Name: _____

Lab 10: Food Production and Plant Domestication
Fall 2019

"Popped Secret: The Mysterious Origin of Corn"
Answer the questions on the next 2 pages while watching the video "Popped Secret: The Mysterious Origin of Corn"; found here: http://www.hhmi.org/biointeractive/popped-secret-mysterious-origin-corn.

Q1. What did George Beadle discover?

Q2. Does teosinte go extinct when corn (maize) evolved? How can we tell?

Q3. How are teosinte plants different from corn plants?

Q4. How many genes are different between teosinte and corn? Describe Beadle's experiment to determine this.

Q5. The geneticists compared the DNA of corn and teosinte; based on this comparison, how long ago do they think corn was originally domesticated?

Q6. How do stone tools from Mexico relate to the corn domestication story? What evidence do these archaeological artifacts provide?

Q7. The archaeologists used radiocarbon dating to date charcoal found at the same layer as the stone tools. What was the earliest date they found associated with evidence of corn being domesticated?

Q8. How many genes affect the thickness of the fruitcasing that surrounds kernels in teosinte vs. corn?

Q9. How does the geneticist in the video think humans ate teosinte and later domesticated corn?

Domesticating Foods Via Artificial Selection

Most of us do not think much about the history of the foods we eat or even where our food comes from or how our foods are produced. Most of the time, we choose foods from the grocery store or cafeteria based on how it tastes, how it looks, individual cultural preferences, or even how much it costs. When we stop to think about it, many of us may be shocked when we discover that the majority of the foods we eat today look very different from how they may have appeared in the past. That is because the same evolutionary forces that act on animals (including primates) also act on plants; through **genetic drift**, **gene flow**, **mutation**, and **natural selection** plants have also changed forms over the years.

Humans have had an effect on the evolution of certain plants. For most of us, the majority of the foods we eat on a daily basis are **domesticated**. Domestication is the process of adapting wild plants or animals for human use, and is done through the process of **artificial selection**. During artificial selection, humans pick what types of existing variation in a species they want to encourage, and help that variety pass on their genes to the next generation so that the traits preferred by humans will be more common. This is the same process that goes on during evolution via **natural selection**. The difference is that without direct human involvement, during natural selection the traits passed on to the next generation affect survival and reproduction in a particular environment that lacks direct human care. The result of domestication is forms of plants and animals today that look very different than the **wild type**, or the variety that exists in the wild and remains unaffected by human intervention.

One example of artificial selection is dog breeding. All dog breeds are the same subspecies (*Canis lupus familiaris*) and are the same species as wild wolves like the arctic and great plains wolves shown below. We know that today's dogs, from large breeds like the Saint Bernard or Great Dane to small ones like toy poodles, evolved from wild wolf populations (or potentially recent ancestors of modern wolves). Over the last several hundred years, humans have artificially selected particular traits desired for specific dog breeds, and we are left with a plethora of dog types in all shapes, colors, and sizes.

All of these animals are the same species:

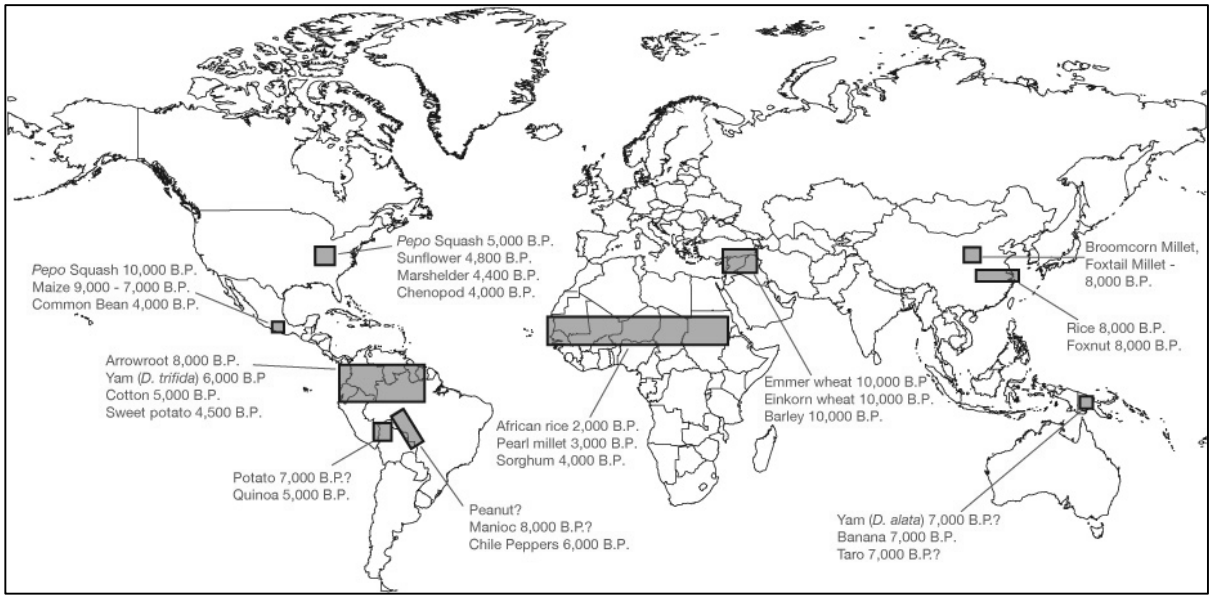
All *Canis lupus familiaris*
All domesticated dogs

Canis lupus arctos
Arctic Wolf

Canis lupus nubilus
Great Plains Wolf

Humans have been domesticating animals and plants via artificial selection for nearly 10,000 years! That means that when Darwin was looking at organism variation in the 1800s, artificial selection was already very well understood. Darwin himself was very familiar with how farmers and animal breeders artificially selected for certain traits during animal breeding. He used that concept to help formulate his theory of evolution by **natural selection**. So in simple terms, **domesticated** plant and animal populations are those that have evolved from their wild ancestors by selection that is led by humans in place of nature. Said another way, instead of adapting to better survive and reproduce in their particular environment (natural selection) domesticated plants adapted to suit the desires of humans who in turn helped make sure they were planted in greater and greater quantities (artificial selection).

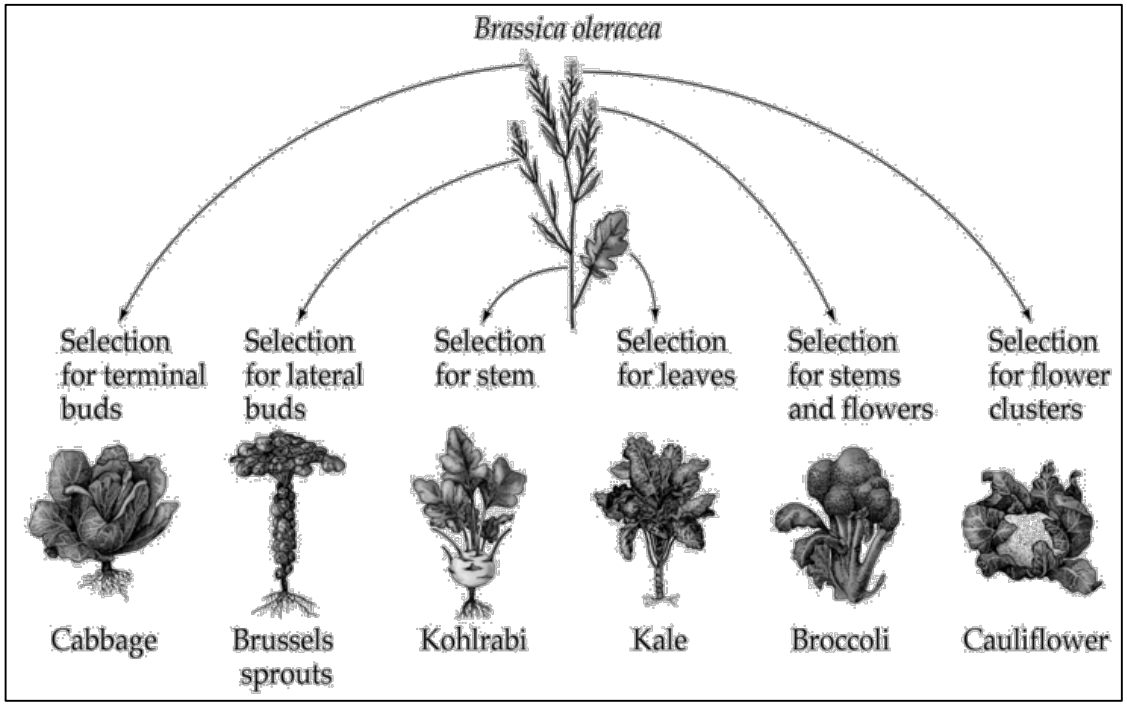
Before 10,000 years ago, all humans around the world subsisted entirely from hunting and gathering wild plants and animals. Starting around 10,000 years ago, some human groups began domesticating certain plants and animals, eventually leading to agricultural-based economies that focused on farming and/or herding. Archaeologists have recovered evidence for the earliest domesticated plants and animals in the Middle East (e.g., wheat, barley, and rye; sheep, goats, cattle, and pigs). The map below displays where certain plants were first domesticated; note that some regions independently domesticated the same plants around the same time periods.



Q10. Think about your usual diet. Where were some of the plants that you've eaten recently first domesticated (refer to the map)? What are some non-domesticated foods you've eaten recently (e.g., wild-caught fish)? Discuss your responses with your group and write about them here.

Domesticating Plants

Processes of domestication have left some plants and animals looking very different from their wild progenitors (just like how Chihuahuas look very different from wild wolves). For example, all of the commonly eaten cruciferous vegetables shown in the picture below (including a few others not shown here) have evolved from the same plant, a type of wild mustard plant. These domesticated plants (like cabbage, Brussels sprouts, kale, cauliflower) are actually variants of the same species: *Brassica oleracea*. Humans started with the original wild mustard plant, which already had some variation in it. By selecting for specific traits, humans caused the mustard plant to produce different variants that do not exist in the wild; today we call each of these variants different names.



Q11. Why do you think each of the traits artificially selected for by humans would have been preferred? Think about how each trait appears in the domesticated variants relative to the wild type.

Q12. For each set of pictures: What features appear to be selected for/against by humans when they domesticated each plant? Why do you think these traits were artificially selected?

Wild watermelon

Domesticated watermelon

Wild banana

Domesticated banana

Wild carrot

Domesticated carrots

Wild eggplant

Domesticated eggplant

Q13. Are there any similarities in the features that humans artificially select for when domesticating a plant based on these examples? Why do you think there would or would not be?

For many plants, archaeologists have recovered substantial evidence that allows us to understand what traits were under artificial selection as human groups began to rely on them more for their resource needs. Some of the traits that changed in (some) plants when they were domesticated include:

- **Loss of their mechanism for natural dispersal**. Within grasses (like rice, wheat, and teosinte), wild phenotypes have a brittle rachis (the stem of a grass that holds the flower stalk) that breaks easily when a grain is ripe, allowing it to scatter or blow away to propagate. Domesticated grass species have a tough rachis that do not allow a ripened grain to break away and requires human harvesting.
- **The part of the plant that humans eat/use becomes enlarged**.
- **The part of the plant that humans use become clustered in one place**. For example, some domesticated plants have many larger seeds within one pod or spike rather than having seeds spread across multiple pods or spikes.
- **Loss of dormancy**. Wild phenotypes may have thick outer seed coats that protect dispersed seeds and keeps them from germinating until weather and soil conditions are optimal. When humans started planting their own crops, they chose when conditions were optimal, so this feature was no longer needed. Often the thick outer seed coats made eating the seeds difficult, so humans selected against them. Domesticated seeds often have thin seed coats that allow them to germinate quickly once sown or planted, which means most of these seeds will begin to sprout at the same time.
- **Synchronous ripening**. Wild plants often ripen at different times to ensure that not all plants are killed off in the event of a late snowfall, or will not be eaten all at once by a group of herbivores walking by. Humans selected for phenotypes that would ripen at around the same time to make harvesting more efficient.
- **Loss of protective mechanisms**. Domestic plants often lack the thorns or toxins that the wild variety might have. Eating just a dozen wild almonds could be fatal, for example, because they contain a compound that is poisonous to humans. Domesticated almonds, however, largely lack this compound and are tasty and safe to eat (luckily, for us!).

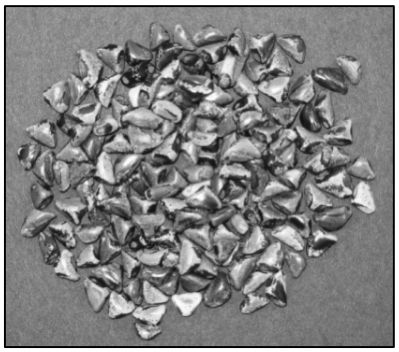
Q14. Think about the traits listed above that are commonly seen in many domesticated foods. Discuss with your neighbors the advantages these changes would have brought to humans. Why would human groups select for these phenotypic traits?

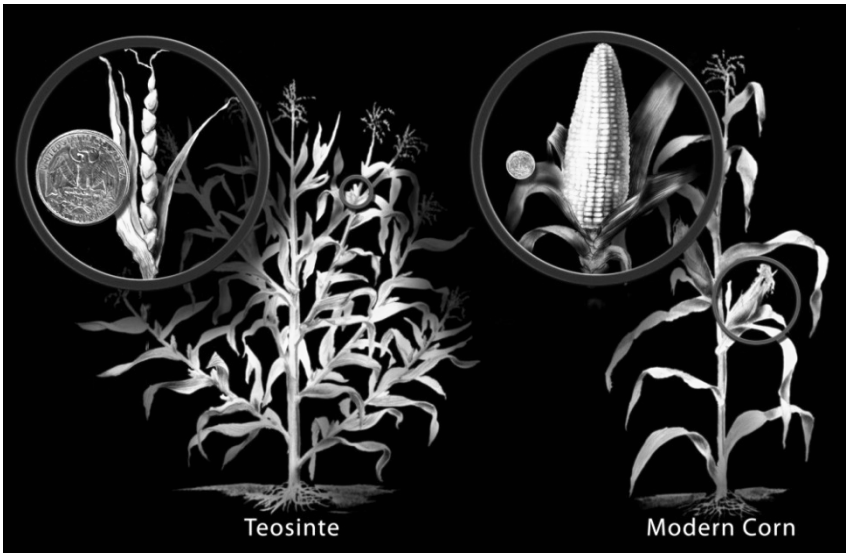
Q15. Describe any situations where some of these changes could have negative consequences for human groups that come to rely on just one or a few domesticated crops.

History of maize domestication

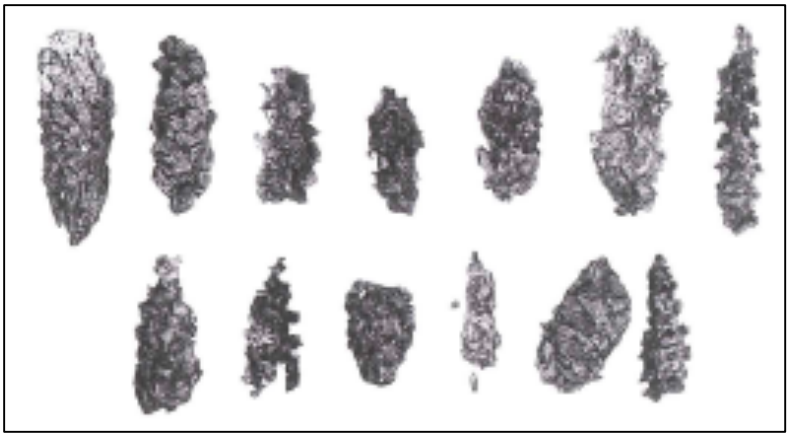
As you learned in the video at the start of lab, today's maize/corn (*Zea mays*) is a grass that was undergoing domestication in Mexico starting between 9,000 and 7,000 years ago. The wild ancestor of maize is called teosinte (*Zea mays* subsp. *parviglumis*). Wild teosinte can still be found today growing in a few parts of Mexico. Fields of wild teosinte require no human intervention at all to reproduce; it reproduces on its own just like any other wild grass. Recent studies of DNA extracted from modern corn and wild teosinte demonstrate their genetic relatedness. The picture below shows the major differences between wild teosinte and our domesticated maize.

Comparison between teosinte and domesticated corn (right); teosinte kernels (below).





As humans were domesticating teosinte in Mexico, the plant didn't change overnight from its wild form to the form that we eat today, however. From excavations in Mexico, archaeologists have recovered specimens demonstrating evolutionary changes through time. The pictures below show the actual cobs recovered from early archaeological sites in Mexico's Tehuacan Valley (left), as well as a drawing of what this transitional maize population may have looked like (right). You can see that it was still fairly small.



Q16. Carefully look at the actual wild teosinte on your table. Closely examine the cobs of the teosinte plant. In the space below, draw the teosinte plant and label what has changed since maize was domesticated. Be very careful, because these seeds will easily break apart!

Q17. What are some of the major morphological changes that have occurred between wild teosinte and domesticated corn? Think about the differences in the strategies for seed dispersal between the two plants (e.g., teosinte was naturally selected to reproduce on its own, while corn was artificially selected to benefit humans who would be responsible for planting and harvesting it). Describe how seeds are dispersed and protected in each plant.

Q18. Which of the changes listed on page 8 of this handout might explain the differences in seed dispersal strategies between teosinte and corn? Why are these so important? (Hint: if a farmer plants a field of corn today but neglects to harvest it to have seeds to plant for the following year, within a year or two there will be *no* corn at all growing in that field.)