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Welcome

The world is changing – and it's important for us to track the changes!
Celebrate Hummingbirds is an educational unit that introduces students to the studies of hummingbirds, nectar-producing plants, phenology, and the impacts of climate change. Through field education programs in pollinator gardens, neighborhoods, and natural areas, participants will record data on hummingbirds and flowers and submit it to the National Phenology Network.

Why Hummingbirds?

The highly charismatic nature of hummingbirds and the corresponding public interest in them provides a strong basis for successfully integrating public outreach, environmental education, and citizen science components into conservation efforts for these species. While the current gaps in our knowledge about many of the ecological attributes of hummingbirds can present a challenge for the design of education and outreach programs, they also represent an opportunity to involve the public in collecting valuable basic ecological information and becoming invested in hummingbird conservation. Through the Western Hummingbird Partnership, we seek to make science-based knowledge about hummingbirds available and to engage wide audiences through programs that address gaps in our understanding of these species and the conservation challenges they face.
Given the migratory nature of most hummingbirds in the United States and the large number of species concentrated in Mexico, Central America and South America, education and outreach efforts should focus on the need to conserve important hummingbird habitats, including breeding areas, wintering areas, and migration corridors. Each of the major conservation concerns identified for hummingbirds – climate change, invasive species, and habitat loss – span hummingbirds' ranges, and successful conservation initiatives will need to address these challenges throughout the Americas. This will necessitate an international approach and require partnerships between many different groups to be effective. With such a diverse audience, design of outreach and education programs must be targeted to specific audiences to be effective.

About the Program

Celebrate Hummingbirds is a field-based education program that provides opportunities for students to discover and explore connections between hummingbirds, plants, phenology and climate change. Students learn basic ecological principles and the process of science by monitoring local hummingbirds and plants and submitting their observations to the National Phenology Network and other citizen science databases. The program empowers people to understand and address the conservation challenges facing hummingbirds and their habitats today.

Program Goals

• Increased Interest, Awareness, and Appreciation:
Participants will continue to learn about hummingbirds, the plants they use, and the conservation issues they face. *(Measure: Participants will read more about hummingbirds in books or online, watch a documentary about hummingbirds, write about hummingbirds in a journal, and continue to submit hummingbird observations.)*

• Changed Attitude:
Participants will feel heightened concern about hummingbirds, hummingbird habitats and the environment; they will feel empowered to take action. *(Measure: Participants will express care and concern about hummingbirds, plants, and the environment.)*

• Increased Knowledge:
Participants will come to understand some ways in which hummingbirds, plants, and the environment are interconnected – and how climate change and humans might affect these connections. *(Measure: Students will perform well on written tests issued after each lesson.)*

• Changed Behavior:
Participants will make an impact by doing the following:

o Taking personal and/or community actions to support hummingbirds & reduce carbon footprint
o Helping pollinators by planting pollinator-friendly flowers and reducing pesticide use
o Monitoring hummingbirds
o Monitoring nectar-producing flowers
o Submitting observations to scientists/participating in citizen science
o Educating others about hummingbird conservation issues
o Taking actions that help hummingbirds (and other birds) throughout their life cycle–applying "systems thinking"

What should students know by the end of the program?

1. Hummingbirds are unique pollinating nectar-feeders that occur only in the Western Hemisphere.
2. Hummingbirds have a life cycle (breeding, raising young, and migration).
3. The timing of the hummingbird's life cycle is synchronized with the resources and conditions it needs in each stage.
4. This synchronized timing may be disrupted with environmental change, such as climate change.
5. Climate influences which plants and animals can survive in a region.
6. Climate also influences life cycles in nature, such as when leaf-out, flowering, fruiting, and bird nesting occurs.
7. Phenology is the study of periodic plant and animal events (life cycles) and their relationship to the surrounding environment.
8. Many small disruptions in the environment are likely to lead to big changes.
9. In order to better understand how these changes will unfold, data need to be collected and submitted by a network of participants from across the globe.
10. A person can make an impact by observing, monitoring, and caring for the plants and animals in their community.

What should students be able to do by the end of the program?

1. Find and identify local hummingbirds and hummingbird flowers
2. Collect "good" data
3. Submit observations
4. Read a map (e.g., range map)
5. Model a system (e.g., create an ecological web)
6. Construct an explanation using evidence
7. Explore existing data (e.g., National Phenology Network, eBird)
8. Educate/communicate/advocate about hummingbirds

Activities: Inquiry Approach

Many of the **Celebrate Hummingbirds** activities will take an inquiry approach to learning. The inquiry approach almost always involves giving students time to explore a topic independently (i.e., What is a bird? Where do birds live?) before specific information about the topic is distributed. After students have been allowed to explore and see certain principles in action, explanations are provided.

The most common inquiry approach uses the "5E" learning model:

Engage	Object, event or question used to engage students. Connections facilitated between what students know and can do.
Explore	Objects and phenomena are explored. Hands-on activities, with guidance.
Explain	Students explain their understanding of concepts and processes. New concepts and skills are introduced as conceptual clarity and cohesion are sought.
Elaborate	Activities allow students to apply concepts in contexts, and build on or extend understanding and skill.
Evaluate	Students assess their knowledge, skills and abilities. Activities permit evaluation of student development and lesson effectiveness. (Write, draw a picture, create a song, construct a diorama, etc.)

More about the 5E learning model:

Effectiveness of the 5E Instructional Model (Office of Science Education, National Institutes of Health)
http://bit.ly/5Estudy

Meet the Hummingbirds

Before starting: Print the attached hummingbird picture cards and checklists of characteristics.

Overview

Identify hummingbird species by playing this game! Use the checklist of characteristics and the picture cards to find a match.

Objective

Learn the parts of a bird and become familiar with how to identify hummingbirds.

Ages

Ages 8-Adult

Time

60 Minutes

Materials

Hummingbird picture cards, checklist of characteristics, field guides

Conduct the Activity

Engage

1. Ask the students if they have ever seen a hummingbird. What do they know about them? Explain that we will be getting to know some of them today.

Explore

2. Give each student one hummingbird picture card and one checklist of characteristics.
3. Review the directions with students.
4. Give students about ten minutes to complete the task.
5. If possible/appropriate, have students practice using their field guides to collect additional information about each species.

Explain

Ask the students:

6. How are the hummingbirds you studied similar? *(They are colorful; they have long beaks; they are small.)* How are they different? *(They are different sizes and colors; they occur in different areas.)* Which is the smallest? Which is the largest?
7. What features do you think are most important to look at when identifying hummingbirds? *(Crown; chin; throat; gorget; chest; geographical region the hummingbird occurs in.)*
8. All of the hummingbirds we looked at today are male. Males are easier to identify than females, who are mostly plain, dull, and without bright colors *(show some examples in a field guide)*. How does being colorful help the males? *(Being colorful helps males attract females and defend their territory from other males.)* How does being dull help the females? *(They can hide while raising young.)*
9. Why do you think hummingbirds have a long bill? *(For drinking nectar from flowers.)*
10. What other features help hummingbirds feed on flowers? *(Small size, ability to hover.)*

Elaborate

11. Hummingbirds are special birds. They not only drink nectar, but they pollinate the flowers they feed on. Hummingbirds need flowers, but flowers need hummingbirds!
12. Hummingbirds occur only in the Western Hemisphere. There are about 13 species of hummingbirds that live in the United States. There are an astounding 350 species altogether – most occurring in Mexico, Central America and South America. Each species is slightly different.
13. By being slightly different – for example, by feeding on slightly different types of flowers or living in slightly different habitats – each species of hummingbird can exist in their own "niche" and reduce competition with other hummingbirds for food. One great example of a hummingbird species occupying a niche is the Sword-billed Hummingbird, which feeds on and pollinates only very large, trumpet-shaped flowers.

Evaluate

Ask the students:

1. What details should you look for when identifying hummingbirds?
2. What do hummingbirds eat? How do they get their food?
3. What special relationship do hummingbirds have with flowers?

Citizen Science Connection

• Knowing how to accurately identify birds is an important skill of field ornithologists (people who study birds). After students learn to identify birds, they can submit their observations on the eBird website (http://www.ebird.org; use the eBird Quick Start Guide).

For More Information

• Anatomical diagram from The Parts of a Bird by Linda Dow:
http://www.learnnc.org/lp/media/articles/wildnb0701/birddiagram.pdf

*** niche:**

An environment that has all the things that a particular plant or animal needs in order to live.

Source: Merriam-Webster's Learner's Dictionary

Meet the Hummingbirds

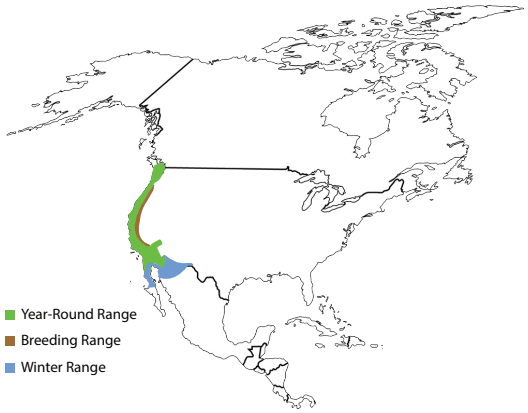
Directions: Try to find a match and write down the species!

Characteristic	Species
A ruby throat	
A hot pink forehead	
A hummingbird that lives in the mountains	
Orange-colored feathers	
A purple crown	
A hummingbird that lives in the desert	
A hummingbird with a black chin	
A hot pink throat and green forehead	
The hummingbird with the northernmost range	
A hummingbird that lives in the Eastern U.S.	

Meet the Hummingbirds (KEY)

Characteristic	Species
A ruby throat	Broad-tailed Hummingbird, Ruby-throated Hummingbird
A hot pink forehead	Anna's Hummingbird
A hummingbird that lives in the mountains	Broad-tailed Hummingbird
Orange-colored feathers	Rufous Hummingbird Allen's Hummingbird
A purple crown	Costa's Hummingbird
A hummingbird that lives in the desert	Costa's Hummingbird
A hummingbird with a black chin	Black-chinned Hummingbird
A hot pink throat and green forehead	Calliope Hummingbird
The hummingbird with the northernmost range	Rufous Hummingbird
A hummingbird that lives in the Eastern U.S.	Ruby-throated Hummingbird

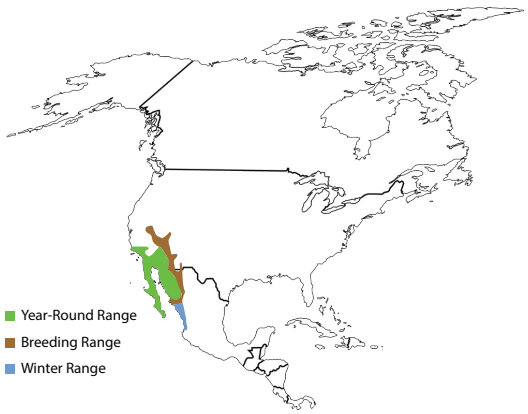
Anna's Hummingbird Scientific name: *Calypte anna*



Breeding Range
Widespread year-round in Washington, Oregon, California, Arizona, and in Baja California.

Winter Range
Range expands to western coast of British Columbia (Canada), and Texas in addition to the year-round ranges of Washington, Oregon, California, Arizona, and deeper inland into Northwest Mexico.

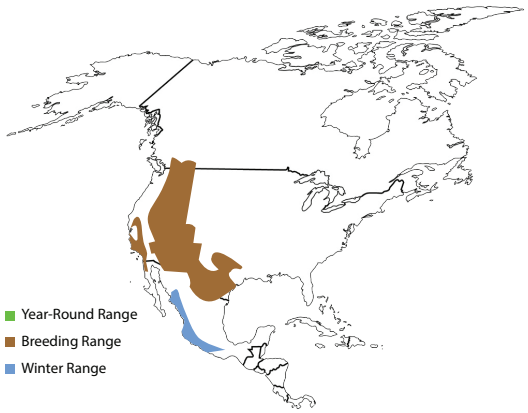
Costa's Hummingbird Scientific name: *Calypte costae*



Breeding Range
A desert hummingbird, Costa's Hummingbird breeds in the Mojave Desert (California, Nevada, Arizona) and the Sonoran Desert (Arizona and Sonora Mexico). It departs the desert in the hottest days of summer, moving to chaparral, scrub, or woodland habitat.

Winter Range
Costa's Hummingbird's range generally contracts in colder months to the southern portion of the range within Mexico. (Image source: Joan Gellatly, Flickr)

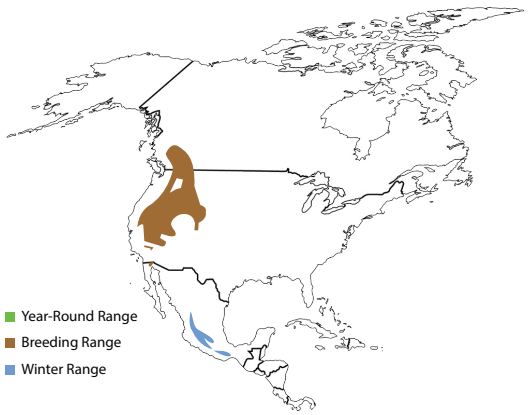
Black-chinned Hummingbird Scientific name: *Archilochus alexandri*



Breeding Range
Black-chinned Hummingbirds are exceptionally widespread, found from deserts to mountain forests throughout the West and Rocky Mountains.

Winter Range
West coast of Mexico, many also winter along the Gulf Coast.
(Image source: Robinsegg, Flickr)

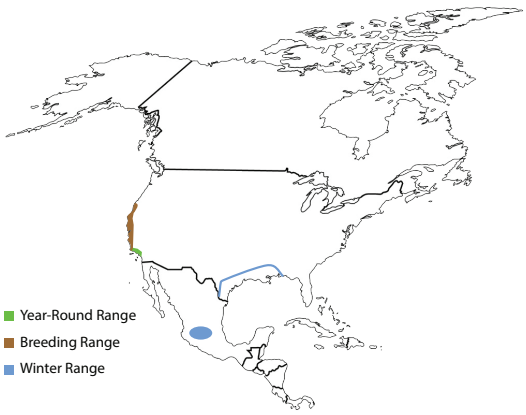
Calliope Hummingbird Scientific name: *Selasphorus calliope*



Breeding Range
Breeds in mountains from interior and southern coastal British Columbia south through Pacific states and east to Colorado. Some breed in Baja California as well.

Winter Range
Winters in southern Mexico.
(Source: National Audubon Society; Image source: Glenn Bartley/VIREO on audubon.org)

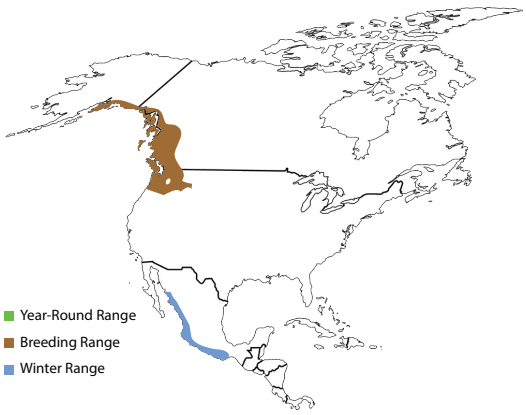
Allen's Hummingbird Scientific name: *Selasphorus sasi*



Breeding Range
One of the smallest breeding ranges of all U.S. hummingbirds. They breed in a narrow strip along the Pacific coast from southwest Oregon to southern California.

Winter Range
Winters in central Mexico
(Source: National Audubon Society, Mike Forsman on allaboutbirds.org

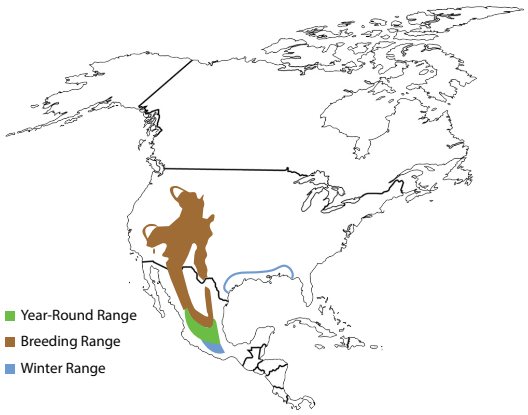
Rufous Hummingbird Scientific name: *Selasphorus rufus*



Breeding Range
Breeds from southeastern Alaska, British Columbia, southwestern Alberta, and western Montana south to Washington, Oregon, Idaho, and northern California.

Winter Range
Winters mainly in southern Mexico. Occurs in small numbers along Gulf Coast during migration and in winter.
(Source: National Audubon Society; Image source: Lare W. Neish/VIREO, Audubon.org)

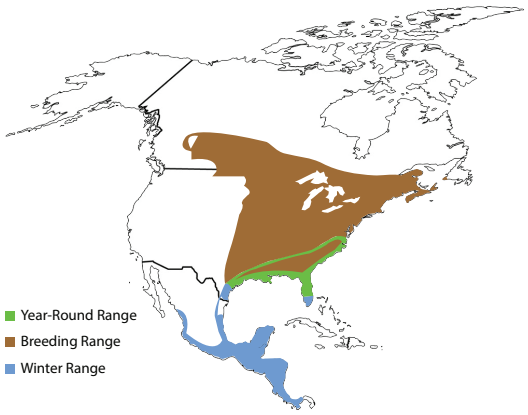
Broad-tailed Hummingbird Scientific name: *Selasphorus platycercus*



Breeding Range
Subalpine (higher altitudes, near mountains) areas of Idaho, Nevada, Utah, Colorado, Wyoming, Arizona, New Mexico, and western parts of Texas.

Winter Range
Mexico, Guatemala
(Image source: VIREO, Audubon.org)

Ruby-throated Hummingbird Scientific name: *Archilochus colubris*



Breeding Range
Breeds across Eastern North America and into the southern provinces of Canada. This species occupies the largest breeding range of any North American hummingbird.

Winter Range
Southern tip of Florida, southernmost parts of Mexico and throughout Central America. (Image source: Michael Hogan, Flickr)

Count Hummingbirds for Science

Before starting: Create an account at eBird or Hummingbirds at Home.

Overview

Learn to identify hummingbirds and submit observations of hummingbirds to help scientists understand population distribution and trends over time.

Objective

Identify local hummingbird species in the field. Collect and organize data during a count, and explain what citizen science is and why scientists count birds.

Ages

Ages 8-Adult

Time

60 Minutes

Materials

Computer with internet connection, hummingbird picture cards, eBird data form, clipboards, pencils, stopwatch

Conduct the Activity

Engage

1. Ask the students if they have ever counted birds?
2. Have they heard of the Christmas Bird Count or Great Backyard Bird Count?
3. Why is it important to study nature and the environment?
4. What kinds of people study nature and the environment? (scientists – biologists, ecologists; also birdwatchers, hunters, fishermen, farmers, gardeners, naturalists, hikers, artists, etc.)
5. Tell the students: When most of us think about science and research, we might think about a scientist performing experiments in an indoor laboratory full of equipment and test tubes. Science and research also take place in nature and the environment. The environment – and our whole planet – can be thought of as the biggest laboratory of all.
6. Most people assume that scientists, by themselves, can answer all of our questions and solve all of our problems related to nature and the environment. This is not true! For example, much of our knowledge about climate and climate change came from weather records kept by farmers. A lot of what we know about the stars came from amateur stargazers. In other words, a lot of important scientific knowledge is generated by non-scientists, who act as the "eyes and ears" spread across space and time. Science that requires the help of people like you and me is called "citizen science" – and we are "citizen scientists."
7. One of the longest-running and most organized types of citizen science is bird watching. Not only does birdwatching help track where birds are, it can also give us clues about the changing conditions of the environment. Birds are connected to so many other things in nature – plants, insects, weather, seasons, climate, and more, which makes them good indicators of the overall health of the environment. Today we will learn a little bit about how to monitor birds for science.
8. Explain that while a lot of data exists for other species of birds, data on hummingbirds is lacking because they are not picked up in traditional survey methods (e.g., their small sizes and lack of song excludes them from most bird watching surveys; they also require a special permit to handle, so aren't banded by most bird banders.) Furthermore, they are thought to be vulnerable to climate change since their life cycle stages (e.g., migration) tend to synchronize with certain flowering plants, which are even more sensitive to changing environmental conditions…so gathering more data on hummingbirds is important!

Explore

9. Give each student a hummingbird picture card featuring a hummingbird species in your area. Explain that they are going to identify and count males only, since females are difficult to identify even for experts.
10. Explain that an important part of good science is accurate data. In other words, we need to be able to accurately identify each species we see.
11. Explain that studying the physical characteristics (size, shape, color of crown, chin, throat, body, etc.) and field marks (spots, stripes, colors and other distinct features) before going outside is a good way to prepare to watch birds that may be at a distance or are moving quickly.
12. Now have students look for hummingbirds. Observe either outside on a walk through nature or from a window where you can see a garden or feeder(s). Students should record the characteristics they observe, identify species when possible, and count the number of each species seen.

Explain

13. Come together after about 15 minutes of observation. Have students share the lists they made of characteristics and species they think they identified.
14. Ask the students what was challenging about watching, identifying, and counting hummingbirds? How do they think they can overcome these challenges?
15. Were there any "mystery birds?" What made these particular birds hard to identify?
16. If there were few or no birds, do students see any value in recording "zero?" Explain that zero is a number too – just like in class, recording absence is just as important as recording presence.

Elaborate

17. Make a master list of the hummingbird species – including how many of each one – that were sighted by the class. 'Unknowns' can go into their own category.
18. Demonstrate on a big screen how to submit the master list using the eBird or Hummingbirds at Home website.
19. Demonstrate how data is used:

- Start off simple! Show a hummingbird's static range map (e.g., from a field guide) or dynamic range maps (e.g., on the eBird website, see map links below). Talk about how citizen science data helps us track where birds are now and how these maps might change over time.
- Follow up by sharing the most recent State of the Birds report (http://www.stateofthebirds.org), which uses eBird data (in part) to identify bird populations that are "doing well" (e.g., growing in number) and other populations that might be in decline.
- Show how citizen science data helps build an understanding of how climate change will affect birds using the Climate Forecast Maps on the Audubon website (climate.audubon.org).

Evaluate

Ask the students the following questions:

- Was it harder or easier to identify birds than you thought it would be?
- Do you think all of the birds were accurately identified?
- Why is accurate identification important?
- How can a person become better at accurately identifying birds?
- When we submit data, what is that data used for? What kinds of questions can be answered using that data?

Citizen Science Connection

- Students and their families can continue their hummingbird and other citizen science bird counts by signing up for their own eBird account at *http://www.ebird.org* or Hummingbirds at Home account at *http://www.hummingbirdsathome.org/*. They can also visit *http://www.citizenscience.org* to learn about other projects.

For More Information

State of the Birds Report (and look for references to hummingbirds):
http://www.stateofthebirds.org/eBird Maps:

- o eBird Species Maps: http://ebird.org/ebird/map/
- o eBird Real-time Checklist Submissions Map: http://ebird.org/ebird/livesubs
- o eBird Occurrence Maps: http://ebird.org/content/ebird/occurrence/

The Cornell Lab of Ornithology's All About Birds website offers many helpful resources for learning to identify birds:

- o Recognizing Size and Shape: http://www.allaboutbirds.org/Page.aspx?pid=1054
- o Color Pattern: http://www.allaboutbirds.org/page.aspx?pid=1055
- o Field Marks: http://www.allaboutbirds.org/page.aspx?pid=1056

Hummingbirds in Art & Culture

Before starting: Print out pictures of hummingbirds in arts and culture (some examples are attached). Set out art materials on the tables.

Conduct the Activity

Engage

1. We all know that we see birds in nature, but we also see birds in other places. Ask: Where can we find birds today?
2. Have students make a list of the birds or bird characters they know from television shows, movies, stories, books, brands, history, music, art, and more.
3. Ask: Are there any qualities or characteristics associated with the birds you named? What do you think birds, tend to represent or symbolize?
4. Explain that people use animals as symbols. Animals symbolize different things to different people. The earliest animal symbols were found on cave walls. Later, animals appeared on pottery, jewelry, and clothing. They were also made into large statues or small trinkets and carried around by people. Putting an animal symbol on an object is thought by some to confer qualities of that animal to the object. The same goes for wearing or carrying an animal symbol with you.

Explore

5. Review the characteristics and functions of hummingbirds: they tend to be small; they are colorful and beautiful; they sparkle when they're in the sun light; they are fiercely territorial; they are incredibly fast and efficient; they drink nectar; they pollinate flowers (and bring about new plant life through fertilization); they migrate incredibly long distances on very little fuel.
6. Hummingbirds and their qualities have dazzled, inspired, and mystified people for centuries. In some stories, they are messengers between worlds. In others, they convince Gods to bring rain.
7. Have each student pick a hummingbird characteristic or quality to illustrate.
8. Challenge each student to design a hummingbird that symbolizes one or more of the qualities mentioned above. Students can draw the symbol stylistically onto paper, create a piece from craft materials, or apply the symbol to an object (e.g. a vase, a pair of shoes). It can be a modern or traditional symbol/object.

Overview

Learn about hummingbirds in art and culture.

Objective

Describe how hummingbirds are used in arts and culture and explain what they symbolize in the past and present.

Ages

Ages 8-Adult

Time

60 Minutes

Materials

Art supplies, hummingbirds in modern and traditional art (pictures, postcards, etc.)

9. Make your classroom into an art gallery! Have students display their hummingbird symbols/ decorated objects around the room with a small written description next to their piece.

Explain

10. Have students explain their pieces to the class. What qualities does the hummingbird represent in the piece?
11. How are the hummingbird symbols similar? How are they different? What do they reveal about the way we individually think about hummingbirds – or ourselves?

Elaborate

12. Show students pictures or a slideshow of hummingbirds in traditional art (Zuni pottery, Mayan legends). Point out the origin of each piece on a world map.
13. Explain that people who lived long ago created these pieces. Because they did not have technology and materials like we have today, things were made by hand using natural materials found around them in their environment.
14. It should be noted that some of the groups and cultures that made these pieces, and pieces like this, are still around today. Their ancestors were the original inhabitants of the Americas, here long before European settlers came. They are sometimes called "indigenous" or "native" people which means that they (or their families) originate from the place they live.
15. Many early religions involved rituals and beliefs linked closely to nature. Nature was reflected in the various symbols that they used in their everyday objects and ceremonial clothing. Although sometimes used simply as decoration, such symbols were often believed to impart certain qualities to the object or wearer.

Evaluate

16. Ask the students:

- Besides in nature, where else are hummingbirds "found"? (In art, cultures, stories, legends, etc.)
- What did/does the hummingbird symbolize to different people?
- How might hummingbirds be used to symbolize modern-day conservation issues?

For More Information:

- *World Cultures Through Art Activities* by Dindy Robinson. Engelwood, CO: Teacher Idea, 1996.
- *Global Art* by MaryAnn Kohl. Beltsville, MD: Gryphon House, 1998.
- *Organic Crafts: 75 Earth-Friendly Art Activities* by Kimberly Monaghan. Chicago: Chicago Review P, 2007.
- *Storytelling and ecological management: understanding kinship and complexity:* http://www.jsedimensions.org/wordpress/content/storytelling-and-ecological-management-understanding-kinship-and-complexity_2013_02/

Hummingbirds on Zuni Pottery

Location: New Mexico & Arizona

www.anthroposgallery.com

The Zuni are a Native American tribe living in western New Mexico. Traditionally, Zuni women made pottery to store food and water; the vessels were usually decorated with meaningful designs related to the vessel's purpose.

To the Zuni people, hummingbirds, frogs, tadpoles, and dragonflies were symbols of rain and water, which were precious resources in an arid land. Hummingbirds were related to agricultural fertility because they drink flower nectar and spread pollen. They were also seen as messengers who traveled between heavenly and earthly realms, helping humans by convincing gods to bring rain – which is why they are "honored" on water vessels such as the one above.

Animal symbols were typically used on jars for religious ceremonies. Tourist demand for these jars led to the creation of vessels like this one, decorated with animal symbols and sold on the market.

Hummingbirds in Mayan Legends

Hummingbirds were often featured in legends from the Mayan civilization, which was based in southern Mexico and northern Central America (Guatemala, Belize, Honduras, El Salvador). One Mayan legend relates how there were tiny scraps of material left over after the Great Spirit had created all the birds. Not wishing to throw them away, he used them to make a hummingbird pair, which thus came to be composed of all the colors. The sun also wished to make a contribution, so he gave his light, and since then hummingbird feathers have shone and glittered.

Project Ideas:
Students create their own hummingbirds out of shining scraps of paper and display them around the classroom.

Artist Octavio Medellin's art and sculpture was profoundly influenced by Mexican Indian cultures. In this case, he photographed a Mayan bas-relief sculpture of a hummingbird in the Lower Temple of the Jaguar during his trip to Chichén Itzá in 1938 and made a tracing. The colorful linocut of the bird was created in 1975.

Hummingbirds Feathers

Hummingbirds have beguiled humans across the centuries with their variety of brilliant colors. Our love of hummingbird colors is reflected in the names we give them, including emerald, sapphire, starthroat, sunangel, and jewelfront. Many cultures have their own unique stories about how hummingbirds – and their feathers – became so incredibly beautiful.

While both males and females have iridescent feathers, males have more colors. This is because males and females do very different things – colorful plumage helps males attract females and defend territory, while dull plumage hides the female as she sits on eggs and raises young. Feather color is formed in two different ways, either from pigmentation or by feather structure at the microscopic level.

The iridescent colors of a male hummingbird's shimmering throat, called a gorget, are the result of the microscopic structure of the feather refracting incident light. If you were to look at an iridescent feather under a microscope, you see that the barbules are covered with a mosaic of tiny platelets that resemble a tiled floor. The platelets exhibit interference (interaction of light waves) coloration, like the surface of a soap bubble. The color changes according to the angle of observation, the thickness of the platelets, and the concentration of air pockets in the matrix.

At certain angles, little or no light is reflected back to the viewer and the gorget can appear black. At other angles, the light refracts (bending of light waves) and forms a shimmering iridescent display. In this way, the platelets function like tiny prisms, breaking down light and spreading it out into rich component colors.

Hummingbirds Feathers

Before starting: Prepare the materials. Make sure you have a variety of feathers, enough hand lenses and/or microscopes to go around, and enough color images of hummingbird feathers. *(Note: You can buy different types of feathers from a craft store or ask to borrow them from a natural history museum's teaching collection. It is illegal to collect and use feathers from most wild birds, which are protected by the Migratory Bird Treaty Act.)*

Overview

Learn about color and light by exploring hummingbird feathers.

Objective

Learn feather colors from pigmentation to microscopic structure and light waves that contribute to iridescence.

Ages

Ages 8-Adult

Time

60 Minutes

Materials

Feathers (contour, down, flight, iridescent, pigmented), hand lenses/microscopes, paper, coloring materials, hummingbird picture cards. Optional: Bubbles, actual hummingbird study skins.

Conduct the Activity

Engage

1. What is one of the first things the students notice about hummingbirds? (Show picture cards if necessary.)
2. Are all hummingbirds colorful?
   (No; the male tends to be more colorful than the female.)
3. Hummingbirds can have feathers that shine and glitter in the sunlight. These feathers are called iridescent feathers. Do hummingbirds have these types of feathers everywhere on their body? *(No, usually only on their throat.)*
   Show the Ruby-throated Hummingbird card and point out its name.

Explore

Activity 1: Explore Types of Feathers

4. Divide students into groups based on the magnification equipment available. Hand out a set of feathers (contour, down, flight feathers) to each group. Instruct them to look at the feathers carefully with their unaided eyes and then with the hand lens and/or microscope.
5. Have them sketch the way each feather looks with the unaided eye and then the way it looks with the hand lens or microscope. Encourage students to be detailed.
6. Have the students talk about the appearance and structure of the different feathers. Ask them to describe the differences and similarities between each feather. What is the function of each type?
   - *Contour feathers give shape, streamline, make a "seal" from the elements, provide color*
   - *Down feathers insulate the bird and prevent overheating*
   - *Flight feathers, found on the wings and tail, aid in flight*
7. Show the class the diagram of different feather parts and ask them to label their own drawings. Point out that the rachis is hollow which makes the feather lightweight. Discuss why the light weight of feathers is beneficial to birds.

Activity 2: Explore Color vs. Structure

8. Have students look at an iridescent feather first with their unaided eyes then with a hand lens or microscope. Use a feather from a turkey, peacock, or other domestic fowl.
9. Have them look at the feather from different angles. What do they notice about the color?
10. Compare the iridescent coloration of feathers to the color of bubbles, which also show iridescence. Explain how the material, or medium (in this case, the bubble) affects the path of light traveling through it. The medium (e.g., the moving surface of a bubble or the tiny platelets on a hummingbird feather) changes or interferes with the path of light as it travels in or out of that medium. The degree of interference determines the colors we see.
11. Review the pros and cons of being iridescent. (It's eye-catching to females and intimidates intruders; it can also be eye-catching to predators.

Explain

12. Male and female hummingbirds are sexually dimorphic, meaning that they look different from one another. Their differences allow them to each promote successful reproduction. Males must attract females and defend territory, so are visually striking and colorful. Females must sit on the eggs and raise young, so have duller colors that blend into the surroundings.
13. Male hummingbirds have shiny throats; this is because these are the parts most involved in courtship and territorial defense displays. Other parts, such as wings and back, are not usually as brightly colored.
14. Hummingbirds have feathers with two kinds of colors: colors created by pigmentation and colors created by structure. Iridescence is caused by feather structure, which explains why you can see the color from some angles but not others. Pigments are only one color and reflect that color at all times. Structural colors scatter light as it hits them, causing colors to shift and shimmer.

Elaborate

15. Hummingbirds were once a popular decoration for hats, but that use became illegal when people realized that the hummingbird populations were declining because of the fashion trends.
16. Hummingbirds were revered by the Aztecs who saw them as tiny, dazzling symbols of the gods. Their famous feathered headdresses were often made of hummingbird and quetzal feathers.
17. One Mayan legend tells that the hummingbird was originally created with drab colors. After he couldn't go to his own wedding looking good, he became depressed. Feeling bad for him, the other birds each gave him one feather, making him shine in all colors – but then he became so happy he lost his voice!
18. Another Mayan legend says that hummingbirds were created from the shimmering scraps left over from making other birds, hence their rainbow colors. The sun also contributed its light, making them shine.

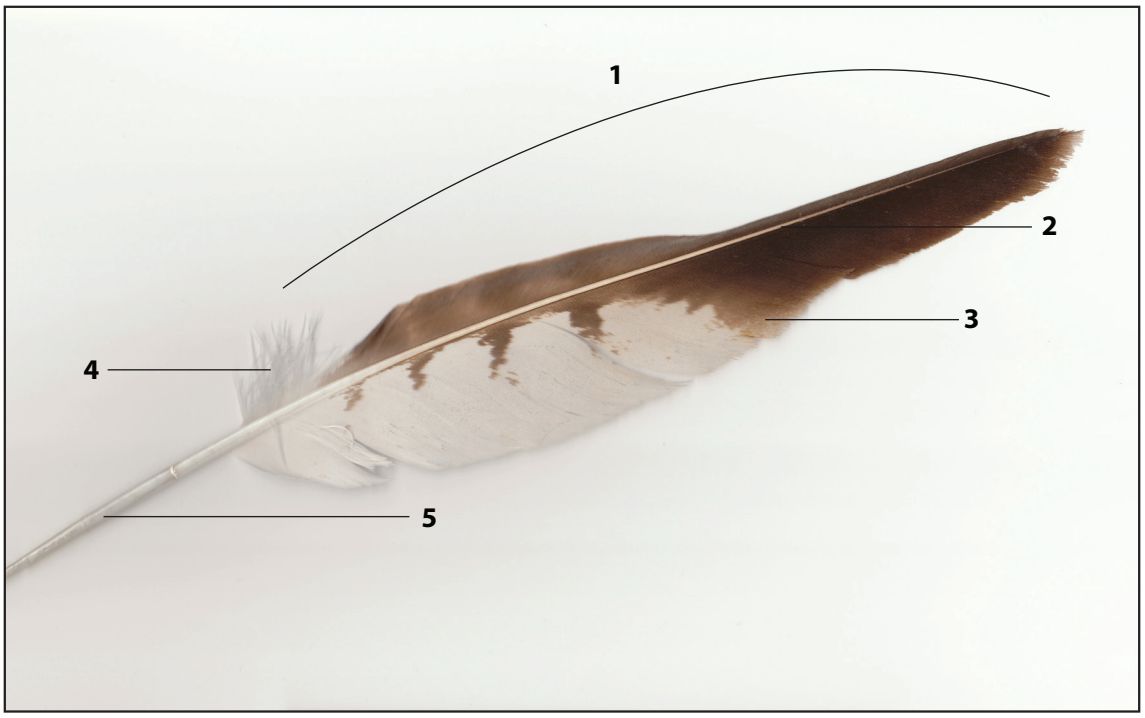
Evaluate

19. Have students create one or more iridescent "feathers" of their own using the instructions on the next page. While wearing the "feathers," have students explain the benefits and drawbacks of being iridescent. Have students explain how the structure of the feather affects the colors observed at different angles.

For More Information

- *All About Bird Biology - All About Feathers* from The Cornell Lab of Ornithology http://biology.allaboutbirds.org/all-about-feathers/
- *Feathers and Nests Lesson Plan* from the Arkansas Game and Fish Commission: http://www.agfc.com/education/justForEducators/Pages/lessonPlanDetails.aspx?show=58
- *Why are Hummingbirds Iridescent?* http://www.hummingbirdworld.com/h/iridescent.htm
- Information on Light Interference: http://www.microscopyu.com/articles/polarized/interferenceintro.html

Parts of a Feather



By BirdingInSpain

1. Vane

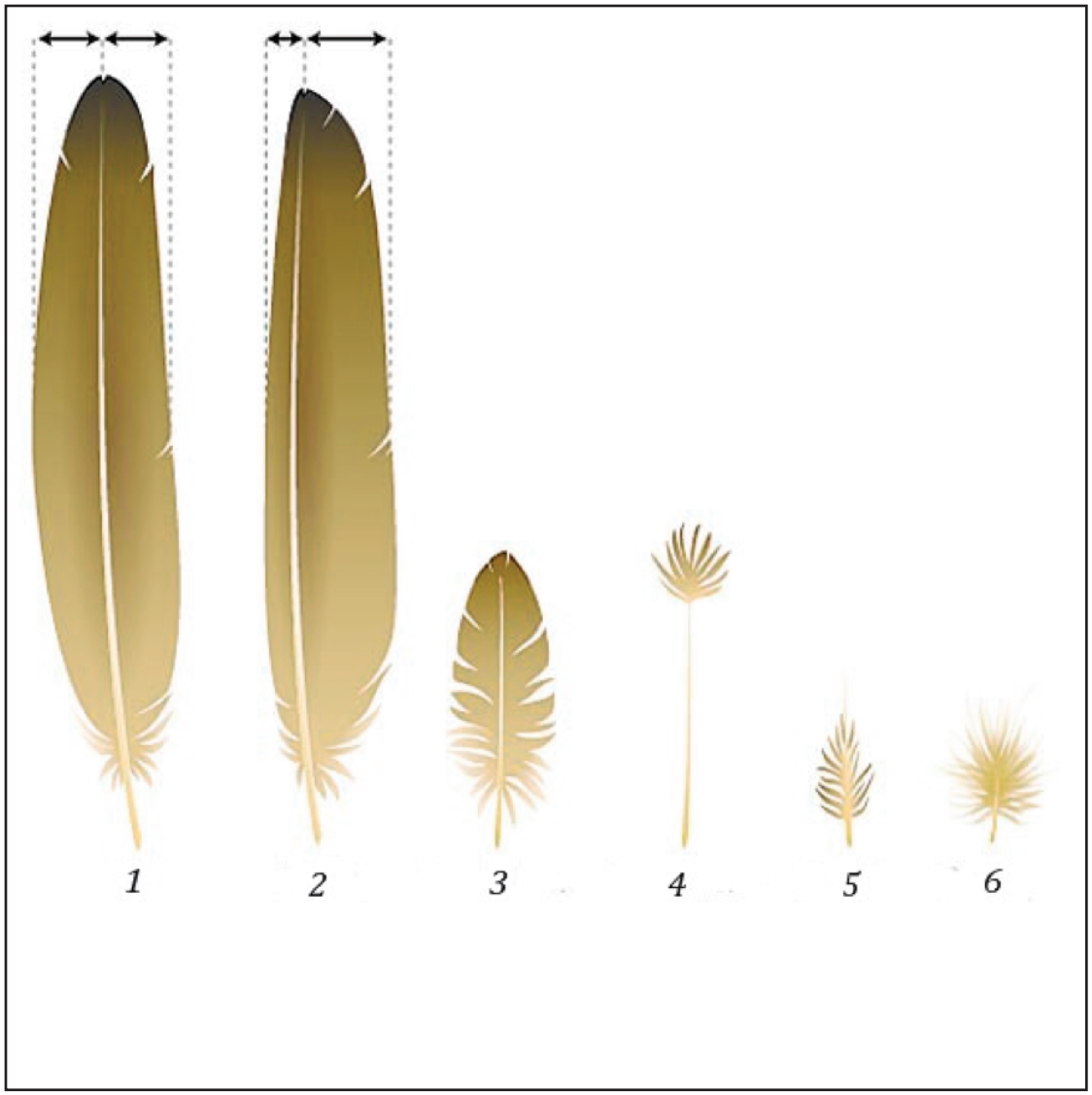
2. Rachis

3. Barb

4. Afterfeather

5. Hollow shaft, calamus

Types of Feathers



Source: Wikimedia Commons (user: Anaxibia)

1. Tail feather
2. Flight feather
3. Semiplume (contour feather)
4. Filoplume
5. Bristle feather
6. Down feather

Craft: Iridescent Paper Feather

This craft is a simplified way of showing how iridescence is caused by the structure of feather as well as the angle of the observer.

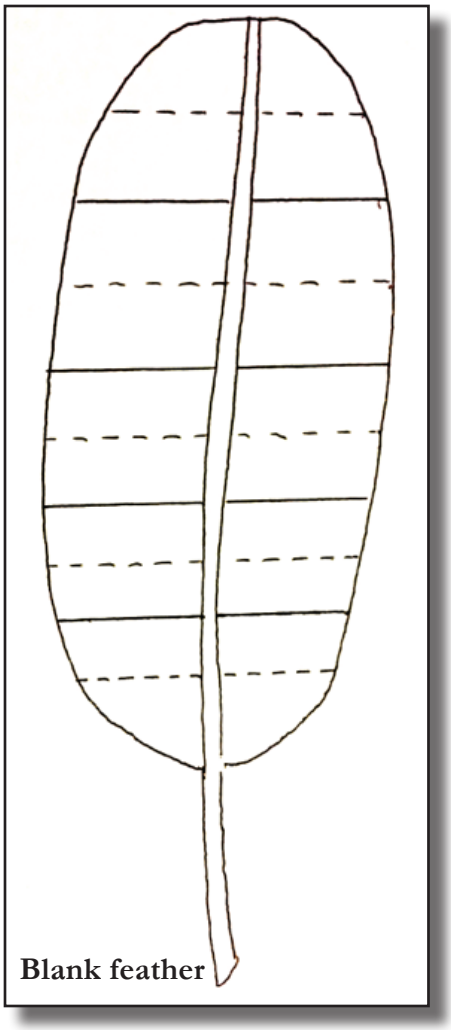
Materials:

- One "foldable feather" printout
- Black markers or crayons
- Scissors
- Glue
- Glitter
- Hole punch
- Yarn/string

Steps:

1. Color the "foldable feather" as directed. (For more dramatic effects, make more than one feather.)
   - Every other line should be filled in with solid black.
   - The lines in between should be filled in with glue and lightly dusted with glitter.
   - The glitter represents the platelets on the iridescent feathers.
2. Fold the feather "accordion-style" as directed.
3. Use the hole punch to make a hole in the rachis (the "quill" part of the feather).
4. Become a hummingbird! Display the feather(s) from a necklace made of yarn, a headband, or a bird mask. The glittering side should be visible to people looking at the student head-on.
5. Have students walk around and look at each other's iridescent feathers, as well as real iridescent feathers(e.g., peacock feathers, turkey feathers, or actual hummingbird study skins).
6. If time allows, have students make a hummingbird mask on which they can display their iridescent feathers.

Foldable Iridescent Feather

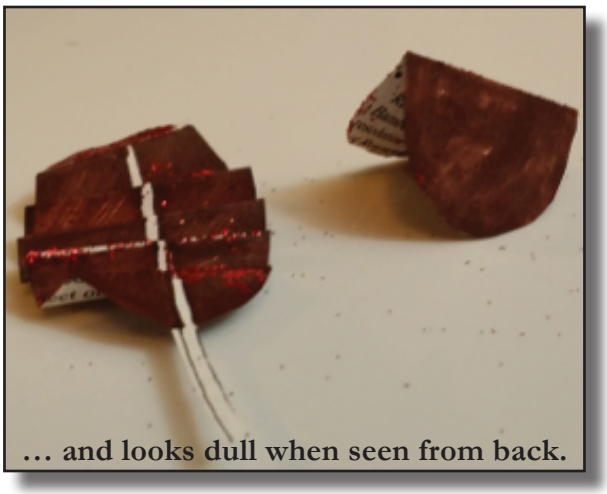


Blank feather

Regular feather

Simplified version (use multiple)

Feather sparkles from front



… and looks dull when seen from back.

Hummingbird Nests

How does the design and placement of a bird's nest meet the needs of particular bird species? Size, shape, materials, and location are all important factors.

A hummingbird nest is one of the daintiest structures in the world. A typical nest is cup-shaped and is made from grass and leaf pieces, fibrous rootlets, and small twigs all cemented together with silk from spider webs. The inside of the nest cup is lined with downy seeds, feathers, or other soft material. The outside is often decorated with tiny plates of lichen and moss, which help camouflage it from predators.

Hummingbird nests are very difficult to find! They are most often cemented to the top of a tree bough with gauzy cobweb, which most people might mistake for a moss-colored knot. Other species attach their nests to a leaf, cactus, or even cliff side. It takes most species about a week to finish the elfin nest.

The function of a nest is to hold eggs and chicks – while keeping them safe from predators, as well as the elements (wind, rain, sun). The nest's construction and placement both help meet the hummingbird's needs.

"Engineer" a Hummingbird Nest

Before starting: Designate the boundaries of the nest material collection site. Make sure that the collection area is safe and that there are no hazards to students collecting materials. If searching outdoors is not possible, have nesting materials ready indoors. If possible, borrow a real nest from a local natural history museum's teaching collection to use as model.

Conduct the Activity

Engage

1. Ask if the students have ever seen a bird's nest. Have them share their stories.
2. Follow up by asking: Why do birds build nests? (*They protect the eggs and young.*) What does a nest protect them from? (*Rain, wind, direct sunlight, extreme temperatures, and predators.*) How does a nest protect them? (*Shape, construction, materials, location of nest.*)
3. Explain: Raising young is one of the biggest challenges of a bird's life and the design, construction, materials, and placement of a nest plays a major role in whether or not the bird succeeds in protecting eggs and raising young.
4. In a way, birds are a little bit like engineers. Engineers are problem-solvers who specialize in identifying problems and brainstorming, designing, and creating solutions.
5. Explain: Today we will be thinking about birds as problem-solvers or engineers. We will look for problems that nesting birds face and explore how the design, construction and location of nests helps birds address some of those problems. We will also be building nests of our own.

Explore

6. Take the students outside. Explain that when most people think of a nest, they think of how the nest looks or what it's made out of. Where a nest is placed, however, is just as important as how the nest is built! Together as a group (imagine you are hummingbirds!), investigate a few potential nest sites. Have students discuss what might be good or bad about each site. How is the temperature? How exposed is it to the elements? Is the spot too high or too low? Does it offer protection from predators? Are there other hazards around? Where will the mother get the food for herself and to feed her young?

Overview

Design and create a nest to meet a hummingbird's needs.

Objective

Learn how hummingbird build nests.

Ages

Ages 8-Adult

Time

90 Minutes

Materials

Nest specimens (or pictures of nest specimens), nest materials, drawing materials

7. Return to the classroom. Based on what they saw outdoors, have the students make a list of some problems faced by nesting birds (they face exposure to wind, rain, sun, predators; they need to be close to food). How does nest location address some of those problems? Have students design and construct their ideal hummingbird nest with materials they found around the site.

Explain

8. As we've learned, location plays a key role in protecting eggs and young – but what else is important? (Design and construction.)
9. Ask students to explain what a hummingbird nest might look like. How big would it be? Where would it be located? What materials would it be made of?
10. The final nest must be structurally sound, hold the mother, eggs, and young, and protect them from harm (sun, rain, wind, and predators).

Elaborate

11. Most hummingbirds build their nests on branches within trees and shrubs, although species like the Violet-headed and Giant Hummingbirds prefer to build their nests on branches that overhang streams for extra protection from predators. Andean Hillstar hummingbirds use their saliva to attach their nests to cliffsides facing the morning sun.
12. One of the most remarkable nests is the Sooty-capped Hermit of Venezuela, which hangs by a single stout cable of spider silk. Pebbles or small balls of dry clay are added which serve as a counterweight to keep the nest level.

Evaluate

13. Give students a few minutes to look at each others' completed nests.
14. When everyone is ready, have students present their designs and/or nests. Have each presenter talk about the design process and share how they went about constructing the nest. What was the plan? How was the nest made?
15. Next, ask students how the nest performed – was it structurally sound? Would it hold the eggs/chicks? Would it stand up to sun, rain, wind, and predators? Did it look like a realistic nest? What were unexpected surprises/challenges of building a nest?
16. After all nests have been presented, show a picture of a real hummingbird nest. (Explain that nests are illegal to own without a special permit.)
17. Point out how the nest "tells a story" – the materials and construction of a nest often give clues about the bird, its habits, and the habitat it lives in. Remind students that birds use nests only during the breeding season and that most birds build a new nest every year.

Citizen Science Connection

If your students are interested in monitoring nests, introduce them to The Cornell Lab of Ornithology's *Nestwatch* – a citizen science program developed to help scientists understand breeding birds: http://nestwatch.org/

For More Information

- *Avian Architecture: How Birds Design, Engineer, and Build* by Peter Goodfellow
- *How and Why Birds Build Nests* by Elaine Pascoe
- *Birds, Nests & Eggs (Take Along Guide)* by Mel Boring
- *Birds Build Nests* by Yvonne Winer
- The following site contains some wonderful short videos of different birds interacting with their nests, as well as information on nest types, materials used, and typical building times for various bird species: http://people.eku.edu/ritchisong/birdnests.html

Map a Hummingbird Habitat

Like all birds, hummingbirds can only survive in an area that meets their basic needs for food, water, shelter, and space to nest and rest. Hummingbirds can be found in a remarkable variety of habitats, including grasslands, deserts, forests, and even backyards. No matter what your site is like, it is easy to create a mini-habitat for hummingbirds using the habitat checklist provided to guide you.

Food:
Hummingbirds are tiny calorie-burning machines that feed frequently to support their high-energy nutritional needs. They have the highest metabolic rate of any known warm-blooded animal, consuming more than twice as much times their weight in food per day. In nature, hummingbirds feed on two things: flower nectar and small insects. Nectar is an important source of carbohydrates, and insects are an important source of protein.

Water:
While hummingbirds get most of their water from nectar, they occasionally need fresh water for drinking and bathing. An ideal hummingbird bath is a very shallow pool being replenished by a gentle, misty spray of water.

Shelter:
Thick, leafy trees and shrubs are the ideal place for hummingbirds to perch, roost, and nest. Trees and plants with thorns provide extra protection from predators.

Space and Materials for Nesting:
Humans are not the only species that need materials to build a home. All species of hummingbirds build nests, most often in trees and shrubs. A typical nest is composed of soft down from seeds or hairs from furry leaves, bound together with spider silk. The outside of the nest is often decorated with lichen and moss.

Map a Hummingbird Habitat

Before starting: Designate the boundaries of the site you want the students to explore. Within those boundaries, know where to find some of the items on the habitat checklist. Pre-print maps of the site on which students can draw the features they find. Make one map as a group, or have students make maps individually or in teams.

Conduct the Activity

Engage

1. Every living thing has basic needs. Ask the students what these are (food, water, shelter, and space). A place that supplies these needs is called a habitat.
2. Next ask: Do all living things have the same needs? Discuss how the needs of two organisms are different, and how their habitat reflects that. Tell them that today we are going to evaluate our site as a hummingbird habitat.

Explore

3. Take students outside and have them look for the items on the checklist. Have students indicate and label the items on a blank site map (optional).

Explain

4. Take students back to the classroom to discuss what they found. Ask:

- How would they describe the habitat?
- Is this site a good place for hummingbirds? Why or why not?
- What did they find? Where did they find it?
- What was missing?
- Did anything surprise them?
- What features were added or removed by people? And what other ways have people changed this place?
- What might be the positive and negative effects of those changes on hummingbirds and other living things?

Elaborate

5. Point out how different parts of the habitat meet or do not meet a hummingbird's basic needs (food, water, shelter, space). Explain that tiny changes in the environment, such as the removal or addition of nectar-producing plants, can have a big impact on hummingbirds that rely on those things to survive.

Overview

Map the features of the site and discuss ways it could be improved for hummingbirds.

Objective

Identify site features that help or harm hummingbirds.

Ages

8-Adult

Time

90 Minutes

Materials

Copies of the habitat checklist, writing utensils, clipboards, and paper (if needed)

6. Point out that hummingbirds don't live in the same habitat year-round. They migrate, meaning that they move from place to place during different seasons, to find the resources they need. Many of them have a breeding ground and wintering ground, and fly along a certain migration corridor between these areas (which can be thought of as a highway in the sky).
7. Migratory hummingbirds must have food and shelter at every stage of their life, which is why it's important we maintain healthy habitats everywhere – near and far – through small-scale actions (e.g., planting flowers) and large scale actions (e.g., creating international partnerships).

Evaluate

8. Ask students what could be done to make the site a more hummingbird-friendly habitat. Make a list of their responses on the board or have them indicate their ideas on maps and share. Be sure to discuss how hummingbird needs might change throughout the year and how those changes might affect what changes students would make to the habitat.

Take Action!

Work with the site to implement some of the students' ideas! Here are just a few suggestions to try:

- Grow native hummingbird flower plants that also support beneficial insects (an important food source for hummingbirds and their young).
- Plant flowers with overlapping bloom times to make sure hummingbirds have a regular supply of food.
- If planting more flowers is not possible, students can put up and maintain hummingbird feeders filled with a homemade sugar-water solution (one cup sugar, four cups water). Do not add artificial food coloring as it may be harmful. Remember that hummingbird feeders need to be cleaned thoroughly every few days to prevent the growth of mold and fungus, which can be toxic to hummingbirds.
- Do not spray the lawn or garden with chemical fertilizer or pesticides. Exposure to these chemicals can either kill birds outright or result in decreased breeding success, physical deformities, or impaired ability to migrate or avoid predators.
- Prevent collisions with windows by putting up streamers or decals placed closely together. This sounds odd, but check window screens for trapped hummingbirds that have gotten their body or beak stuck.
- Reduce risk of predation (by cats, jays, crows, roadrunners, chipmunks, and squirrels) by providing cover like shrubs and trees. Keep cats and dogs indoors, especially during the breeding and nesting season.

Citizen Science Connection

Digitize and submit your site map to *YardMap*, an online tool that helps scientists study how birds use urban and suburban spaces. Website: http://content.yardmap.org

For More Information

- *Mapmaking with Children: Sense of Place Education for the Elementary Years* by Davis Sobel
- *You Are Here: Personal Geographies and Other Maps of the Imagination* by Katharine Harmon
- *Hummingbird-Healthy Habitats* by Audubon:
  http://web4.audubon.org/bird/at_home/bird_feeding/hum_habitats.html
- *Conservation Corner: Attracting Hummingbirds to Your Yard:*
  http://www2.dnr.cornell.edu/ext/info/pubs/Wildlife/hummingbird%20fact%20sheet.pdf

Hummingbird Habitat Checklist

Basic Needs

- ☐ High place to perch
- ☐ Medium-high place to perch
- ☐ Space to fly
- ☐ Sun
- ☐ Shade
- ☐ Safe place to build a nest

Food

- ☐ Flower with a long nectar tube
- ☐ Flower that hasn't opened yet
- ☐ Nectar
- ☐ Flying insect
- ☐ Insect inside of a flower
- ☐ Spider

Nest Materials

- ☐ Moss
- ☐ Mud
- ☐ Lichen
- ☐ Spider silk
- ☐ Downy plant seed
- ☐ Plant rootlets
- ☐ Grass fragment

Hazards

- ☐ Glass window
- ☐ Outdoor cats
- ☐ Pesticides, fertilizers, pollution
- ☐ Parking lot
- ☐ Window screen
- ☐ Unclean hummingbird feeder

Hummingbirds & Flowers: The Plant-Pollinator Partnership

Many hummingbird qualities – their small size, slender bill, hovering ability, iridescent colors, and social behavior – stem from their dependence on nectar. Their size generally corresponds to the size of flowers; their slender bill corresponds to the flower's nectar tubes; their hovering ability helps them access nectar at the base of the flowers; their flashy, iridescent throat patch helps them scare away intruders; and the males' defense of a flower patch is the way they secure food. In a similar way, the shape, color, and other characteristics of certain flowers have evolved as a way to attract hummingbirds as pollinators. These characteristics, which are commonly found in North American hummingbird flowers, include:

- *Tend to 'hang' or 'nod,' singly, in loose clusters, or in inflorescences.* This is a feature that excludes pollinators such as butterflies and moths that need a "landing pad" to feed. Pollinators that cling or hover are the only ones able to access this nectar. The flowers tend to face outward, where the hummingbird can hover in front of them without striking its wings against the leaves.
- *Often red or red-and-yellow.* Flowers that rely on hummingbirds tend to be "invisible" to bees, which prefer flowers that are purple, blue, white, and/or have nectar guides.
- *Tend not to smell.* Flowers that have evolved to attract hummingbirds do not need to invest energy in producing scent, since birds have a poor sense of smell. This is another way in which these flowers stay "invisible" to pollinators that may be attracted by scent.
- *Often trumpet-shaped.* The only nectar-feeders that can access the nectar in long nectar tubes are hummingbirds, as well as long-tongued bees and butterflies. The flowers may be composed of fused petals or separate petals fitted closely together.
- *Tend to have thick floral tissue, or a deposit of nectar removed from the ovary.* This is to protect the ovary of the flower from the long, pointed bill of the hummingbird. If you were to look inside of a hummingbird flower, you might find that the stamens form a sheath around the ovary, or that the grooves direct the bill to a deposit of nectar away from the ovary.
- *Have anthers situated in a place that would deposit pollen on a bird's crown, throat, or bill.* Correspondingly, the flower's stigma is situated in a place where it can pick up this pollen.

Meet the Hummingbird Flowers

Before starting: Designate the boundaries of the flower hunt site.

Conduct the Activity

Engage

1. Ask: Why do plants have flowers? Have students think about how plants reproduce – and what they have to do since they can't move around, unlike animals. *(They need a way to get pollen from one flower to another.)*
2. Ask: What kinds of pollinators do you know? Make a list on the board.
3. How do plants attract pollinators?
   (With nectar, smell, shape, color, bloom time and more.)
4. Different pollinators are attracted by different flower characteristics – and pollinators tend to have characteristics that "match" the plants they transfer pollen for.

Explore

5. Take a guided walk around the site and look for pollinators visiting flowers. Have the students pay special attention to things like the pollinator mouthparts and how they feed on or carry pollen. Students should also note the characteristics of each flower being visited (size, color, shape, arrangement, and scent).

Explain

6. What pollinators did they see? How were they alike? How were they different? What kinds of flowers were the pollinators visiting? Why might that pollinator be visiting certain types of others but not others?

Elaborate

7. As a group, introduce the information on the attached chart describing pollinator characteristics and the types of flowers they visit ("Adaptations of Pollinator Vectors and their Plants").

Overview

Learn about the characteristics that make flowers attractive to different pollinators.

Objective

Identify key characteristics of hummingbird flowers and the bird's dependence on nectar.

Ages

Ages 8-Adult

Time

90 Minutes

Materials

Local wildflower field guide, flowers, pollinator-flower adaptations chart, hummingbird flower picture cards

8. Share with the students that a hummingbird's hippocampus, the part of the brain responsible for memory and learning, is up to five times bigger than the hippocampus of other birds. The result is that hummingbirds remember which flowers they've visited, their locations and when they'll have nectar again. Given that hummingbirds can visit a thousand or more flowers a day and can fly 500 miles before resting, that's no easy feat!

Evaluate

9. As a group, return to the flower hunt site. Have students look for flowers with characteristics that attract hummingbirds *(red, large, deep nectar tube and abundant nectar, little or no fragrance, open in day, no landing platform, no nectar guide)*. Use the attached "Hummingbird Flower Checklist" if needed. Have students record each hummingbird flower they find. Each record should include a sketch that shows the characteristics that qualify it as a hummingbird flower, species name (if possible), and phenophase.
10. Get together as a group and have students share information about the hummingbird flowers they found. Have students help each other out: are the flowers they found probably visited by hummingbirds? Why or why not?
11. Use the hummingbird flower picture cards below to review why these flowers attract hummingbirds, and to introduce some hummingbird flower families.

Citizen Science Connection

If your students are interested in monitoring flowers for science, introduce them to Project BudBurst: http://www.budburst.org

For More Information

- *Hummingbirds and their Flowers, Grant & Grant (1967)*
- Project BudBurst: Pollinators and their Flowers
  http://budburst.org/documents/871408/879751/PBB_plantandpollinatoradapt.pdf/f94c9d53-7254-4bba-afbd-bca2e24cda55

Is it a Hummingbird Flower?

Use this form to help students focus on the details of hummingbird flowers.

Is it a Hummingbird Flower?

- Is the flower hanging/nodding?
- Is it red or orange?
- Does it have a smell?
- Does it have a long floral tube?
- Does it have nectar?

Sketch of flower

Is it a Hummingbird Flower?

- Is the flower hanging/nodding?
- Is it red or orange?
- Does it have a smell?
- Does it have a long floral tube?
- Does it have nectar?

Sketch of flower

Adaptations of Pollinator Vectors and their Plants

Vector	Characteristics of Vector	Characteristics of Flower
Bees	• Good sense of vision, smell • Often have body hairs • Can perceive depth, "count" petals • Do not see true red – see UV	• Often blue or yellow, with landing platform • Often have markings that act as nectar guides, sometimes in UV spectrum • Reduced numbers of floral parts • Often irregular in shape • May have deep tube or spur for nectar
Butterflies	• Active in day • Have long, thin proboscis for nectar acquisition • Can see red • Alight on blossoms	• Open in day, emit some odor in day • Landing platform • Long corolla tube, narrow • May be blue, purple, red, yellow • May have nectar guide
Beetles, flies	• Good sense of smell • Some lay eggs in rotting flesh	• Dull colors, dark red, strong, spicy odor, or odor of rotting flesh, flat shape • May have light window (flies)
Hummingbirds	• Vision much like human - see red • Long bill and tongue, large body • Little sense of smell • Intelligent – remember and return to flowers with abundant reward • Active in day • Approach flower and hover	• Red, large flowers with deep nectar tube and abundant nectar • Little or no fragrance • Open in day • No landing platform • No nectar guide
Moths (and bats in some areas)	• Most active at night • Strong sense of smell • Have long proboscis for nectar acquisition	• Open at dusk or night, emit sweet odor at night • Often dull or white • Long corolla, no landing platform
Wind	• Abiotic	• Inconspicuous, green or dull in color, petals reduced or absent, abundant and in canopy

From: Parrish, Judy. 2004. Pollination ecology: Field studies of insect visitation and pollen transfer rates. Teaching Issues and Experiments in Ecology: Volume 2, August.

Western Hummingbird Flowers

Photo by Raffi Kojian

Red Morning Glory

SCIENTIFIC NAME: *Ipomoea coccinea*
REGION: Arizona to Western Texas, South to Tropics

Photo by Eric in SF

Red Larkspur

SCIENTIFIC NAME: *Delphinium nudicaule*
REGION: Western North America

Photo by Joshua Mayer

Bee Balm

SCIENTIFIC NAME: *Monarda fistulosa*
REGION: Rocky Mountain region from Canada to Arizona, and Eastern United States

Photo by Western New Mexico University Department of Natural Sciences and the Dale A. Zimmerman Herbarium

Crimson Sage

SCIENTIFIC NAME: *Salvia henryi*
REGION: Southern Arizona to Western Texas and Mexico

Photo by Steve Berardi

Hummingbird Sage

SCIENTIFIC NAME: *Salvia spathacea*
REGION: California Coastal Range

Photo by Peter Stevens

Coastal Hedge-nettle

SCIENTIFIC NAME: *Stachys chamissonis*
REGION: Coastal California

Photo by Becks

Indian Paintbrush

SCIENTIFIC NAME: *Castilleja exilis*
REGION: Throughout North America

Photo by Dcrjsr

Scarlet Monkey Flower

SCIENTIFIC NAME: *Mimulus cardinalis*
REGION: California to Oregon, East to Arizona and Nevada

Photo by Eugene Zelenko

Indian Warrior

SCIENTIFIC NAME: *Pedicularis densiflora*
REGION: California to Southern Oregon

Photo by Sten

Beardtongue

SCIENTIFIC NAME: *Penstemon barbatus*
REGION: Southern California; Arizona to Utah and southern Colorado

Photo by Dawn Endico from Menlo Park, California

Mountain Pride

SCIENTIFIC NAME: *Penstemon newberryi*
REGION: Central California to northern Oregon

Photo by Stan Shebs

Agave

SCIENTIFIC NAME: *Agave schottii*
REGION: Southern Arizona to southwestern New Mexico

Photo by Thomas Skyt

Fireweed

SCIENTIFIC NAME: *Epilobium angustifolium*
REGION: Temperate Northern Hemisphere

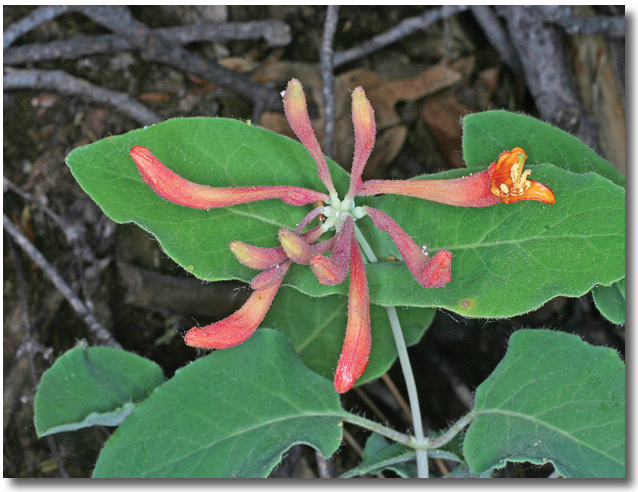


Photo by Western New Mexico University Department of Natural Sciences and the Dale A. Zimmerman Herbarium

Arizona Honeysuckle

SCIENTIFIC NAME: *Lonicera arizonica*
REGION: Arizona, New Mexico, and Utah

Photo by Walter Siegmund

Orange Honeysuckle

SCIENTIFIC NAME: *Lonicera ciliosa*
REGION: Northern California to British Columbia, east to Montana

Photo by linnaeus

Cardinal Flower

SCIENTIFIC NAME: *Lobelia cardinalis*
REGION: Widespread throughout the U.S.

Photo by Ghislain118

California Fuchsia

SCIENTIFIC NAME: *Zauschneria californica*
REGION:California to southern Oregon, east to Mexico

Photo by Western New Mexico University Department of Natural Sciences and the Dale A. Zimmerman Herbarium

Desert Columbine

SCIENTIFIC NAME: *Aquilegia desertorum*
REGION: Northern Arizona

Photo by Dave Powell / USDA Forest Service, Bugwood.org

Western Red Columbine

SCIENTIFIC NAME: *Aquilegia elegantula*
REGION: Arizona and New Mexico, north to southern Utah and Colorado

Photo by Stickpen

Fuchsia-Flowering Gooseberry

SCIENTIFIC NAME: *Ribes speciosum*
REGION: Coast from central California to northern Baja California

Photo by Ciar

Hedgehog Cactus

SCIENTIFIC NAME: *Echinocereus triglochidiatus*
REGION: Southern California to New Mexico and Colorado

Photo by Dcrjsr

Glacier Lily

SCIENTIFIC NAME: *Erythronium grandiflorum*
REGION: Wide range in West

What is Phenology?

Monitoring natural events is an important part of phenology, the scientific study of recurring plant and animal life cycle stages, such as leafing, flowering, fruiting, emergence of insects, and migration of birds. Through the simple act of monitoring the timing of these stages, scientists are "taking the pulse of our planet" – better able to understand large-scale environmental change over time, especially climate change.

Monitoring life cycles of plants remains one of the most scientifically fruitful (literally), in part because they are highly sensitive to environmental cues such as temperature and moisture. Through collecting "small" data such as when a certain plant leafs or flowers, scientists are able to make "big" discoveries – such as how spring is arriving sooner in some places than it did in the past. The effects of an "earlier spring" on different species are not yet well known. What if nectar-producing flowers are not in bloom when the hummingbirds arrive?

Climate change – earlier springs, later falls, hotter summers, more extreme weather events – threatens to restructure entire natural and human systems in ways we don't yet understand. Collectively monitoring these changes is essential for understanding and preparing for what's ahead – and a whole network of observers is needed to do it!

Project BudBurst is a program that recruits observers from across the country to record the leafing, flowering and fruiting time of plants (called "plant phenophase") in their neighborhood. Observers are also asked to describe the aspects of the plants' location, such as proximity to buildings, asphalt surfaces, amount of sunlight, and sources of water. This data is used by scientists to learn about how different plants across the country respond to changes in climate.

Plant Phenology Scavenger Hunt

Before starting: Prepare one nature journal for each student in which they can record their observations.

Conduct the Activity

Engage

1. Ask the students: What is the life cycle of a plant? What characterizes each stage of a plant's life cycle? Consider creating a drawing to help visualize the process using a hummingbird flower (e.g., a honeysuckle or columbine) as an example.
2. Show students a proper chart of the life cycle of a plant. Review terms like bud, leaf, flower, fruit and seed. Point out that a plant's life cycle stages occur in the same predictable order, often around the same time, every year. These plant stages will be the focus of our scavenger hunt today.

Explore

3. Have the students get into groups of two or three.
4. Give each group a Phenology Scavenger Hunt checklist.
5. Give the rules and set site boundaries for the hunt.
6. Give the students 20 minutes to search for items on the checklist. Emphasize that it is not a race – the quality of observations matters more than speed at which they are made!

Explain

7. After 20 minutes, have the students gather and sit in a circle.
8. Ask students:

- What are some words to describe the items you found?
- How many items did you find? How many types of each one?
- What was the easiest item to find? What was hardest to find?

Elaborate

9. People have been monitoring plants for thousands of years. Farmers are perhaps the most famous for monitoring rainfall and plant growth – knowing when to plant and when to harvest. The Japanese have monitored the cherry blossoms, holding celebrations when they came into bloom.

Overview

Explore the phenology of plants found on the site.

Objective

Identify plant phenophases and practice making careful observations.

Ages

8-Adult

Time

60 Minutes

Materials

Clipboard, phenology scavenger hunt checklist, pencils

10. We still monitor plants today – and doing so is perhaps more important than ever before, as our planet is undergoing rapid changes caused by environmental degradation and climate change. Plants are one of the best and easiest things to monitor because they don't move around, and tend to occur in the same place year after year.
11. Although monitoring is a scientific endeavor, anyone can do it – and in fact, scientists rely on everyday people to monitor since scientists can't be everywhere all at once. Scientists call a plant life cycle stage a phenophase and the study of plant life cycles phenology. The root word phenol- means "to appear" and -ology means "the study of." Phenology is the study of when things appear.
12. Review with the students the "Supplemental Reading: How Do Environmental Conditions Affect Each Phenophase?" and discuss.
13. Show students an example of a long-term plant phenology data set of your choice (e.g., Aldo Leopold's springtime events data, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC22273/table/T1/.)
14. If possible, show students the video "Chasing the Green Wave": (https://www.youtube.com/watch?v=8RVunLJg1jY). Explain that these grand visualizations would not be possible without people doing the simple act of monitoring plants on the ground.

Evaluate

15. Ask students:

- What is phenology?
- What are the main life cycle stages or phenophases of a plant?
- Why is it important to monitor plant phenophases? How can this information help us?

Citizen Science Connection

Download and print "Single Report" form from the Project BudBurst Website. Teach students how to fill it out and submit it online. The form is available at: http://budburst.org/documents/871408/879711/Wildflowers_single_report.pdf/0ee20bb0-db08-43d4-9669-4b44e97797b2

For More Information

- *How We Know What We Know About Our Changing Climate* by Lynne Cherry and Gary Braasch
- Phenological Literacy Curriculum: Phenology Scavenger Hunt
  https://www.usanpn.org/pheno-scavenger-hunt
- Earth Partnership for Schools: Phenology & Climate Change in your Schoolyard
  http://www.litzsinger.org/EPS/10-18-Phenology-2-Climate-Change.pdf

Phenology Scavenger Hunt Checklist

☐ A seed	☐ A plant in the "early" flowering stage
☐ A germinated seed (a sprout)	☐ A plant in the "peak" flowering stage
☐ A new leaf	☐ A plant in the "late" flowering stage
☐ An old leaf	☐ A plant with no fruits
☐ A plant with no flowers	☐ A plant in the "early" fruiting stage
☐ A flower bud	☐ A plant in the "peak" fruiting stage
☐ A flower	☐ A plant in the "late" fruiting stage
	☐ A unique sign of the season (describe)

Supplemental Reading: How Do Environmental Conditions Affect Each Phenophase?

Germination: Germination is the term that describes the process whereby a seed begins to grow. Germination is activated by temperature, moisture, or both, depending on the type of seed. Some seeds require very specific temperature and moisture conditions to be met before they can germinate while others can germinate in a wider variety of conditions. The seeds with very specific requirements are thought to be most sensitive to temperature range changes.

Many seeds require a prolonged cold period in order for germination to occur (the hours required are often expressed in "chill hours"). This is a requirement that has evolved that ensures that the flower blooms in spring rather than fall or winter, or after it has been dispersed. If a seed does not receive the requisite number of "chill hours" (such as what may happen in the case of a warm winter), it may germinate at a suboptimal time or fail to germinate entirely.

Leaf-out: The main environmental cue that drives leaf-out is sunlight (certain variations in day length). Leaves collect the sun's energy, combine it with water and carbon dioxide, and then photosynthesize to produce sugar. The rate at which a plant can photosynthesize depends on temperature, light, and moisture conditions. Because leaves are filled with water, they are vulnerable to extreme tempertaures (e.g., in freezing conditions, the water inside the plant cells can expand and cause the cells to burst; in extreme heat conditions, the plant transpires more water into the air than it can replace, which can lead to wilted or total loss of leaves).

Flowering: Flowers are the reproductive parts of the plant. Flowering in many plants is activated by amount of hours of light in the day (i.e., they are "photoperiodic"). The flower is the part of the plant that makes the seed. Flower and flower parts require a lot of energy to grow and maintain. Conditions need to be just right in order for the flower structures to exist, for nectar to be produced, and for pollen to be made. Additionally, temperature conditions have to be just right for pollinators to pollinate the flower; they won't be active if it's too cold and may not get as much nectar if it's too hot.

Fruiting: If flowers are pollinated, they can turn into fruit – but flowers will not turn into fruit if they are not pollinated. If flowers are destroyed (such as by frost), fruit cannot grow. Fruit will also fail to grow if pollinators are not active (e.g., due to extreme weather events).

Understanding the conditions that influence each plant phenophase is critical for getting a better idea about how plants and plant populations might respond to change (e.g., climate change). This makes it important for people to monitor every stage.

Meet the National Phenology Network

Before starting: Create an account on the National Phenology Network website.

Conduct the Activity

Engage

1. Review the basics of hummingbirds, their flowers, phenology, and the relationship with weather/climate. Review how one small change, such as the amount of rainfall or a flower's bloom date, could affect other things. Have students think of some examples based on what they've learned.
2. Tell the students: This is one reason why it's important to monitor different types of cycles in nature – e.g., cycles pertaining to weather, plants, birds, and more. While there are many databases we can submit ecological data to (e.g., eBird, Project BudBurst, Journey North), each database stores a specific kind of data (e.g., eBird has only bird data). These databases help people to look up phenology data related to one kind of plant or animal, but you are not able to compare that plant or animal's phenology to other types of plants or animals.
3. The National Phenology Network exists, in part, as a place to house many different kinds of phenological data sets so that these dynamic interrelationships (e.g., a hummingbird and a flower) can be explored. It is a place you can both explore and submit many different types of data.

Explore

4. As a group or individually, log onto the National Phenology Network(NPN) website. Access the data sets (https://www.usanpn.org/results/dataset-list).
5. Explore some data sets together. Notice what category each data set might fall into (e.g., plant, bird, etc.). Look at who submitted each set and/or what location it was submitted from. Do a search: Is there a hummingbird data set? Are there hummingbird flower data sets? Are there data sets from your region?
6. Scan the names of the different data sets. Have students identify at least two data sets that could hypothetically relate to one another (e.g., bumble bee phenology data and flower bloom dates data). Next, download one of the data sets, open it up, and explore the data.

Overview

Explore the National Phenology Network website and discuss why phenology data sets are important.

Objective

Learn how phenological data sets are important for understanding and predicting how the environment might change over time.

Ages

Ages 8-Adult

Time

60 Minutes

Materials

Computer(s) with internet connection, an original data set (e.g., bird data collected during an earlier lesson)

Explain

7. Have students describe the data set. What software was used to submit the data? (Usually it's Excel) What kind of data is included in the data set (e.g., variables such as location, phenophase, date, etc.)? How is it organized?

Elaborate

8. Tell students that scientists are just beginning to learn about interactions between species. This area of study is becoming more important as more things in the environment undergo change (e.g., habitat modification, habitat loss, climate change, pollution, etc.).
9. Tell students that we can also submit our own data. Show them how to format one of the data sets you have collected as a group (e.g., hummingbird or plant phenophase data) using Microsoft Excel. (Being familiar with NPN's existing data sets will make this process easier.)
10. Go to the NPN Share Existing Data page (https://www.usanpn.org/data/share) and log in.
11. Following the instructions on the website, share your group's data set. Model this process if possible. Once the submission has been confirmed, share the link with your students so they can access it later.
12. Also consider showing students the phenology data visualization tool (https://www.usanpn.org/data/visualizations). Watch the video and explain that this is a tool that can be used to show relationships between organisms.

Evaluate

13. Close by asking the following questions:

- What is phenology?
- Why is it important to monitor phenology and life cycles?
- Why is it important to monitor interactions between organisms?
- What can we do to help shed light on these interactions and how they might be changing in response to environmental change over time?
- What can we conclude about the importance of phenology to hummingbirds, and how can we help hummingbirds as phenology changes?

For More Information

- National Phenology Network Website: https://www.usanpn.org/
- Climate Wisconsin: Climate Change (Video): http://climatewisconsin.org/story/phenology
- Bad Timing: Hummingbirds and Lilies are Out of Sync (Article in Conservation Magazine): http://conservationmagazine.org/2012/09/bad-timing/
- Hummingbirds Journey North: https://www.learner.org/jnorth/humm/index.html