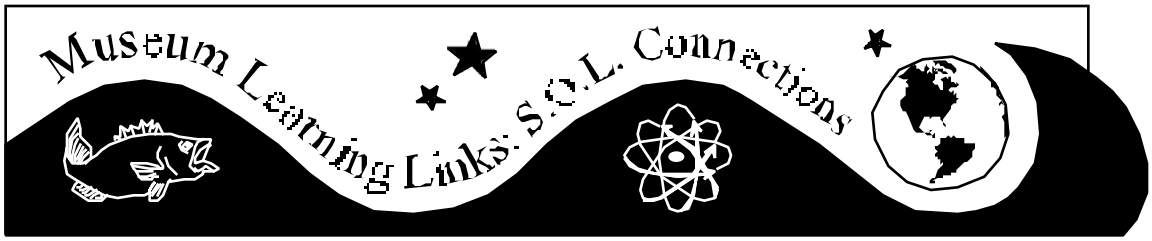


Can Plants Tell Time? A Classroom Activity

(Grades K-2)

In this activity, students recognize their own biological clocks and observe biological clocks in nature.

Time Required: One 45-minute class; ten to fifteen minutes during the day for two weeks.

1995 Virginia Science S.O.L.s: K.1, K.6, K.8, 1.1, 1.7, 2.1, 2.5

Purpose: Students will create and test theories about the biological clocks in flowering plants. Students will also describe the need for biological clocks in nature.

Museum Connection: Visit the following exhibits in the **Time of Your Life** gallery to explore the concepts and S.O.L.s covered in this activity: ***Morning Glory*** and ***Linnaeus' Garden Clock.***

Materials:

1 clock
flowering plants (see Appendix, page 5)
several magazines
construction paper
glue sticks
scissors
crayons
science journals

Science Background:

Biological timing plays an important role in the survival of plants and animals. Many organisms follow a rhythm that is controlled internally. These rhythms are as varied as the organisms that exhibit them. Birds know to migrate for the winter; salmon know when to swim upstream for mating; and grunion know to spawn during the highest tide in the spring and summer when there is a full or new moon.

A **biological clock** is an internal mechanism in a living organism that controls the timing of physiological functions and activities. Biological clocks are found in almost all living things and they control many of the rhythms that we can observe in nature and ourselves every day.

Depending on the organism, biological clocks can follow one of several rhythms. The names of these rhythms stem from the Latin word ***circa***, which means circle. The names refer to the circular nature of the rhythms. Seasonal rhythms, such as migration and hibernation, are called **circannual** (circle of the year) **rhythms**. Organisms that live near the ocean, such as fiddler crabs, often follow **circatidal** (circle of the tide) **rhythms**, which repeat every 12.4 hours. **Circalunar rhythms** repeat every 29 to 30 days and are tied to the rhythm of the moon. Most organisms, including humans, follow **circadian** (circle of the day) **rhythms**, or daily rhythms, which repeat every 24-hours. The sleep/wake pattern of humans is an example of a circadian rhythm.

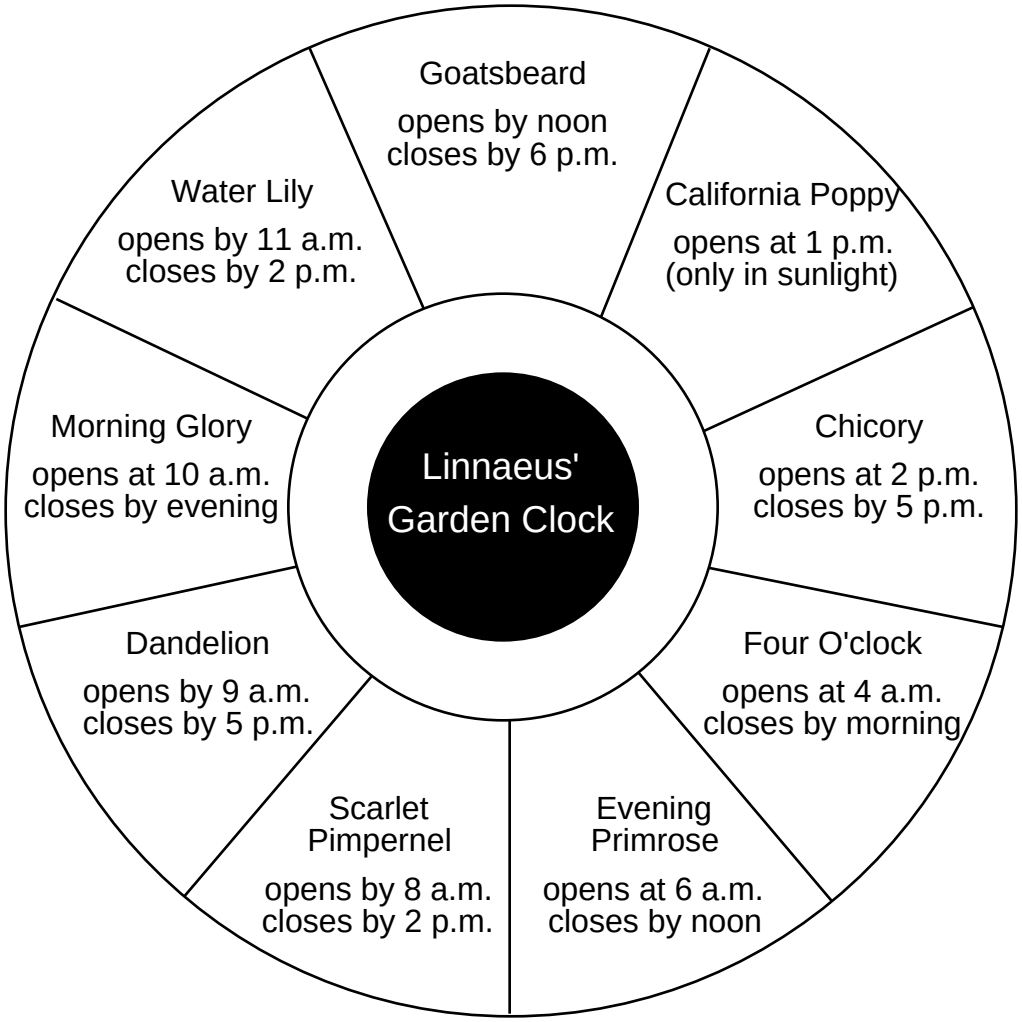
Circadian rhythms have been studied in great depth. Though all organisms that follow circadian rhythms are on a 24-hour cycle, or period, not all organisms are active at the same time. **Nocturnal** organisms, such as bats and owls, are active during the night. **Diurnal** organisms, such as humans and Day Lilies, are active during the day.

Biological rhythms can easily be observed in plants. Bean plants raise and lower their leaves at the same time each day. Flowering plants, such as California Poppies, Morning Glories and Four O'clocks, open and close their flowers at certain times during each day. How is the biological clock controlled? Biological clocks are **endogenous**, which means that they are controlled internally, not by outside signals. A scientist named Jacques de Mairan experimented with the biological clocks in Mimosa plants to see if the plants would continue to raise and lower their leaves without the outside signal of the sun. He placed the plants in a dark cabinet and made observations at regular intervals. He found that the leaves continued to raise and lower, but they slowly drifted off of their original schedule. In the cabinet, the plants were able to **free run.** The plants had no environmental time cues to regulate their rhythms. When de Mairan took the plants out of the cabinet, they were no longer in sync with the day/night cycle. From this experiment, de Mairan concluded that biological clocks, although not controlled by outside signals, are often in sync with, or **entrained** to the outside world. **Entrainment** happens when an organism senses outside cues, such as light, and sends those signals to its biological clock. When these outside signals are present, the organism follows the time cues of its environment, so that it is not operating in its free running rhythm.

What causes circadian rhythms in plants? Scientists are still learning about this phenomenon, but they have observed increased nectar production in diurnal flowers during the times of day that the flowers are open. The times that flowers are open also matches the schedules of their pollinators.

Linnaeus' Garden Clock

In 1751, a Swedish botanist/naturalist named Carolus Linnaeus designed a flower garden clock using certain diurnal flowers. By arranging selected species of flowering plants in a circular garden, he was able to devise a clock that indicated the time of day by observing which flowers were open and which ones were closed. The diagram below is inspired by the clock that Linnaus designed. The flowers in the diagram, however, are more commonly found in the United States.



Getting Started: Lead the class in your version of the following discussion:

Hold up the clock for the students to see. Why do we need clocks? How do clocks help us in our daily lives?

Humans need clocks to tell time. We need to know what time it is so that we can get to places on time.

Can you think of some things that you do at about the same times everyday?

Most people wake up, go to sleep, go to work or school, and eat at about the same times each day. These schedules vary from person to person, but most people do have a schedule that they follow. Having a clock keeps us on schedule.

Many living things, including humans, also have a biological clock. A biological clock is something inside our bodies that lets us know when it is time to do something. Do you need a clock to tell you when you are hungry? Do you need a clock to tell you when you are sleepy?

Your body lets you know when it is hungry. You may feel a rumbling in your stomach. Your body also lets you know when you are sleepy. Your biological clock is what tells you when it is time to go to sleep and when it is time to eat. In this lesson we are going to learn about other biological clocks found in nature.

Procedure:

1. As a class, discuss some other animals and plants that have biological clocks. Consider animals that migrate or hibernate, plants, bees, and flowers that open and close.

1. Give each student a piece of construction paper, a glue stick, crayons, and a Clock: Student Handout Sheet. Students should color the clock face, cut it out, and glue it onto the construction paper.

1. In class or for homework, have the students cut out four pictures of plants and animals that have biological clocks. Students should glue these pictures at twelve, three, six and nine o'clock. Hang up the pictures around the room.

1. Some flowers have biological clocks that tell them when to open and close. Why do flowers need to open? (Flowers need to open to be pollinated.) Ask the students to observe their flowering plants. When do the flowers open? When do they close? Observe the flowers at different times over several days. Does the opening and closing pattern of the flowers change? Have students write down their observations in their science journals.

1. Discuss other factors that might affect the opening and closing of flowers. Do they open and close due to light? How about heat? Encourage the students to come up with theories about what makes the flowers open and close. Test these theories. Place some plants in a dark cabinet. Observe the plants in the dark and the plants left in light at the same time for several days. Are the flowers still opening and closing at the same times every day? Have students write their observations in their science journals.

Conclusions:

Why does a plant need a biological clock to tell its flowers when to open and close?

Can you affect the time at which a flower opens and closes by changing its environment?

Assessment:

Give students the following questions as a pre- and post-test:

1. Which of the following has a biological clock?

   A. Canada Geese B. People
   C. California Poppies D. All of the Above

1. Why do flowers need to open at certain times of the day?

   A. To get sunshine B. To be pollinated
   C. To get water D. To look pretty

Extensions:

Make a poster, and submit the class' observations and conclusions from this activity as a science fair project.

Grow bean plants in the classroom. Observe the plants lifting and lowering their leaves. Place some bean plants in the dark to see if the pattern changes.

Use the illustration of Linnaeus' Garden Clock to plan your own garden clock and plant it outside the school. Make observations.

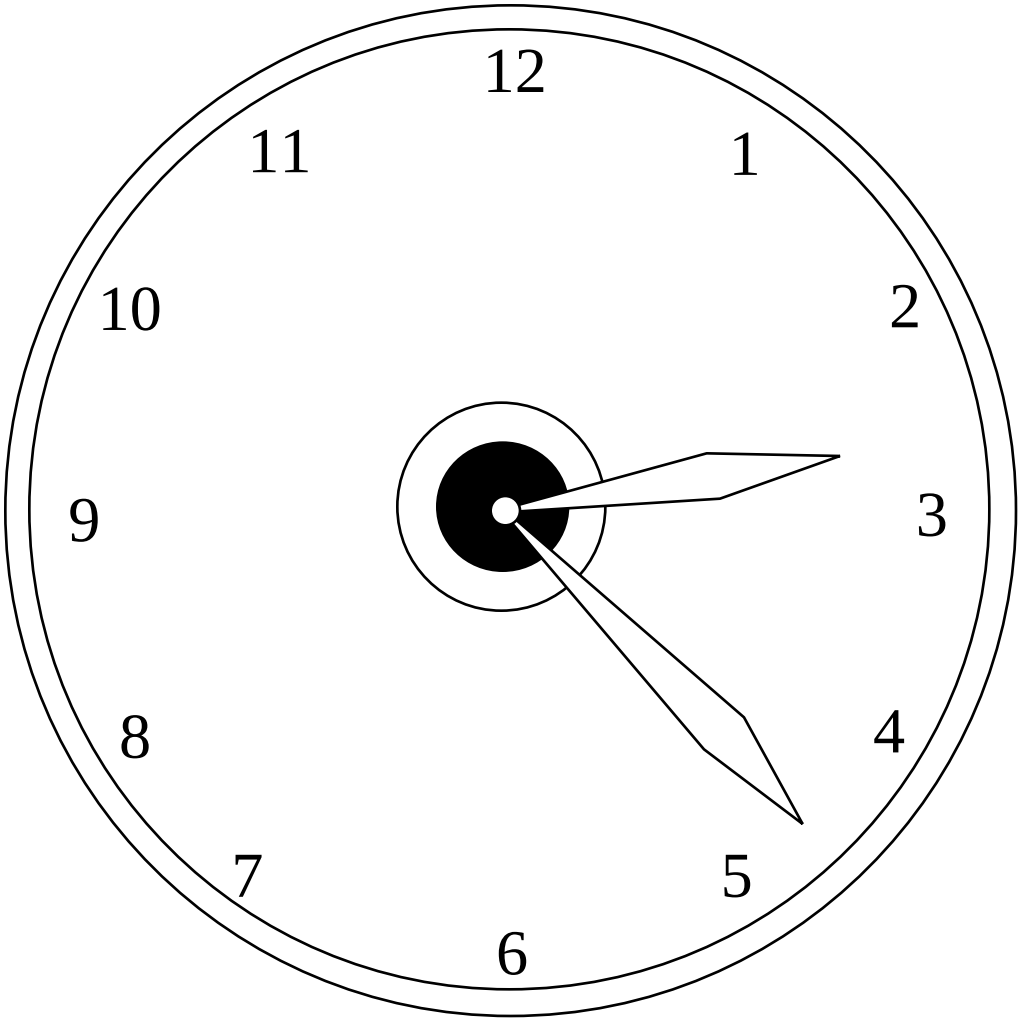
Resources:

The following resources are available in Shop 4 Science, the Science Museum of Virginia Gift Shop. The materials can also be ordered by contacting Eugene Maurakis at maurakis@smv.org.

Biological Timing: Teacher Resource and Activity Guide. Kira Berman, Laura Young, Ian Koffler. Science Museum of Virginia, 1999.

Time of Your Life: Interactive CD-ROM. National Science Foundation for Biological Timing, 1999

Clock: Student Handout Sheet



Appendix: The following plants can be used for this activity. Most of these plants can be purchased at your local garden center or grown easily from seed. The blooming dates refer to the time when the plants will flower when planted outdoors.

Flowers	Opening Time	Description
Scarlett Pimpernel ***Anagalis arvensis***	8 a.m.	A low-branching plant, which often grows in sandy soils along roadsides. It blooms outdoors from June to August and is 10 to 30 cm tall.
Dandelion ***Taxacum officinale***	9 a.m.	A small yellow flower that is in common in every lawn. It blooms from March to September and is 5 to 45 cm tall.
Morning Glory ***Ipomoes purpurea***	10 a.m.	A funnel-shaped flower grown on a vine. It blooms from July to October and can grow to be 3 meters in length.
Water Lily ***Nymphaea sp.***	11 a.m.	A white flower that floats on ponds and quiet waters. It blooms from June to September.
Goatsbeard ***Tragopogon pratensis***	12 p.m.	A bright yellow flower on a long stalk, often mistaken for a dandelion. It blooms from May to July and can grow to be 70 to 100 cm tall.
California Poppy ***Escholtzia californica***	1 p.m.	A brightly-colored, four petal flower. It blooms from May to September and grows 20 to 30 cm tall.
Chicory ***Cichorium intybus***	2 p.m.	A flower with square-tipped, blue petals, common on roadsides and in open fields. It blooms from June to October and grows 3 to 120 cm tall.
Four O'clock Flower ***Mirabilis jalapa***	4 p.m.	A common garden plant with yellow, red, white or mottled flowers on long vines. It blooms in the spring and grows to be about 1 m in length.
Evening Primrose ***Oenothera biennis***	6 p.m.	A lemon-scented, large, yellow flower on a hairy stem. It blooms from June to September and grows to be 60 to 150 cm tall.