



A curriculum and activity guide for Bee Awareness

Biodiversity - Bee Week

Middle School Curriculum



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A. Day 1 Topic: External Observation of a Honey Bee

Focus Question: What adaptations do bees have to be effective pollinators and to survive?

Warm-Up: Students will watch short video (1:06) "Flight of the Bumble (Honey) Bee" to introduce different bee adaptations. As the video is being shown, the instructor will point out different structures that students are going to see in their external observation lab of the honey bee.

Lesson: External Observation of a Honey Bee. Students will follow detailed directions on a lab sheet to complete an external observation of a honey bee, observing the different adaptations that help the bees be effective pollinators and survive.

Post Lesson Assessment: Think – Pair – Share. The instructor will pose question to whole class: "What is the most important adaptation that a bee has to be an effective pollinator and to survive? Students will "Think – Pair – Share" their ideas.

B. Day 2 Topic: Flower Dissection / Insect Pollination

Focus Question: What adaptations do flowers have to ensure their pollination and survival?

Warm-Up: Flowers for the lab should be displayed in a central area where students can look at them. The instructor will write this statement on board for students to answer: Give five examples of how the flowers are different and five examples of how the flowers are alike.

Lesson: Flower Dissection. Through the dissection of a flower, students will explore the different parts of a flower and learn the functions of these parts that

ensure the flower's survival. Different types of flowers need different types of pollinators.

Post Lesson Assessment: Recall Card. On a 3x5 notecard, the students will write down three things that they learned about the structures of a flower. This notecard will be the student's ticket out the door.

C. Day 3 Topic: The Importance of Pollinators

Focus Question: What is a pollinator?

Warm-Up: Why do we care about entomophily? Lead a classroom discussion to help students break down the word into its word parts to discover its meaning and to answer the question.

Lesson: The Importance of Pollinators (PowerPoint). This is the teaching portion of the lesson that focuses on pollinators, especially bees, and their importance to the pollination of food crops and wild plants.

Activity: Field of Plants. How long does it take for humans to pollinate a field? In this activity, students simulate how long it takes to pollinate plants and how the world would be different without pollinators.

Post Lesson Assessment: Tweet About the Importance of Bees. As their ticket out the door, students will "tweet" about the importance of bees, using 140 characters or less.

D. Day 4 Topic: Engineering a Bee

Focus Question: If you were an engineer, how would you create a "bee" to help pollinate plants?

Warm-Up: Robert Wood is an electrical engineer participating in National Geographic's Emerging Explorers program. This short video clip shows the potential of how robotics can impact our lives in the future.

Lesson: Engineering a Bee. Students will "engineer" a bee, using different building materials— pipe cleaners, toothpicks, etc., and reflect back on the adaptations bees need to be effective pollinators.

Post Lesson Assessment: 3-2-1 Ticket. In pairs, students will brainstorm three things their "engineered bees" need to be effective pollinators; two problems with releasing engineered bees into nature; and one way to solve a problem that may result from releasing engineered bees into nature.

E. Day 5 Topic: Pollinators in our World

Focus Question: What can you do to help pollinators?

Warm-Up: The instructor will show examples of different structures that students can build to provide habitat for different types of pollinators. The instructor will ask the students to discuss the purpose of the different structures and guess which pollinator is served by each structure. The instructor will also

ask students to consider how the structure is designed to help that particular pollinator survive.

Lesson: Build a “Bee Helper.” Students will learn about how they can help pollinators and be given the option of building a “bee house” and/or planting seeds of flowers that can provide habitat for bees in their backyard.

Post Lesson Assessment: Postcard to Parents. Students will design a postcard to send to their parents asking them to help pollinators using any of the ideas from their handout.



Introduction

In the mid to late 2000's, beekeepers noticed a problem with their bees. Bees were leaving the hives during the day and not returning. Their hives were not thriving. Thousands of bees were dying, threatening the livelihood of many beekeepers and the pollination of thousands of plants, including crops upon which we rely for food. Scientists investigated the die-off of the bees, calling the problem "Colony Collapse Disorder" (CCD). Unsure of the cause(s), scientists collected data on the numbers of bees being lost each year. The numbers were staggering: 2006-07 saw a 32 percent decline in bee numbers, 2007-08 saw a 36 percent decline in bee numbers, and 2008-09 saw a 29 percent decline in bee numbers. There has been an overall decline or leveling off in the percent of bee losses through the years, with the losses at 23.2 percent for winter 2013-14. Beekeepers consider 18.9 percent as a level that is acceptable for bee loss each year in order to sustain their populations (Kaplan, 2014).

We are dependent upon bees for our own survival. Members of the *Apidae* family (honeybees, bumblebees, carpenter bees, etc...) are the "pollinators of the agricultural world." Bees are vital to the health of our food supply and also wild plant pollination. Their bodies are covered with hair which allows them to pick up pollen and transfer it from plant to plant to promote pollination. Bees are responsible for pollinating one third of the food that we consume on a daily basis; their loss would mean that our food supply would be dramatically reduced. Also, pollinators are very important for maintaining and creating our wild plant populations, basic habitat for wildlife, and to support crops that feed grazing animals, such as cows (Michigan, 2014; Tucker, 2014).

Currently, bee decline appears to have leveled off, but the causes still remain unknown. There are many theories about the reasons for the decline in bee populations. Ideas include global warming, causing flowers to bloom at different times; loss of habitat and diversity in pollen sources due to development; pesticide use on farms; parasites, such as mites; or perhaps a combination of these factors (Sass, 2011).

This one-week module is designed to expose middle-school students to the issue of Colony Collapse Disorder and to give them background knowledge to help understand this problem. Knowledge is the first step towards understanding and becoming an agent of change to help solve this problem.

For other education resources, webcasts, and webinars, "Pollinator LIVE: a distance learning adventure" is a great website, and is sponsored by federal and private partners. <http://pollinatorlive.pwnet.org/index.php>.

Introduction Resources

Kaplan, Kim. "Survey Reports Fewer Winter Honey Bee Losses." ARS : Agricultural Research Service. US Department of Agriculture, 15 May 2014. Web. 13 Feb. 2015. <<http://www.ars.usda.gov/is/pr/2014/140515.htm>>.

"Michigan State University Native Plants and Ecosystem Services." *Pollination*. Michigan State University, 28 May 2014. Web. 02 May 2015. <<http://nativeplants.msu.edu/about/pollination>>.

"Pollinator Live." *Pollinator Live*. USDA Forest Service, n.d. Web. 02 May 2015. <<http://pollinatorlive.pwnet.org/index.php>>.

Sass, Jennifer. Bee Facts. Washington, DC: Library of Congress, National Library Service for the Blind and Physically Handicapped, 1982. National Resources Defense Council. National Resources Defense Council, Mar. 2011. Web. 16 Feb. 2015. <<http://www.nrdc.org/wildlife/animals/files/bees.pdf>>.

Tucker, Jessica. "Why Bees Are Important to Our Planet." One Green Planet. One Green Planet, 17 June 2014. Web. 09 Jan. 2015. <<http://www.onegreenplanet.org/animalsandnature/why-bees-are-important-to-our-planet/#>>.



Bee Week – Day 1

Day 1 Topic: External Observation of a Honeybee

Focus Question: What adaptations do bees have to help them survive and function as pollinators?

Summary: Students will conduct an external observation lab using dried honey bees to look at the different structural components that allow honey bees to be effective pollinators and survivors.

Duration: 1 – 45 minute class period

Vocabulary: structural adaptation, honey bee brood, forewings, hindwings, pollinator

Objectives: Students will

- observe and dissect the external structural adaptations of honey bees
- compare the form of the structural adaptations of honey bees to their functions
- explain how the adaptations allow honey bees to be effective pollinators and survivors

Next Generation Science Standards:

LS2.A: Interdependent Relationships in Ecosystems—Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors (MS-LS2-1)

LS4.C: Adaptation—Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS4-6)

Warm-Up: Students will watch short video, “Flight of the Bumble (Honey) Bee,” to introduce different bee adaptations. As the video is being shown, the instructor will point out different structures that students are going to see in their external observation lab of the honey bee.

Lesson: External Observation of a Honey Bee. Students will follow detailed directions on lab sheet to complete an external observation of a honey bee observing the different adaptations that help the bees be effective pollinators and survivors.

Post Lesson Assessment: Think – Pair – Share. The instructor will pose question to whole class: “What is the most important adaptation that a honeybee has to survive and function as pollinators? Students will “Think – Pair – Share” their ideas.

Day 1 Lesson Plan

Warm-Up: Show the video “Flight of the Bumble (Honey) Bee which shows pictures of honey bees set to Rimsky-Korsakov’s “Flight of the Bumblebee” (1:06). Video is one of a series by *Backyard Beekeeping*.

As the video is being shown, the instructor will point out different structures that students will observe in their external observation lab of the honey bee

<https://www.youtube.com/watch?v=kaZ6DB2Uxc8>

Lesson: External Bee Observation Lab

Students will become familiar with the external structural adaptations of the honey bee that help the insect to be an efficient pollinator and survivor. Bees need nectar and pollen for their survival and the survival of their broods. Nectar is gathered by honey bees and deposited in honeycomb cells in the hive to be used as a food source. Nectar provides energy (carbohydrate) and pollen provides proteins and fats for honey bee broods. As bees collect pollen to take to their hive, they are also pollinating different plants with pollen that has become attached to hairs on their bodies. For the lab, you will need dried honey bees, along with the observation lab worksheet. Before starting the lab, the instructor should ask if any students are allergic to bees and take the appropriate cautionary measures.

Sources for dried honey bees:

Carolina Biological Supply Company:

<http://www.carolina.com/stc-science-elementary-replacement-parts/honeybee-dried-pack/971919.pr?catId=&mCat=&sCat=&ssCat=&question=dried+bees>

Dead Insects.net:

<http://deadinsects.net/Honeybee-Apidae01.htm>

Post Lesson Assessment: Think-Pair-Share

Think—Teacher poses question to whole class: “What is the most important adaptation that a honeybee has to survive and function as a pollinator?”

Pair—Students discuss their opinions related to the question with a partner from another lab group.

Share—Students share their opinions with the whole class.

Day 1 Resources

- Adjare, Stephen O. "Chapter 3 Anatomy of the Honeybee." *Beekeeping in Africa*. Rome: FAO Agricultural Services, 1990. N. pag. FAO Corporate Document Repository. Agriculture and Consumer Protection. Web. 18 Jan. 2015.
<<http://www.fao.org/docrep/t0104e/T0104E06.htm#Chapter%203%20Anatomy%20of%20the%20honeybee>>.
- Blackiston, Howland. "How to Identify the Basic Body Parts of Honey Bees." *For Dummies-- Making Everything Easier*. John Wiley & Sons, n.d. Web. 16 Jan. 2015.
<<http://www.dummies.com/how-to/content/how-to-identify-the-basic-body-parts-of-honey-bees.html>>.
- Huang, Zachary. "Anatomy of the Honey Bee." eXtension Research-Based Learning Network. eXtension, June-July 2014. Web. 18 Jan. 2015.
<<https://www.extension.org/pages/21754/anatomy-of-the-honey-bee#.VLwj9cl1ySp>>.
- "What Is a Bee?" *What Is a Bee?* Canada Agriculture and Food Museum, 2015. Web. 20 Feb. 2015. <<http://bees.techno-science.ca/english/bees/what-is-a-bee/default.php>>.
- "Why Do Bees Need Nectar And Pollen?" *BuzzAboutBees.net*. N.p., 2015. Web. 03 May 2015. <<http://www.buzzaboutbees.net/why-do-bees-need-nectar-and-pollen.html>>.
- Wilson, Tracy V. "Bee Anatomy - HowStuffWorks." *HowStuffWorks*. N.p., n.d. Web. 03 May 2015. <<http://animals.howstuffworks.com/insects/bee1.htm>>.

External Observation of Honey Bee

Name _____ Date _____

Background Information: Honey bees have many interesting structural adaptations to help them survive and function as pollinators. Today you will get an up-close look at those structures, using binocular / dissecting microscopes. During your observations, refer to the drawing for identification of the different parts. You will be using 3-4 honey bees for your observations. Refer to several specimens since some bees will be missing parts due to collection and shipping. You will need to compare bees in order to make accurate observations.

Materials:

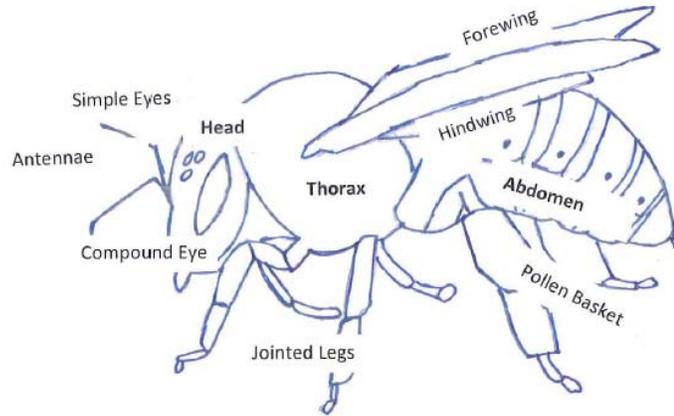
Dried honey bees (3-4 per student group)

Binocular / dissecting scope

Forceps and probe

Ruler

Petri dish



Directions for external observation:

- Using your forceps to hold the bee, look at the bee under the binocular microscope. Look for different parts as you turn your bees around and make an initial survey of your specimens. Bees are covered with little hairs that pick up pollen. Pollen that is not in the pollen baskets can be dropped off at other flowers for fertilization.
- Look for the two sets of wings on your bee (forewings and hindwings). Wings are important for flight so the bee can fly from the hive to the flowers (their food source). Bees are unique in that their two sets of wings “hook” together during flight to make one larger wing. Sometimes, bees “fan” the hive to help cool it off. Use your ruler to measure the length of several forewings and record those lengths for your bees. Draw a picture of a forewing as it looks under the microscope (include the veins and hairs on the wing). The wings are attached to which body part (head, thorax, or abdomen)?

Length of the forewings:	
Draw a picture:	
Attached to what part:	

3. Observe the abdomen of your bees. Use three words to describe the abdomen. Look for the spiracles (holes) along the side of the abdomen. Spiracles are how bees and other insects are able to exchange gases (breathe). Only female bees have stingers—you will probably not see the stinger because it is usually pulled into the body.

Three words to describe the abdomen:	
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4. Find the legs on your honeybee. Bees taste with their feet to locate nectar. Using your diagram, look for all the legs. How many are there and what body part are they attached to (head, thorax, or abdomen)?

How many legs?	
Attached to what part?	

5. Using the drawing, find where the pollen baskets are located on the leg. They are surrounded by several long hairs that help pack the pollen to take back to the hive. Identify that area on the leg. Draw a picture of the back leg and indicate where the pollen basket is located.

Is there pollen in the basket of your bees?	
Draw a picture of the back leg and label the pollen basket.	

6. Examine the head of the bee and locate the compound eyes, simple eyes, antennae, and mouthparts. Each compound eye is made of thousands of light-sensitive cells to see colors and ultraviolet light. Bees have three simple eyes that can only sense light and dark. Locate the two antennae on the top of the head. They are used to feel or touch or smell. Mouthparts: A bee has two mandibles that suspend from the bottom of the mouth and are used for chewing. They also have a proboscis which is a tube for drinking liquids.

Draw the head from the front showing the compound eyes, simple eyes, antennae, mandibles, and proboscis.	
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Bee Week – Day 2

Day 2 Topic: Flower Dissection / Insect Pollination

Focus Question: What adaptations do flowers have to ensure their pollination and survival?

Summary: Students will dissect a flower to learn the different flower parts and how they are built to ensure pollination and survival.

Duration: 1 – 45 minute class period

Vocabulary: dissection, sepals, petals, pistil, stigma, style, ovary, stamen, anther, filament

Objectives: Students will

- Observe and dissect the parts of flowers that help them survive
- Compare the form of the structural adaptations of a flower to their functions
- Explain how the adaptations allow flowers to survive

Next Generation Science Standards:

LS1.B: Growth and Development of Organisms—Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction (MS-LS1-4)

Warm-Up: Flowers for the lab should be displayed in a central area where students can look at them. Instructors will write this statement on board for students to answer: Give five examples of how the flowers are different and five examples of how the flowers are alike.

Lesson: Flower Dissection. Through the dissection of a flower, students will explore the different parts of a flower and learn their functions to ensure the flower's survival. Different types of flowers need different types of pollinators.

Post Lesson Assessment: Recall Card. On a 3x5 note card, students will write three things that they learned about the structures of a flower. This note card will be a student's ticket out the door.

Day 2 Lesson Plan

Warm-Up: Flowers for the lab should be displayed in a central area where students can look at them. The instructor will write this statement on board for students to answer: Give five examples of how the flowers are different and five examples of how the flowers are alike.

Lesson: Flower Dissection Lab. Students will explore the parts of a flower while dissecting a real flower. For the lab, the instructor will need flowers. Sometimes, flower shops will donate “older” but still usable flowers to schools for educational use.

As bees are collecting pollen for their hive, their body hair also picks up pollen from the anther of the plant. As the bee moves to another flower, the pollen from the anther is deposited on the sticky top of the new flower’s stigma, where it travels down to the ovary to fertilize the flower’s eggs.

Post Lesson Assessment: Recall Card. On a 3x5 note card, the students will write down three things that they learned about the structures of a flower. This note card will be the student’s ticket out the door.

Day 2 Resources

KNPC Rare Plants." KNPC Rare Plants. US Fish and Wildlife Service, 28 May 2014. Web. 26 Jan. 2015. <http://eppcapp.ky.gov/nprareplants/glossary.aspx>

"What Is Pollination?" What Is Pollination? US Department of Agriculture, n.d. Web. 27 Jan. 2015. <http://www.fs.fed.us/wildflowers/pollinators/What_is_Pollination/index.shtml>.

Whiting, David, Michael Roll, and Larry Vickerman. "Plant Structures: Flowers." Plant Structures: Flowers. Colorado State University Extension, Oct. 2014. Web. 27 Jan. 2015. <<http://www.ext.colostate.edu/mg/gardennotes/135.html>>.

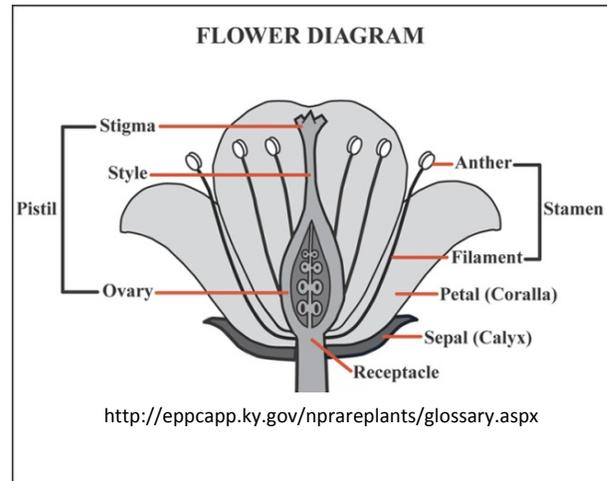
Flower Dissection

Name _____ Date _____

Background Information:

Flowers are the reproductive parts of many plants. It may surprise you to know that flowers have female and male parts. The female part of the plant is called the pistil. It includes the stigma, style, and ovary (which contains the eggs). The male part is called the stamen. It includes the anther and filament. The anther holds the pollen (sperm) of the plant.

Using the flower provided by your teacher, take time to look for all the parts of the flower shown in the picture. If you are unsure of the parts, verify with your teacher before starting your dissection. After his/her approval, you may start the dissection. You will be color coding the flower parts with the boxes as you examine them. As you find the parts, carefully cut them off and set aside. **OPTION:** Tape either one or all parts next to the box with the part's name, how many there are, and the function. Textbooks or other source of information (internet access) will be provided for students to look up the functions of the different flower parts.



Materials: Flowers, Scissors, Magnifying Glass, Resource Materials (textbook, internet), Tape (optional)

Directions for Dissection: On the back side of this sheet, fill in a box with the name, how many, and function of each part. Color code the box to match the flower part.

1. Find and count the sepals at the base of your flower. Why is the sepal important to the development of the flower?
2. Find and count the petals of your flower. Why are petals usually brightly colored?
3. Find both parts of the stamen on your plant (the male part—anther and filament). Why is it important for the anthers to be towards the top of the flower?
4. Find all three parts of the pistil on your plant (the female part—stigma, style, and ovary). Cut open the ovary. How many eggs are inside the ovary?

Name(s)

How many?

Function	

Name(s)

How many?

Function	

Name(s)

How many?

Function	

Name(s)

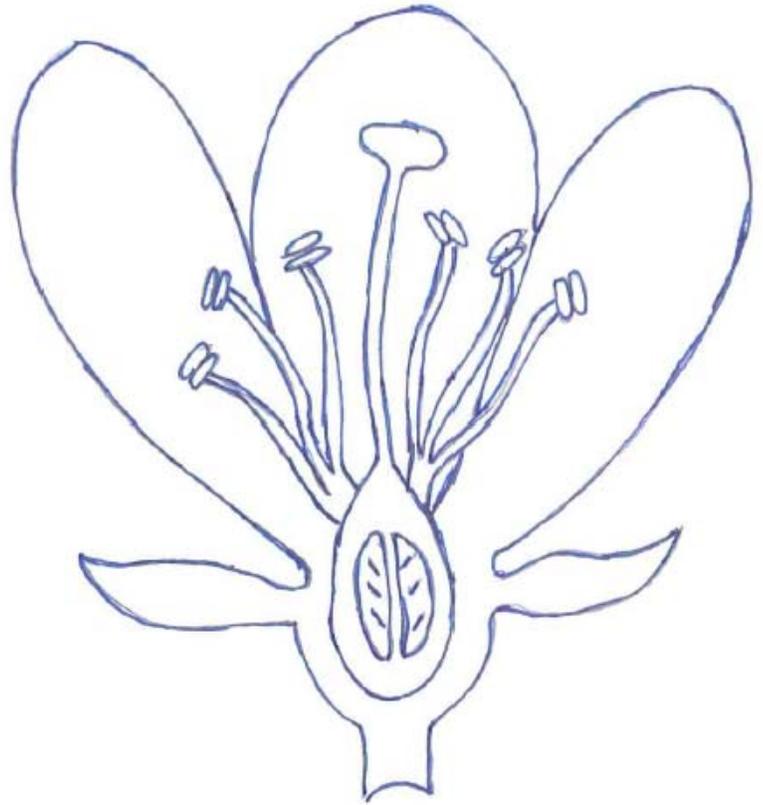
How many?

Function	

Name(s)

How many?

Function	



Name(s)

How many?

Function	

Name(s)

How many?

Function	



Bee Week – Day 3

Day 3 Topic: The Importance of Pollinators

Focus Question: What is a pollinator?

Summary: Students will learn about different pollinators and their importance to the survival of many other living organisms

Duration: 1 – 45 minute class period

Vocabulary: entomophily, pollinator

Objectives: Students will

- identify different pollinators
- explain the importance of pollinators in the environment
- calculate the amount of time and work it takes to be a pollinator

Next Generation Science Standards:

LS4.D: Biodiversity and Humans—Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on (MS-LS2-5)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience—Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)

LS2.A: Interdependent Relationships in Ecosystems—Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)

Warm-Up: Why do we care about entomophily? The instructor will lead a classroom discussion to help students break down the word into its word parts, allowing students to discover its meaning and to answer the question.

Lesson: The Importance of Pollinators (PowerPoint). Teaching portion of the lesson that focuses on pollinators, especially bees, and their importance to pollination of food crops and wild plants.

Activity—Field of Plants—How long does it take for humans to pollinate a field? In this activity, students will simulate how long it takes to pollinate plants and how the world would be different without pollinators.

Post Lesson Assessment: Tweet #Importance of Bees. As their ticket out the door, students will “tweet” about the importance of bees, using 140 characters or less.

Day 3 Lesson Plan

Warm up: Why do we care about entomophily?

Instructor will put this question on the board: Why do we care about entomophily? Instructor will lead a classroom discussion to help students break down the word into its word parts, allowing students to discover the word's meaning and answer the question. Here is the entry from the *Botany Word of the Day* to help with understanding the meaning of entomophily:

“Entomophily en'to-mof-il'e *n.*

Entomophilous en'to-mof'i-lus

(Gr. entomos: insect, philos: friend, loved)

Pollination by insects. Including wasps, bees, ants, beetles, moths, butterflies, crickets and flies amongst others. An **entomophilous** flower has adaptations that encourage pollination by insects. The flowers are actinomorphic and crowded together. This arrangement allows insects the ability to enter the flower from any direction and encourages the easy spread of pollen.”

Lesson:

1. **The Importance of Pollinators (PowerPoint).** This powerpoint helps students learn about and focus on pollinators and their importance to the survival of food crops and wild plants. The slide show focuses briefly on pollinators in general and then highlights bees. The powerpoint exposes students to the current problem of Colony Collapse Disorder affecting bee populations across the nation.
2. **Activity: Field of Plants.** How long does it take humans to pollinate a field? Using basic math skills, this activity challenges students to calculate how long it would take for humans to pollinate plants (in this case, almond trees) in place of bees. Along with a worksheet for the students, a key is attached with possible answers for the activity.
3. **Follow-Up Reading to Activity.** “Honey Bees Are More Effective At Pollinating Almonds When Other Species Of Bees Are Present”. This article further emphasizes that bees are more efficient at pollinating than humans.
http://entomology.ucdavis.edu/News/Honey_Bees_Are_More_Effective_at_Pollinating_Almonds_When_Other_Species_of_Bees_Are_Present/

Post Lesson Assessment: Tweet #Importance of Bees As their ticket out the door, students will “tweet” about the importance of bees using 140 characters or less.

Busy as a Bee 😊

Name _____ Date _____

In this activity, we are going to look at the production of just one food crop—almonds. California produces 82 percent of total almonds in the world. Almond producers depend upon bees to pollinate their almond trees. What would happen if bees were not available and we had to depend on humans to pollinate the trees?

Calculate Some Almond Pollination Numbers from California's Central Valley:

1. There are approximately 810,000 acres of trees with 112 trees on each acre (810,000 acres of trees X 112 trees = 90,720,000 total trees to pollinate in California's Central Valley). To make the numbers a little easier to calculate, we are going to just focus on just one farm. The average farm size in California is 64 acres. How many total almond trees are found in the average farm size? Show your work.

2. Without bees to pollinate these trees, your class has been hired to pollinate the almond trees for one farm. Each tree has 28,000 flowers to pollinate, but only about 25 percent (7,000) of the flowers actually produce almonds. We are only going to pollinate 7,000 flowers per tree. How long would it take your class to pollinate all the trees? In order to solve this problem, you will be placed into groups of 4-5 "bees" to get some average pollination times. First we will determine how long it takes each of you to pollinate 50 flowers on a "tree". Within your group, each "bee" (that's you) will touch the flowers on the almond tree outline, in order by number (from 1-50). The other members in your group will time how long it takes you to do this. You will do four separate trials pollinating your tree and then determine your average time to pollinate fifty flowers.

	Trial 1 (secs)	Trial 2 (secs)	Trial 3 (secs)	Trial 4 (secs)	Average Time
"Bee" #1					
"Bee" #2					
"Bee" #3					
"Bee" #4					

3. What is the average of the times of all four of the practice "bees" in your group? Show your work.

4. What is the average time for all the "bee" groups in your class? Show your work.

5. We currently know that you need to pollinate 7,000 flowers on a tree and we have the average time it takes one person to pollinate only fifty of those flowers. How long would it take one person to pollinate one tree? For your answer, figure the number of seconds and convert to minutes.

6. If you work an eight-hour day, how many trees can one person pollinate? Show your work. Let's assume that your class has thirty students. That means your class can pollinate _____ trees per day. Show your work.

7. Your class can pollinate (answer from #8) _____ trees per day. There are 7,168 (answer from #2) trees total per farm to pollinate. Divide that number to determine how long it would take your class to pollinate one farm.

8. We need to pay your class for their work. Minimum wage is about \$9.00 per hour in California. How much will you be paid per day? Show your work. How much for _____ days? How much for your whole class?

9. Compare that cost to that of renting bees to do the work. Usually two hives are placed on each acre at the cost of \$150.00 per hive. A rental colony usually has eight frames with 1,500-2,000 bees per frame. Populations might triple in size depending upon how nutritious the crop is being pollinated. The average farm size is 640 acres. How much would the bees cost?

10. What kinds of things would impact the cost of hiring your class to do the work? Think of the conditions—pollinating 50 flowers every _____ seconds for 8 hours a day.

Busy as a Bee ☺ KEY

Answers are highlighted in red to help work through this activity.

In this activity, we are going to look at the production of just one food crop—almonds. California produces 82 percent of the total almonds in the world. Almond producers depend upon bees to pollinate their almond trees. What would happen if bees were not available and we had to depend on humans to pollinate the trees?

Calculate Some Almond Pollination Numbers from California's Central Valley:

1. There are approximately 810,000 acres of trees with 112 trees on each acre (810,000 acres of trees X 112 trees = 90,720,000 total trees to pollinate in California's Central Valley). To make the numbers a little easier to calculate, we are going to just focus on just one farm. The average farm size in California is 64 acres. How many total almond trees are found in the average farm? Show your work.

$$64 \text{ acres} \times 112 \text{ trees} = 7,168 \text{ total trees to pollinate}$$

2. Without bees to pollinate these trees, your class has been hired to pollinate the almond trees for one farm. Each tree has 28,000 flowers to pollinate, but only about 25 percent (7,000) of the flowers actually produce almonds. We are only going to pollinate 7,000 flowers per tree. How long would it take your class to pollinate all the trees? In order to solve this problem, you will be placed into groups of 4-5 "bees" to get some average pollination times. First we will determine how long it takes each of you to pollinate 50 flowers on a "tree". Within your group, each "bee" (that's you) will touch the flowers on the almond tree outline, in order by number (from 1-50). The other members in your group will time how long it takes you to do this. You will do four separate trials pollinating your tree and then determine your average time to pollinate fifty flowers.

	Trial 1 (secs)	Trial 2 (secs)	Trial 3 (secs)	Trial 4 (secs)	Average Time
"Bee" #1					
"Bee" #2					
"Bee" #3					
"Bee" #4					

3. What is the average of the times of all four of the practice "bees" in your group? Show your work.

$$\text{Averages of Bee \#1 + Bee \#2 + Bee \#3 + Bee \#4} = \underline{\hspace{2cm}} \text{ divided by four}$$

4. What is the average time for all the "bee" groups in your class? Show your work.

$$\text{Averages of Group \#1 + Group \#2 + Group \#3 + Group \#4} = \underline{\hspace{2cm}} \text{ divided by four}$$

Answers highlighted in green are the answers to this problem with an average of 15 seconds for one person to pollinate 50 flowers.

5. We currently know that you need to pollinate 7,000 flowers on a tree and we have the average time it takes one person to pollinate only fifty of those flowers. How long would it take one person to pollinate one tree? For your answer, figure the number of seconds and convert to minutes.

$$7,000 \text{ flowers divided by } 50 = 140$$

$$15 \text{ Seconds} \times 140 \text{ times} = 2100 \text{ seconds average time of one person to pollinate 7000 flowers (one tree)}$$

$$\underline{2100} \text{ seconds divided by } 60 = \underline{35} \text{ minutes for one tree}$$

6. If you work an eight-hour day, how many trees can one person pollinate? Show your work. Let's assume that your class has thirty students. That means your class can pollinate _____ trees per day. Show your work.

$$8 \text{ hours} \times 60 = 480 \text{ minutes of work per day}$$

$$480 \text{ minutes divided by } 35 \text{ minutes per tree} = 13.71 \text{ trees per day per student}$$

$$13.71 \text{ trees per day} \times 30 \text{ students} = 411.30 \text{ trees per day per class}$$

7. Your class can pollinate (answer from #8) **411.30** trees per day. There are 7,168 (answer from #2) trees total per farm to pollinate. Divide that number to determine how long it would take your class to pollinate one farm.

$$7,168 \text{ divided by } 411.30 \text{ trees per day} = 17.42 \text{ number of days for your class to pollinate all the trees.}$$

8. We need to pay your class for their work. Minimum wage is about \$9.00 per hour in California. How much will you paid per day? Show your work. How much for **17.42** days? How much for your whole class?

$$\$9.00 \text{ per hour} \times 8 \text{ hours} = \$72.00 \text{ per day}$$

$$\$72.00 \times 17.42 \text{ days} = \$1254.24 \text{ per student}$$

$$\$1254.24 \times 30 \text{ students} = \$37,627.20 \text{ pay for the whole class}$$

9. Compare that cost to that of renting bees to do the work. Usually two hives are placed on each acre at the cost of \$150.00 per hive. A rental colony usually has eight frames with 1,500-2,000 bees per frame. Populations might triple in size depending upon how nutritious the crop is being pollinated. The average farm size is 640 acres. How much would the bees cost?

$$64 \text{ acres} \times 2 \text{ bee hives/per acre} = 128$$

$$128 \times 150.00 = \$19,200 \text{ total}$$

10. What kinds of things would impact the cost of hiring your class to do the work? Think of the conditions—pollinating 50 flowers every **15** seconds for 8 hours a day.

Day 3 Resources

- Colopy, Michele. "80,000+ Beehives Damaged or Dead; Congressional Briefing; Bumble Bees, and More." Pollinator Stewardship Council RSS. Pollinator Stewardship Council, 03 Apr. 2014. Web. 20 Feb. 2015. <<http://pollinatorstewardship.org/?p=2192>>.
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- "POLLINATION BY HONEY BEES." Chapter 8. University of Illinois--Urbana Champaign, n.d. Web. 20 Feb. 2015. <http://www.aces.uiuc.edu/vista/html_pubs/BEEKEEP/CHAPT8/chapt8.html>.
- Sass, Jennifer. Bee Facts. Washington, DC: Library of Congress, National Library Service for the Blind and Physically Handicapped, 1982. National Resources Defense Council. National Resources Defense Council, Mar. 2011. Web. 16 Feb. 2015. <<http://www.nrdc.org/wildlife/animals/files/bees.pdf>>.
- Tucker, Jessica. "Why Bees Are Important to Our Planet." One Green Planet. One Green Planet, 17 June 2014. Web. 09 Jan. 2015. <<http://www.onegreenplanet.org/animalsandnature/why-bees-are-important-to-our-planet/#>>.

Resources for “Busy as a Bee”

Jabr, Ferris. "The Mind-Boggling Math of Migratory Beekeeping." *Scientific American Global* RSS. *Scientific American*, 20 Aug. 2013. Web. 02 Mar. 2015.
<<http://www.scientificamerican.com/article/migratory-beekeeping-mind-boggling-math/>>.

Leibenluft, Jacob. "How Much Does It Cost to Borrow a Colony of Honeybees?" *Slate*. The Slate Group, 27 June 2008. Web. 30 Apr. 2015.
<http://www.slate.com/articles/news_and_politics/explainer/2008/06/rentahive.html>.

"Minimum Wage." *Minimum Wage*. State of California, 2015. Web. 23 Feb. 2015.
<http://www.dir.ca.gov/dlse/faq_minimumwage.htm>.

Pierson, David. "California Farms Lead the Way in Almond Production." *Los Angeles Times*. *Los Angeles Times*, 12 Jan. 2014. Web. 02 Mar. 2015.
<<http://www.latimes.com/business/la-fi-california-almonds-20140112-story.html>>.



Bee Week – Day 4

Day 4 Topic: Engineering a Bee

Focus Question: If you were an engineer, how would you create a “bee” to help pollinate plants?

Summary: Students will design a robotic “bee” that would have the potential to pollinate our crops in place of a native bee

Duration: 1 – 45 minute class period

Vocabulary: engineer, pollinate

Objectives: Students will

- analyze parts needed by a robotic bee to operate efficiently
- describe different structures and functions of their robotic bee
- create a robotic bee that would be able to accomplish pollination

Next Generation Science Standards:

ETS1.B: Developing Possible Solutions: Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution: Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)

ETSC1.C: Optimizing the Design Solution: The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Warm-Up: Robert Wood is an electrical engineer participating in National Geographic’s Emerging Explorers program. This short video clip (3:01) shows the potential of how robotics can impact our lives in the future.

Lesson: Engineering a Bee. Students will “engineer” a bee using different building materials— pipe cleaners, toothpicks, etc., and reflect on the adaptations honey bees have in order to accomplish pollination and survive.

Post Lesson Assessment: 3-2-1 Ticket. In pairs, students will brainstorm three things their “engineered bees” need to be effective pollinators; two problems with releasing engineered bees into nature; and one way to solve a problem that may result from releasing engineered bees into nature.

Day 4 Lesson Plan

Warm-Up: Robert Wood is an electrical engineer participating in National Geographic's Emerging Explorers program. This short video clip (3:01) shows the potential of how robotics can impact our lives in the future.

<http://www.nationalgeographic.com/explorers/bios/robert-wood/>

Lesson: Engineering a Bee. Students will “engineer” a bee using different building materials— pipe cleaners, toothpicks, etc... and reflect back on the adaptations honey bees have in order to survive and accomplish pollination.

Post Lesson Assessment: 3-2-1 Ticket. In pairs, students will brainstorm three things their “engineered bees” need to be effective pollinators; two problems with releasing engineered bees into nature; and one way to solve a problem that may result from releasing engineered bees into nature.

Day 4 Resources

- "Explorers Bio." National Geographic - Explorers. National Geographic Society, n.d. Web. 28 Jan. 2015.
<<http://www.nationalgeographic.com/explorers/bios/robert-wood/>>.
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- Spector, Dina. "Tiny Flying Robots Are Being Built To Pollinate Crops Instead Of Real Bees." Business Insider. Business Insider, Inc, 07 July 2014. Web. 26 Feb. 2015.
<<http://www.businessinsider.com/harvard-robobees-closer-to-pollinating-crops-2014-6>>.

Engineering a Bee

Name _____ Date _____

When thinking about engineering a bee, you must consider the phrase “form follows function.” What adaptations (form) do bees have to move from plant to plant gathering nectar and in the process pollinating plants (function)? In order to pollinate plants, bees need (1) a power source to provide energy for movement, (2) the ability to move from plant to plant (wings, legs, etc...), (3) ability to see a flower in ultraviolet light to see the flowers, (4) ability to land on that flower, and (5) the ability to collect the pollen to carry from plant to plant for pollination. In the space below, sketch out how an engineered bee will look and label all the parts they will need to accomplish the functions listed above.



After sketching, you will be building your own engineered bee using materials provided by your teacher so that it looks as close to your sketch as possible. Turn in your completed project along with this paper to your teacher.

	4	3	2	1
Scientific Knowledge:	The drawing shows an understanding of the adaptations of bees with all parts included.	The drawing shows an understanding of the adaptations of bees but missing 1-2 parts.	The drawing shows an understanding of the adaptations of bees but missing more than 2 parts.	The drawing shows a lack of understanding of the adaptations of bees and is incomplete.
Drawing—Attention to Detail:	The drawing is neatly drawn with all the parts labeled and easy to understand.	The drawing is complete with all the parts labeled and easy to understand.	The drawing is incomplete missing some parts and labels.	The drawing is not neatly drawn and missing many parts and labels.
Construction Materials:	Construction materials chosen for model are realistic looking and appropriate.	Construction materials are mostly realistic looking and appropriate.	Construction materials were chosen with limited thought to the end product.	Inappropriate construction materials. Little thought given to construction.
Quality of End Product:	While building made an effort to get all parts built, using appropriate materials.	While building made an effort to get all parts built, but inappropriate choice of materials.	Building that was completed was appropriate but lacking some parts.	Little effort was made to build lacking parts and appropriate materials.
TOTAL POINTS:				

Teacher Comments:	
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Bee Week – Day 5

Day 5 Topic: Pollinators in our World

Focus Question: What can you do to help pollinators?

Summary: Students will be given information on how they can help pollinators and will build and/or plant a “bee helper” for their backyards

Duration: 1 – 45 minute class period

Vocabulary: pollinator

Objectives: Students will

- explain different threats to pollinators in the world
- describe one or two actions they can take to help pollinators
- build and/or plant a “bee helper” for their backyards

Next Generation Science Standards:

LS2.A: Interdependent Relationships in Ecosystems—Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)

Warm-Up: The instructor will show examples of different types of structures that students can build for different pollinators. The instructor will ask the students what they think is the purpose of the different structures. As the students guess which pollinators the different structures serve, the instructor will ask students how the structure is designed to help that particular pollinator survive.

Lesson: Build a “Bee Helper.” Students will learn about how they can help pollinators and be given the option of building a “bee house” and/or planting seeds of flowers that can provide habitat for bees in their backyard.

Post Lesson Assessment: Postcard to Parents. Students will design a postcard to send to their parents asking them to help pollinators using any of the ideas from their handout.

Day 5 Lesson Plan

Warm-Up: The instructor will show examples of different types of structures that students can build for bees, birds, butterflies**, or bats. The instructors will ask the students to consider which pollinators would be served by each of the different structures. The instructor will also ask students to speculate on how the house is designed to help a particular pollinator.

**Most research has shown that butterfly houses don't actually work, so instructors may not want to use them as an example. Robert Snetsinger, an entomologist who conducted research on butterfly houses, suggests "if you want to do something useful for butterflies, build them a mud puddle." <http://www.georgiawildlife.com/node/3461>

Lesson: Help A Pollinator

Part 1: The instructor will hand out papers: "Spread the Word." While reading through the suggestions, the instructor will ask students to checkmark things they feel they can personally do to help pollinators. The instructor will guide the classroom discussion to show that everyone can help pollinators.

Part 2: Students will choose a particular project to build or plant flowers to help pollinators. Websites are included with plans on how to build different structures for pollinators or learn about growing plants to attract different types of pollinators. The "bee house" plans are designed to attract mason bees. Mason bees are less likely to sting than honey bees and live a more solitary life.

Sources for bee houses:

<http://www.nwf.org/How-to-Help/Garden-for-Wildlife/Gardening-Tips/Build-a-Bee-House.aspx>
[Dead](http://www.nwf.org/How-to-Help/Garden-for-Wildlife/Gardening-Tips/Build-a-Bee-House.aspx)
[Insects.net](http://www.insects.net)

Project 1—Build a "Bee House":

By web searching "mason bee houses", the instructor will see many ideas and images to help provide students with ideas on how they can build their bee houses. After completion, the students should be directed to attach their bee houses to the south side of a building, fence post, or tree in their yards or communities. Here are two simple ideas:

Bee House #1: This bee house consists of a block of wood in which students will drill holes into, but not through, the wood. Supplies needed: scrap pieces of lumber, drill and drill bits, hammer and nails for attaching roof <http://www.nwf.org/How-to-Help/Garden-for-Wildlife/Gardening-Tips/Build-a-Bee-House.aspx>

Bee House #2: This bee house consists of a can filled with bamboo shoots cut to length. Supplies needed: can, bamboo shoots, and a hand saw. <http://tallcloverfarm.com/224/baked-beans-bamboo-beesrecipe-for-a-mason-orchard-bee-home>

Project 2—Plant Flowers for Pollinators. Planting seeds is an easy and fun way for kids to help pollinators. The instructor may want to keep the plants in the classroom for a while and collect data on different variables, such as days to germination, height, number of leaves, etc. Local greenhouses or gardening clubs are a good resource for information about plants that are bee friendly, and possibly, supplies.

Pollinator friendly plants #1: The Center for Food Safety website includes plants that are pollinator friendly, based upon the season:

<http://www.centerforfoodsafety.org/issues/304/pollinators-and-pesticides/pollinator-friendly-plants>

Pollinator friendly plants #2: “The North American Pollinator Protection Campaign (NAPPC) has planting guides for pollinator friendly trees, shrubs, and flowers specific to different regions. Students will need to submit their five-digit zip code to get a free guide to pollinator friendly plants for their areas: <http://www.pollinator.org/guides.htm>

Pollinator friendly plants #3: “Buzz About Bees” is a website with lots of information about bees. This particular page is devoted to plants for bees:

<http://www.buzzaboutbees.net/bee-plants.html>

Post Lesson Assessment: Postcard to Parents. Students will design a postcard to send to their parents asking them to help pollinators, using any of the ideas from their handout.

Day 5 Resources

- "Best Bee Plants." BuzzAboutBees.net. N.p., n.d. Web. 26 Feb. 2015.
<<http://www.buzzaboutbees.net/bee-plants.html>>.
- "Center for Food Safety | Issues | Pollinators & Pesticides | Pollinator-Friendly Plants." Center for Food Safety. Center for Food Safety, n.d. Web. 26 Feb. 2015.
<<http://www.centerforfoodsafety.org/issues/304/pollinators-and-pesticides/pollinator-friendly-plants>>.
- Conway, Tom. "Baked Beans, Bamboo & Bees: Recipe for a Mason Orchard Bee Home - Tall Clover Farm." Tall Clover Farm. N.p., 08 Apr. 2009. Web. 26 Feb. 2015.
<<http://tallcloverfarm.com/224/baked-beans-bamboo-beesrecipe-for-a-mason-orchard-bee-home>>.
- "How Gardeners Can Help Pollinators." USDA Natural Resources Conservation Service. US Department of Agriculture, n.d. Web. 19 Feb. 2015.
<<http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/plantsanimals/pollinate/gardeners/>>.
- "How to Build a Bee House - National Wildlife Federation." How to Build a Bee House - National Wildlife Federation. National Wildlife Federation, n.d. Web. 26 Feb. 2015.
<<http://www.nwf.org/How-to-Help/Garden-for-Wildlife/Gardening-Tips/Build-a-Bee-House.aspx>>.
- Kaplan, Kim. "Survey Reports Fewer Winter Honey Bee Losses." ARS : Agricultural Research Service. US Department of Agriculture, 15 May 2014. Web. 13 Feb. 2015.
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- "Pollinators: How You Can Help." Pollinators: How You Can Help. US Fish and Wildlife Service, 10 Feb. 2015. Web. 17 Feb. 2015.
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- Sass, Jennifer. Bee Facts. Washington, DC: Library of Congress, National Library Service for the Blind and Physically Handicapped, 1982. National Resources Defense Council. National Resources Defense Council, Mar. 2011. Web. 16 Feb. 2015.
<<http://www.nrdc.org/wildlife/animals/files/bees.pdf>>.
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<<http://www.onegreenplanet.org/animalsandnature/why-bees-are-important-to-our-planet/#>>.

SPREAD THE WORD...

1. Provide Food and Water

- ___ choose plants that flower at different times**
- ___ plant in clumps rather than single plants**
- ___ provide a variety of colors and shapes**
- ___ choose plants that pollinators are attracted to**
- ___ choose native plants**
- ___ provide a source of clean water in your garden or backyard**

2. Provide Shelter

- ___ build bee nesting boxes**
- ___ build butterfly houses**
- ___ leave dead limbs on trees (if not safety hazard)**
- ___ leave natural habitat in your yard**

3. Avoid or Limit Pesticides

- ___ remove pests by hand**
- ___ encourage native predators**
- ___ share and accept pests in your garden**
- ___ apply them only when needed and where needed**
- ___ choose least toxic pesticide**