

Pollinators Around Us

STEM Pillars

Informal Audience

Families with children aged 6–10 years old (K–5th grade).

Content Goal

Pollinators have diverse traits and unique observable behaviors that influence their life in the colony.

Practice Goal

Collect data and conduct biological observation of pollinator specimens and bumblebee mini-colonies.

Affinity Goal

Pollinators are important to me, my family, and my community.

Driving Question

How do bumblebees work together in a colony?

Teaching Style

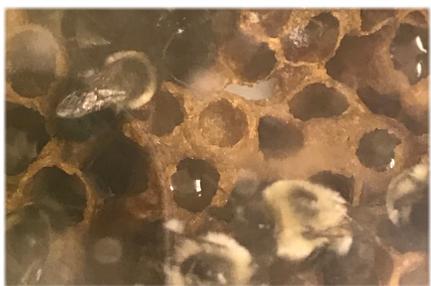
Narrative, free-form exploration, driving question, content, exploration of the driving question.



Pollinators Around Us Summary

Families work together to understand how pollinators have diverse traits and unique observable behaviors that influence their life in a colony. Families will examine preserved pollinator specimen's physical traits, and the behaviors of bumblebees in mini colonies.

This workshop is for children and adults working together. This curriculum is written to be facilitated by entomologists, horticulturists, life scientists and extension agents in the community. This curriculum assumes that you are a competent bee handler who can transport and secure bees for both the safety of the bees and the people participating in the workshop.



Talk supports learning!

Look for **blue family-focused prompts** throughout this curriculum. Our team has developed questions to encourage families to talk together at their tables.

Think-pair-share strategy:

The question format is for you to ask questions about which families can **think** together and then interact (**pair**) with each other before being asked to **share** their ideas with the group.

For example, you can begin a family prompt by saying, “**Take a moment to discuss with your family ...**”

When you see these prompts, **give the families 2–3 minutes to talk**. Then, you can ask for a volunteer to share their ideas with the larger group.

If families are engaged in conversation, you are helping them to **make connections to life science**. This family talk time will increase learning outcomes and affinity towards life science and pollinators!

Teaching with Project-based Learning

This workshop curriculum was designed with the **project-based learning teaching strategy** for parents and children working together. This means each workshop includes teaching strategies that are NOT lecture-based. Instead, you will facilitate families to:

- ✦ engage in **free-form exploration** with scientific tools, concepts, and ideas relate to pollinators and life science
- ✦ work toward answering a **driving question** that transforms early free-form exploration into a developmentally appropriate version of the work that a life scientist does
- ✦ collaborate in scientific work that creates a **product to share with others**.

Project-based learning is a **learner-centered** facilitation style. When you teach with the project-based learning teaching strategy, you do not deliver a lecture to the whole group; instead, you encourage the working teams to talk together. You provide less content at the start to build learners’ prior knowledge of the topic in order to encourage discovery. Because you are empowering small teams (families, in our case) to work, think, and talk together, you provide content after the learners have explored the tools together — rather than providing all content at the start of the workshop. Families then use the content to engage in the workshop once they are familiar with the tools, concepts, and ideas that a life scientist would use!

By using project-based learning, we intend to give families a collaborative style of doing science together that they can continue to use in other settings, such as **museums, libraries, homes, and parks**.



Pollinators Around Us: Overview

Project-based Learning Phase 1: Exploration

- ✦ Tell a story about how you became interested in the life sciences and pollinators.

Family Prompt 1: Take a few minutes to discuss with your family what you think the life sciences are.

- ✦ Brief introduction to topic of pollinators.
- ✦ Introduce part 1 of specimen observation activity: Free-form explore different specimens.

Family Prompt 2: Take a few minutes to discuss within your family what you noticed about the insects you observed. What were their unique and shared traits?

- ✦ Briefly present content about insect types and their shared and unique traits.
- ✦ Introduce part 2 of specimen observation activity: Explore specimens using worksheets.

Project-based Learning Phase 2: Driving Question and Pollinator Content

- ✦ Driving Question: **How do bumblebees work together in a colony?**
- ✦ Content: Introduce the concept of bumblebee colonies; describe the different castes within a colony.

Project-based Learning Phase 3: Behavioral Observation of Bumblebee Colonies

- ✦ Introduce part 1 of behavioral observation activity: Open-ended observation of behaviors in a mini-colony.

Family Prompt 3: Take a few minutes to talk with your family about the things you saw the bees do. What happened when you knocked on the table, covered up the hive with a cloth, and put pollen in the slots?

- ✦ Content: Introduce common bee behaviors by caste.
- ✦ Introduce part 2 of behavioral observation activity: Observations of behaviors in a mini-colony using worksheets.

Family Prompt 4: Now that you have learned about the types of behaviors in the bumblebee hive and types of bees (queen, worker, drone), what did your family learn about how bees divide up the tasks they need to do to survive?

Project-based Learning Phase 4: Share

- ✦ Share: Have families share out their data sheets/observations to the whole group.
- ✦ Wrap-up: Re-address driving question: **How do bumblebees work together in a colony?**

Pollinators Around Us: Curriculum

Project-based Learning Phase 1: Exploration

✦ Start the workshop.

- Begin by introducing yourself and welcoming the families to the workshop.
- Tell a story about how you became interested in life sciences and pollinators.

✦ After introductions, ask:

Family Question Prompt 1: Take a few minutes to discuss with your family what you think the life sciences are.

Facilitation Tip: Provide a few minutes for families to talk. This may feel like a long time, but you are facilitating families making connections.

✦ Introduce pollinators and the study of insects.

- Introduce what pollinators are: animals that move pollen from one flower to another. Explain that most pollinators are insects.

Facilitation Tip: To engage families in this initial content, ask them to list examples of pollinators to engage them in this initial content.

- Introduce entomologists. Say, “Life scientists who study insects such as pollinators are called entomologists.”
- Say, “Today, we are going to work on two parts of an entomologists work. Entomologists study how pollinators develop traits and behaviors to survive. These traits and behaviors are called adaptations. First, we are going to observe specimens to compare their physical features, or their physical adaptations. Second, we are going to observe live bumblebees in mini-colonies to observe behavior adaptations.”

Facilitation Tip: To help younger children in attendance avoid disappointment at the end of the workshop, indicate that the insects, preserved and live, will be borrowed for the day.

✦ Introduce part 1 of the specimen observation activity.

- Distribute vials of preserved specimens: honeybee worker, bumblebee worker, and wasp, one of each per family. Also distribute magnifying glasses.
- Explain that the first activity will involve observing specimens of three different insects. If the families ask, say that the group will discuss what the insects are at the end of the activity.

♦ Engage families in part 1 of the specimen observation activity.

- Say, “Look at these insects in detail and talk about what you see together.”
- Allow families enough time to work through the three specimens.

Facilitation Tip: Walk around to the tables to prompt individual families with questions. Encourage them to think about and observe differences in physical characteristics, rather than telling them the answer during this first stage.

- Provide the queen bumblebee specimen as an extension when families start to wrap up, telling the families that the specimen is a different insect from the others, but do not tell them what type it is.



Photo credit: Bees - Nick Sloff, provided by Center for Pollinator Research; Wasp - [istockphoto.com](https://www.istockphoto.com)

- After a few minutes of specimen observation, bring the families’ attention back to you. Say:

Family Prompt 2: Take a few minutes to discuss within your family what you noticed about the insects you observed. What were the unique and shared traits?

Facilitation Tip: If the families seem stuck, ask them to talk about the size, color, shape, and features of the insects they observed. For example, ask them to compare the wings, eyes, and abdomens of the three insects.

Facilitation Tip: You may need to use an attention-getting technique to get the families’ focus after they work with the specimens. Examples include saying loudly “one-two-three, eyes on me!,” clapping, or ringing a bell.

- After families have a few minutes to discuss, ask them to share their ideas with the group. Ask families to guess what kinds of insects the preserved specimens are.
- Provide content on the three preserved specimen, using the large images of each insect to introduce what they are. Include content on the shapes and traits of the honeybee, bumblebee, and wasp.
- If the queen bumblebee has been passed out, tell children and families that it is also a bumblebee, and hint that the difference in size between the two bumblebees is important when thinking about the next activity, because these bumblebees do different things in a hive.

♦ Introduce part 2 of the specimen observation activity.

- Distribute specimen observation activity worksheet and pencils to families.
- Say, “Record your observations on this sheet, now that you know which insect is which. You can write down observed traits in the blank spots if they are different from the traits included.”
- ✦ **Engage families in part 2 of the specimen observation activity.**
 - Give families enough time to go through the worksheet.
 - When families have completed the worksheet, or appear to be slowing down, briefly go through the worksheet with them, asking the families what they recorded for each trait.

Project-based Learning Phase 2: Driving Question and Pollinator Content

- ✦ **Introduce the driving question: **How do bumblebees work together in a colony?****
 - **Facilitation Tip:** Make sure that the driving question poster is clearly visible to all families. You may want to refer back to this poster and driving question throughout the workshop.
- ✦ **Briefly deliver content on bee castes.**
 - Say, “Bees have different roles within a bee colony. Each role is important, because they each have special adaptations in the form of different behaviors. These bees work together using their adaptations to ensure the survival of the colony.”
 - Explain that the families will learn more about these roles and how these different roles help bee colonies survive through the next activity.

Project-based Learning Phase 3: Behavioral Observation of Bumblebee Colonies

- ✦ **Introduce part 1 of the behavioral observation activity.**
 - Depending on the number of families present and the number of mini bumblebee colonies, either have families work in groups of two, or have families work independently.
 - Distribute the mini-colonies to the families, so that either individual families or groups of two families have one mini-colony to observe (see pg. 11 for hive set up).
 - Remind families that these are live bees, and that even though the cages are securely closed, safety precautions are important. This means that the **cages need to stay on the table** for the duration of the activity.
- ✦ **Engage families in part 1 of the behavioral observation activity.**
 - Ask each family to observe the hive at their table.
 - Say, “The different types of bees have different colors. Pay attention to the colors, and try to see if different-color of bees have different behavior patterns.”
 - Assign each family/group a color of bee to focus on, then ask them to switch every few minutes.
 - Allow the families enough time to observe behaviors of each bee for a few minutes.

Facilitation Tip: (a) As families observe, walk around to the tables to answer questions and encourage them to continue making observations, and (b) As families finish, walk around the tables and give them more challenging things to look for.

- After families have had time to freely observe the mini-colonies, ask families to:

1. Tap lightly on the table near the hive, then observe.
2. Push pollen into the cage tube, then observe.
3. Gently breathe on the colony, then observe.
4. Cover the cage with a cloth, wait 30 seconds, and uncover the cage, then observe.

- After guiding families through these exercises, get their attention again, and ask:

Family Prompt 3: Take a few minutes to talk with your family about the things you saw the bees do. What happened when you knocked on the table, covered up the hive with a cloth, and put pollen in the slots?

- After families have a few minutes to discuss, ask them to share their observations with the group.

♦ **Deliver detailed content on bee castes and bee behaviors.**

- Ask the families what the different color of bees represented, and which of the bees had the most observed behaviors, and which of the bees had the fewest observed behaviors.
- Say, “Remember how we talked about bees having different roles earlier? The different colored bees have different roles in the colony. We call the system of bees having specific, functional roles a caste system. There are three different castes—the queen bee (purple dot), the worker bee (pink dot), and the drone bee (green dot). Both the queen and the worker bees are female, and the drone bees are male.”
- Say, “Now that you know which bee is which, we are now going to talk about the types of behaviors you may have seen the bees exhibit. But first, let’s go over what the behaviors are.” (see pg. 8 for detailed descriptions)

Behavior	Description
Buzzing	The beating of the bee's wings. Buzzing helps remove pollen from flowers.
Collecting pollen or nectar	Workers extend their proboscises to suck up sugar water. They collect and store pollen to feed the brood.
Raising a leg	A defensive behavior that tells unwanted intruders to back away.
Laying eggs	The queen places her abdomen into cells to lay eggs.
Feeding brood	Workers stick their heads into cells to check on larvae and see if they are healthy. If they are hungry, workers feed them pollen.
Visiting honey pots	Workers visit honey pots to drop off nectar or pollen they collect. This food will later be used to feed the brood. Workers also often taste stored food to budget food quality and quantity. The amount and quality of food stored helps bees communicate with one another. If high quality food has recently been stored, this means that more workers should invest time in collecting food for the colony.
Antennating	Bees use their antennae to smell, and will touch pollen and nectar sources with their antennae before eating. They also touch their antenna, or antennate, on other bees to pick up chemical messages, or pheromones, from one another.
Grooming	Bees use their legs to comb pollen grains off their bodies. This pollen is then stored for later use.
Rolling on back and spraying feces (frass)	A defensive behavior that tells unwanted intruders to back away.
Warming eggs	The queen bee lays on top of her eggs, keeping them warm so that they will hatch into larvae.

- Explain that some castes may be more likely to do a certain type of behavior than others, and that the next activity will help illustrate this.

♦ **Introduce part 2 of the behavioral observation activity.**

- Distribute the behavioral observation activity worksheet to the families.
- Say, “Now that you now more about bee behaviors and bee castes, observe the bees in their mini-colonies again and pay attention to which caste is displaying which behavior. Check off the bee behaviors that you see each bee caste do! If you notice a behavior that is not listed, feel free to write it down as well.”

♦ Engage families in part 2 of the behavioral observation activity.

- Give families enough time to make their way through the worksheet.
- Walk around to each family, asking them prompting questions to guide their observations, and answer any questions they may have.
- After families have had enough time to observe, ask:

Family Prompt 4: Now that you have learned about the types of behaviors in the bumblebee hive and types of bees (queen, worker, drone), what did your family learn about how bees divide up the tasks they need to do to survive?

Project-based Learning Phase 4: Share**♦ Share observations and worksheets with the group.**

- After families have a few minutes to discuss the prompt, ask them to share what they discussed.
- Have families share any additional observations they made during part 2 of the behavioral observation activity.

♦ Wrap-up the workshop.

- Provide some additional content about how bees survive as a group. Say, “Bumblebees, like many insects that live in large social groups, like honeybees, ants, termites, and some other animals, like wolves and naked mole rats, split up their work via reproduction, or the creation of offspring or babies. This means that queen bees produce the offspring by mating with drone bees. Worker bees do all of the other work in the colony. This allows the group as a whole produce more offspring, which means survival of the colony!”
- Re-address the driving question: **How do bumblebees work together in a colony?**
- Emphasize that all families engaged in the practices of life scientists and did a great job!
- Answer any remaining questions.

End of the Workshop

Appendix

Pollinators Around Us: Materials

- Pollinators Around Us driving question poster
- Large images of bumblebees (queen and worker), honeybees (queen and worker), and wasps
- Preserved specimen sets: Bumblebees, honeybees, wasps (one set of each per family)
- Magnifying glasses (one per family)
- Bumblebee mini-colonies (one per family or group of two families)
- Dark, opaque cloth (one per family or group of two families)
- Pollen (1 tsp per family or group of two families)
- 2 activity worksheets: Specimen Observation Activity Worksheet and Behavioral Observation Activity Worksheet
- Pencils
- Name tags for workshop attendees and facilitator (optional)

Notes:

1. The specimens can be preserved in multiple ways. One recommendation is to suspend the specimen in hand sanitizer in a small vial.
2. Each bumblebee mini colony can be made from a small plexiglass container, approximately 5x3x3 inches, and should be sealed shut by soldering, duct tape, or superglue. The bees should be labeled with a dot of paint somewhere on their thoraxes. Queen bees should either be purple, worker bees should be pink, and drone bees should be green.

Acknowledgments

The adaptation of this lesson for families and live bees was a collaboration between Christina Grozinger, Rong Ma, Makaylee Crone, Heather Zimmerman, and Katharine Grills with input on the pedagogical format and family discussion prompts from Michele Crowl, Lucy McClain, Soo Hyeon Kim, and Zachary McKinley.

Appreciation to the Penn State College of Education, College of Agricultural Science, Huck Institutes of the Life Sciences, and Center for Pollinator Research.



**This project was made possible in part by the Institute
of Museum and Library Services.**

**For more information, contact:
STEMPillars@gmail.com or heather@psu.edu.**



Pollinators Around Us: Specimen Observation Activity Worksheet



Be a Bee Investigator!

With your family, observe the differences among pollinators. Compare three insects. Record their unique and shared traits using the chart below:

	Honeybee	Bumblebee	Wasp
Ovipositor (long “stinger”)			
Hairy body			
Antennae			
Wings visible			
Narrow waist			
Add your own observation categories below:			

Pollinators Around Us: Behavioral Observation Activity Worksheet

Be a Bee Investigator!

Look at a bee hive. First, with your family, figure out which type of bee is which color:

Queen:_____ **Worker:**_____ **Drone:**_____

Try these activities to see how the bees will react:

Then, record the behaviors you observe from each bee caste using the chart below:

Bee behavior type	Pink Bee	Green Bee	Purple Bee
Buzzing			
Collecting pollen or nectar			
Raising a leg			
Laying eggs			
Feeding brood			
Visiting honey pots			
Antennating			
Grooming			
Rolling on back and spraying feces (frass)			
Warming eggs			