many types of plants in the world.

First, look around you, and make a list of all the plants you can identify. You may need to walk outside and a little bit away from your building.

Nearby, we have the following plants:

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Explore (~10 minutes)

How often do you think about the variety of plants around you? Think about a grocery store flower aisle alone. (There are roses, tulips, carnations, lilies, and many more!) There is an enormous variety of colors, shapes, and sizes! You can find similar variation in leaves, stems, and all the other plant parts we've explored.

Variation exists in all species. The way we get variation is by mixing gene variants during reproduction. In *A Plant Primer*, you learned:

- The anther produces sperm-containing pollen.
- The ovary contains ovules that mature into seeds.
- When sperm reaches the ovules, seeds grow to produce the next generation of plants.

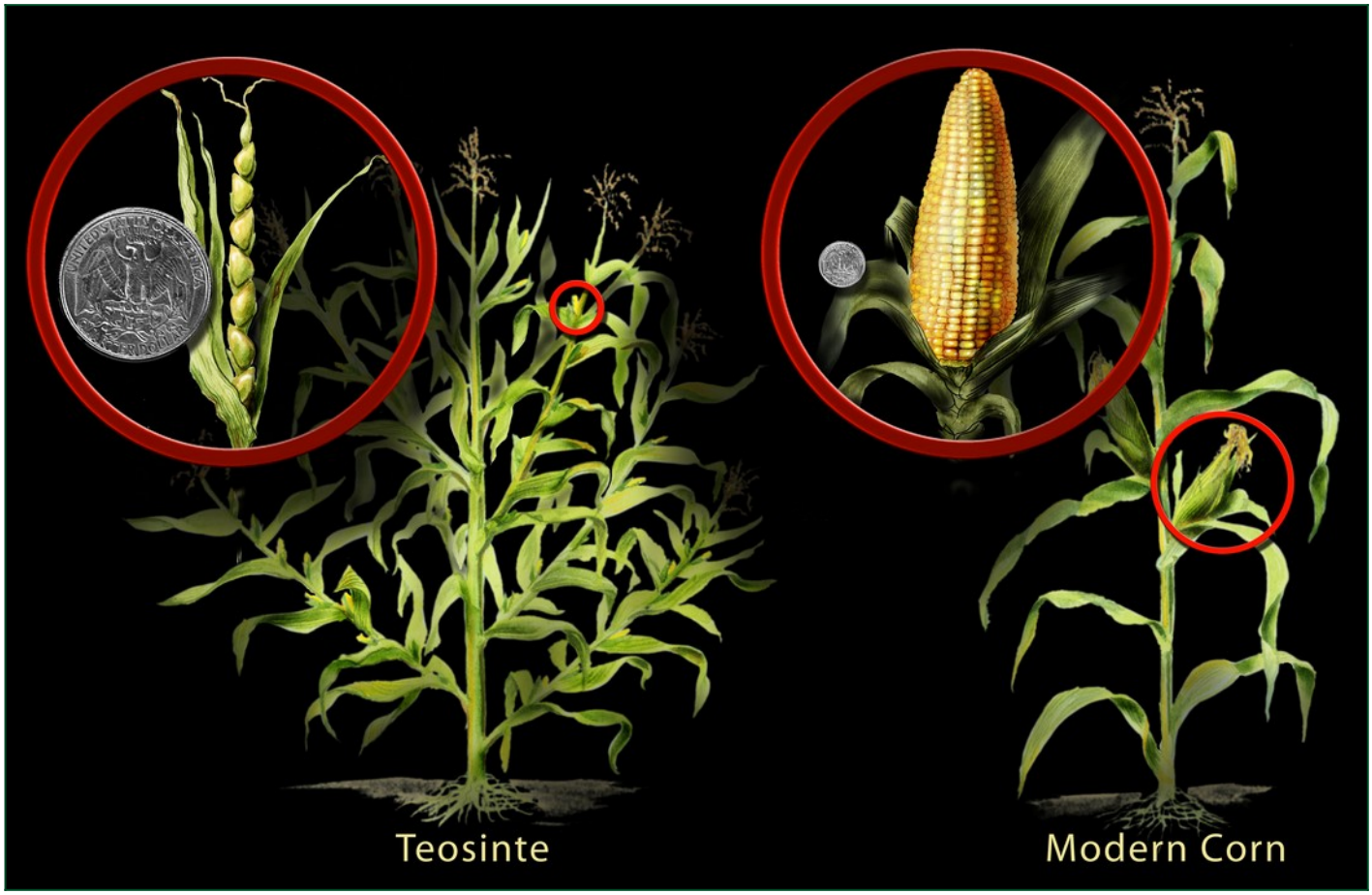
Through this process of sexual reproduction, offspring are different from both parents. Each offspring is a unique organism! It will have new combinations of its parents' gene variants.

The same gene can come in different forms called alleles. Different alleles lead to different phenotypes. (Phenotypes are the traits we can see resulting from alleles.) Your hair color shows a phenotype of the hair color alleles you got from your parents. Phenotypes are also shaped by the environment. Without enough water, peas bred for large size will still be small.

Some individuals reproduce more successfully than others, so not all alleles will be passed on at the same rate. To know how common alleles are in a population, we look at allele frequency.

A high allele frequency means that allele is very common. A low allele frequency means that allele is rare. Scientists often wonder how allele frequencies occur. Fortunately, plants are very helpful in exploring these questions.

To see how plants have changed over generations, let's look at two related plants. Corn and teosinte share a common ancestor. They both evolved from the same plant species 9,000 years ago.



Although corn and teosinte have a common ancestor, they look very different. Use the image above to compare these two plants. Record your observations in the table below. If you have an ear of corn, look at it to see these traits in real life!

Plant Structure	What does it look like in teosinte?	What does it look like in corn?
Seed / kernel		
Size of ear		
Overall plant width		

Corn and teosinte are very different. There are many differences we can't even see in this picture!

It is useful to compare corn and teosinte. Their traits have changed for different reasons. Teosinte has gone through natural selection for 9,000 years. In the same time, corn has gone through artificial selection.

Selection refers to how often we see different alleles over time. As organisms with different phenotypes reproduce, some alleles will be found more often. Natural selection is when allele frequencies change naturally over time. Natural selection occurs when one phenotype leads to better breeding in the wild.

Artificial selection occurs when humans shape which alleles are passed on. Humans look for desired phenotypes (larger fruit, for example). They select for these alleles by helping those plants reproduce. This makes the desired phenotype more common in later generations.

Explain (~20 minutes)

Consider the phenotypes below. For each phenotype we can observe, identify the matching function.

Phenotype	Function
1. ___ Soft kernels without an outer case	A. Protects seed from digestion, letting it survive and grow wherever it is excreted by animals
2. ___ Kernels have hard outer case	B. Makes kernels easier for humans to digest

3. ___ Many branches that produce many ears per plant, with a small number of kernels per ear	A. As different branches dry at different rates, seeds drop at different times
4. ___ One stalk with no branches, producing fewer ears per plant but many kernels per ear	B. Keeps kernels in one or two locations for easier harvesting and processing

5. ___ Ear shattering to spread seeds/kernels	A. Spreads seeds nearby even if they are not consumed and excreted elsewhere
6. ___ Ear not shattering; seeds/kernels all stay on ear	B. Prevents loss of kernels to ensure plentiful harvest

7. ___ Few leaves	A. Gives greater surface area to capture light energy
8. ___ Many leaves	B. Enables multiple plants to be planted close to each other

What are the benefits of each phenotype?

Describe why it would be desirable or beneficial.

The traits that help the plant survive in the wild are the ones that were naturally selected. These are present in modern teosinte. The traits that humans would want the plant to have were artificially selected. These are present in corn.

Phenotype	Beneficial For:	Why Beneficial?
1. Soft kernels without an outer case	Wild plants / Humans (circle one)	
2. Kernels have hard outer case	Wild plants / Humans (circle one)	
3. Many branches that produce many ears per plant, with a small number of kernels per ear	Wild plants / Humans (circle one)	
4. One stalk with no branches, producing fewer ears per plant but many kernels per ear	Wild plants / Humans (circle one)	
5. Ear shattering to release seeds/kernels	Wild plants / Humans (circle one)	
6. Ear not shattering; seeds/kernels all stay on ear	Wild plants / Humans (circle one)	
7. Few leaves	Wild plants / Humans (circle one)	
8. Many leaves	Wild plants / Humans (circle one)	

If you planted corn and teosinte in the wild, which would you expect to be more successful? (Think about survival and reproduction.) Why?

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Extend (~20 minutes)

You now know how natural and artificial selection can cause two plants to diverge from their ancestor and evolve into new varieties. Corn became a staple in the human diet thanks to ancient farmers in Mexico. They selected plants with phenotypes they wanted and then bred these plants with each other. This is selective breeding, one of the ways artificial selection happens.

All the fruits and vegetables we eat come from selective breeding. Take a look at the image below. All these foods come from the same plant: wild cabbage (*Brassica oleracea*). You can see an undomesticated wild cabbage above.

broccoli
var. *italica*

brussels sprouts
var. *gemmifera*

cabbage
var. *capitata*

cauliflower
var. *botrytis*

Chinese kale
var. *alboglabra*

kale
var. *acephala*

kohlrabi
var. *gongylodes*

Each of these foods comes from different plant structures. Farmers selectively bred cabbage plants to enhance these plant structures and make these varieties.

There are now dozens of different varieties (or cultivars) of wild cabbage. Each grows a different food. Recall the different plant structures that you learned about in *A Plant Primer*. What plant structure(s) do you think humans focused their breeding efforts on to make each variety? Record your answers in the table on the next page.

Cultivar	Plant Structure(s)
1. __ Cabbage	A. leaves and stems
2. __ Kale	B. flower bud clusters
3. __ Broccoli	C. lateral buds (buds along the stem)
4. __ Cauliflower	D. stem and root
5. __ Chinese kale	E. flower buds and stem
6. __ Kohlrabi	F. leaves
7. __ Brussels sprouts	G. terminal buds (buds at the end of a leaf)

Remember, all of these foods come from the same ancient plant! Farmers had to carefully breed cabbage to make these different foods. To learn a bit more, check out a SciShow episode: https://youtu.be/JcVJDz1-8Lc.

Choose one of the foods listed above. Check your answer using the video. What actions might farmers have taken to selectively breed it?

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Uncultivated wild cabbage, or wild cabbage that hasn't been selectively bred, still exists. It is also different from ancient wild cabbage.

Why do you think modern wild cabbage has phenotypes different from ancient wild cabbage? How could that have happened?

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Reflect (~15 minutes)

Look back at the list of plants that you made in the *Introduction*. For each plant, do you think it is a product of artificial selection or natural selection?

Plant	Selection (circle one)
	Natural / Artificial
	Natural / Artificial

Plant	Selection (circle one)
	Natural / Artificial
	Natural / Artificial
	Natural / Artificial
	Natural / Artificial
	Natural / Artificial

When you thought about plants before completing this module, what did you picture? What do you picture now when you think about plants?

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This lesson focused on how plants that we eat have changed over time. These are the plants that have been selectively bred for the longest time. (Humans have always needed to eat!) However, there are plants that humans don't eat but still breed.

Some of these plants may include cover crops like pennycress or sorghum sudangrass, house plants like aloe or spider plants, and decorative flowers like roses and lilies.

Pick a few of these plants. You can look them up if you need to. Do you think these non-food plants have gone through natural selection, artificial selection, or both? Why?

Plant	Selection (circle one)	Why?
	Natural / Artificial	
	Natural / Artificial	
	Natural / Artificial	
	Natural / Artificial	
	Natural / Artificial	

Career Connection: Molecular Biologist

There are many processes that happen deep inside living things. Molecular biologists look at molecules and cells. They try to understand how organisms grow and develop, one cell at a time. They need skill with lab equipment and knowledge of biology, chemistry, and genetics.

Entry-level positions require a bachelor's degree in biology. Researchers often have master's or doctoral degrees. Higher education is rewarded with higher salary.