



A Biological Riddle

How can things that look so different be the same?

A trip to the local supermarket will provide all of the materials for you to answer this riddle. At the same time you will begin to understand one of the great themes underlying all of biology: the nature of diversity and speciation.

To explore the riddle, purchase two or three of the following kinds of fresh vegetables: purple-top or white turnip, Chinese cabbage (napa cabbage or petsai), celery cabbage (pak choi), choy sum, rapini, turnip greens. Have your students examine and compare characteristics of the vegetables and some rapid cycling *Brassica rapa* (Rbr) plants. How can things that look so different be the same?

The answer is easy to give, but not so easy to understand or to demonstrate scientifically. Though the Rbr, the turnip, Chinese cabbage and these other vegetables look very different, they all belong to the same *species*, *Brassica rapa* (Figure 1). What does it mean to be the same species and how can you prove that they are the same?

Most scientists accept the species concept that has developed from the thinking of the famous 19th century biologists, *Charles Darwin* and *Alfred Wallace*. With a few exceptions, a species is defined as a population of organisms having many characteristics in common and which produce fertile offspring through the exchange of genetic information (in seed plants, pollination and fertilization). Different types of *Brassica rapa*, including Rbr, can provide the basis for experimentally testing the theory.

The mature vegetative stages of the various forms of *Brassica rapa*, appear to have little in common. If, however, you plant a few seeds of turnip or Chinese cabbage along with the Rbr, you will find that the seedlings and first few leaves of all the young plants look similar. They even taste similar. Try some! Only when the vegetative parts grow further do the plants become different. These changes in form are the result of the *domestication* process.

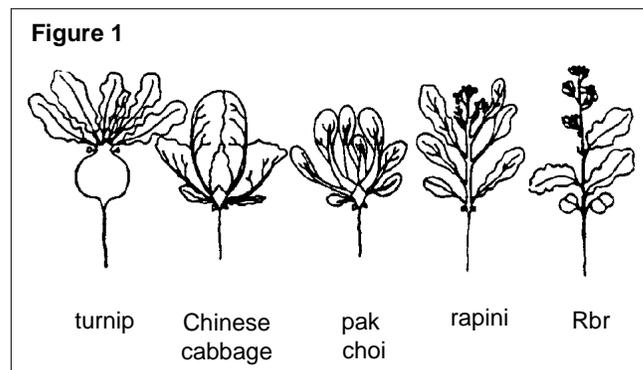
Wild *B. rapa* looks similar to a large Rbr. More than 3000 years ago farmers around the Mediterranean Sea collected seed from *B. rapa* plants having the most succulent leaves and enlarged roots that could be stored over winter for food and animal feed. In ancient China types were selected with large numbers of fleshy petioles and leaves, some of which curled inward to form a head. From each generation, seeds produced on the best plants were saved, resulting in the improvement of different forms of *B. rapa*.

Today in northern China, just as in ancient times, heads of Chinese cabbage are stored for winter in large quantities as a delicious vegetable rich in vitamins. During storage the outer leaves dry down, forming a natural wrapper, protecting the head from desiccation and rot.

The enlarged roots and heads of *Brassica rapa* are rich in sugars needed by the plant to remain alive over the winter. Under cool conditions (2-8°C) of winter the leaf-producing growing point (vegetative meristem) converts to a flowering meristem. In the spring the turnip and cabbage send up a branched flower stalk with many flowers. It is during this flowering or reproductive stage that once again the turnip or Chinese cabbage resemble the flowering stages of Rbr.

Botanists interested in the classification of plants (the science of *taxonomy*) developed a system of characteristics of the flower parts and structure. Thus, flowering plants having four sepals, four petals, six stamens and a pistil composed of two fused carpels were placed in the family Cruciferae named for the cross-shaped arrangement of the four petals. Within the Cruciferae the genus *Brassica* has several species with rather similar seedling, floral and chemical characteristics.

There are six common species of *Brassica*, each with different numbers of chromosomes carrying the genes which determine how the plant appears. *Brassica rapa* has 20 chromosomes, whereas other species have different numbers. Plants of the same genus having the same number of chromosomes are normally able to cross-pollinate (exchange genetic information), and thus form a species. Thus, we can understand how different forms of the same species have arisen through the process of domestication at different times in history and in different cultures. Can you think of some other examples of familiar organisms that are different and yet the same?



Plant breeding from grocery store vegetables

Introduction

Turnips, Chinese cabbage and Wisconsin Fast Plants (Rbr) look very different. Yet, they actually belong to the same species. This means that they have the same number of chromosomes and they can cross breed and produce fertile offspring. But how can you prove that plants that look so different are really the same species? The "Biological Riddle" and the following investigations will allow you to explore this question.

Materials

- turnips
- Chinese cabbage
- Wisconsin Fast Plant (Rbr) seeds and kit supplies
- 2-liter soda bottles
- soil mixture (peat moss and vermiculite)

Experiment I

Stage 1 (time required - 4 weeks, requiring no tending):

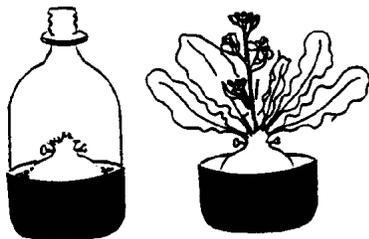
1. Purchase a turnip and Chinese cabbage from your local grocery store. (If turnip is waxed, remove wax). Place them in a plastic bag in the refrigerator for 4 weeks. This cold treatment, called *vernalization*, stimulates overwintering and the plants will convert from vegetative to flowering stage.



2. Make two growing containers from 2-liter soda bottles. Fill bottle with hot tap water, replace cap. Hold bottle firmly and twist off the opaque bottom. Seal holes on bottom with black electrical tape. Fill containers with a soil mixture of equal parts of peat moss and vermiculite (or sand).

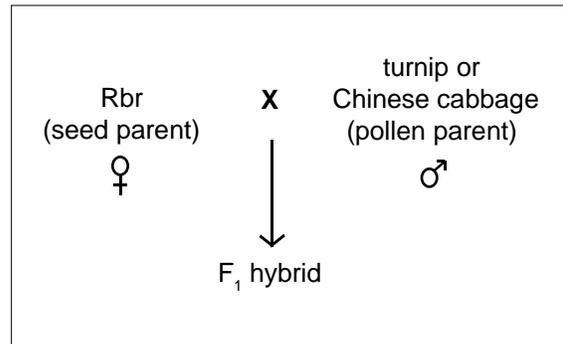
Stage 2 (time required - 3-4 weeks):

3. After 4 weeks remove turnip and Chinese cabbage from refrigerator and place vegetables on soil mixture in containers. Keep the soil moist at all times. Place them in good light, keep cool and partly covered to prevent excess wilting. Cover with the top portion of a 2-liter soda bottle which has been cut to be about 8 inches high. Leave the cap off of this bottle.
4. Within 3-4 weeks the plants should produce flower buds. When the first buds appear, plant four quads of Fast Plant (Rbr) seeds. In two weeks all three types of *Brassica rapa* should be flowering.



Stage 3 (time required - approximately 20 days):

5. Cross pollinate each of the vegetables to the Rbr as shown below. Use separate beesticks for each cross.
6. After 20 days you should have mature seed pods on your Rbr plants.



Question:

- If your Rbr plants produced seeds, is this proof that all three are the same species?

Experiment II

Save the seed you have produced from Experiment I and plant them in soda bottle growing containers in class or in the garden over the summer. These plants constitute the first (F₁) generation.

Questions:

- What is your hypothesis about how these intraspecific (within a species) hybrid plants will look?
- If the plants flower, do they produce pollen?
- Can you produce seed by interpollinating two or more hybrid plants?

Experiment III

If you get seed from the intraspecific hybrid, sow it. What do plants from this (F₂) generation look like? If you get this far, you are well on your way to becoming a plant breeder, and you will understand the riddle of how things that look so different can be the same. Good luck!