Artificial selection in Brassica oleracea

Kristína Hudáková

Barbora Trubenová

IST AUSTRIA
Institute of Science and Technology

5 Artificial selection in *Brassica oleracea*

This long-term lab activity focuses on the most common variants of *Brassica oleracea*, commonly found growing in our gardens or used in our kitchens. During this activity, students may be surprised to discover that broccoli, kohlrabi, cabbage and Brussels sprouts actually all belong to one biological species. They will study and compare the ripe forms of these vegetables, as they are found in supermarkets or collected from gardens. Then, they will compare different life stages of these plants to observe during which parts of their life cycle the cultivars of the same species are still unrecognizable, and when the plants start to develop the characteristics typical of the vegetable. This activity includes manipulation of the ripe vegetables (cutting, smelling and tasting them), which is usually enjoyed by students. What is more, students plant seeds and observe the seedlings themselves, which is not such a common experience for students, especially those living in cities.

5.1 Aims

- To discover that different vegetables (e.g. broccoli, kohlrabi, cabbage) are all products of artificial selection of *Brassica oleracea*, and are actually just cultivars of the same species.
- To understand the process of artificial selection.
- To participate in a long-term plant-growing experiment and witness the development of distinctive features from initially identical seedlings.
- To review the concept of biological classification.

5.2 Structure

- Students should work in groups of three to five when planting the *B. oleracea* cultivars and recording data from the planted seeds. The unit consists of:
  - One 45-minute class period for the initial discussion and the observation and comparison of the ripe vegetables.
  - One 45-minute class period to set up the planting experiment
  - About two months to grow the plants in a classroom greenhouse (ideal start time is in February/March), during which the students water the plants and take pictures of their growth.
- Discussion with the entire class (45 min), or individual assignment to write a formal lab report.

5.3 Materials

- Camera (shared)
- Magnifying glass
- Marking pens
- Paper towels
- Planting mix (shared)
- Labels for pots
- Pots
- Ruler
- Scissors

5.4 Procedure

Part 1: Observing the vegetables and identifying them as belonging to the same species

1. The teacher buys the vegetables—green kohlrabi, purple kohlrabi, green cabbage, purple cabbage, broccoli, cauliflower, kale, and Brussels sprouts—in the local supermarket and brings them to class.
2. The teacher instructs the students to study the vegetables and encourages them to sort the vegetables according to any characteristics or rules they find meaningful. Most probably, students will put the kohlrabi together, then the cabbages, possibly with Brussels sprouts and kale, and cauliflower with broccoli.
3. The teacher tells the students that they are going to plant these vegetable and observe their growth.
4. Students are given packets with seeds of these vegetables—these packets should be the original ones bought at a store, and should have the name of the variety as well as the scientific name.
5. The teacher encourages students to look at the seed packets and match the seeds with the ripe vegetables that they have been studying. Students should examine the packets for any information that would help them in sorting the vegetables. Now, students should be able to find out that all these vegetables belong to one species, *Brassica oleracea*. This is usually a moment of surprise and it takes some time to accommodate this fact. The most common question is: How can they be so different, when they are the same species? A discussion follows, during which the teacher reviews the definition of biological species and introduces the idea of artificial selection. A picture of the wild form of *B. oleracea* is presented.
6. Now, when the students are aware of the fact that all these vegetables are members of the same species, they examine the specimens closely and look for similarities and differences. They should cut the specimens, identify the basic plant parts, identify the plant organs that are eaten, smell and taste the vegetables, and fill in a data table.

Part 2: Setting up the experiment, planting the seeds

1. In groups of three to four, students set up an experiment, comparing the growth and development of two or three variants of *B. oleracea*. It is also possible to purchase seeds of the wild form of *B. oleracea*, and include the wild form in the comparison.
2. Students decide which variants of *B. oleracea* they are going to observe and compare. They formulate a hypothesis regarding the emergence of distinct features in their development. The teacher should arrange the class so that all *B. oleracea* variants are planted.
3. The teacher then gives the desired seeds to each group of students.
4. Students plant the seeds, ensuring that all variants are properly labeled.
5. Students take care of the growing plants, watering them as needed, and take notes several times a week.
6. The seedlings should start to develop observable differences after about two months.

(A) (B)

Figure 1: Growing plants of one of the *Brassica oleracea* variants.

Part 3: Gathering results, discussion, writing a lab report

There are two options to consider before handling the seeds and recording data: You can either destroy the seedlings or keep them to plant outside. Uprooting and eventually destroying the seeds enables more precise measurements to be taken, while keeping them to grow outside enables the students to witness their development into the ripe vegetables. We recommend that from each variant some seedlings be kept, planted first individually into pots and then outside, while other seedlings be removed from the soil and measured completely.

1. Students study the seedlings and record quantitative (e.g. plant height, number of leaves per plant) and qualitative (e.g. color, shape of the cotyledons and the first true leaves) data.
2. For the quantitative data, students calculate and record the group averages.
3. Students analyze and discuss the results of their experiments. This can be done in pairs, small groups, during a discussion with a whole class, or the students may submit the outcomes of this activity as a formal lab report.

Artificial selection in *Brassica oleracea*

In this investigation, you are going to observe some common vegetables, which are all domesticated variants of one species: *Brassica oleracea*. All these different-looking plants were cultivated from the same wild ancestor by artificially selecting for certain traits. First, you will study the ripe vegetables you are familiar with from the supermarkets or the kitchen. Then, you will look for the development of their distinctive features by planting the seeds and watching them grow.

Materials

- Ripe vegetables of the domesticated variants of *Brassica oleracea* (green kohlrabi, purple kohlrabi, green cabbage, purple cabbage, broccoli, cauliflower, kale and Brussels sprouts)
- Seeds of *Brassica oleracea* domesticated variants (green kohlrabi, purple kohlrabi, green cabbage, purple cabbage, broccoli, cauliflower, kale and Brussels sprouts) and the wild variant
- Camera (shared)
- Magnifying glass
- Marking pens
- Paper towels
- Potting soil (shared)
- Plastic greenhouse flats
- Labels and sticks
- Ruler
- Scissors

Part 1: Studying the ripe vegetables

1. Examine the ripe vegetables you have been given.
2. Cut each vegetable in half and draw or describe its internal structure. Record the color, smell and taste of each vegetable. Record the size and shape of the main plant parts. Which plant organ is typically consumed?
3. Select three varieties to work with during this investigation and fill in Table 1.
4. All of the variants you are studying are products of artificial selection. What traits were their ancestors selected for?

Part 2: Making a hypothesis and planting the seeds

1. State your hypothesis about the development of the *Brassica oleracea* variants you have decided to work with. You may select two domesticated variants to compare with one another and with the wild form; or you may compare three domesticated variants with one another. When making your hypothesis, address the following questions.
   - Do you expect these variants to show some of the characteristics of the ripe vegetables during the first days of their growth? Why or why not? If yes, which variants? Which characteristics?
   - Do you expect that the seedlings of the domesticated variants will differ from the seedlings of the wild form? How do you expect them to differ?
   - Do you expect that seedlings of some variants will be more similar to one another than to some other variants? If so, which variants will be more similar?

   State your hypothesis clearly. Make sure that it is testable.

Hypothesis:

2. Take the seeds of the three chosen variants of *Brassica oleracea* and the prepared planting set.
3. Plant the seeds in the plastic greenhouse flats, three to four seeds per pot. Label the pots carefully with the variant planted, the day of planting, and the student group responsible for the plants.
4. Water the plants and put them in a sunny location (such as a window sill).
5. As the plants grow, water them as needed and take notes and pictures to document their growth.

Part 3: Gathering results and writing a lab report

1. Record how many plants of each variant are growing in the pots.
2. Decide which plants you are going to keep to grow outside and which can be destroyed while taking measurements.
3. Take pictures of the plants.
4. Briefly describe the plants of each variant (size, color, position and size of the leaves, shape and size of the stem, and anything else you find interesting).
5. Record more detailed data of the chosen variants focusing on the features you mentioned in your hypothesis.
6. Compute and record the group average for all quantitative characteristics (e.g. seedling height) of each *Brassica oleracea* variant.

Analysis

1. Do your data support or contradict your hypothesis? Explain why you think so, providing some evidence.
2. Try to explain your results. If the seedlings you observed differed from one another and/or from the wild from, try to find some explanation for this. If they were all very similar, try to explain this fact. Keep in mind the properties of the ripe vegetables while you compare the seedlings.
3. Do the seedlings have any of the properties of the adult plants (ripe vegetable)?
4. What do you expect to happen with the properties of the vegetables if you crossed two of the variants you were working with? What would the resulting hybrids look like? Explain.
5. What do you expect would happen to the properties of any of the vegetables you were working with if you just let it grow freely in nature? Explain.
6. Do you think that the process of artificial selection is still going on in the group of *Brassica oleracea* variants? Why or why not?
7. Submit the outcomes of this activity as a written lab report.

Table 1: Typical traits of various variants of *Brassica oleracea*

plant trait	***Brassica oleracea*—variant**		
sketch			
stem color			
stem thickness			
edible part			
leaf color			
leaf shape and measurements			
taste			
smell			
flower bud color			
selected traits			

Table 2: Number of grown plants

green kohlrabi	blue kohlrabi	green cabbage	purple cabbage
broccoli	cauliflower	kale	Brussels sprouts

Table 3: Seedling observations

observed trait	***Brassica oleracea*—variant**		
number of growing plants			
stem color			
stem thickness			
leaf color			
leaf shape and measurements			
taste			
smell			
leaf number (individual data)			
leaf number (individual data)			
leaf number (individual data)			
seedling height (individual data)			
seedling height (individual data)			
seedling height (individual data)			
stem thickness (individual data)			
stem thickness (individual data)			
stem thickness (individual data)			

Seedlings planted on (date):

Data collected on (date):

Plants growing (no. of days):