CHAPTER 3

FLOWERING

How do plants get ready to reproduce?

Chapter 3

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Overview

A sequence of four short activities guide students in an exploration of flowers and flowering. In Activity 1, students study flowers in the context of the whole plant by examining timing of flowering and patterns of flower location on a plant. In Activities 2, 3, and 4 students dissect the flower in order to observe floral parts and their function.

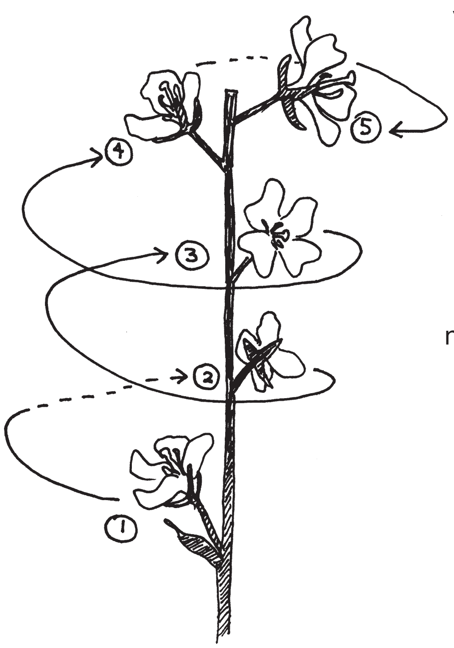
Data collected by students on their plants can become part of a class data set, which can then be analyzed, plotted and displayed. Through this process students may gain a better understanding of the normal variation within a population of Fast Plants.

These activities can be done singly or as a group and the sequence can be altered. Each observation contains launching points for further student-led inquiry.

Objectives

By participating in this activity students will have the opportunity to:

- understand that flowering is a key stage of sexual reproduction;
- observe, measure and analyze variation in flowering among individuals in a population of plants;
- explore the parts of the flower and the role that each part plays in reproduction; and
- observe the reproductive tissues of plants, including pollen and stigma, under magnification.



Time Required

For All Activities

- Seed must be planted approximately 13–14 days* before Activity 1; 15–17 days* before Activities 2–5 (see calendar).
- 5 minutes are required for thinning plants at 4–8 days after sowing (see calendar).

Activity 1:
The First Flowers

- 5 minutes for observation and recording data for 2–3 days surrounding first flowering date.

Activity 2:
What's in a Flower?

- 50 minutes for dissection.

Activity 3:
Orientation of Flower Parts

- 20–30 minutes for observation and recording data.

Activity 4:
Go for the Glucose

- 20–30 minutes for dissection.

* Days to flowering will vary depending on environmental conditions in your classroom. If temperatures tend to be cool at night, for example, flowers may open a day or two later.

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Materials

Each student will need:

Activity 1
- 1 flowering Fast Plant (13–14 *days after sowing*)
- hand lens or microscope
- Student Data Sheet, *Time to Flower*

Activity 2
- 1 flowering Fast Plant (15–17 *days*)
- hand lens or microscope
- fine-tipped forceps, dissecting needle or toothpick
- white index card with about 8-cm piece of tape, taped to card, sticky side out

Activity 3
- 1 flowering Fast Plant (15–17 *days*)
- hand lens or microscope

Activity 4
- 1 flowering Fast Plant (15–17 *days*)
- hand lens or microscope
- forceps
- white index card with about 8-cm piece of tape, taped to card, sticky side out
- toothpick
- Glucose Diastix® reagent strip for urinalysis, available from local drugstore (one strip is sufficient for 8–10 tests)

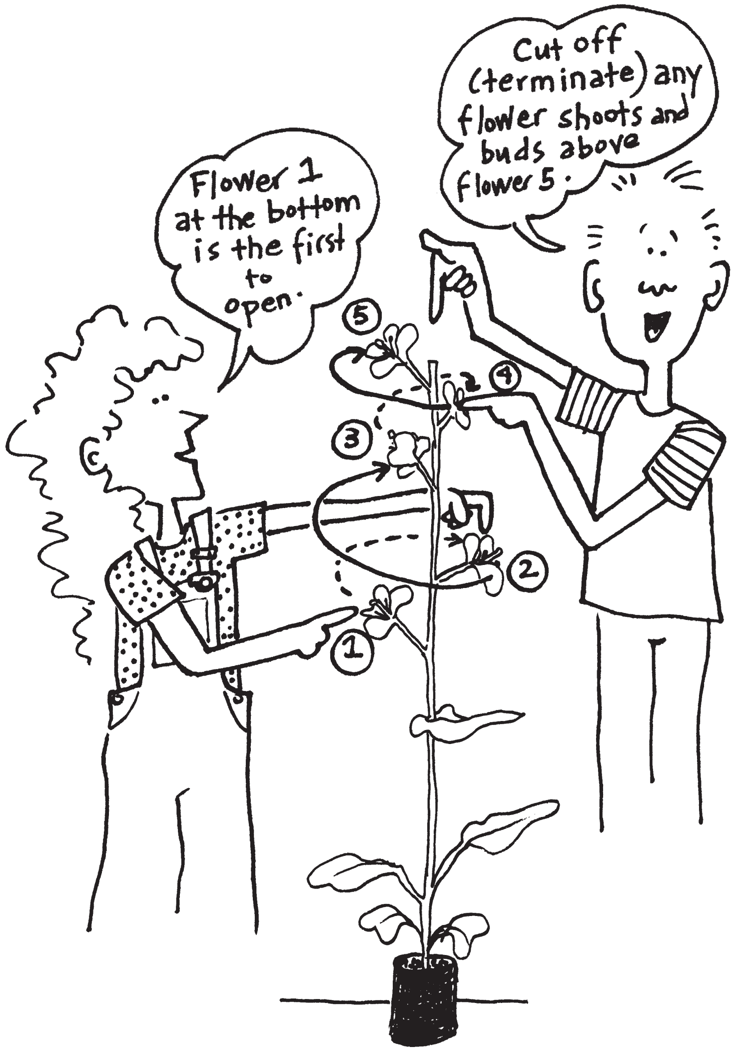
* See growing instructions.

Classroom Management Tips

Approximately 13–14 days after sowing, plants will begin flowering. The actual timing varies with the environmental conditions. Optimal temperature is 18–26°C (65–78°F). Cooler temperatures will slow flowering. Lowering the temperature can be used to slow development somewhat if necessary to fit your class schedule.

Fast Plants: Flowering Activities Calendar

Monday	Tuesday	Wednesday	Thursday	Friday
	Plant	1 day	2 days	3 days
←--- Thin plants 6 days	Thin plants 7 days	---→ 8 days	9 days	10 days
←-- Record Opening of 1st Flower 13 days	Record Opening of 1st Flower --→ ←-- Record Opening of Flowers #2-5 ←-- DISSECTION 14 days	Record Opening of Flowers #2-5 DISSECTION 15 days	Record Opening of Flowers #2-5 DISSECTION 16 days	--→ --→ 17 days



Activities

Activity 1
The First Flowers

1. Sometime between **Day 13** and **Day 15**, flowers on individual plants will begin to open. Note the number of days after sowing when the first flower opens. Consider a flower to be open when the pollen on anthers is visible.
   Record the opening of the flowers on the data sheet *The First Flowers* (page 64).
   How much variation exists in time to first flower within the population of Fast Plants in your classroom?
   What is the timing and sequence of the opening of the next flowers on the shoot? What might be an advantage of flowering sequentially, one flower at a time? What might be the disadvantages?

2. Starting with the oldest, lowermost flower on the main stalk, number the flowers as 1, 2, 3, 4 and 5 with number 1 being the oldest flower. With a sharp pair of fine scissors, terminate flowering by snipping off all remaining flowers *above* flower number 5. Snip off all side shoots. On subsequent days, you may need to terminate further flowering by snipping new buds and side shoots.

Activity 2
What's in a Flower?

Take the *top open flower* of the first plant and carefully remove it with a forceps.

While observing with a hand lens or microscope, carefully remove the flower parts with fine tipped forceps, a dissecting needle, or a sharp-tipped toothpick. For each part, note the relative positions on the receptacle. Place each part on the sticky side of a piece of tape, taped to a card as shown in the illustration. Refer to the illustration on page 62 for help in identifying the floral parts.

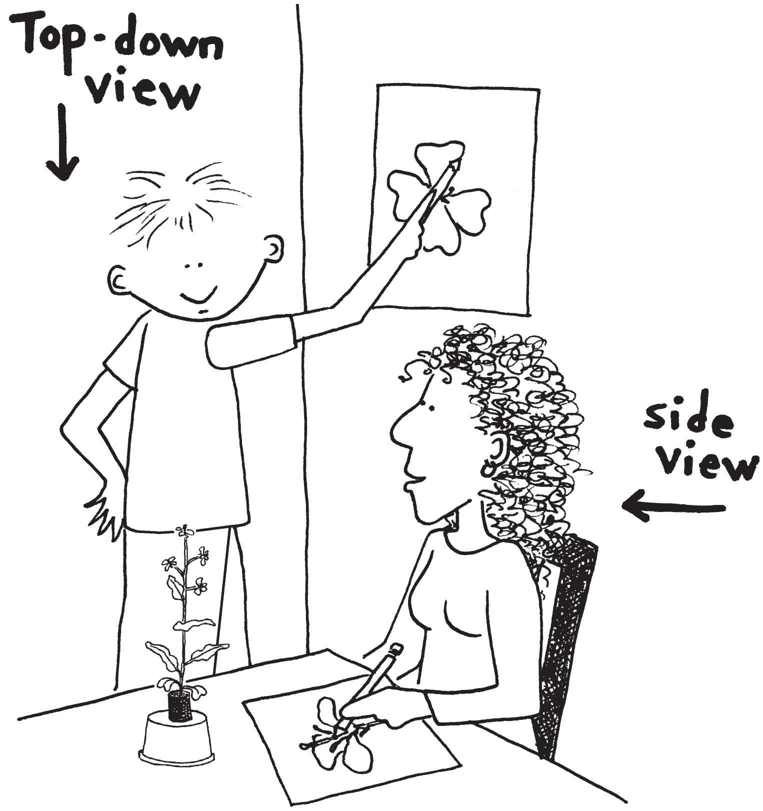
Compare the Fast Plant's flower parts to those of another flower such as a tulip.

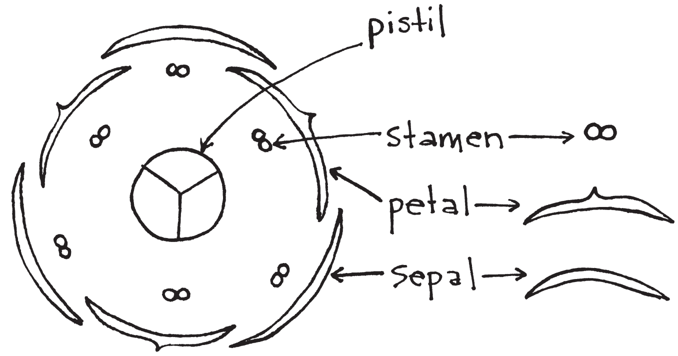
Activity 3
Orientation of Flower Parts
The relative arrangement of the basic flower parts is important in understanding how a flower functions, as well as in taxonomic identification of the plant. The relative location of flower parts can be illustrated with a floral diagram.

A floral diagram represents a **cross section** of a flower as it would appear if all the parts were at the same level. Generally nectaries are not included in floral diagrams because, while important, nectary location is not used in taxonomic identification of plants. Note the standardized symbols that are used to represent the flower parts in the basic floral diagram illustration to the right. This flower has three petals, three sepals, six stamens and a pistil made of three united carpels.

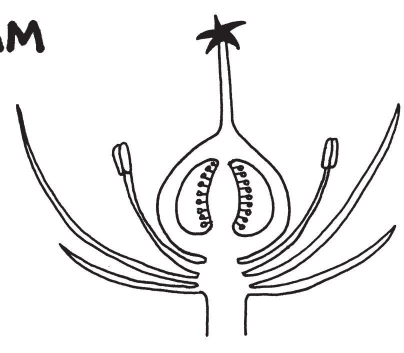
1. Select a fully open flower and observe it from above.
   Draw a top view and record it on the *Orientation of Flower Parts* sketch sheet (page 65).
   From this same perspective, create a second drawing that is a floral diagram (cross section) on the same sketch sheet.

2. A **longitudinal section** of a flower represents a side view of the flower as it would appear if it were cut vertically. The longitudinal section can show flower parts and their attachment locations on the receptacle, or central floral axis.
   Viewing the Fast Plant flower from the side, create a longitudinal section of the flower on the sketch sheet.

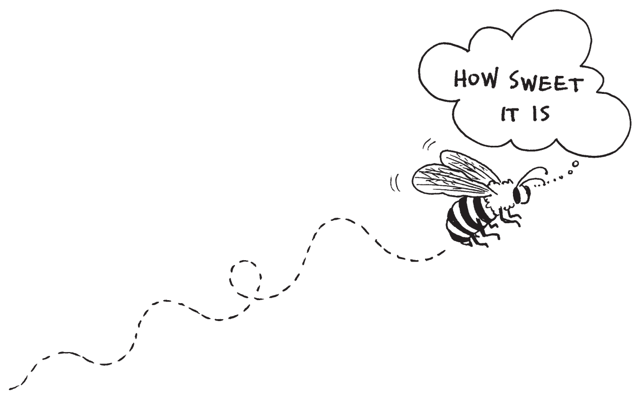


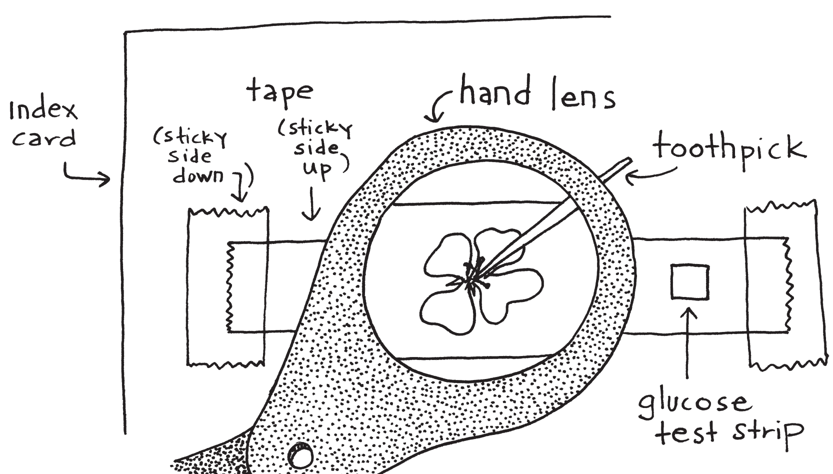


EXAMPLE OF A FLORAL DIAGRAM



A longitudinal section of the same flower.





ACTIVITIES, continued

Activity 4
Go for the Glucose
Nectaries are less distinct than other parts of the flower. They can be recognized by the presence of varying quantities of sweet, liquid nectar. With a glucose reagent strip, the presence and concentration of nectar can be easily tested. A glucose reagent strip, generally used to detect sugar levels in urine, reacts with glucose to produce a spectrum of color changes depending on the glucose concentration of the solution.

At the base of the two short anthers in the Fast Plants flowers are two dark green, glistening nectaries producing nectar. Can you prove that the flower really produces nectar? Follow the procedure and go for the glucose!

Procedure
1. Tape an 8-cm piece of tape, sticky side out, to a white index card.

2. Place a Fast Plant flower, which is undergoing anthesis, at one end of the tape and a square of glucose reagent strip at the other end.

3. Moisten the test strip with a very small drop of water using the clean, flat end of a toothpick.

4. While looking through a magnifier, use a toothpick to spread open the flower parts and gently press them to the sticky tape. Note the green nectaries and glistening nectar at the base of the pistil.

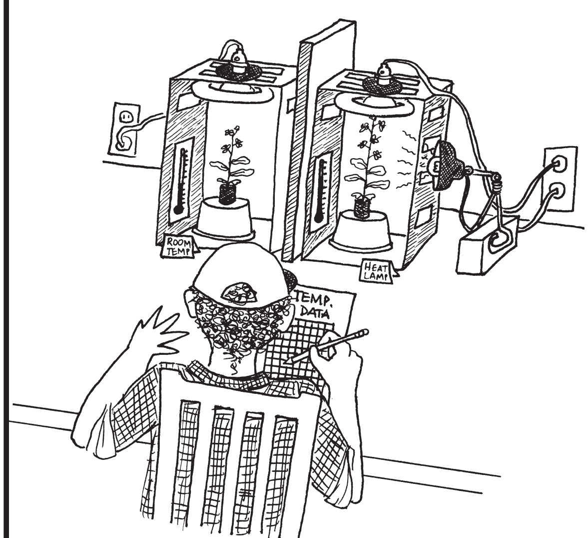
5. Probe the nectaries with the clean, pointed end of the toothpick, then touch the tip of the toothpick to the moist test strip. Is there a color change?

Background

What Is a Flower?
What is a flower? In human eyes, it is something to enjoy, with colorful petals and fragrance. However, for many plants, the critical part of the flower is not the dramatic blossom. Within that blossom are the organs of reproduction that allow the plant to reproduce sexually and create offspring slightly different from itself.

Many plants can arise directly from an existing plant through asexual reproduction. However, when a leaf cutting sprouts new roots or an iris plant is divided, this asexual reproduction gives rise to offspring that are genetically identical to the parent plant. Hence, asexual reproduction will not generate the variation necessary to allow the species to adapt to the slow environmental changes that will inevitably occur.

Sexual reproduction requires the union of two gametes, a male sperm and female egg, to form a *zygote* (fertilized egg). Uniting eggs and sperm from different flowers or different plants provides a challenge for immobile plants. Plants, which are largely immobile, have evolved strategies to move their male gametes long distances to fertilize the female gametes. One common strategy involves employing animals, often insects, to carry *pollen* (male gametes) to the *pistil* (female reproductive organ).

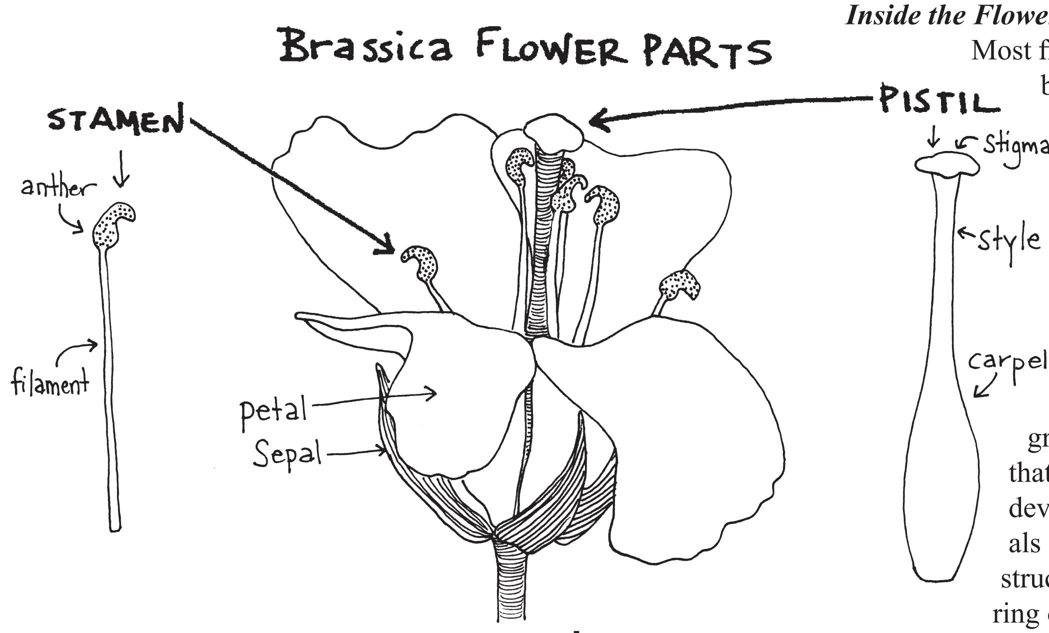


In order to attract the insects into such service, the plants provide food, in the form of nectar or pollen. However, the plant must first attract the insects. This attraction must happen when the reproductive organs within a flower are ready to provide and receive pollen. Plants have evolved a constellation of intriguing features by which they can "advertise" the availability of pollen and nectar to the pollinators. These "advertisements" include familiar flower characteristics such as dramatic colors and color patterns, distinctive fragrances and large or complex shapes. The flower advertises the availability of nectar, which lures the pollinators into service.

So the question, *What is a flower?* is a matter of the perspective of the viewer. For an insect, the flower is an essential source of sugar-rich nectar and protein-rich pollen. To humans, it is a delightful gift of beauty. But for plants, the flower is the means by which they are able to generate, through

BACKGROUND, continued

sexual reproduction, the variation necessary for evolution and survival of their species.



Inside the Flower

Most flowers have the same basic parts, though they are often arranged in different ways. Each of the four main parts of a flower, the *sepals*, *petals*, *stamens*, and *pistil* serve particular functions in flowering and sexual reproduction. The sepals are the green leaflike structures that enclose and protect the developing flower. The petals are the colored leaflike structures that lie within the ring of sepals and frequently serve to attract pollinators.

The stamen consists of the *filament*, a slender stalk upon which is borne the *anther.* Within the anther are the pollen grains, which contain the male gametes or sperm cells.

The pistil usually has three parts, the *stigma* (which traps the pollen), the *carpel* (ovary) and the *style* (the neck between the two). Brassica (Fast Plants) flowers have two carpels fused together and separated by a thin membrane. The carpels house the *ovules*, each of which contains the female gametes.

In brassicas and many other species that need to attract specific pollinators, *nectaries* are also present. These *nectaries*, strategically located in the flower, secrete sugar-rich nectar. Their location ensures that nectar-gathering insects and other animals will receive pollen from anthers and transmit it to its stigmas as they forage for nectar.

Fast Plants and Flowering

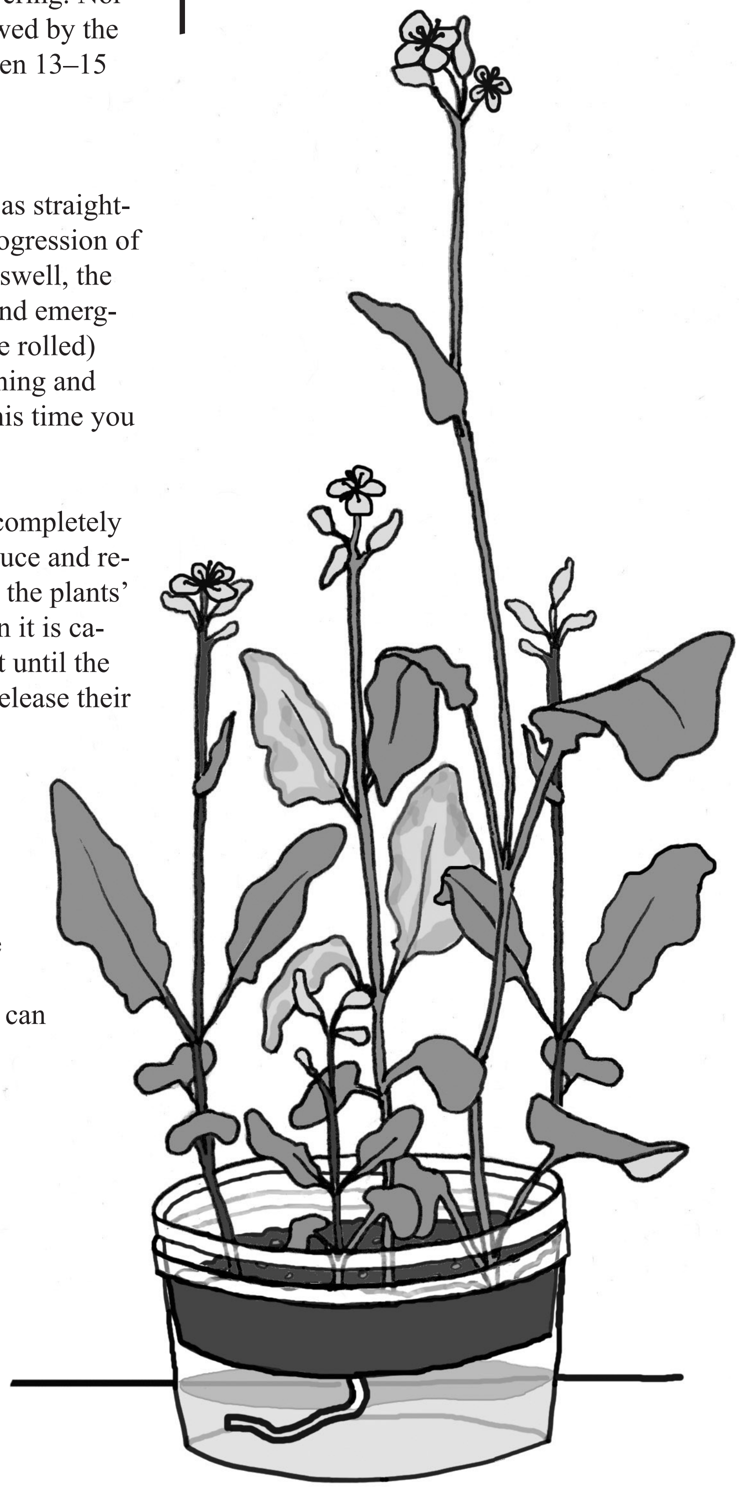
Several days before the flowers open, deep in the apical bud whorl, meiosis is occurring in the anthers and ovules. Meiosis is responsible for the variation that results from sexual reproduction.

About 7 days after sowing your Fast Plants, you will notice a tightly packed whorl of buds, some of which are larger than others. Each successively smaller bud will open after its predecessor, resulting in a beautiful sequence of flowering. Normally the lowest flower on the shoot opens, followed by the next highest, and so forth. The first flower will open 13–15 days after sowing.

When is a Flower Open?
Determining exactly when a flower is open is not as straightforward as it might appear. As you observe the progression of flowers opening, you will notice that, as the buds swell, the sepals are pushed apart by the enlarging anthers and emerging yellow petals. Eventually the petals (which are rolled) fold outward about halfway up their length, flattening and spreading to reveal their bright yellow color. At this time you might conclude that the flowers are fully open.

A flower is fully functioning when the petals are completely opened, the reproductive organs are ready to produce and receive pollen and nectar is being produced. Taking the plants' perspective, a flower is defined as fully open when it is capable of providing and receiving pollen. Thus, not until the anthers *dehisce* (open up; Latin for *to open*) and release their pollen is a flower functionally open.

The shedding of pollen is known as *anthesis* (Greek for *full bloom*). When you observe a succession of flowers on your Fast Plants you will observe whether anthesis has occurred by noting the release of the powdery yellow pollen from the anthers. Technically, we consider a flower to be fully open when anthesis first occurs. A hand lens can be helpful in detecting anthesis.



The First Flowers

Individual Data Sheet

When do flowers open on a Fast Plant?

Observation Time	Observation Date	days after sowing	Number of open flowers	Number of open flowers in last 24 hours

Assuming that Fast Plant flowers open at regular time intervals, what is the average time between the opening of successive flowers? Show your calculations below.

Orientation of Flower Parts

Sketch Sheet

How are the parts of a flower arranged?

Sketches of a Fast Plant Flower from Three Perspectives

Top-Down View

Floral Diagram (Top-down, cross section)

Longitudinal Section (side view, sliced vertically)

What are the advantages and disadvantages of each of the three ways of drawing a flower? What information is conveyed in some views that is not conveyed in others?

Additional reading

M. P. Buckles, *The Flowers Around Us: A Photographic Essay on Their Reproductive Structures*, University of Missouri Press, Columbia, 1985.

R. B. Finnell (editor), "The Flower Issue," *Natural History* **108**, 1999. A series of articles focused on the biology of flowers.

P. Leins & C. Erbar, "Floral Developmental Studies," *International Journal of Plant Science* **158**:S3–S12, 1997.

D. J. Mabberly, *The Plant-Book: A Portable Dictionary of the Vascular Plants*, 2nd ed., Cambridge University Press, New York, 1997.

M. A. McKenna & J. D. Thomson, "A Technique for Sampling and Measuring Small Amounts of Floral Nectar," *Ecology*, **69**:1306–1307, 1998.

E. M. Meyerowitz, "The Genetics of Flower Development," *Scientific American* (November), 56–65, 1994. By altering genes for flowering, this researcher has been able to make great strides in understanding how flowers work.

L. Schiebinger, "The Loves of the Plants," *Scientific American* (February), 110–115, 1996. An interesting anthropological story of how the great plant taxonomist Carl Linnaeus used human sexuality concepts of his day (the 18th century) to develop the plant classification system still used today.

A. Zwinger, "Drawing on Experience," in P. Sauer (ed.) *Finding Home,* Beacon Press, Boston, 1992.