CITIZEN SCIENCE

15 LESSONS THAT BRING BIOLOGY TO LIFE, 6–12

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L E S S O N 9

Flight of the Pollinators

Plant Phenology From a Pollinator's Perspective

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Overview

Students learn how to observe, quantify, and record how plants change across seasons. They participate in a nationwide citizen science effort to track phenology (seasonal change) and study the effects of climate change on plants and animals. Applying these concepts to conservation issues, they consider supporting pollinator diversity in the local landscape by planting phenologically diverse gardens.

Big Idea

Seasonal variations in climate influence plant life cycles, with consequent impacts on the availability of resources for various pollinators.

Citizen Science Connection

Nature's Notebook (*www.usanpn.org*)

Time Required/Location

Two 50-minute class sessions, one indoors and one outdoors. The activity can be repeated as often as desired over the seasons.

Learning Objectives

Students will be able to:

- Recognize the sequence of reproductive events that lead to seed production in most species of flowering plants
- Identify pollinator syndromes and predict which pollinator(s) are likely to visit the flowers of any plant species they come across
- Identify simple methods for helping to conserve local pollinator diversity across the seasons
- Contribute observation data to the Nature's Notebook citizen science project
- Interpret the ecological significance of plant reproductive phenology for plants, pollinators, and animals that consume the resulting fruits and seeds

Resources Needed

- Computer with internet access
- Smartboard or projector
- Pollination Syndrome Guide (1 per student or group, see sample provided)
- Flight of the Pollinators Data Sheet (1 per student or group, see sample provided)
- Plant species ID guide, visual aids, or signs
- Journals or paper for journaling activity
- Clipboards
- Hand lenses and magnifying glasses
- Cameras (optional)

Background Information

The conservation of plant species requires the availability of pollinators that are abundant when the plants are in flower, just as the conservation of pollinators requires that the flowers they feed on are available and abundant. Through the Nature's Notebook citizen science project, scientists, students, and others are learning about the influence of climate on plants and pollinators. The more complete the data set becomes, the higher its value for research and decision making in fields such as natural resource management, agriculture, and health. Participation can occur in school yards, urban green spaces, or larger natural areas such as wildlife refuges and parks. This lesson is adapted from a longer unit (Haggerty, Hove, Mazer, and Barnett 2012). A 13-minute video at *www.usanpn.org/about* provides further information about phenology and citizen science.

Conducting the Activity

Engage

1. Activate awareness of phenology by exploring students' connections with the seasons. For example, the discussion could focus on:
    - Nearby plants: What's happening with the plants in your neighborhood or school yard right now? Are they actively producing new leaves, or are the leaves changing their colors or aging?
    - Seasonal human health: Does anyone suffer from seasonal allergies, and at what times of year? When do mosquitoes emerge and begin to bite? In what seasons do colds and flu spread quickly?
    - Sports and outdoor activities: What sports are played each spring? Summer? Fall? Winter? Do nearby trees have leaves on them during those sports?
2. Follow with questions such as these about the seasonal availability of food:
    - What foods are currently in season or ready to harvest locally?
    - Which are you looking forward to in the coming season?
    - What season comes to mind for tomatoes, peaches, berries, and pumpkins?
3. Finally, connect students' awareness of their food with pollination. Reinforce their knowledge that fruits and seeds develop from pollinated (and fertilized) flowers.

    The critical point is that the peaches and berries that are ripe today started as flowers that were pollinated by an animal weeks prior. Similarly, flowers that are visible today represent the future *food supply for birds, deer, bears, caterpillars, squirrels, and many other animals, including humans.*

4. Consider discussing one or more of these additional questions:
   - What is pollination? (*Transfer of pollen from anthers (male pollen-producing structures)* to stigma (*female pollen-receiving structure); this can happen between flowers on different plants, between flowers on one plant, or even within one flower.*)
   - What is a pollinator? (*An animal that carries pollen from anthers to stigma.*)
   - Why do pollinators visit flowers? (*Usually to obtain food, including nectar or pollen.*)
   - What attracts pollinators to specific types of flowers? (*Some plants have brightly colored blossoms, or ones with patterns of contrasting colors to attract pollinators. Others produce scents. Some of the earliest spring blooms such as skunk cabbage and Jack in the Pulpit produce heat that attracts insects.*)
   - Who is a pollinator? (*Name as many as possible—bees, butterflies, birds, moths, flies, beetles, bats, rodents and so on.*)
   - What types of flowers attract each type of pollinator? (*For example, hummingbirds are attracted to red, tube-shaped flowers. Think about how pollinators are attracted to a combination of traits in flowers, including color, structure, and reward.*)

Explore[1]

1. Explore the concept of phenology from a pollinator's perspective by actively searching for and identifying pollination syndromes—these are flower traits such as size, shape, color, and scent that collectively tend to attract and offer rewards to a particular type of pollinator or suite of pollinators.
2. To prepare students for their time outdoors, share the Pollination Syndrome Guide and discuss the types of floral features needed by various types of pollinators. Then have students use this guide while exploring your school yard or other outdoor area and record information on the data sheet. You could

1. Be aware of any students who may have allergies to bee stings. Follow your school's prescribed safety guidelines.

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organize students into groups according to pollinator type (bee group, moth group, and so on) or groups containing one of each pollinator type (such as a bee, a moth, a butterfly, and a hummingbird). Tell students they will be taking the perspective of pollinators as they explore the school yard.

3. Ask, "What is citizen science?"

   Citizen science *refers to efforts in which volunteers partner with professional scientists to collect or analyze data. Through the USA National Phenology Network's Nature's Notebook citizen science project, scientists monitor the influence of climate on the phenology of plants, animals, and landscapes. See Chapter 1, "What Is Citizen Science?" for more information.*

4. To align this activity with species targeted by the Nature's Notebook citizen science project (*www.usanpn.org*), use the "Participate" tab to learn which of the targeted plant species occur in your region. If you are unfamiliar with the species at your site, you could consult with the local chapter of your state's Native Plant Society or agricultural extension service or with nearby botanic gardens, natural reserves, nurseries, or native plant landscapers.

   Decide how you would like to organize the students' data collection. Possibilities include:

   - Each pollinator/student records his/her own observations (using the data sheet provided at the end of this lesson plan), or
   - Pollinator/students work in pairs, with one counting flowers and the other recording the counts, or
   - Pollinator/students work in groups, with the data sheet passed around and everyone taking turns counting flowers and recording data.

   Students could use a field guide for plant identification, or you could simplify their ID process by bringing samples (including stems, leaves, and flowers) of available species into class before the field day or by labeling selected varieties or flagging particular plants in the field for them to identify.

5. Go to your outdoor site and instruct students to keep an eye out for pollinators and observe how they interact with flowers. Describe the kinds of observations to make, such as:

- Are the flower visitors drinking nectar, collecting pollen, and/or eating pollen?
- Do the visitors crawl inside the flower, stay perched on top, or hover in front?
- Do they tend to visit several flowers on the same plant, or just one flower per plant?
- After a pollinator visits a flower, can you see pollen deposited on the stigma, or can you see signs that pollen was removed?

From the perspective of a pollinator, ask students to consider the following questions for each flowering plant that they visit:

- Are you the right type of pollinator for this plant? Why or why not?
- What characteristics of the flowers on this plant are attractive to you as a pollinator?
- What pollinators would you expect to find visiting this plant?

Explain

Back in the classroom, engage students in a discussion about their observations and results. Construct a summary data table using everyone's data, and then ask students to construct graphs (examples provided in the detailed lesson online). Topics for discussion could include:

- *Observations of real pollinators:* Did anyone see real pollinators? What were they doing? How did they interact with flowers? Were some types of pollinators more abundant than others?
- *Analyzing and interpreting data:* Which type of pollinator has the fewest flowers available today? (In other words, which type of pollination syndrome is NOT represented among today's flowers?) Is this because their plants haven't flowered yet or have finished flowering? Do you predict that more flowers will soon become available for the types of pollinators that have few flowers available today (i.e., are flower buds present)? For each type of pollinator that you saw, were suitable flowers available for it to visit?
- *Human influence:* Is this area intensely managed or relatively wild? Are plants being watered and if so, might that influence the number of flowers or the number of pollinators observed?

- *Potential extension questions:*
  - o How is pollination different from fertilization?

    Pollination is the deposition of pollen on a flower's stigma; fertilization occurs when the sperm carried by a pollen grain fertilizes an egg in an ovule at the base of a flower, enabling the ovule to develop into a seed.

  - o What do you know about the global pollinator crisis?

    See the Xerces Society website for information on this topic.

Elaborate

1. Consider having your students enter their observation data into the Nature's Notebook citizen science database. Viewing the data there allows you to review submissions, check for accuracy, and discuss with the group any discrepancies. You also could discuss the importance of accurate data collection for use in scientific climate change research.
2. If your classes repeat their observations over multiple dates, students can graph the availability of blooms across seasons to visualize trends in food available to pollinators. If they identify the species of flowering plants that they observe, they could graph species-specific timing of blooms and illustrate progression of food sources for pollinators across the season (examples provided in the detailed lesson online).

Evaluate

Depending on the level of involvement of your class, you might consider any of the following assessment options:

- Students submit observation notes from the Explore portion of this lesson.
- Students write personal summaries of the class discussion from the Explain portion of this lesson with prompt questions such as: "Define pollination" or "Based on our discussion of how pollinators' form correlates with their pollination function, describe the pollinator form and function associated with specific types of flowers that we observed today."

- Students write detailed essays interpreting the ecological significance of plant reproductive phenology for plants, pollinators, and animals that consume the resulting fruits and seeds.
- Students write a story about "A Day in the Life of a Pollinator" from the perspective of a single pollinator type, describing the sequence of events that lead to successful reproduction. Digital stories could be created using online tools. (A search for "digital story tools" will reveal many different possibilities for doing this.)
- Students answer matching test questions demonstrating their ability to identify pollinator syndromes and predict which pollinator(s) are likely to visit the flowers of particular plant species.
- Students answer lab practice questions by looking at flower samples, listing potential pollinators for each, and describing how each flower might attach each pollinator.

Extend

1. Create opportunities for students to analyze their data within the context of broader trends. For example, they could compare their results to those from nearby sites or from the same site in previous years and interpret the meaning of any trends that are found.
2. Consider planting native species or cultivating a garden in your schoolyard to support pollinators across seasons. On any given day, pollinator diversity in a garden or landscape may range from low to high—we can begin to measure this by identifying the types of pollinator syndromes that are represented by the plants in flower. Cultivating a garden in which the plant species represent several pollination syndromes throughout the season is one way to make a simple and significant contribution to pollinator conservation.

Lesson Resources

- Pollination Syndrome Guide
- Flight of the Pollinators Data Sheet

On the Web

- North American Pollinator Protection Campaign (*www.pollinator.org*): Includes downloadable guides on selecting plants for pollinators, customized by ecoregion

- The Xerces Society, an international nonprofit organization dedicated to protecting wildlife through the conservation of invertebrates and their habitats (*www.xerces.org*): Provides fact sheets on the importance of pollinators and simple steps for conservation of bees and butterflies
- U.S. Forest Service, Celebrating Wildflowers (*www.fs.fed.us/wildflowers/pollinators*): The Pollinators section includes information and advice about gardening for pollinators

Reference

Haggerty, B., A. Hove, S. Mazer, and L. Barnett. 2012. *Flight of the pollinators: A repeatable hands-on exploration of plant phenology from a pollinator's perspective*. USA National Phenology Network and University of California, Santa Barbara. *www.usanpn.org/education*

Additional Resources

Buchmann, S. L., and G. P. Nabhan. 1997. *The forgotten pollinators*. Washington, DC: Island Press/Shearwater Books.
Summary: Explores the relationship between plants and the bees, beetles, butterflies, hummingbirds, moths, bats, and other animals they depend on for reproduction, and discusses connections between endangered species and threatened habitats

Magney, T., K. Eitel, J. Eitel, V. Jansen, J. Schon, R. Rittenburg, and L. Vierling. 2013. Keeping a (digital) eye on nature's clock. *The Science Teacher* 80 (1): 37–43. *www.jstor.org/stable/10.1525/bio.2010.60.issue-3*
Summary: Describes student use of digital cameras to monitor plant phenology throughout the school year and share results through Nature's Notebook or other citizen science projects. Includes comparison of leaf color change detected by the human eye versus image analysis software

Mayer, A. 2010. Phenology and citizen science. *BioScience* 60 (3): 172–175.
Summary: Describes ways in which volunteers have documented seasonal events for the past 100 years and how scientific studies are making use of these long-term data.

Proctor, M. C. F., P. Yeo, and A. Lack. 2003. *The natural history of pollination*. Portland, OR: Timber Press.
Summary: Describes the array of amazing adaptations through which birds, bats, other animals and insects interact with plants and spread pollen to flowers

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Pollination Syndrome Guide*

Each cell shows the floral features preferred by the pollinator indicated at the top of the column.

	Bats	Bees	Beetles	Birds	Butterflies	Flies	Humming-birds	Moths
Color of flowers or other attractive structures	White, green, or purple	Bright white, yellow, blue, or UV	White or green	Scarlet, orange, red, or white	Bright, including yellow, red, and purple	Pale /dull to dark brown and purple; flecked with trans-lucent patches	Red mostly, but also orange or yellow	Pale and dull red, purple, pink, or white
Nectar guide	Absent	Present	Absent	Absent	Present	Absent	Absent	Absent
Odor	Strong musty, emitted at night	Fresh, mild, pleasant	None to strongly fruity or foul	None to slight	Faint but fresh	Putrid	None to slight	Strong, fresh, sweet; emitted at night
Nectar	Abundant, somewhat hidden	Usually present	Some-times present, not hidden	Ample, deeply hidden	Ample, deeply hidden	Usually absent	Abundant, deeply hidden	Ample, deeply hidden
Pollen	Ample	Limited to ample, often sticky, scented	Ample	Modest; anthers dangle outside flower	Limited	Limited	Ample; anthers dangle outside flower	Limited
Flower shape	Bowl-shaped; closed during day	Shallow to tubular, with landing platform	Small to large; bowl-like	Large, tubular to cup; strong perch support	Narrow tube with spur; wide landing pad	Shallow; funnel-like or complex with trap	Large, tubular to bell-shaped; no landing platform	Regular, tubular without a lip

*Adapted from North American Pollinator Protection Campaign (www.pollinator.org)

Flight of the Pollinators Data Sheet

Name (s): ______________________________

What type of pollinator are you? ____________ Date:__________ Location: ____________

Plant name:
Is this plant on the Nature's Notebook list of currently monitored plants? ___**Yes** ___**No**
If yes, indicate here when these observations have been entered online:

Do you see...	**Presence** (circle one)			**Abundance*** (circle one)						
Flowers or flower buds	Y	N	?	How many?	< 3	3–10	11– 100	101–1,000	1,001–10,000	> 10,000
Open flowers	Y	N	?	What % of fresh flowers is open?	< 5%	5–24%	25–49%	50–74%	75–94%	≥95%
Fruits (unripe as well as ripe ones)	Y	N	?	How many?	< 3	3–10	11–100	101–1,000	1,001–10,000	> 10,000
Ripe fruits	Y	N	?	What % are ripe?	< 5%	5–24%	25–49%	50–74%	75–94%	≥95%
Recent fruit or seed drop	Y	N	?	How many have recently fallen?	< 3	3–10	11–100	101–1,000	1,001–10,000	> 10,000

* Numerical categories for estimating abundance are from USA-NPN phenological data collection sheets

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