Disneynature

WINGS OF LIFE

NARRATED BY
MERYL STREEP

EDUCATOR'S GUIDE

GRADES 2–4

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From Disneynature, the studio that brought you "Earth," "Oceans," "African Cats" and "Chimpanzee," comes "Wings of Life"— a stunning adventure full of intrigue, drama and mesmerizing beauty. Narrated by Academy Award® winner Meryl Streep, this intimate and unprecedented look at butterflies, hummingbirds, bees, bats and flowers is a celebration of life, as a third of the world's food supply depends on these incredible--and increasingly threatened-creatures.

Directed by acclaimed filmmaker Louie Schwartzberg, "Wings of Life" utilizes riveting high-speed, time lapse and macro filmmaking techniques to showcase in spectacular detail these unsung heroes of our planet.

Disneynature's next True Life Adventure will be available on Disney Blu-ray combo pack on April 16, 2013—just in time for Earth Day! **www.disney.com/wingsoflife**

ACKNOWLEDGEMENTS

This WINGS OF LIFE Educator's Guide was a collaborative effort and the result of a cadre of great brainpower.

At the Walt Disney Studios, Paul Baribault and Catherine Stephens presented the Disney's Animal Kingdom Education Team with the opportunity to take on a new project to introduce learners in grades 2 – 4 to the amazing , and often, unseen world of pollinators. Dr. Liz Fogel brought all the right people together to create a multidisciplinary Educator's Guide that benefits classroom teachers, zoo educators and parents.

At Disney's Animal Kingdom, Laurie Cummins led this project, wrote lessons and developed activities with the expert assistance of Erika Talatinian. Jamie Sincage, Zoological Manager of Invertebrates, applied his knowledge and understanding of pollinators to ensure the accuracy of all information. Dr. Jill Mellen and Allyson Atkins from Disney's Animal Kingdom and Dr. Stephen Buchmann, Lead Scientific Advisor and Head of Research (Univ. of Arizona and the Pollinator Partnership) reviewed and commented on the drafts.

The direct curriculum links and experience in the classroom could not have happened without the special talents of the subject matter experts, including Drs. NaJuana Lee, John Hoge, Linda Labbo, John Olive, Michael Orey and Deborah Tippins from the Univ. of Georgia and Dr. Wayne Nelson from the Univ. of Southern Illinois.

Kathy Lehnhardt
Curator of Education, Disney's Animal Kingdom

PARTNERSHIP FOR 21ST CENTURY SKILLS

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NATIONAL STANDARDS ALIGNMENT CHART

WINGS OF LIFE	SCIENCE AS INQUIRY			LIFE SCIENCE				SCIENCE & TECHNOLOGY			SCIENCE IN PERSONAL & SOCIAL PERSPECTIVES	
		Ability necessary to do scientific inquiry	Understanding about scientific inquiry		The characteristics of organisms	Life cycle of organisms	Organisms and environment		Abilities of technological design	Understanding about science & technology		Changes in environment
LESSON 1					✓	✓	✓					
LESSON 2		✓	✓		✓	✓	✓					
LESSON 3		✓	✓		✓	✓	✓		✓			✓
LESSON 4		✓			✓					✓		

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TEACHER'S BACKGROUND INFORMATION

Welcome to the WINGS OF LIFE

I have a story to tell. It's a story that's over 100 million years old. This story takes place on every climate and every continent except Antarctica. It is happening in gardens, in fields, on farms; in bustling cities and quiet suburbs. The cast includes beetles, butterflies, birds, plants and people. Yes, even you are a part of my story.

I am the star. I am purple. Others are orange, blue and red. I am fragrant and sweet. I blossom during the day. Others open only at night. I have nectar. Others bear fruit, have thorns or catch animals in their sticky traps. We are all essential to life on Earth. I am a flower, and this is my story.

Life Before Flowers

My story begins during the Cretaceous period when life on Earth looked very different. There were no flowers then, only woody plants and shrubs pollinated mostly by the wind, similar to the palms, pine trees and ferns still alive today. About 130 million years ago in what is now southwestern China, something amazing happened: leaves became flowers. The world would never be the same again. With flowers came a vast array of new life forms; the biodiversity of plants on earth multiplied and new animals appeared too. The flowers depended on the animals to spread their pollen. The animals depended on the flowers for food. A pollinator partnership, carried on the wings of life, was born.

What is Pollination?

All living things grow and change, and plants are no exception. Under the right conditions, seeds sprout into plants and many plants produce beautiful flowers. In nature, flowers like me have a very important purpose: we exist so that plants can reproduce. This happens through pollination - the process in which pollen is transferred from a flower's stamen to the pistil on a different flower. Cells in the pollen fertilize the eggs at the base of the pistil and the fertilized eggs become seeds. Seeds spread to grow new plants that ultimately produce new flowers, beginning the cycle again. Flowers like me are colorful and showy for a reason: we depend on animals - the pollinators. The pollinators move pollen, ensuring that new seeds (often surrounded by fruit) are created and spread so that future generations of plants can grow.

Who Are The Pollinators?

Every star (and every good story) depends upon a team of great supporting actors. As it turns out, over 200,000 species of animals help pollinate almost 90 percent of all flowering plants worldwide. Let me introduce you to these important pollinators - the butterflies, hummingbirds, bees and bats that make my story possible.

Butterflies

Butterflies are a beautiful and diverse group of insects, with about 750 species of butterflies found in the United States and 18,000 species of butterflies found worldwide! These colorful, daytime flyers have long, thin legs to perch atop flowers and a special tongue, called a proboscis, which uncurls into a long straw-like structure for drinking and soaking up nectar. In this process, pollen grains stick to the butterflies' bodies, legs and feet and are transferred as the butterflies float between flowers.

Butterflies rely on vision and smell to find their food. Unlike bees, butterflies can see red so the flowers they pollinate are usually colorful, blooming in hues of red, pink, yellow, orange and purple. In addition, these flowers tend to grow in clusters, provide multiple landing platforms, produce large amounts of nectar hidden deep within the flower and open during the day. Examples of flowers pollinated by butterflies include: goldenrod, butterfly weed, asters, milkweed and many species of wildflowers.

The amazing migration of the monarch butterfly *(Danaus plexippus)* is showcased in Disneynature **WINGS OF LIFE**. Over four to five generations, these monarchs migrate in search of milkweed for nectar and a place to lay their eggs. Monarch butterflies, in turn, help to pollinate milkweed so that both species may live on. In spring, the western population of monarchs migrates north from southern California to Washington; the eastern population travels north from the Sierra Madre Mountains, Mexico

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to the eastern United States and Canada. The last and longest-lived generation of monarchs returns to California or Mexico to spend the winter.

Hummingbirds

About 2,000 species of birds worldwide play an important role in pollination, including doves, parrots, honeycreepers, honeyeaters and sunbirds. The hummingbirds (352 species in the New World) in Disneynature **WINGS OF LIFE** are stunning examples of how adaptations are important for both plants and animals.

Hummingbirds can fly upside-down and backwards! Their acrobatic flights are possible thanks to wings that beat seventy times each second. These small birds are also incredibly light - imagine holding a few coins in the palm of your hand: that's about the same weight as the average hummingbird (between two and eight grams). Despite their size, a large amount of energy is required to sustain their impressive flights. As a result, hummingbirds will eat several times their body weight in nectar every day! They may also supplement their diet with small insects.

Hummingbirds' bills are long and curved, perfectly built for extracting nectar from the hardest-to-reach places. Because hummingbirds have a poor sense of smell but good eyesight, the flowers they pollinate are odorless but brightly colored, often blooming in vibrant shades of red, yellow or orange. The flowers are funnel-shaped or tubular, produce large amounts of nectar (usually hidden deep within the flower) and open during the day. As hummingbirds extract nectar from flowers, their faces and back become covered in pollen. With each visit to a new flower, pollen is exchanged, helping flowers reproduce. Examples of North American plants that depend on hummingbirds for pollination are honeysuckle, azalea, morning glory, lupine, hosta, fuschia, red buckeye, salvia, lantana and firebush.

The hummingbirds in Disneynature **WINGS OF LIFE**, including the western long-tailed hermit *(Phaethornis longirostris),* white-necked jacobin *(Florisuga mellivora)*, violet-crowned woodnymph *(Thalurania colombica),* rufous-tailed hummingbird *(Amazilla amabilis),* rufous-crested coquette *(Lophornis delattrei)* and violet sabrewing *(Campylopterus hemileucurus),* were filmed in Panama, which is home to 59 species of hummingbirds! In North America, there are approximately 112 species of hummingbirds!

Bees

From the unique orchid bees, fuzzy bumble bees and busy honey bees in Disneynature **WINGS OF LIFE** to the lesser-known sweat bees, carpenter bees and leafcutter bees, these diverse flyers help make the world go around. As a result, bees are often considered to be pollinator superheroes.

Flowers pollinated by bees tend to be rather flat, have small amounts of nectar and are brightly colored in shades of blue or yellow (bees cannot see red), have a sweet fragrance, large landing platforms and open during the day. In addition, many of these flowers have nectar guides. Although humans cannot see ultraviolet light, bees see this contrasting pattern as an advertisement to guide them towards nutrient-rich nectar at the center of the flower.

The fuzzy black-and-yellow bodies of adult bumble bees (Bombus spp.) make them an iconic garden visitor. Bumble bees are large, black bees with yellow or orange markings, averaging one to two-and-one half centimeters (one-half to one inch) in length. They may nest underground or in abandoned burrows, creating nests with entrances that can reach up to 30 centimeters (12 inches) in diameter and accommodate colonies of less than 500 bees. Bumble bees do not produce or store large quantities of honey, but pollen and nectar are still vital for these busy animals.

Each spring, queen bees emerge from hibernation and construct their nest to raise a brood of female workers. After the first generation of workers hatch, they take over the collection of pollen and nectar, bringing this back to the hive. The pollen is the most important source of food for newly-hatched bees. Each generation works tirelessly to collect pollen for the colony, as several generations are born throughout the summer. The final generation, born in late summer, contains queens and the males that will mate with them. By fall, only the queen bees survive to hibernate over the winter and emerge next year, beginning the cycle again.

The almost 50 species of bumble bees in the United States are well adapted for doing their job! Bumble bees can be classified based on the length of their tongue, called a proboscis. A variation in tongue size allows different bee species and even different bees in the same species to visit flowers of varying shapes. In addition, all queen and worker bumble bees

Busy Bees

Amidst the bustle of New York City, scientists have documented at least 250 different bee species, eleven of which have only been discovered within the last five years! With about 3,500 species of native bees in the United States, and approximately 20,000 described species of bees found worldwide (including habitats in the Arctic Circle), they are proof that pollinators can live almost anywhere!

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have large pollen "baskets" on their hind legs. As each bee moves from flower to flower, this bowl-shaped area covered in long hairs collects and carries pollen back to the nest. Another unique bumble bee adaptation is their ability to "buzz pollinate" plant species with ample pollen but no nectar. Tomato flowers, for example, do not produce nectar but have a large amount of pollen. The bees become living tuning forks! Bees visit tomato flowers and vibrate their flight muscles at just the right frequency to shake the pollen grains loose. The bees collect pollen for their hive and the tomato plants are pollinated in return! Other plants pollinated by bumble bees include snapdragons, foxglove, red clover, cranberries, alfalfa, apples, cherries, blackberries and blueberries.

Bats

As the only flying mammals on Earth, bats are pretty amazing! In addition to making up over one-fifth of all mammal species, bats are incredibly important to the environment. While some bats feast on insects and play an important role in pest control, other bats are critical pollinators in desert ecosystems.

The bats featured in Disneynature **WINGS OF LIFE** are lesser long-nosed bats *(Leptonycteris yerbabuenae)*. Lesser long-nosed bats are found in the southwestern United States and throughout northwestern Mexico. These bats are small in size, weighing between 20-27 grams (less than one ounce) and measuring about six to nine centimeters long (2.36-3.54 inches). During the day, lesser long-nosed bats roost in colonies of between 1,000 and 100,000 individuals! Just after sunset, the colonies emerge, searching for nectar, pollen and fruit from saguaro, organ pipe and cardon cacti, as well as many species of agave. The large flowers on these plants are usually white in color, filled with nectar, have a strong melon-like or fruity odor and are timed to open only at night, when their nocturnal pollinators will be on the move.

Lesser long-nosed bats are excellent flyers and can rapidly beat their wings to hover over cactus flowers. A pointed snout and long tongue, which is covered in brush-like papillae, help bats reach deep inside flowers to lap up nutrient-rich nectar. In return, the bats' faces and bodies become covered in pollen which is transferred between flowers as the bats search for nectar throughout the night. The pollinated flowers produce seeds surrounded by fruit that soon become an important summer food source for lesser long-nosed bats. After gorging themselves on fruit, the bats spread the seeds in their dung, helping to plant new cacti. Because the lesser long-nosed bats depend on the nutrient-rich nectar, pollen and ripened fruit to reproduce and raise their young, and the cactus plants depend on the bats to pollinate their flowers and spread their seeds, these two life cycles are delicately intertwined. It's a great story of the powerful partnership between plants and pollinators!

The Other Pollinators: Flies, Moths, Wasps, Mammals And Reptiles

Did you know that chocolate depends on a pollinator no larger than the head of a pin? Midge flies are the only animals small enough to pollinate the cacao flower, giving us billions of pounds of chocolate per year! In addition to bees, birds, butterflies and bats, other animals such as beetles, flies, wasps, moths, reptiles and even mammals are important pollinators around the world.

How Do Pollinators Help People?

Think about what you ate today: a banana for breakfast, a peanut butter and jelly sandwich with an apple for lunch, a chocolate chip cookie as a snack. Maybe you're washing all that down with a glass of tomato juice? Well, take a big sip – and now thank the plants and pollinators that have made mealtime possible.

When flowers are pollinated, they produce seeds. In many plants, these seeds are surrounded by a protective casing that people call fruit. Fruits like apples, bananas, oranges, strawberries, raspberries, blueberries, cucumbers, peppers and tomatoes are actually the result of a pollinated flower. Vegetables, like carrots, cabbage, lettuce, celery and cauliflower, are the roots, leaves, stems or immature parts of plants. Although the vegetables themselves do not require pollination, the plants that produce them do: pollinators make it possible for these plants to reproduce, giving life to new generations of vegetable crops. It is estimated that animals are responsible for pollinating over 150 food crops in the United States alone!

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In addition to food, without flowering plants like me and the pollinators we depend on, you wouldn't have many of the things you need to survive: oxygen, clothing, building materials, cosmetics, dyes, waxes, cleaning products and medicine. The products and services that pollinators provide are worth an estimated $10 to $15 billion dollars per year in the United States! It just goes to show that my story is one in which everyone and everything is connected. That's the power of the pollinator partnership.

How Was The Plant And Pollinator Partnership Filmed?

Disneynature **WINGS OF LIFE** was filmed using time-lapse photography. Time-lapse nature photography began in 1909. In 1956, Walt Disney's *Secrets of Life* initiated the modern use of time-lapse on film and television to show intricate views of blooming flowers. Today, advances in digital cameras, lenses and high-speed film have truly changed the way people view the world. Through time-lapse photography, Disneynature **WINGS OF LIFE** offers an up-close view of the partnership between flowers and pollinators from the vantage point of these amazing creatures.

How Can People Help Pollinators?

Despite their importance, global conservation issues currently threaten pollinators. Bees, birds, butterflies and bats all over North America are facing challenges from habitat fragmentation, pesticide use, disease and loss of native flowers. For example, the population of lesser long-nosed bats has declined by over 30% in the past 10 years. Scientists believe this decline is the result of habitat loss, human disturbance to caves and roosting sites, overharvesting of agave plants for human use, and illegal hunting. At least five bumble bee species have declined and one species, the Franklin's bumble bee may have gone extinct. For all of these reasons it is important that people work together to protect pollinators.

Here are some ways you can be sure the story of flowers, pollinators and people is told for years to come:

1. Create a pollination garden! Plant native flowers around your home, school or community to provide natural food sources. Make sure to have blooming plants during spring, summer and fall. Use heirloom varieties and not modern hybrids which may not contain nectar or pollen.
2. Say no to spray! Avoid using pesticides in the garden to help protect pollinators. Opt for natural pest control, such as native ladybugs, assassin bugs and spiders. If you must use insecticides please use them at night when bees aren't active.
3. Make pollinators feel welcome! Create a home or shelter for birds and bees in your backyard. A row of large shrubs or small trees can provide refuge from the wind for animals such as hummingbirds. A wooden log with holes drilled through can provide nesting sites for bees (to learn how to make your own bee box, visit **www.fs.fed.us/wildflowers/pollinators/beebox.shtml**). Try to leave dead trees or branches alone since these contain beetle holes which are essential homes for leafcutter and mason bees.
4. Get people "buzzing"! Check out wildlife field guides, visit your library and contact your local or state wildlife department to learn more about the pollinators in your area. Then, share this knowledge to inspire others to care!
5. Visit your local AZA zoo! The Association of Zoos & Aquariums (AZA) is dedicated to the global protection of species and their habitats. Find out if your local AZA zoo has a butterfly house or aviary. Take a trip to the zoo with your family to see these pollinators in person, while supporting the conservation of wildlife and wild places all over the world.
6. Support organizations working to protect pollinators! Learn more about organizations such as the Pollinator Partnership sponsored by the North American Pollinator Protection Campaign, Bat Conservation International, Disney Worldwide Conservation Fund, The Xerces Society, The Nature Conservancy and citizen science groups such as Journey North that are making a difference for pollinators every day.

How is Disney working to protect pollinators?

The Disney Worldwide Conservation Fund (DWCF) is an annual awards program focused on the study and protection of the world's wildlife and ecosystems. In 2012, DWCF supported the ECOLIFE Foundation's Monarch Butterfly Conservation Project. This project is aimed at improving the lives of local people and monarch butterfly habitat near Mexico's Monarch Butterfly Biosphere Reserve. With support from DWCF, this project will plant 10,000 new oyamel fir trees (crucial to the survival of overwintering monarchs) in this region.

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HOW DO PLANTS ATTRACT POLLINATORS?

LESSON 1

Grade Level: **2-4** | Subject Areas: **Science, Math, Art** | Time Frame: **1 hour**
Background Information: ***Who Are The Pollinators?*** (Pages 3 - 6) | Connect with the Film:
The Purpose of Flowers **clip from Disneynature WINGS OF LIFE Blu-ray, DVD, or Digital Download**

VOCABULARY:

adaptation, anther, filament, flower, leaves, petals, pistil, plant, pollen, pollinator, roots, stamen, stem, stigma, ultraviolet light

STUDENTS WILL BE ABLE TO…

- Define the term adaptation and explain why plant adaptations are important
- Explain the purpose of pollen and the role of pollinators in helping plants grow
- Compare at least three different flower adaptations
- Identify how different flower adaptations help attract pollinators

WHAT YOU NEED

- Pictures of plants or plant field guides from local library
- Flower Adaptation Clues (for Teacher)
- Flower Adaptation Cards
- Activity Sheet 1: How Do Plants Attract Pollinators?
- Pollinator Garden Background or SMARTBoard Activity

LEARNING ACTIVITIES

1. Introduce the parts of a flower using the following website (www.kidsgrowingstrong.org/Flowers). Distribute various pictures of flowers from field guides or reference books to students (a great online resource is (www.bhg.com/gardening/plant-dictionary/). Ask students for their initial observations: how do the parts of the **flower** (**anther, filament, pistil, petals, stamen** and **stigma**) compare? How might these differences provide flowers with an advantage?
2. Explain the purpose of **pollen** and discuss ways **pollen** can be spread. Discuss with students why flowers are a special **adaptation** that only some plants have. Certain animals that help spread pollen between flowers are called **pollinators**.
3. Together, watch the Disneynature **WINGS OF LIFE** trailer on **www.disney.com/wingsoflife** or *The Purpose of Flowers* clip (12:40-14:10 on Blu-ray, DVD, or Digital Download) to view the relationship between flowers and pollinators. Students should conclude that flowers have different adaptations to attract pollinators.
4. Break the class into small groups to investigate flower adaptations in more detail. Distribute Activity Sheet 1 and one flower card to each group. Have each group complete Activity Sheet 1 for their card.
5. As a class, complete the remainder of Activity Sheet 1. Display the Pollinator Garden background in front of the class or use the SMARTBoard activity. Read each set of flower adaptation clues out loud. As you read, each group should decide if their flower has all of the adaptations described. If so, the group should come up to the front of the class and put their flower into the pollinator garden. The rest of the class should mark off the corresponding adaptations on Activity Sheet 1. Continue until all groups have placed their flower card into the garden and Activity Sheet 1 is complete. Discuss the variety of flowers and flower adaptations as a class. Predict how these adaptations might attract pollinators to the flowers in the garden.

WRAP UP & CHECK FOR UNDERSTANDING

6. Use the following questions to wrap up the lesson and check for understanding:
   - **Define the term adaptation in your own words and explain why plant adaptations are important.** *An adaptation is a trait that allows an organism to survive in its environment. Adaptations are important because they help plants grow, make food and reproduce.*
   - **Explain the purpose of pollen and the role of pollinators in helping plants grow.** *Pollen is a sticky substance found inside every flower. When pollen is spread from one flower to another, it fertilizes eggs that become seeds which may germinate into new plants. Seeds are spread by wind and animals, get buried in the soil and eventually grow to become new plants. Without pollen, this process would not be possible. Pollen can be moved by the wind or water. Animals can also move it. Animals that move pollen between flowers are called pollinators.*
   - **Compare at least three different flower adaptations and describe how these adaptations help attract pollinators.** *Examples of flower adaptations include smell, color, abundant pollen, abundant nectar, and whether they open during the day or night. Smell and color advertise to pollinators that the flower is full of pollen or nectar. Because pollen and*

Hi, We're daisies! Flowers like us smell good in the spring and our bright colors make your garden beautiful. But did you know that we help plants grow? We use adaptations to attract animals, called pollinators, who spread our pollen from flower to flower. Don't believe us? Just ask the butterflies, birds and bees.

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nectar are an important food source, having a lot of it is also an adaptation that attracts pollinators. Finally, flowers that open at night attract nocturnal pollinators such as bats, whereas flowers that open during the day attract bees, birds and butterflies.

- **Imagine if you had many of the same type of flower; would they all look exactly the same? Why or why not?** *Connect your answer to the role flower adaptations play in attracting pollinators. Every rose in a bouquet of roses would look similar but they wouldn't be exactly the same. Some roses might be brighter than others. Some might have a stronger smell. This is because the flower that attracts the most pollinators has the best chance of spreading its pollen and passing its genes on to the next generation. Individual flowers (flowers on the same plant or plants in the same species) are adapted to compete for a pollinator's attention.*

EXTENDING THE LESSON

SCIENCE: See Lesson 2 to discover which animals pollinate the plants in this lesson and to learn more about the flowers and pollinators featured in Disneynature **WINGS OF LIFE.**

SCIENCE AND MATH: Take students outdoors or to a local botanical garden. Encourage students to use as many senses as possible to discover the flowers and plant-life around them (what do they see, feel, hear and smell?) Have students count and record the number and types of plants they see using a simple data sheet (categories could include: flowers/no flowers, color, size, smell). After returning to the classroom, create a bar graph showing the number and different types of flowers that students' observed. Compare the various adaptations of these flowers to the flowers in this lesson.

ART: Some flowers use ultraviolet light to attract insects! Although ultraviolet light is invisible to people, ultraviolet light marks on some petals act as visual guides to direct pollinators to the hidden nectar. To demonstrate this effect, have students use colored pencils, oil pastels or paint to illustrate a beautiful flower garden. Then, have students trace over some of the flowers' petals with invisible ink or paint. Shuffle the students' artwork and randomly redistribute their paintings to the class. Have students pretend to be pollinators. They should first try to guess which flowers they would "pollinate" keeping adaptations in mind. Then, give students small blacklight flashlights. They should use these flashlights to detect the invisible ink, giving them special "pollinator power" to find new plants to pollinate while mimicking the concept of ultraviolet light. As a class, compare students' initial choices to the choices they made when using the flashlights. Discuss how ultraviolet light is a helpful adaptation for flowers in nature.

RESOURCES

FOR STUDENTS:

1. Aloian, Molly and Bobbie Kalman. *The Life Cycle of a Flower.* New York, NY: Crabtree Publishing Company, 2004.
2. Cole, Joanna. *The Magic School Bus: Plants Seeds – A Book About How Living Things Grow.* New York, NY: Scholastic, 1995.
3. Heller, Ruth. *The Reason for a Flower.* New York, NY: PaperStar Books/ Penguin Putnam Books for Young Readers, 1999.
4. Lundgren, Julie K. *Plant Adaptations.* Rourke Publishing, 2011.
5. Worth, Bonnie and Aristides Ruiz. *Oh Say Can You Seed?: All About Flowering Plants.* New York, NY: Random House, Inc./Dr. Seuss Enterprises, 2001.

FOR TEACHERS:

1. Celebrating Wildflowers. *Pollinators.* US Forest Service. **www.fs.fed.us/wildflowers/nativegardening/index.shtml**
2. The Xerces Society. *Attracting Native Pollinators: The Xerces Society Guide to Conserving North American Bees and Butterflies and their Habitat.* Portland, OR: The Xerces Society. 2011 **www.xerces.org/books**
3. Buchmann, Stephen and Gary Paul Nabhan. 1996. *The Forgotten Pollinators.* Island Press, Washington, D.C., 292 pp.
4. Pollinator Partnership. *Bee Smart School Garden Kit.* North American Pollinator Protection Campaign. **www.pollinator.org/beesmart_give.htm**

ANSWER KEY – ACTIVITY 1

PROTECTING POLLINATORS

Create a pollination garden near your school or community! Download the Pollinator Partnership's BeeSmart App or visit their website **(www.pollinator.org)** to choose native plants that will thrive in your area. For more ideas on how to attract pollinators to your garden, refer to ***Lesson 3: Why do people depend on pollinators?***

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Teacher's Notes for Lesson 1: Flower Adaptations Clues

How do plants attract pollinators?

Read each set of Flower Adaptations Clues to the class. Each small group should decide if the adaptation clue set is decribing their flower. If so, the group should place their flower into the pollination garden using the projected garden image or the SMARTBoard activity.

Agave

- I open only at night.
- I smell like rotting meat.
- I make a lot of nectar.
- I have yellow petals shaped like trumpets.

Corpse Flower

- I open during the day.
- I smell like rotting meat.
- I am very large with dark purple and white petals.

Hibiscus

- I open during the day.
- I am very colorful.
- I have large, bright pink petals.

Milkweed

- I open during the day.
- I make a lot of nectar.
- I have small purple petals.

Tomato Plant

- I open during the day.
- I make a lot of pollen.
- I have small yellow petals.

Cacao

- I open during the day.
- I have a strong smell.
- I am small with white petals.

Goldenrod

- I open during the day.
- I am very colorful.
- I make a lot of pollen.
- I make a lot of nectar.
- I have small yellow petals.

Firebush

- I open during the day.
- I am very colorful.
- I make a lot of nectar.
- I have yellow and orange petals shaped like tubes.

Pineapple

- I open during the day.
- I make a lot of nectar.
- I have spiky orange and yellow petals.

Saguaro Cactus

- I open only at night.
- I have a very sweet smell.
- I make a lot of nectar.
- I have large white petals and a bright yellow center.

PROTECTING POLLINATORS

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Flower Adaptations Cards

Tomato Plant

Pollen

Open at Day

Cacao

Smell

Open at Day

Milkweed

Nectar

Open at Day

Agave

Smell

Nectar

Open at Night

Corpse Flower

Smell

Open at Day

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Flower Adaptations Cards

Pineapple

Nectar Open at Day

Firebush

Color Nectar Open at Day

Saguaro Cactus

Smell Nectar Open at Night

Goldenrod

Pollen Nectar Color Open at Day

Hibiscus

Color Open at Day

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How do plants attract pollinators?

As each group reads their plant card to the class, check off the adaptations that each plant uses to attract pollinators.

	Smell	Nectar	Pollen	Color	Open at Night	Open at Day
Agave						
Cacao						
Corpse Flower						
Firebush						
Goldenrod						
Hibiscus						
Milkweed						
Pineapple						
Saguaro Cactus						
Tomato Plant						

PROTECTING POLLINATORS

Create a pollination garden near your school or community! Visit the Pollinator Partnership's website (**www.pollinator.org**) or use their BeeSmart App to choose native plants that will thrive in your area.

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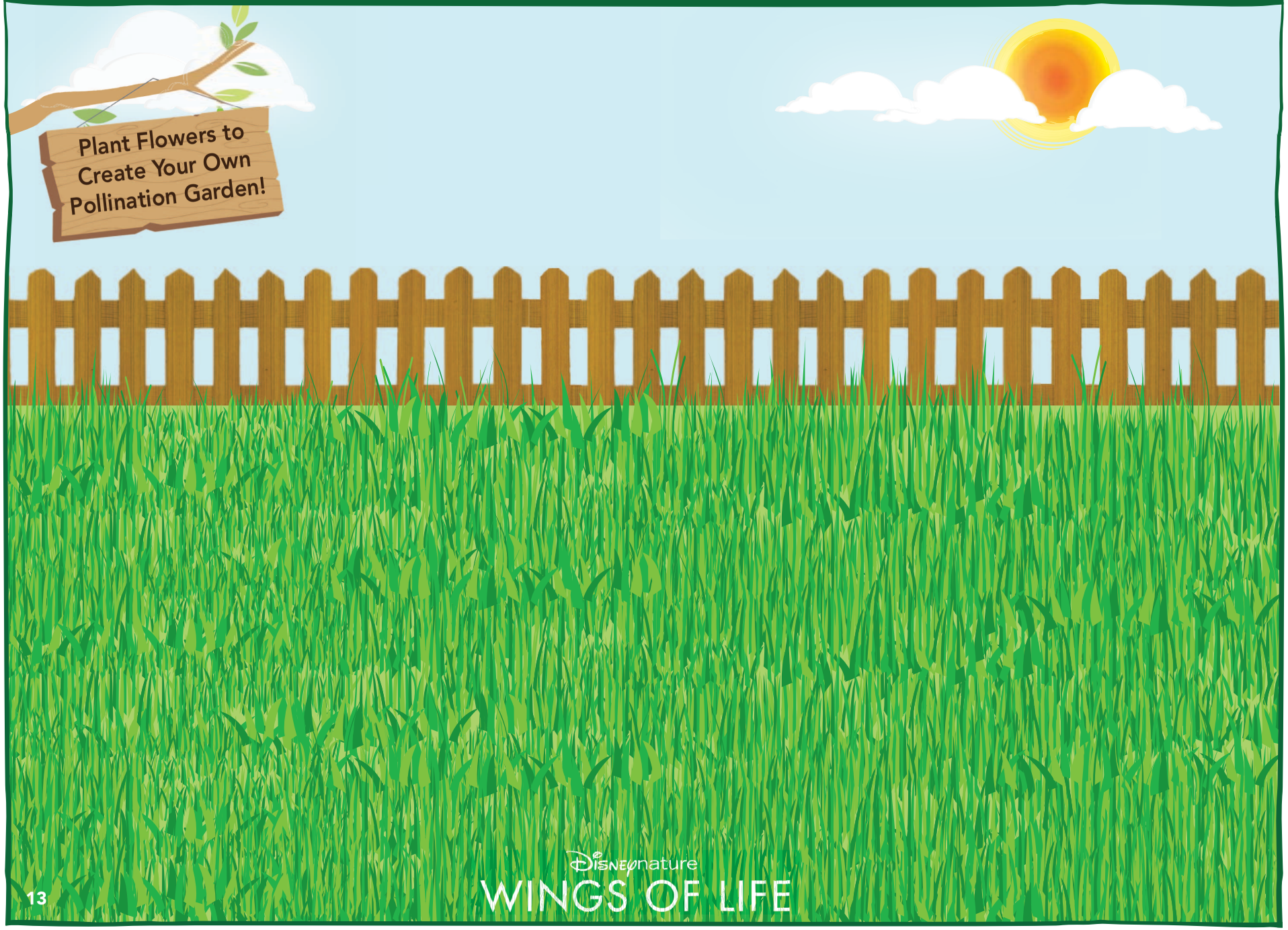

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HOW DO ANIMALS POLLINATE FLOWERS?

LESSON 2

Grade Level: **2-4** | Subject Areas: **Science, Language Arts, Geography, Music and Dance**
Time Frame: **2 hours** | Background Information: ***Who Are The Pollinators?*** (Pages 3 - 6) | Connect with the Film:
Refer to "What You Need" section for accompanying clips from *www.disney.com/wingsoflife*

VOCABULARY:

adaptation, buzz pollination, color vision, energy, migration, pollinator, proboscis, pollen baskets, ultraviolet light

STUDENTS WILL BE ABLE TO…

- Explain the term adaptation and describe how adaptations help animals survive
- Identify four types of pollinators and connect them to the flowers they pollinate
- Compare at least three different pollinator adaptations
- Demonstrate how at least one pollinator collects pollen and nectar

WHAT YOU NEED

- Activity Sheet 2
- *Beauty of Pollination* clip from **www.disney.com/wingsoflife**
  - Optional: View *Collecting Pollen for the Hive – Part 1, Collecting Pollen for the Hive – Part 2,* and *Fueling the Monarch Migration* film clips from the Disneynature **WINGS OF LIFE** Blu-ray, DVD, or Digital Download.
- Materials for pollinator activities:
  - **Hummingbird:** 12 jars or milk jugs, 30 small cups, 30 pipettes, turkey basters or drinking straws
  - **Bumble bee:** Hula hoops or string, plastic sandwich bags, cotton balls or craft poms, safety pins
  - **Lesser long-nosed bat:** Flag football belts, elastic, string or fabric for students to tie around their waist, 40 yellow pollen flags, 40 blue nectar flags (flags can be purchased or made from strips of plastic tablecloth, old pieces of fabric, construction paper or bandanas)

LEARNING ACTIVITIES

1. Review the term **adaptation** with the class and the flower adaptations featured in Lesson 1. Discuss how flowers provide animals like bumble bees, birds, butterflies and bats with nectar and pollen to eat. Without pollen and nectar, these animals would not have enough **energy** to walk, fly, reproduce and raise their young. **Pollinators** have adaptations that help them reach and collect pollen and nectar from flowers.
2. Use the background information to review adaptations of butterflies, hummingbirds, bumble bees and lesser long-nosed bats, including: wings, hair, long nose, long beak, long tongue, **proboscis**, **pollen baskets**, **color vision**, ability to see **ultraviolet light** and the process of **buzz pollination**. Discuss how each of these adaptations might help pollinators collect pollen and nectar.
3. Watch the *Beauty of Pollination* clip on **www.disney.com/wingsoflife**. After watching the clip, have students describe the adaptations of each pollinator using the word bank on Activity Sheet 2. Then, have students decide which flower each animal is best adapted to pollinate.
4. Next, complete one or more of the following activities to further investigate pollinator adaptations:
   a. **Bumble bee:** in this modified version of an egg hunt, have students practice being bumble bees by collecting pollen for their hive in pollen baskets.
      i. [Optional] Watch the *Collecting Pollen for the Hive – Part 1* (31:10-32:00) and *Collecting Pollen for the Hive – Part 2* film clips (53:25-54:55 on Blu-ray, DVD, or Digital Download) to discover why bumble bees collect nectar and pollen.
      ii. Take the class outdoors. Scatter cotton balls or craft poms around the field to represent the pollen of many different flowers. Optional: Have students create their own flowers using construction paper and set the cotton balls in the center of these flowers.
      iii. Break the class into small groups. Each group represents a colony of bees. Give each colony a hula hoop or piece of string to represent their hive. Each colony should place their hive somewhere on the field where they think they have the best advantage for collecting the most pollen.
      iv. Give every student two sandwich bags. Help students attach one bag to each of their pant legs using safety pins to represent pollen baskets on a worker bumble bee's legs.
      v. Every colony starts in their hive. Give the bumble bees 60 seconds to travel the field and collect as much pollen in their pollen baskets as possible. Each time a bumble bee collects a piece of pollen, they must make a buzzing sound to simulate buzz pollination.
      vi. After 60 seconds, all bumble bees must return to their hive. Each colony must collect 25 pollen loads to feed their young and

Hi! I'm a lesser long-nosed bat! I depend on the nectar and fruit from the saguaro cactus. But, the cactus needs me too! I pollinate its flowers and spread its seeds. It's a great story of the partnership between plants and pollinators!

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ensure the colony survives. The team with the most pollen in their hive represents the most successful colony.

vii. Use the following questions to discuss the results of this first round of play.

1. Why is pollen important to bumble bees? *Pollen is the most important source of food for newly-hatched bees. Worker bees must bring enough pollen back to the hive to feed their young.*
2. Were there any groups that did not collect enough pollen? What would happen to this colony in nature? *Because pollen provides newly-hatched bees with the energy they need to grow, colonies that did not collect enough pollen would not survive.*
3. How did hive placement impact pollen collection? What might this mean for bumble bees in nature? *When bee colonies build their hives closer to the food source, they are likely to collect more pollen because they don't have to travel as far. In nature, the successful bumble bee colonies will typically build their hive close to their food source.*
4. What bumble bee adaptations do the sandwich bags and buzzing noise represent? *The sandwich bags represent pollen baskets, used by worker bees to collect and transport pollen back to the hive. The buzzing noise simulates a bumble bee's ability to buzz pollinate tomatoes.*

viii. Try the activity again with uneven groups of large colonies and small colonies. Discuss how being part of a group helps animals obtain food.

1. How did the size of the bee colony impact pollen collection? Were larger or smaller bee colonies more successful? *Students should conclude that larger colonies are typically more successful in collecting pollen because there are more worker bees contributing to the colony's food source.*
2. What would happen to the future of a colony if the number of bees declined? *If the number of bees declined, worker bees would have to do more work to collect the amount of pollen needed for the colony. They may not be able to collect enough pollen to support the newly-hatched young, meaning fewer bees become adults. Ultimately, the colony could collapse because there would not be any bees to reproduce.*

b. **Hummingbirds:** in this activity, students will learn how hummingbirds extract nectar from flowers, while also competing for access to flowers when multiple hummingbirds are present.

i. Prepare for the activity by placing 12-15 tall, thin plastic containers or open milk cartons around the field. Fill each container with water to symbolize flowers filled with nectar.

ii. Provide each student with a small cup to represent their hummingbird stomach. Use a pipette, drinking straw or turkey baster to symbolize a hummingbird's long beak and tongue.

iii. Start students around the perimeter of the field. Hummingbirds can only use their beak to collect nectar from the flowers (with drinking straws, students can create suction by placing their thumb over the top of the straw and inserting the straw into the container). Give hummingbirds three minutes to collect as much nectar as they can and return to their perch at the perimeter of the field.

iv. Compare how much nectar each hummingbird collected. Repeat the activity several times with different numbers of containers on the field. Discuss how nectar collection changed as the number of flowers changed.

v. Was there competition between the hummingbirds (students) to collect the nectar in this activity? Discuss how hummingbirds compete in order to find enough nectar. Return to the classroom and watch the Hummingbird Competition clip. Discuss how hummingbirds compete in order to find enough nectar.

1. Why do hummingbirds compete for access to flowers? *Nectar is food for hummingbirds; it gives them the energy needed to survive. Because hummingbirds use a lot of energy to fly, they must drink several times their body weight in nectar each day. When there are fewer flowers, it makes it harder to find food. This causes competition between hummingbirds.*
2. How might individual hummingbirds be better adapted than others to reaching nectar within flowers? *Differences in beak length, body size and ability to defend their territory make certain hummingbirds better adapted to collecting nectar.*

c. **Lesser long-nosed bat:** in this modified version of flag football, students will learn about the amazing relationship between the lesser long-nosed bat and the saguaro cactus.

i. Divide the class into flowers and bats with twice as many flowers as bats (for a class of 30, have 20 flowers and 10 bats). Give each flower two pollen flags and two nectar flags. Use different colored flags to represent nectar and pollen.

ii. Start with the flowers scattered in the center of the field. Draw a line at the edge of the field to designate the bats' cave. Bats should begin by roosting in their cave.

iii. Explain that flowers must remain stationary while bats leave their cave to visit flowers. The bats' goal is to collect five nectar flags before returning to their cave. Bats can only collect one nectar flag at each flower but multiple bats can visit the same flower. Bats cannot take nectar from other bats.

iv. When a bat collects a nectar flag, pollen flags are also transferred to represent the bat pollinating the flower. If the bat does not have a pollen flag, the flower must give up a pollen flag to the bat. If the bat has a pollen flag, the bat must give a pollen flag to the flower.

v. Once a flower runs out of nectar, it should sit down. Allow every bat to collect nectar flags until all bats have five flags or all flowers are sitting down. At the end of the activity, flowers with one or more pollen flags have been pollinated; flowers without pollen flags have not been pollinated. Repeat the activity several times until all students have the opportunity to be bats.

vi. Return to the classroom and discuss the outcome of this activity as it relates to bat adaptations and the relationship between bats and the saguaro cactus flower.

1. Were all the flowers pollinated? Even if they were not pollinated, are these flowers still important? Why or why not? *At the end of the activity, some flowers were not pollinated. Any flower that gave up at least one nectar flag was an important food source for bats. Without them, the bats and their young would not survive.*
2. What do the pollinated saguaro flowers eventually become? Why is this important to bats? *Pollinated saguaro cactus flowers eventually*

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become fruit. The fruit gives energy to the bats and their young during the hot summer months.

3. How do the bats help to plant future generations of saguaro cactus? What would the desert look like without these bats? *After eating fruit, the bats spread seeds in their dung, helping plant new cacti throughout the desert. Without bats, there would be no saguaro cacti, which in turn would impact the survival of many species, including bats.*

d. **Monarch butterfly:** [Optional] *Watch the Fueling the Monarch Migration* film clip (28:45-30:33 on Blu-ray, DVD, or Digital Download) to learn how nectar fuels the **migration** of monarchs over multiple generations and how monarch butterflies help pollinate milkweed throughout their journey. Visit the JourneyNorth website **(www.learner.org/jnorth/)** to research the migration routes of monarch butterflies. Give students a map of North America and have them color the migration routes of the eastern and western migratory populations of monarchs. Help students label countries, states and major cities along the migration route. Discuss and compare these migrations as a class.

WRAP UP & CHECK FOR UNDERSTANDING

5. Use the following questions to wrap up your class discussion:

a. What is an adaptation? How do adaptations help pollinators survive in their environment? *An adaptation allows an organism to survive in its environment. Adaptations help pollinators collect pollen and nectar which provides energy to reproduce and raise young.*

b. Identify the four main pollinators featured in Disneynature **WINGS OF LIFE** and connect these animals to the flowers they pollinate. *Bumble bees pollinate tomato plants, monarch butterflies pollinate milkweed, lesser long-nosed bats pollinate the saguaro cactus and hummingbirds pollinate firebush.*

c. Compare adaptations of the four pollinators using Activity Sheet 2. The wings of hummingbirds and bats allow them to hover over flowers to collect nectar. *Bats, bumble bees and hummingbirds have long tongues and butterflies have a long proboscis to help reach the nectar within a flower. Hummingbirds have long bills and bats have long noses to help them reach deep inside tube-shaped flowers. Bumble bees have pollen baskets to carry pollen.*

EXTENDING THE LESSON

SCIENCE AND LANGUAGE ARTS: Research the plants in Lesson 1. Discover who their pollinators are and learn how these pollinators are adapted to specific flowers. Write or illustrate a short story that describes this relationship from the perspective of the pollinator. Share your story with the class. Discuss similarities and differences in pollinator adaptations.

ART: Use clay, paint, crayons, markers or pastels to create a new creature to pollinate a new breed of flower! Combine two or more of the adaptations in this lesson and explain how these adaptations will help your new animal gather pollen and nectar. Then, create a new species of flower that will be best suited for your pollinator's adaptations and add this flower to your artwork. Share your artwork with the class as you explain how the adaptations you chose will help your new animal survive.

MUSIC AND DANCE: Create a pollinator dance that mimics one of the four pollinators in this lesson. Students may also want to learn more about the "bee waggle" dance used by honey bees to communicate. After viewing a short clip **(www.youtube.com/watch?v=-7ijI-g4jHg)**, have students create a waggle dance of their own. They can even try hiding an object around the classroom and using their bee waggle dance to communicate the location of this object.

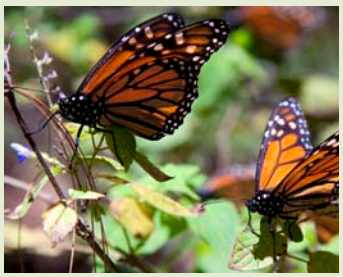
RESOURCES

FOR STUDENTS:

1. Fredericks, Anthony D. and Jennifer Dirubbio. *Around One Cactus: Owls, Bats and Leaping Rats.* Nevada City, CA: Dawn Publications, 2003.
2. Frost, Heather and Leonid Gore. *Monarch and Milkweed.* New York, NY: Atheneum Books for Young Readers, 2008.
3. Micucci, Charles. *The Life and Times of the Honey bee.* New York: Houghton Mifflin, 1997.
4. Sill, Cathryn and John Sill. *About Hummingbirds: A Guide for Children.* 2011.
5. Slade, Suzanne Buckingham and Carol Schwartz. *What if there were no bees?: A Book about the Grassland Ecosystem.* 2010.

FOR TEACHERS:

1. Bee Inspired! **www.savenature.org/content/nature_academy/Bees**
2. Buchman, Stephen L. and Gary Paul Nabhan. *The Forgotten Pollinators.* Washington, DC: Island Press, 1997.
3. Colla, Sheila, Richardson, Leif and Paul Williams. *Bumble bees of the Eastern United States.* USDA and Pollinator Partnership. **www.pollinator.org/books.htm**
4. Koch, Jonathan, Strange, Jamie and Paul Williams. *Bumble bees of the Western United States.* USDA and Pollinator Partnership. **www.pollinator.org/books.htm**
5. Life Science: Flowers and Pollination. Annenberg Learning. **www.learner.org/courses/essential/life/session4/closer3.html**
6. Moisset, Beatriz and Stephen Buchmann. *Bee Basics – An Introduction to Our Native Bees.* USDA Forest Service and Pollinator Partnership Publication. **www.pollinator.org/PDFs/BeeBasicsBook.pdf**
7. North American Pollinator Protection Campaign (NAPPC). **www.pollinator.org/nappc/index.html**
8. PollinatorLIVE: A Distance Learning Adventure. **www.pollinatorlive.pwnet.org/index.php**
9. The Pollinator Partnership. *Nature's Partners: A Comprehensive Pollinator Curriculum for Grades 3-6.* **www.pollinator.org/nappc/PDFs/curriculum.pdf**
10. Waser, Nickolas M. and Jeff Ollerton. *Plant-Pollinator Interactions: From Specialization to Generalization.* Chicago, IL: The University of Chicago Press, 2006.



PROTECTING POLLINATORS

Be a citizen scientist! Make observations of pollinators in your area and record what you see. Report your findings on the JourneyNorth website (www.learner.org/jnorth/) or download their app to note your observations and upload pictures of the pollinators you find!

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ANSWER KEY – ACTIVITY 2A

HOW DO ANIMALS POLLINATE FLOWERS? LESSON 2 ACTIVITY SHEET 2A

Pollinator Adaptations

After you watch the *Beauty of Pollination* clip or additional film clips from Disneynature **WINGS OF LIFE**, record the adaptations you saw. Use the word bank below to help you identify the adaptations of each animal. Then match the pollinator to the flower it pollinates.

POLLINATOR ADAPTATION WORD BANK

long nose • wings • long tongue • long beak

Long-nose bat

Observations:
Eyes: Has great vision at night.
Mouth and Nose: Long nose, long tongue
Body: Wings
Other Observations:
The Flower I Pollinate is: Saguaro Cactus

Hummingbird

Observations:
Eyes: Can see bright colors like red and orange.
Mouth and Nose: Long, bill, long tongue
Body: Wings
Other Observations:
The Flower I Pollinate is: Firebush

Firebush

Milkweed

Saguaro Cactus

Tomato Plant

PROTECTING POLLINATORS

Get people "buzzing!" Check out wildlife field guides, visit your library and contact your local or state wildlife department to learn more about the pollinators in your area. Then, share this knowledge to inspire others to care!

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ANSWER KEY – ACTIVITY 2B

HOW DO ANIMALS POLLINATE FLOWERS? LESSON 2 ACTIVITY SHEET 2B

Pollinator Adaptations

After you watch the *Beauty of Pollination* clip or additional film clips from Disneynature **WINGS OF LIFE**, record the adaptations you saw. Use the word bank below to help you identify the adaptations of each animal. Then match the pollinator to the flower it pollinates.

POLLINATOR ADAPTATION WORD BANK

antennae • wings • proboscis • pollen baskets
hair • long legs • buzz pollination

Bumblebee

Observations:
Eyes: Can only see yellow and blue (not red). Can see ultraviolet light.
Mouth and Nose: Proboscis
Body: Wings, antennae, pollen baskets, hair
Other Observations: Buzz pollination
The Flower I Pollinate is: Tomato plant

Monarch Butterfly

Observations:
Eyes: Can see red and purple colors.
Mouth and Nose: Proboscis
Body: Wings, long legs, antennae
Other Observations:
The Flower I Pollinate is: Milkweed

Firebush

Milkweed

Saguaro Cactus

Tomato Plant

PROTECTING POLLINATORS

Get people "buzzing!" Download a free booklet on bees. *Bee Basics – An introduction to Our Native Bees* by Beatriz Mosset and Stephen Buchmann at www.pollinator.org/PDFs/BeeBasicsBook.pdf.

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Pollinator Adaptations

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POLLINATOR ADAPTATION WORD BANK

long nose • wings • long tongue • long beak

Long-nose bat

Observations:
Eyes: _____
_____
Mouth and Nose: _____
_____
Body: _____
_____
Other Observations: _____
_____
_____
The Flower I Pollinate is: _____
_____

Hummingbird

Observations:
Eyes: _____
_____
Mouth and Nose: _____
_____
Body: _____
_____
Other Observations: _____
_____
_____
The Flower I Pollinate is: _____
_____

Firebush

Milkweed

Saguaro Cactus

Tomato Plant

PROTECTING POLLINATORS

Get people "buzzing!" Check out wildlife field guides, visit your library and contact your local or state wildlife department to learn more about the pollinators in your area. Then, share this knowledge to inspire others to care!

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POLLINATOR ADAPTATION WORD BANK

antennae • wings • proboscis • pollen baskets
hair • long legs • buzz pollination

Bumblebee

Observations:
Eyes: _____
_____
Mouth and Nose: _____
_____
Body: _____
_____
Other Observations: _____
_____
_____
The Flower I Pollinate is: _____
_____

Monarch Butterfly

Observations:
Eyes: _____
_____
Mouth and Nose: _____
_____
Body: _____
_____
Other Observations: _____
_____
_____
The Flower I Pollinate is: _____
_____

Firebush

Milkweed

Saguaro Cactus

Tomato Plant

PROTECTING POLLINATORS

Get people "buzzing!" Download a free booklet on bees. *Bee Basics – An introduction to Our Native Bees* by Beatriz Moisset and Stephen Buchmann at **www.pollinator.org/PDFs/BeeBasicsBook.pdf**.

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WHY DO PEOPLE DEPEND ON PLANTS AND POLLINATORS?

LESSON 3

Grade Level: **2-4** | Subject Areas: **Science, Math, Social Studies, Language Arts** | Time Frame: **2 hours**
Background Information: ***What Is Pollination?*** (Page 3), ***How Do Pollinators Help People?*** (Page 5)
Connect with the Film: ***Plants, Pollinators and People*** **and** ***Pollinators and Farming*** **clips from Disneynature WINGS OF LIFE Blu-ray, DVD, or Digital Download.**

VOCABULARY:

biodegradable, fruit, growth cycle, pollinator, vegetable

STUDENTS WILL BE ABLE TO…

- Classify food as fruit or vegetable
- Predict how seeds and plants grow
- Observe plants and write about their observations in a Plant Field Journal
- Discover how plants and animals need each other
- Explain how pollinators impact people

WHAT YOU NEED

- Optional: View *Plants, Pollinators and People* and *Pollinators and Farming* clips from Disneynature **WINGS OF LIFE** Blu-ray, DVD, or Digital *Download*
- Plant Field Journal (or pieces of paper to record your journal entries)
- Black construction paper
- Biodegradable paper egg cartoons
- Container soil
- Flowering plants
- Flowerpots or raised flower beds
- Fruits and/or vegetables
- Magnifying glass
- Paper plates
- Plant food
- Plant seedlings
- Plastic cups (clear)
- Plastic knife (for teacher use only)
- Watering cans/hose

LEARNING ACTIVITIES

1. Discuss the purpose and outcome of pollination with the class. Explain that when a flower is pollinated, it produces seeds, which are often surrounded by a protective and tasty casing which we call **fruit**. Vegetables are the roots, leaves, stems or immature parts of plants. Although the vegetables themselves do not require pollination, the plants that produce them do.
2. Use local, in-season fruits and vegetables that were either organically grown or purchased from a Farmers' Market to ensure that the seeds are viable. Distribute these fruits and vegetables among the class. Have students examine each fruit or vegetable. Do they think they have a fruit or a **vegetable**? What does it look like? What does it feel like? What does it smell like? Where might the seeds be located within the fruit or vegetable? Have students draw and predict in their Plant Field Journals how many seeds they will find.
3. Help students cut the food in half. An apple is especially good for this. A fully pollinated apple should contain 10 seeds. Does it? Students may use a magnifying glass to find and observe the seeds more closely. Compare the different seeds. Why do some fruits or vegetables have more or less seeds? Students should draw and write observations in their Plant Field Journals. As a class, create a chart or Venn diagram listing similarities and differences of the seeds' features. Save the seeds for the planting activity in experiment three of this lesson.
4. Break the class into two or three small groups. In these groups, students will complete two or three experiments to explore conditions for optimal plant growth and connections between plants and animals. Each group will think like a scientist to record their predictions and observations in their Plant Field Journals and share their findings with the class.

Hi, I'm a tomato plant! Before I become the juicy red tomato you put on your sandwich or the tomato sauce that covers your pizza, I start life as a little yellow flower. My world depends on the power of a single pollinator – the bumble bee.

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EXPERIMENT 1 – Seed in a cup: Do seeds need sunlight and soil to grow?

a. In this experiment, students will:
   i. Write their names on clear plastic cups.
   ii. Roll up a sheet of black construction paper and fit it into the plastic cup.
   iii. Fill the cups with water and wedge the seeds from their fruit or vegetable between the black construction paper and the cup, half way down and in a row.
   iv. Place one cup in a cabinet - place the other cups near a sunny window.
   v. Write predictions in their Plant Field Journal about what will happen to the seeds in the sunny light versus the seeds in the cabinet. Predict if the seeds will produce roots and sprout in water without soil.
   vi. Record daily observations about seed growth in Plant Field Journals. Compare seed growth in the sun versus seed growth in the dark. Do any seeds fail to sprout? Do roots or stems emerge first? How many days does it take for the seeds to produce roots? How much does the sprout grow over one week? Measure the water in the cup. Does the amount of water change each day? Why or why not? Share findings with the class.

EXPERIMENT 2 – Seedlings in an eggcup and soil: Do seedlings grow inside and outside?

b. In this experiment, students will:
   i. Fill two **biodegradable** egg carton sections three-quarters of the way full with moist planting soil.
   ii. Plant seedlings in each section. Plants that do well when started inside include squash, tomatoes and pepper or visit the Pollinator Partnership website (www.pollinator.org) and enter your zip code to find a list of native plants for your area.
   iii. Place one carton inside by a sunny window. Place the other carton outside where it can be observed from the window.
   iv. Record daily observations by drawing and writing in their Plant Field Journal. Measure the height of the plants daily. Keep track of how much water is needed to keep the soil moist inside and outside. Does one location require more or less water? Do the seedlings outside attract any pollinators? Share findings with the class.

EXPERIMENT 3 – Do flowering plants in an outside container garden grow and attract pollinators? (Optional)

c. Teacher note: Bring in more mature native plants purchased from a local nursery. Purchase flowers and vegetable plants (like tomatoes - they grow quickly) that will attract local pollinators. A wide variety of flowers (different shapes, sizes and colors) will attract a greater number of pollinators.

d. To create a container garden, students will:
   i. Help select plants. Visit the Pollinator Partnership website www.pollinator.org and enter your zip code to find a list of native pollinator plants for your area. Be sure that the plants selected are close to the flowering stage.
   ii. Choose the site. Select a sunny spot in a flat area and remember, you do not need a lot of space. You can plant your garden along the edges of fences, in window planters, in a collection of flowerpots or in a space for a larger garden.
   iii. Plant the flowering plants in a container with soil, following the directions on attached tags. Place nectar-producing flower containers around the edges of the other plants, where pollinators can easily see them. Place larval plants (milkweed, fennel or thistle) in the center. You may choose to place other items for pollinators in your garden as well, such as a small pan of water (for pollinators to drink), pieces of bark (where some pollinators may lay eggs), a small bowl of mud (for bees and wasps), overripe bananas, oranges or other fruit and rocks (butterflies will eat the fruit and will sun themselves on the rocks).
   iv. As the plants grow, students (with adults help) should place stakes or wire cages around them to support their growth.
   v. Record daily observations by drawing and writing in your Plant Field Journal. Gently measure the height of the plants daily. Keep track of how much water is needed to keep the soil moist.
   vi. Discuss your gardening results as a class. Do some plants require more or less water? Do the flowers on the vegetables or fruits change? Do the flowering parts of the plants attract pollinators? If so, which pollinators visit the plants?

WRAP UP & CHECK FOR UNDERSTANDING

1. Use the following activities to wrap up your lesson:
   a. [Optional] View the *Plants, Pollinators and People* film clip (36:40-40:10 on Blu-ray, DVD, or Digital Download) where we see bats fly to cactus fruit and learn that they drop the seeds, scattering them across the desert. Next, watch people harvesting, selling and eating the cactus fruit at a farmer's market. Finally, watch as people plant the seeds and grow the cactus in their gardens, too. Discuss how this segment of the film illustrates the connections among people, pollinators, plants and **growth cycles**.

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b. Have small groups of students present what they learned from observing plants at different stages of the growth cycle. Have students discuss how their observations compare to the connections they saw in Disneynature **WINGS OF LIFE**.

EXTENDING THE LESSON

SCIENCE: Create a **pollinator** pizza! Pollinators are very important to people. Students will make a pizza with items that depend on pollinators. Have students use English muffins as the base. Provide them with tomato sauce and a variety of toppings such as pineapple, avocado, spinach, eggplant, peppers, onions, oregano, garlic and basil. Also include cheese and any meat toppings such as sausage or pepperoni. Be sure to check for any allergies before students make their pizza. Have students construct their pizza as you talk about the importance of pollinators. Which foods are made possible by pollinators? What would the pizza look like without pollinators? (Students would just be left with crust. Even meat and cheese wouldn't be possible without pollinators. Alfalfa hay, the major crop grown to feed livestock (from which we get both meat and cheese), depends on pollinators such as leafcutter bees and honey bees). Why is it important to protect pollinators? Cook the pizzas in a toaster oven to have a party that celebrates pollinators everywhere! Students may also view the three minute video **(www.natureworkseverywhere.org/video-tour)** about what would be left if you removed food that relies on pollination from a picnic.

SOCIAL STUDIES: View the *Pollinators and Farming* film clip (57:28-1:00:55 on Blu-ray, DVD, or Digital Download). Take a class trip or suggest that parents take their children to a local Farmers' Market. Invite them to explore the entire market, keeping a list of the types of fruits, vegetables, flowers and products sold there. Have some fun and taste as many new vegetables as possible. Compare flavors of different types of tomatoes or other vegetables. Then, interview the farmers using a few of the following questions: How do you know what to plant, when to plant and how to plant your vegetables? Does the climate play a role in your plant selections? Have gardens in your community changed in the past decade or two? What are heirloom vegetables and flowers? Have heirloom seed banks been created? If the children take pictures, they can make photo essays and share findings with classmates.

RESOURCES

FOR STUDENTS:

1. Art Lesson-Draw an animal. **www.hellokids.com/c_17782/ activities/how-to-draw-step-by-step-drawing-tutorials/learn-how-to-draw-wild-animals/how-to-draw-a-bee**
2. Cole, Henry. *Jack's Garden.* New York, NY: Greenwillow Books, 1997.
3. Life Science: Fruit and Dispersal. Annenberg Learner. **www.learner.org/courses/essential/life/session4/closer4.html**
4. Gibbons, Gail. *From Seed to Plant.* New York, NY: Holiday House, 1991.
5. Gibbons, Gail. *The Vegetables We Eat.* New York, NY: Holiday House, 2008.
6. Madison, Alan and Kevin Hawles. *Velma Gratch and the Way Cool Butterfly.* New York, NY: Schwartz & Wade Books, 2007.
7. Nature works. **www.natureworkseverywhere.org/video-tour**
8. Paper Flower Making. **www.wikihow.com/Make-Tissue-Paper-Flowers**
9. Sandved, Kjell B. *The Butterfly Alphabet.* New York, NY: Scholastic, 1999. Ages 4 and up.
10. Zoehfeld, Kathleen Weidner and Priscilla Lamont. *Secrets of the Garden: Food Chains and the Food Web in Our Backyard.* New York, NY: Alfred A. Knopf/Random House, 2012.

FOR TEACHERS:

1. Container garden information. **www.ohioline.osu.edu/hyg-fact/1000/1647.html**
2. Edible Schoolyard Project. **www.edibleschoolyard.org**
3. Garden resources. **www.eeweek.org/resources/garden_curricula.htm**
4. Garden wizard. **www.schoolgardenwizard.org/wizard/make/**
5. Grants for school gardens. **http://www.kidsgardening.org/node/61894**
6. How to start a garden. **www.growtolearn.org/view/howtostartagarden**
7. Kids gardens. **www.kidsgardening.org/node/11941**
8. McDonald, Megan. *Insects Are My Life.* New York, NY: Orchard Books, 1995.
9. Rosenblatt, Lynn. *Monarch Magic!: Butterfly Activities and Nature Discoveries.* Charlotte, VA: Williamson Kids Good Times! Publishing, 1998.
10. Teacher Created Resources (Staff). *Animal Lives: Bees and Wasps.* Westminster, CA: Teacher Created Resources, 2007. Ages 7 and up.
11. Wallace, Nancy Elizabeth. *Fly Monarch! Fly!* Tarrytown, NY: Marshall Cavendish Corporation, 2008.

PROTECTING POLLINATORS

Keep your fruits and vegetables pollinator-friendly! Shop for locally grown organic produce to help support farmers and protect pollinators. At home, avoid using harmful pesticides in your garden. Opt for natural pest control, such as native ladybugs, assassin bugs and spiders. If you must use a pesticide, choose one made from natural sources and try to spray only at night when most garden pollinators are not active.

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HOW CAN TECHNOLOGY HELP REVEAL NATURE'S SECRETS?

LESSON 4

Grade Level: **2-4** | Subject Areas: **Science, Language Arts, Art, Music, Mathematics, Social Studies**
Time Frame: **1 hour** | Background Information: ***How Was The Plant And Pollinator Partnership Filmed?*** (Page 6)
Connect with the Film: ***Opening Flowers*** **and** ***Hummingbird*** **clips from Disneynature WINGS OF LIFE Blu-ray, DVD, or Digital Download**

VOCABULARY:

Flip book, frame, photography, procedure, process, stop-motion animation, time-lapse photography

STUDENTS WILL BE ABLE TO…

- Use technology to alter perception of time to observe and illustrate the movement of plants and animals that are not easily observable with the human eye
- Explain how technology helps scientists study things about plants and animals that are not observable with the human eye
- Create a flip book animation

WHAT YOU NEED

- White construction paper
- Thick black markers
- Cell phone with an animation app, such as iMotion HD app (Free) or a digital camera and a computer with Power Point/slide show software
- Activity Sheet 3: Make a Hummingbird Flip Book
- Small notebooks (2"x4")
- Pencils and crayons
- Simple Calculators
- Stop Watch

LEARNING ACTIVITIES

1. Have students share their personal experiences and knowledge about how flowers open or move their petals. As a class, view the Disneynature **WINGS OF LIFE** trailer on **www.disney.com/wingsoflife** or [optional] the *Opening Flowers* film clip (13:54-14:36 on Blu-ray, DVD, or Digital Download). Ask students to watch how flowers and their petals move.
2. After viewing, ask students how much time it would take for flowers to open and close their petals if they were viewing the film in real time (depending on the flower they can take between five and 20 minutes). Would they be able to see a flower opening and closing if they watched the flower for five minutes? One hour? One day?
3. As a class, discuss how students think the filmmakers were able to show the flowers opening and closing their petals in just one or two minutes. You may want to even show the scene and have students time how long the film took to show the opening and closing of a flower's petals. Explain that technology can help filmmakers and scientists better understand processes in nature. Time-lapse is a filming technique that seems to speed up time because every **frame** or photographic image is separated by a fixed amount of time. For example, photographs or frames of clouds taken from the same position once every two to 30 seconds and then played back at normal speed shows clouds moving across the sky at a faster rate than is seen by the human eye. Stop-motion is an animation technique in which every frame is separated by varied amounts of time. For example, after a frame of an apple is taken, the photographer can take a bite out of the apple, and then take another frame. This **process** may be repeated at different time intervals. When played back, the apple looks as if it's being eaten at different rates of speed until nothing is left but the core. A **flip book** is an animation technique that involves drawing a series of frames of related pictures on the pages of a note pad. Flipping the edges of the note pad at a fast rate produces a continuous animation.
4. Students can work in small groups (two or three students per group) to make their own time-lapse film of a flower over a period of one day. Find a flower on the school grounds or bring in a flowerpot. Have students set-up a camera so they can take several photos of the same flower at 30-minute intervals throughout the school day. Import the photos into a slide show program on a computer. Play back the photos at fastest speed (in a loop) and watch what a day in the life of a flower is like! After viewing, ask the following discussion questions: What new things did you learn about the flower you took pictures of during a whole day? Did any creatures visit the flower when you were taking your photos? Did your flower move? If yes, what caused the flower to move?

Hi, I'm a Western Long-tailed Hermit hummingbird!
Hummingbirds are known for our acrobatic ability. We can fly upside down and backwards and beat our wings at 70 times per second in normal flight or an amazing 200 times per second in a power dive! Impressive, but can you imagine trying to catch this on camera?

Disneynature WINGS OF LIFE

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5. Stop-motion writing:
   a. Find a place with natural light for a photo area.
   b. Distribute a stack of white construction paper and thick black markers to each group.
   c. Have each group write and photograph the first letter of the name of a flower or pollinator on a piece of construction paper. Then write the second letter and photograph, and continue until name is completed. Groups can also add artistic embellishments, such as a growing flower, movement of the pollinator, or a vine that expands in each photograph.
   d. Take at least five photographs of the final name, fully spelled so it will appear long enough on the screen for viewers to be able to read. The rest of the letters will go by quickly.
   e. Import the photos into a cell phone app such as iMotion HD, or transfer to a computer and upload the photos into a slide show program such as Power Point.
   f. Save the stop motion animation or slide show and play as a video for the class to enjoy.
   g. After viewing the animation, discuss as a class the procedures and processes involved in making the film and how this relates to work done by photographers and scientists who worked on Disneynature **WINGS OF LIFE**.
6. Make a hummingbird flip book: Students become stop-motion animators and mathematicians by using a low-tech art option: a flip book.
   a. Distribute Activity Sheet 3 and view the Disneynature **WINGS OF LIFE** *Hummingbirds* clip on **www.disney.com/wingsoflife** (or 14:44-17:12 on Blu-ray, DVD, or Digital Download) that captures hummingbirds flying and drinking nectar from flowers.
   b. Students will calculate how fast they need to flip the pages to simulate the flight of a hummingbird.
   c. Guide students to complete the activity and discuss their answers.
   d. Complete the optional math extension for students grades 4-6.

WRAP UP & CHECK FOR UNDERSTANDING

7. Use the following activities and discussion points to wrap up your lesson:
   - Explain how slowing down or speeding up viewing time may help scientists learn more about flowers and pollinators. Some pollinator and flower interactions occur within the time span of a few seconds. By slowing down the action, scientists observe how hummingbirds' wings help them hover over a flower long enough to drink nectar and contribute to pollination.
   - Discuss the procedures and processes involved in the stop-motion writing activity. How does this activity relate to the work done by photographers and scientists who created Disneynature **WINGS OF LIFE**? A process is a natural series of changes. For example, a process occurs when leaves change color during the fall. A procedure is a series of actions conducted in a certain manner or an established way of doing something. For example, cooks who precisely follow a recipe are following an established procedure. Disneynature **WINGS OF LIFE** filmmakers used technology to capture the process of a natural series of changes, as in the movement of flowers or the activities of pollinators. Students used technology to conduct a procedure that enabled them to show selected moments of an activity - removing the actions of hands writing on paper so that letters and movements of drawn pollinators or flowers appear in an animated sequence.

EXTENDING THE LESSON

SCIENCE AND LANGUAGE ARTS: Create a "Diary of a Pollinator" using flip book animation. Use a Post-it note pad to create an illustrated flip book story about a pollinator in your own yard. Observe the insect and ask these questions: Where does it live? Is it alone or with others? What does it eat or drink? How does it interact with the resources in the yard? How does it move? One way to organize your flip book story is to take the pollinator's point of view and turn your observations into a fictional narrative. To help show change of time over one day in the life of your insect, draw the sun on the left side of the first page and move it slightly up and to the right on the following pages until it ends on the right side of the last page. Remember to write a title and your name as author on the first page of the flip book.

MUSIC: Using different forms of technology, not only can we slow down or speed up video, but we can also change the way music sounds by adjusting the speed of the playback. Invite students to view and listen to a piano/synthesizer version of "Flight of the Bumble Bee" (**www.youtube.com/watch?v=mLamlulovA4**). Have them close their eyes and listen to the music again. What words describe the shape of the melody? Is it smooth or jagged or something else? Slowing the speed of the playback changes the tempo of the music (the speed of the beat), so what does it do to the length of the sounds? Listeners should determine that slowing down the playback not only slows the tempo, but also makes each sound last longer.

ART: Create a time-lapse movie of your class constructing a collage mural of a garden that includes flowers, vegetables, fruit and pollinators. Students can create flowers out of recycled glossy magazine pages (**www.spoonful.com/crafts/glossy-paper-flowers**). They can create bugs out of various materials (**www.spoonful.com/crafts/animal-bug-crafts/bug-themed-crafts/bug-crafts**). Set-up the camera and take photos every 10 seconds as children take turns adding their flowers and pollinators to the bulletin board. Write down the amount of time it takes to complete the collage mural. Import the photos into a slide show program on a computer. Play back the photos at fastest speed (in a loop) and watch how everyone looks as they scurry around like ants! After viewing, ask the following discussion questions: How long did it take to put up the bulletin board? How long did it take to view the video of the bulletin board creation? What did they learn about their creative process or their patterns of movement after watching the fast speed video?

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RESOURCES

FOR STUDENTS:

1. Crew Earth Observations Videos. **http://eol.jsc.nasa.gov/Videos/CrewEarthObservationsVideos/**
2. Cronin, Doreen. *Diary of a Worm.* NY, New York: Scholastic 2004
3. "Flight of the Bumble bee" YouTube. **www.youtube.com/watch?v=mLamluIovA4**

FOR TEACHERS:

1. Free Scores. **www.free-scores.com/download-sheet-music.php?pdf=679**
2. How to Make a Flip Book With Kids. **www.ehow.com/how_12066300_make-flipbook-kids.html**
3. Rufus Butler Seder: Cine Spinners A New Breed of Optical Toys. **www.designboom.com/portrait/rufus.html**
4. Technology in Environmental Education. Wilderness, Plain and simple. **http://islandwood.org/school_programs/studies/technology/Tech_In_EE.pdf/view**
5. Gibbons, Gail. *Click 1: A Book about Cameras and Taking Pictures.* Boston: Little Brown and Company. 1997.
6. McGuiness, Elle J. *Bee & Me.* Denver, CO: Accord Publishing 2008.
7. Seder, Rufus Butler. *Waddle! A Scanimation Picture Book.* New York, NY: Workman Publishing Co. Inc. 2009.
8. Tucker, Jean S. *Come Look With Me: Discovering Photographs With Children.* Charlottesville, VA: Thomasson-Grant. 1994.

GLOSSARY

Adaptation: A trait that helps a plant or animal survive in its environment.

Anther: The part of a flower that makes pollen grains.

Biodegradable: An object that can be broken down by living organisms.

Buzz pollination: The process in which a bumble bee rapidly vibrates its flight muscles to shake up and cause thousands of pollen grains to shoot out the anther pores. About eight percent of the world's flowering plants require buzz pollination.

Color vision: The ability to see in color.

Energy: The ability to do work; energy (usually in the form of food) provides living things with the ability to survive.

Filament: Stalk that supports the anther in a flower's stamen.

Flower: The reproductive part of a plant that makes seeds.

Flip book: Type of animation that involves drawing a series of pictures of similar images on the pages of a note pad. Flipping through the edges of the note pad at a fast rate produces continuous animation.

Frame: One of a series of images that makes up a film.

Fruit: A protective, and nutritious, casing around the seeds of a pollinated plant.

Grow: To become larger by natural development; increase.

Growth cycle: The sequence of changes that a living thing goes through as it grows and develops.

Habitat: A place where plants and animals find everything they need to survive.

Leaves: The part of a plant that turn sunlight, carbon dioxide and water into food (sugars).

Migration: To move from one place to another in search of the climate or resources (food, water, shelter) needed to survive.

Photography: The art of taking pictures.

Plant: A multi-cellular living organism that makes its own energy through the process of photosynthesis.

Petals: The colorful parts of a flower that help attract pollinators.

Pistil: The female part of a flower that produces egg cells. If fertilized, these will become seeds within a soft or hard fruit.

Pollen: The fertilization powder produced by flowering plants.

Pollen baskets: Smooth concave areas with stiff hairs on the hind legs of a bumble bee or honey bee that they use to transport pollen back to the nest. The pollen is wetted with nectar or saliva to hold it together.

Pollinator: An animal that helps to spread pollen between flowers.

Proboscis: Elongated mouthparts, forming a drinking tube, used by some insects, especially butterflies, moths and some bees.

Procedure: A series of actions conducted in a certain manner.

Process: A natural series of changes.

Roots: The part of a plant that grows down into the soil and transports water and nutrients from the soil to the stem of the plant.

Stamen: The male part of a flower that includes the pollen-producing anthers.

Stem: The main support for a plant that moves water and nutrients to the leaves.

Stigma: The female part of a flower that is sticky. This catches and holds the pollen grains. Pollen tubes grow down and sperm cells fuse with the eggs inside the pistil.

Stop-motion animation: An animation technique in which every frame is separated by varied amounts of time.

Time-lapse photography: A type of filming that appears to speed up time because every frame or photographic image is separated by a fixed amount of time.

Ultraviolet light: A type of light with shorter wavelengths than visible light that some insects can see. This is the light that causes sunburn if you stay outdoors too long.

Vegetable: The roots, leaves, stems or immature parts of plants.

PROTECTING POLLINATORS

Visit an AZA accredited zoo **(www.aza.org)** to see bees, butterflies, birds or bats in person. Take a digital camera or video camera with you to film these animals or another amazing animal you find! Use your footage and movie editing software to create your own nature documentary. Share your film with friends, family, or your class to encourage them to care for wildlife and wild places everywhere!

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Make a Hummingbird Flip Book

Be an animator and a mathematician! Create your own flip book using the instructions below.

PROCEDURE:

1) VIEW THE CLIP *HUMMINGBIRDS IN FLIGHT* AND TAKE NOTES:

- Hummingbirds can beat their wings up to 200 beats per second.
- Hummingbirds hover so they can have time to drink nectar from flowers.

2) MAKE YOUR FLIP BOOK:

Visit www.wikihow.com/Draw-Hummingbirds to learn how to draw a hummingbird or make your own drawing. Be sure to keep the small notebooks or post-it note pads together. Do not separate the pages.

a. Start on the last sheet of the small notebook and draw a picture of a hummingbird in the middle of the page.

b. Turn to the next sheet from the bottom and press the paper down to see the outline of the bird from the page below. Trace over the central body of the hummingbird but draw the direction of the wings in reverse (either up or down – pointing opposite of the first drawing).

c. Repeat the process until you have 20 sheets drawn (10 in each alternating position).

d. Go back and color each picture of the hummingbird in the same way. Look at the hummingbirds in the WINGS OF LIFE clips or Blu-ray to determine your bird's color scheme.

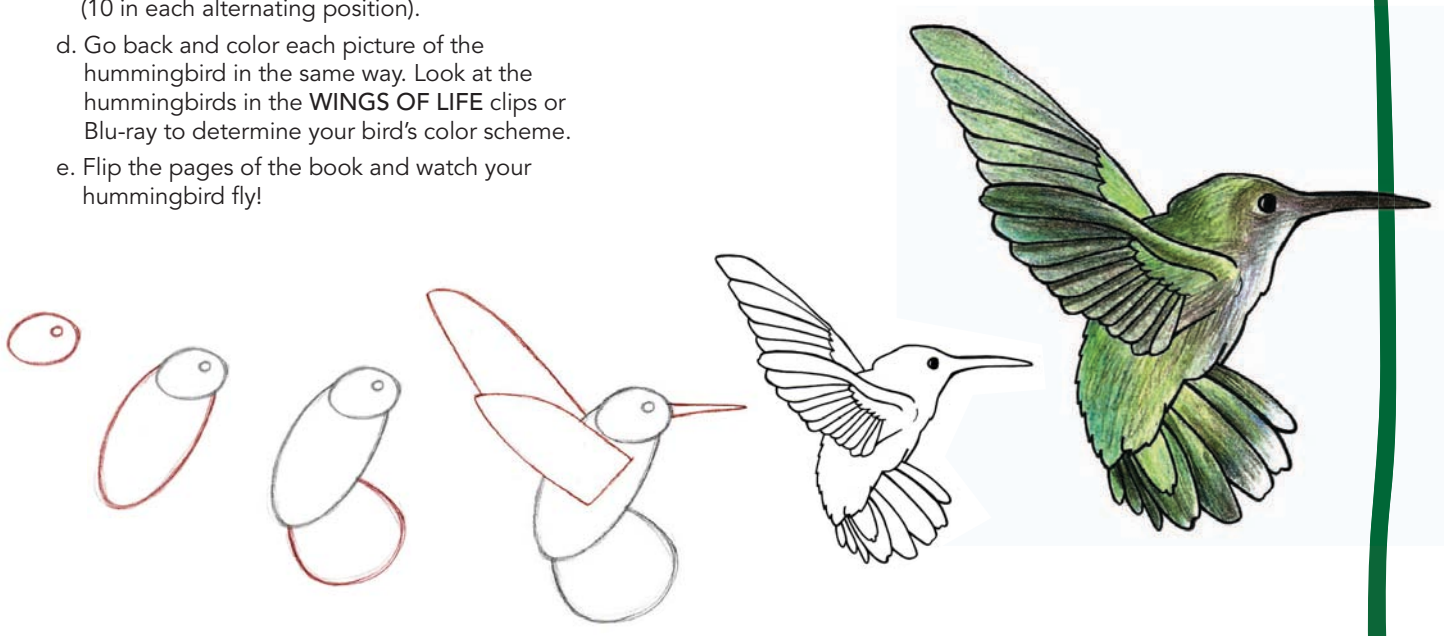
e. Flip the pages of the book and watch your hummingbird fly!

MATH EXTENSION:

MAKE A HUMMINGBIRD FLIP BOOK (GRADES 4 – 6)

Flip the pages using different speeds. Calculate how fast you would need to flip the pages to simulate a hummingbird's wings in flight:

- Flip the 20 pages of your flip book as fast as you can and have a partner use a stop watch to time how long it takes. Use this information to calculate how fast your hummingbird beat its wings (divide 10 by the time it took – one beat takes two pages).
- Ask students how fast they would need to flip their 20 pages in order to have their hummingbird beat 200 beats per second. Remember that each beat (wings up and wings down) takes two pages of your flip book, so your 20 pages represents only 10 beats. You need to flip fast enough so that the hummingbird would be beating its wings at 200 beats per second. How long would it take the hummingbird to just beat its wings 10 times rather than 200 times? How many tens are in 200? (20x10=200). So you would need to flip 20 of your flip books in one second, or one flip book in 1/20 of a second.



PROTECTING POLLINATORS

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