Aims: To help students understand the process of evolutionary selection through plant domestication

1. **Illustrate phenotypic differences between wild and domesticated plants**
    a. Domestication is more frequently referred to with animals, so the first three slides just define that crops are domesticated plants with wild relatives and ancestors.
    b. The next slide uses pictures to show some of the differences between domesticated plants and their wild relatives. In tomatoes, corn, and rice, the domesticated versions have larger fruits and more fruits. The increase in fruit size is often directly related to an increase in sugars, which makes these fruits taste better. This is also accompanied by a decrease in toxic defense compounds. For example, tomatoes are cousins of deadly nightshades but in domesticated species those alkaloids (toxic compounds) have been bred out of the fruits by being selected against by generations of humans. Finally, crop species are often more easily grown than their wild relatives, and there is often a transition to being an annual plant (with the entire life cycle in one year) with domestication.
    c. The next slide touches on some other effects of the domestication processes such as seed shattering, phenology changes, and changes to seed dormancy. These topics are a little more specific to classes with an interest or focus on botany/agriculture and could be left out of a general discussion on selection.
    d. The summary slide is meant as a transition from thinking just about the differences in domesticated plants to the process of how they became different, i.e. artificial selection.

2. **Illustrate the process of artificial selection underlying phenotypic differences**
    a. Instead of just talking through this process, we've included a game with the hopes that seeing changes in (artificial) populations because of different genetic processes will more clearly illustrate how this works than a slideshow diagram.
    b. Refer both to the slides and the game instruction handout to talk your class through this game. Start by breaking the class into groups of four and assigning different selection roles to the different players. Then use the slides to outline the game-play process before giving each group tokens and dice.
    c. Pause on the "Playing the Game" slide to hand out materials and let students set up their initial populations. Then bring the group back together to talk through the scorecard before each group starts the elimination/regeneration turns.
    d. After each group has moved through a few rounds of elimination/regeneration and filled out their scorecards, move on to explaining what the learning goals of the game are.
        i. See Teacher's Note at the end of the game instructions. In that section are explanations behind the game's design, expectations for the different outcomes, how these principles are used by geneticists, and potential alterations to increase the complexity/realistic-ness of the game for curious students.

e. Real genes are not Red, Yellow, Pink etc so the last slide in this section gives some examples of the real genes we've affected through domestication of crop plants. In tomato and maize, only five or six genes are selected during the domestication.

3. **Compare natural selection and artificial selection**
   a. Domestication is one small (though very important) example of selection in the broader biological context. Natural selection is a much more complicated process that is constantly shaping the diversity of phenotypes we see in the world.
   b. Instead of humans deciding which plants to keep and breed based on desirable traits, natural conditions "weed out" plants with traits unsuitable to their environment. These traits can either be involved in the plants' survival to a reproductive state, or directly in the reproductive success of the plant.
   c. Traits involved in survival and reproduction are extremely varied and depend on the environment in which the plant lives. Some of the traits we have selected against in domestication are adaptive traits for survival in the wild. Toxicity for example helps a plant escape damage by herbivores, but we've selectively bred against that in tomatoes because we are herbivores. Fruit size is another trait that could be maladaptive in the wild. Creating a larger fruit is more energetically expensive and a wild plant has to think about using that energy to create other structures as well such as roots, staulks, and leaves. Crop conditions are generally less stressful than wild conditions so investing in a large fruit is fine because we are giving the plant more nutrients than it needs.
   d. Because different conditions select for different traits, and there are many many different conditions in a natural environment, studying the genes involved in natural selection is much harder than studying the subset of genes involved in domestication. But understanding the genes involved, even just in agricultural systems gives us powerful insight into how plants work, and how we can best use them to improve our farming efforts.

4. **Study of plant domestication**
   a. Examples of genes we've affected and discovered through plant domestication. The genes control the fruit size and general growth habit in the tomato domestication are used as an example.
   b. List the six important loci during the domestication in the tomato. Lead the discussion of how could some of these genes be good on a farm but maladaptive in the natural context. For example, why the smaller size of the fruits are favored in nature. The responsibility of the teacher is to guide the students to make more reasonable explanations.
   c. Use the groundcherry (an orphan plant) as an example to illustrate that the genes we found in the plant domestication can be used for improving the plant through gene editing method with the potential of agricultural applications, rapid domestication.

Papers recommended to read before class:

De novo domestication of wild tomato using genome editing
Zsögön A, Čermák T, Naves ER, Notini MM, Edel KH, Weinl S, Freschi L, Voytas DF, Kudla J, Peres LEP
Nat. Biotechnol., 2018 — Journal Article

Rapid improvement of domestication traits in an orphan crop by genome editing
Lemmon ZH, Reem NT, Dalrymple J, Soyk S, Swartwood KE, Rodriguez-Leal D, Van Eck J, Lippman ZB
Nat Plants, 2018 — Journal Article