WILD at Schools: Busy Bees

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In part, based on Busy Bees from the Project WILD curriculum

Target Audience: 2nd & 3rd Grade
Time: 1 hour
Location: classroom / area to hold pollination activity / area with flowers

Pre-material:

Book to introduce the importance of bees in the ecosystem:

- What If There Were No Bees?: A Book About the Grassland Ecosystem (Food Chain Reactions) by Suzanne Slade and Carol Schwartz. Picture Window Books (August 1, 2010).

Book and worksheets on the parts of a flower, including directions for a flower dissection:

- The Magic School Bus Plants Seeds: A Book About How Living Things Grow by Joanna Cole (February 1, 1995).
- Worksheets 'Label the Parts of a Flower' and 'Flower Dissection' pages 21-22 http://dnr.maryland.gov/wildlife/Documents/BusyBeesPollinators.pdf

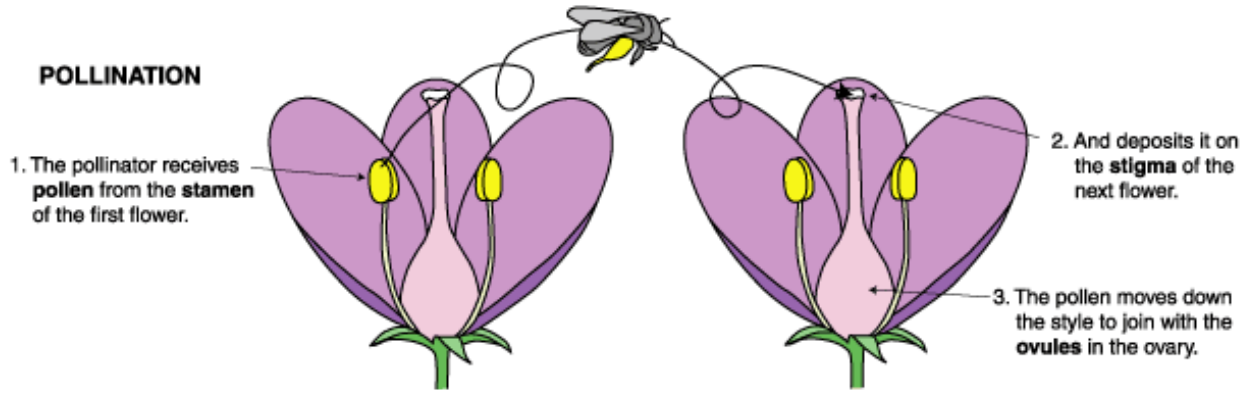
For 3rd Grade students to introduce bumblebees as a native social bee:

- The Bumblebee Queen by April Sayre. Charlesbridge (July 1, 2006).

Background

Plants reproduce via pollination in which pollen is transferred from flower to flower to allow for fertilization. Brightly colored or scented flowers are designed to attract animals to carry out pollination by transporting pollen released by the male **anthers** of one flower to the female **stigma** of a different flower. In comparison, wind pollinated plants have very small or inconspicuous flowers.

Pollinators visit a flower for the rewards they offer, usually nectar and pollen. Pollen is a good source of protein. Some plants also offer oils (which can have medicinal properties), resins or propolis which has antimicrobial properties and is used in nest construction. Once pollen is transferred by a pollinator to the sticky stigma, the pollen travels down the **style** to the **ovary**. In the ovary, the pollen fertilizes an **ovule,** and a seed will form. Many types of animals are involved in pollination particularly insects, birds and mammals. This program will focus on one of the most important group of pollinators: bees.



Bees are one of the best known groups of insects and one of the most economically important. Their pollination activities contribute to many fruits, vegetables, seeds and nuts produced in the United States. Although most attention and knowledge are focused on European honey bees and bumble bees, Earth is home to approximately 20,000 bee species with at least 400 different species in Maryland. Native bees are fascinating insects with unique life histories, behaviors, ecological roles, shapes, colors and sizes. The majority of bee species are **solitary** and nest in the ground. Around 30% of Maryland bees are considered **specialists**, gathering pollen from a limited number of flower species, usually in a single genus and occasionally from a single species.

Bees, like butterflies, go through all the stages of complete metamorphosis**.** They begin their life cycle as a tiny **egg** which hatches into a white, grub-like larva. After feeding, the **larva** develops into a pupa within a **cocoon** from which a winged adult later emerges. In **social** bees, eggs are laid by one female known as the queen and cared for by her workers, usually daughters. In solitary bees (the majority of bee species), each female makes her own nest and collects food to provision for her offspring. Most solitary bees remain in their nest until the following spring/summer. New bumble bee queens leave the nest in the fall and shelter underground for the winter.

Bees have features that make them particularly good pollinators. Friction with the air as they fly causes bees to become slightly positively charged. Flowers have a slight negative charge, so pollen is attracted to the bees by their opposite charge. Honey bees and bumble bees have special structures to carry pollen on their rear legs known as corbicula. Most native bees have long, stiff hairs known as scopa designed to collect pollen located either on their hind leg or, in mason and leaf cutting bees, on the underside of the abdomen. This location allows pollen to be smeared from their abdomens onto the flower's stigma when they walk on the flower and is one reason why these bees are such efficient pollinators.

This lesson will introduce some of the many different animals that perform pollination and look at the diversity of bees. Students will adopt the role of bees and flowers to model the process of pollination in an active simulation. Finally, students will observe bees in the schoolyard to reinforce learning about the connection between pollination and fruit production through direct observation.

Learning Objectives

As a result of this program students will be able to:

- Describe pollination and the types of animals that are involved.
- Explain how diversity and adaptations of plants and animals support pollination.
- Model the process of bee pollination.
- Observe real bees performing pollination services.
- Grade 3 only: Understand that some bees are solitary and some are social and why social behavior can help bees.

Curriculum Standards and Science & Engineering Practices Addressed

Grade	Standard	Detail	Program
2	2-LS2-2 ETS1-2	Develop a simple model that mimics the function of an animal in pollinating plants. Develop a simple sketch or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.	Students mimic the process of pollination. They extend the simulation to include flower diversity. Extension: students build a physical model to illustrate how different pollinators solve the problem of obtaining nectar and pollen from diverse flower species.
3	3-LS2-1 ETS1-2	Construct an argument that some animals form groups that help members survive. . Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem	Students compare social and solitary bees as a survival strategy. Extension: students build a physical model to illustrate how different pollinators solve the problem of obtaining nectar and pollen from diverse flower species.
Science & Engineering Practices		Use information from observations to construct an evidence-based account for natural phenomena. Use a model that represents a concrete event. Conduct a simple investigation to describe relationships in the natural world to answer scientific questions.	Students observe bees visiting flowers and the transfer of pollen to account for the process of pollination. Students model the pollination process. Students observe different bee specimens and their flower preferences to determine which flowers are likely to be pollinated by them.

Key Program Vocabulary

Cocoon: a silky case spun by the larvae of many insects for protection in the pupal stage.

Egg: the first stage in the bee life cycle.

Generalist: refers to bees that will visit a wide range of flower types and species to find pollen and nectar.

Habitat: the natural home of a living organism considered to have four elements: food, water, shelter and space.

Larva: the second, grub-like stage of the bee life cycle.

Native plant: a population of plants within a defined geographic area that exist there without direct or indirect human introduction. For this program, native plant species are those that were present in Maryland before the arrival of Europeans.

Nectar: sugary fluid secreted by plants, especially within flowers to encourage pollination.

Pistil: Female part of a flower consisting of the **stigma**, **style** where pollen tubes form and **ovary** where ovules are fertilized and form seeds.

Pollen: microscopic grains discharged from the male part of a flower that can fertilize the female ovule**.**

Pollination: the transfer of pollen between plants of the same species.

Pollinator: an animal that passes pollen from male to female flower parts of a flower.

Pupa: the third non-feeding stage in the bee life cycle.

Social: refers to bees that live in a colony and share in the task of raising young.

Solitary: refers to bees in which a female builds her own nest and feeds her own young.

Specialist: refers to bees that exhibit a narrow, specialized preference for pollen sources, typically within a single genus of flowering plants.

Stamen: a male part of a flower consisting of a **filament** (stalk-like structure) that holds up the **anther** where pollen is released.

Stigma: a female part of a flower that is sticky to capture pollen.

Equipment / Materials

- Bees in magnifying boxes (optional)
- Bee picture pack (download; 1 set/ 5 students)
- Black, small balloon and yellow tissue paper torn into small pieces on flower picture
- Create-a-Pollinator cards (download)
- Fava beans and 20 yogurt pots
- How to Help Bees (download)
- Magnifying boxes and bee bodies (craft sticks with black felt).
- Bee and flower matching cards (download; 1 set/ 5 students)
- Paper or cloth bags (one per student)
- Pollinator picture pack (download)
- Stickers to represent pollen – yellow and purple
- Flower and bee observation sheet (optional, download)

Before starting program, determine if students have completed some/all of the preparation material and understand the flower reproductive process and parts of the flower. Use the introduction section to determine the current level of understanding by students of the pollination process.

Before the program starts, determine what area will be used for the active pollination simulation. Ideally, it would be best to use a grass playing field if dry or ball courts. If the weather/season is suitable, look for any flowers or even clovers and dandelions where bees may be active adjacent to the activity area. Use this area to allow students to observe bees performing pollination after running the simulation. If weather will allow, the outdoor exploration then reduce the time spent on previous activities.

INTRODUCTION: 5-10 minutes

1. Explain to students that we are going to learn about pollination and pollinators:
   a. Ask students what pollinate means. Answers should include the movement of pollen from one flower to another by a pollinator so the plant can reproduce (make seeds).
   b. Many of the foods we eat are the fruit and seeds of plants that were pollinated by an animal. Ask students for examples of foods that are pollinated by animals. Examples include apples, cherries, blueberries, strawberries, watermelon, peas, beans, cucumbers, sunflower seeds and almonds. Even plants where we don't eat the fruit or seed (like carrots) need pollinators.
   c. Many plants are pollinated by the wind instead of an animal. These plants don't have brightly colored flowers as they don't need to attract an animal pollinator. Instead they produce a lot of very small lightweight pollen that can blow in the wind (causing an allergic reaction in some people). Plants that are wind pollinated include grasses, oak trees and pine trees. Ask students what might be the disadvantage of using the wind as a pollinator. Answers should include that the wind is unreliable and might not be blowing in the right direction.
   d. Plants with brightly colored or obvious flowers are pollinated by animals. Ask students what animals carry out pollination. Examples should include bees, hummingbirds (that pollinate red tubular flowers), bats (that pollinate large flowers that flower at night), some butterflies but more usually moths, beetles and even black and white lemurs (show examples with the Pollinator picture pack). Ask students how do flowers attract different pollinators? Flowers use things like their shape, color, size, smell and when they open, either daytime or nighttime to attract different pollinators.
   e. Ask students what features make an animal a good pollinator. Answers might include fur or hair that pollen can stick to (ask if a bee with a hairy body or wasp with a smooth body makes a better pollinator), animal can travel between flowers (would slugs make good pollinators?), like to visit lots of the same kind of flower (hummingbirds preferentially visit red tubular flowers).

BEE IDENTIFICATION: 10-15 minutes

2. Explain to students that we are going to look more closely at bees because they are such important pollinators. Have students think about what characteristics make a bee a bee by asking some questions for them to think about. Are bees all the same size? What color are bees? Are bees hairy?
3. Demonstrate how static electricity attracts pollen to bees. Blow up a small balloon, have a student rub on hair or clothing and then 'fly' the balloon over pieces of yellow tissue paper on the center of a flower picture. The tissue paper 'pollen' will be attracted to the balloon without being touched.
4. Have students work in groups to look at actual bees in magnifying boxes and enlarged photographs. (If no bees are available, just examine the bee picture pack). Ask students to look at each insect and decide as a group if it is a bee.
5. Have students present their predictions about which of the insects are bees. Explain that these are actually all different species of bees. Ask the students if they are surprised to learn that these are all bees and ones that live in Maryland. Bees can be big or small and can have lots of different colors.

6. Hand out the bee and flower matching cards. Have students try to decide on the names of the bees they have been looking at using the bee name cards and then match each bee species to their preferred flower type. Check the groups made the correct matches using the bee picture pack.
    a. **Number 1** is a honey bee. Explain that these bees are kept by farmers and bee keepers in hives to pollinate their crops and make honey. They pollinate lots of different types of flowers especially weeds like clover. All the other bees the students just looked at are wild bees that take care of themselves.
    b. **Number 2** is a bumble bee. These are hardworking bees that live in a family group and collect pollen and nectar from spring to fall. They often pollinate bell shaped flowers that they can crawl inside as well as flowers in the pea family.
    c. **Number 3** is a green bee. They are solitary bees (find food for their larva themselves rather than with other bees). Green bees often visit very small flowers.
    d. **Number 4**, is a squash bee. It is also a solitary bee. Squash bees are specialists. They only pollinate the flowers of plants in the squash family such as pumpkins, cucumbers and the many types of squash. Squash plants have large flowers and big pollen compared to other flowers so squash bees have widely spaced hairs especially designed to carry it. The hairs look like a comb on their rear legs. Sometimes if you look in a cucumber or pumpkin flower you will see these bees as the male squash bees sleep inside the flowers! The squash bee is a very good pollinator for squash plants as it only visits these plants and doesn't take the pollen to other flowers like a sunflower.
    e. **Number 5** is a mason bee. Mason bees prefer to visit spring blossom such as apple and cherry trees. They are such good pollinators of fruit trees like apples that they are also known as orchard bees and fruit farmers will set up mason bee houses for them.

    Grade 3 extension: Explain to students that some of these bees are social such as the honey bees and bumble bees while the others are solitary.

        i. Ask students what the difference is between animals that are social and solitary. Make sure they understand that social bees work together as a group like a family where everyone shares food. Solitary bees may live close to other bees but don't help feed each other (like neighbors in an apartment block).
        ii. Ask students what are the advantages of living in a group as a social bee. Answers can include: work together to protect nest from a predator, if one of the bees die than the others can care for the larvae (baby bees) so they don't die, just do one job really well (aka specialize).
        iii. Although the green bees are solitary, they often group their nests together. Ask students why this might be helpful. Explain that predators are less likely to attack their nests in groups.
        iv. What are the disadvantages are of living close to other bees? Answers can include both that it increases competition for food (they might have to fly further to find flowers) and that disease may spread more easily.

7. Explain that these bee species are just 5 of the 400 different bee species that live in Maryland. Different bees will often visit and pollinate different flowers. For instance, big bees may pollinate big flowers and small bees may pollinate small flowers. Tell students that we are going to find out more about how the process of pollination works.

POLLINATION ACTIVITY: 20-25 minutes *from the Project WILD curriculum*

8. Explain to students that they are going to pretend to be flowers and bees so they have a chance to be pollinators. Move to an area with space to run the pollination simulations. Have students count off in 3s. Tell all the number 3s they will be 'bees' and the rest of the students will be 'flowers'.
9. **Simulation 1: A field of one flower type**. Explain that the flower students will spread out and then root themselves to the ground. They will have a pot with 10 beans that represent the center of the flower full of nectar rewards for the bees and a sheet of stickers that represent pollen. The flower students put the pots at their feet so bee students have to bend to collect a bean. Explain that bees take one bean per visit to each flower. While the 'bee' is collecting nectar, the 'flower' tries to put a yellow sticker representing pollen onto the bee while also collecting a different piece of pollen (yellow sticker) which they stick on themselves. The 'flowers' should try to get at least 3 stickers of pollen.
10. Tell the bee students that their job is to 'fly' around collecting nectar (but they don't have to worry about collecting pollen). Give the bee students an empty bag to represent their stomach where they can store their 'nectar' beans. Tell the bee students that they need to collect at least 4 beans to survive the day. Give the flower students a pot with beans and a strip of yellow stickers.
11. Remind students that the goal of 'bees' to collect as much nectar as they can. Explain that they cannot visit the same flower twice in a row but that don't have to worry about collecting pollen, that is the flower's job. Remind the flower students that the goal of flowers is to trade as much pollen as possible with other flowers. Allow 'flowers' to spread out then allow the 'bees' to start the pollination activity. Allow the simulation to run for several minutes, then gather students together.
12. Questions to ask students after running the activity:
    a. Did all of the 'flowers' get pollinated (get at least 3 pollen stickers stuck to themselves)? If they didn't, why not? Sometimes flowers out on their own are visited less than flowers that are close together. Students may discover that it can be harder for isolated flowers to be pollinated which would be true for real flowers.
    b. Did all of the 'bees' collect enough food? Ask these students if it was hard work collecting pollen. How can the bee students make their job easier? One answer might be to just visit flowers that are close together. This would also be true for real bees.
    c. Did the 'flowers' manage to both add and remove pollen each time a bee visited? It can be difficult to both put on a pollen sticker and remove one. Sometimes 'flower' students have to focus on doing one or the other and real flowers sometimes also do that. They produce pollen initially and then stop and focus on collecting pollen. In a flower, the stamen produce pollen while the sticky sigma collects it.
13. **Optional: Simulation 2: A field with 2 different flowers**. Explain to students that we just assumed that each flower can pollinate all the other flowers. However, in a real field there would be lots of different flowers and each flower can only be pollinated by a flower of the same kind. We will run the activity again but this time there will be 2 different flowers. The flowers with yellow stickers are

a yellow flower like Black-eyed Susan. Some flower students will now be Purple Coneflowers. Choose 3-5 flower students (depending on class size) and give them pink stickers instead of yellow. Have the flower students spread out and run the simulation again. Let the activity run for several minutes (a short enough time that the purple coneflower students don't collect 3 pink stickers) then gather the students.

14. Questions to ask students after running the 2nd simulation:
    a. Did all the 'bees' collect enough nectar? Bees should be unaffected by the change.
    b. Did all the 'flowers' get pollinated (collect 3 pieces of pollen of the right color)? The smaller the number of each flower species, the harder it will be for those flowers to get pollen from another flower of the same type. This is true for rare flowers in the real world.
    c. Ask students for ways that a flower could attract pollinators to make sure they bees visit. Sometimes students attempt this themselves within the simulation by waving their arms or offering extra nectar. Some flowers offer more nectar or pollen to attract bees to them.
    d. *Only with students who have an advanced understanding of pollination*: Point out to the students that flowers would prefer that a bee visit only another flower of the same species rather than 'wasting' their pollen by visiting many different species of flowers. Explain that some flowers have adapted to try to encourage specialized pollinators to visit only a limited number of flower types. Flowers may have a different shape, color or size so only certain pollinators are able to collect nectar. In Maryland, there are at least 400 species of bees which are attracted to different shapes, sizes and types of flowers.
    e. Ask students if they can think of a way that a flower might attract a special pollinator. An example would be red tubular flowers that attract hummingbirds. Similarly, many bees only visit one type of flower.
15. **Optional: Simulation 3: A decline the number of flowers**. This simulation allows more students to have the chance to pretend to be a bee. Have bees and flowers swap places so there will be more bees than flowers. Have 'bees' empty their stomachs back into the pots. Flowers student who are now to act as bees need to give pot with remaining chips and their pollen stickers to the new flowers. Remind bees that only one bee can visit a flower at a time. (You will need extra bags for bee stomachs as there will now be more bees.)
16. Questions to ask students after running the 3rd simulation:
    a. After the flower decline simulation, ask if all the bee students managed to get enough food. What happens to bees when there aren't many flowers?
    b. Ask the students to suggest what might cause there to be less flowers in an area. Ask if there are many flowers around their school. Is there a larger area of grass or flowers?

OPTIONAL OBSERVATION OF BEE POLLINATION: 10-15 minutes

17. Encourage students to calmly observe bees carrying out pollination. Students may use the Flower and Bee Observation Sheet. Points to direct student observation:

    - Remind students that bees don't want to sting people – they sting only if they think you are going to hurt them or their larvae and some bees can't sting at all. As long as students don't try to stroke a bee or get too close to their nest, they can safely watch a bee on a flower or fly past. The worst thing to do when you see a bee is to start waving your hands wildly because it might think you are trying to hit it.
    - Remind students that windblown pollen causes allergies not pollen from flowering plants (unless they get pollen on their fingers and then rub their eyes).

- Look for different bee species (don't worry about identifying bees, just focus on how one bee is different from another – size, color, number of stripes etc).
- Try to see pollen – is it covering the bee or being carried in a pollen basket?
- Are some flowers more popular than others for bees to visit? Do these flowers have a scent? How are they attracting bees?
- How long do bees tend to stay at each flower before they move on?
- Do bees visit all of the flowers on each plant before they travel to another plant?
- If large, simple flowers are available, point out the stamen (usually a ring around the stigma) that produce pollen and the stigma at the center of the flower which collects it.
- If seed heads are present such as tulips or dandelions, open one to show students ovules/fruit within or point out visible seeds such as dandelion clocks.

18. Use magnifying boxes to capture bees (bumble bees are usually easiest) that are busy feeding so students can safely observe them. Use a 'bee body' (craft stick with black felt) to show how bees get covered in pollen visiting flowers. Put the craft stick into a flower so show how pollen sticks to the black felt. This works best with larger flowers such as daffodils.

CONCLUSION: 5 minutes

19. Many bee species are declining. Ask students what they think that people can do to help bees. Suggestions should include:
    a. Improve their habitat by planting flowers and adding bee homes.
    b. Reduce the use of chemicals. Pesticides kill insects that damage plants but also kill many insects that benefit plants like bees and ladybugs. Try to avoid using chemicals in your yard.
20. Some parts of China use so many chemicals on their apple trees that any bees that visit die. Instead, people have to do the pollination by hand using little paintbrushes. Ask the students to imagine trying to pollinate a whole field of blueberries or beans by hand! It is a much better idea to protect our bees.
21. Ask the students if they think their school yard is a good habitat for bees. How could it be improved? Suggest to the students that they can plant flowers like black-eyed susans.

Student Assessment

Ask students to work in a group to 'fashion' or create a pollinator. Print a set of double-sided Create-a-Pollinator cards or make your own. Assign each group a particular flower card with different characteristics. Students use their imagination to create a pollinator adapted to pollinating that type of flower. Pollinators can either be drawn or preferably created as a 2D or 3D model using recycled materials and craft supplies. The process should focus on creativity rather than realism.

Students should present their pollinator to the class with the following information:

- Name of their pollinator.
- How the pollinator travels from flower to flower.
- How the animal transports pollen.
- Why the pollinator is well adapted to pollinate the flower they were assigned.

Follow-up Activities

Maryland Bee Identification Sheet http://dnr.maryland.gov/wildlife/Documents/CommonBees.pdf
How Can We Help Bees? Sheet.
Create a pollinator cards

EXTRA INFORMATION

Answers to common questions:

Q: Do all bees sting?
A: No, only the females have a stinger and some native bees are too small to sting people (or for you to notice). Honey bee workers do sting and then die.

Q: What is the bee's stinger made of. so it can push through the skin?
A: The stinger is made of chitin (it's tough like our finger nails), a special kind of substance that makes up most of insects' outsides. Chitin can be hard or soft and flexible. In the case of the bee, it is very hard and extremely effective!

Q. How fast can bees fly?
A: 12 to 20 mph.

Q. Do bees sleep?
A: No, but they will rest in their nest and sometimes inside flowers.

Q How many bees does it take to weigh as much as 1 M&M?
A: 10 honey bee sized bees.

Q Were bees on Earth at the same time as the Dinosaurs?
A: Yes. Bees have been around about 100 million years (much longer than humans) and coevolved with flowers.

Q Where do bees carry their nectar?
A: They have a special 'honey stomach' – fun kid fact = honey is regurgitated nectar, but it is stored in a special honey sac and unchanged from the nectar form.

MARYLAND
Larry Hogan, Governor

April 2019
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