Curriculum Units by Fellows of the National Initiative
2023 Volume V: Nature-inspired Solutions to Disease Problems

Biodiversity and Bees in the Primary Classroom

Curriculum Unit 23.05.01, published September 2023
by Carol Boynton

Introduction

In this unit, my young students will learn about the importance of understanding and preserving biodiversity through the study of bees. To introduce this complex topic to Kindergarteners and give us a launching point for discussion and awareness, the unit begins with a read-aloud, *Please Please the Bees* by Gerald Kelley. This picture book tells the story of a bear who eats honey made by the bees who live in his yard, a total of three jars each day, delivered to him by the bees themselves. Benedict fails to maintain and preserve the area to keep the bees healthy and happy, so they go on strike, refusing to produce honey. The story shows the reliance the "animals" in this story have on each other and how an imbalance can occur. In this story, plants and flowers are essential for the survival of the bees and the bear. This unit covers the study of bees and their role in preserving biodiversity. We will discuss problems they encounter, including their recent problem with varroa mites, and learn about methods to help save them by planting nectar-producing plants and building bee boxes.

As a Kindergarten teacher in a self-contained classroom at Edgewood Magnet School in New Haven, I find the neighborhood/ magnet setting a rewarding environment, with students coming to school each day from a variety of home circumstances and with differences in academic levels. As a result of these variables, the children arrive with differing levels of background knowledge and life experiences. The classroom is a mixture of varied ethnicities, economic strata, and social and emotional strengths and weaknesses. Edgewood is a STEAM school with curricula focused on science, technology, engineering, arts, and mathematics. This planned unit aligns with the philosophy of the school. The use of scientific inquiry allows all students at all levels to learn in an inherently differentiated environment, learning new concepts and experiencing science in the classroom and outside, not only on the school property but across the street at Edgewood Park. This unit will support the place-based learning that Edgewood Magnet School encourages. Trips to Edgewood Park to visit the ponds and river for hands-on investigation and experimentation will be modeled on experiences from the seminar.

Rationale

People are spending increasingly more time indoors. As much as 96% of our day is spent inside; so consequently, we are experiencing the outdoors less and less. This is an unfortunate and unhealthy trend. Nature deficit disorder, a term coined by Richard Louv in his book, *Last Child in the Woods*, identifies a result of this extreme amount of time spent indoors. Children are not being exposed to nature on a regular basis and are not making a connection to their natural world. He points out that the children who play outside are less likely to get sick, be stressed, or become aggressive, and are more adaptable to life's unpredictable turns.[1] I want to mention this phenomenon because I think it pertains to many of my students. Preparing and teaching a unit about nature gives me an opportunity to change this, even just a bit. Each year I have young students who are uncomfortable being outside and interacting with 'nature' and students who are the opposite, ready to participate in any activities or lessons. Certainly, to understand, or at least be aware of how we can use nature as an example to model from, I want my students to be exposed to the fun and learning that happens through scientific exploration and discovery, particularly outside. One additional advantage will be, in this case, that hopefully, my young learners will no longer be afraid of bees!

Essential questions to consider during this unit:

What can we learn from bees that can help us?

How do honeybees help plants and people?

What do honeybees eat? How do bees communicate? What do bees do during winter?

How do they collect and use nectar from plants and is there something we can learn and repeat from the bees' methods?

Why is it important to think about how we can mimic the behaviors of animals (and plants) to improve our lives?

The Lives of Bees

"If the bee disappeared off the face of the Earth, man would only have four years left to live." This quote is generally attributed to Albert Einstein, although there is some dispute over its author. Nevertheless, it is a profound and unsettling statement and certainly gives us pause when we consider how dramatic it sounds and seems. It characterizes the interconnectedness of our world and the function of biodiversity for plants and animals to live and thrive. This unit will cover the lives and behaviors of bees to understand what they do, how they do it, and why their actions create an essential balance in nature.

Honeybees, bumblebees, mining bees, dwarf bees, carpenter, leafcutter, and mason bees: bees come in many different types, with more than 20,000 species worldwide. The bees we are most familiar with, bumblebees and honeybees, live in colonies and play a major role in pollinating the crops, plants, and flowers around us. Bees produce honey, a function of bees' lifecycle, which humans have utilized for millennia. The ancient

Egyptians called bee pollen “the powder that gives life.” The nutritious mix of nectar, flower pollen, enzymes, honey, wax, and bee secretions were placed in their tombs to nourish them in the next life. Bees were seen as the servants of the gods, delivering messages and healing powers. In ancient Greece, bee pollen was called Ambrosia – the food of the gods. It was said to hold the power of immortality and eternal youth. Its health benefits were well established and both the father of modern medicine, Hippocrates, and the philosopher Pythagoras prescribed bee pollen for its healing properties. The Romans considered bee pollen to be a panacea. Roman soldiers carried dried pollen cakes with them to provide sustenance. The ancient cultures of China, India, and the Far East have the same references to the power and therapeutical benefits of bee pollen. To many, it was a necessary dietary staple. Native Americans, like the Romans, carried bee pollen in bags around their necks to give them energy on long journeys. In New Zealand, the Māori have a long tradition of using bee pollen for food.

Many bees today are domesticated, and beekeepers collect honey, beeswax, pollen, and royal jelly from hives for human use. Surprisingly, a typical bee produces a teaspoon of honey in her lifetime. Bees can communicate in many ways through the movement of their wings and bodies, most famously with the “waggle dance,” where they make figure-eight circles to let other bees know the direction and distance of nectar.[2]

Honeybees are considered super-organisms due to their complex social systems and dynamic, tight-knit interactions with one another and their environments. Colonies can number in the tens of thousands of bees, with 90 percent of them female worker bees who maintain the hive and population. There is a single queen, who can lay eggs for several years. Male drones are responsible for the fertilization of new queens.

Humans have kept honeybees in hives for millennia, yet only in recent decades have biologists begun to investigate how these industrious insects live in the wild. Thomas Seeley explains in *The Lives of Bees* what scientists are learning about the behavior, social life, and survival strategies of honeybees living outside the beekeeper’s hive—and how wild honeybees may hold the key to reversing the alarming die-off of the planet’s managed honeybee populations.

As a world authority on honeybees, Seeley describes why wild honeybees are still thriving while those living in managed colonies are in crisis. This is interesting as his research and suggestions show beekeepers how to use the principles of natural selection to guide their practices, and how beekeeping can better align with the natural habits of honeybees, a specific example of mimicking what nature does on its own.

Honeybees are the most important pollinators in most regions of the world where flowering plants exist but are by no means the only insects that play this role. Flies, butterflies, beetles, and other hymenopterans related to bees, such as solitary bees, wasps, bumblebees, and even ants can pollinate plants. Very few flowers are dependent on a single insect species, although no other pollinators are as effective as honeybees. In all, 80% of flowering plants worldwide are pollinated by insects, and of these about 85% by honeybees. As many as 90% of fruit tree flowers are dependent on honeybees. The list of flowering plants pollinated by honeybees includes about 170,000 species. [3]

A single colony of honeybees may well visit several million flowers on a single working day. Because the bees inform one another about newly discovered areas of flowers, visits to all flowers are rapidly achieved. Hardly a single bloom remains unattended. Bees are also generalists that can cope with just about all flower types so that all have the same chance of being visited by bees.[4]

Pollination

Pollination is the transfer of pollen from the male parts of a flower to the female parts of a flower of the same species, which results in the fertilization of plant ovaries and the production of seeds. Flowering plants have existed for about 130 million years. Initially, the wind alone was the "postillon d'amour" (love's messenger), and the sexual exchange was somewhat inefficient, requiring huge amounts of pollen to be dispatched on an uncertain and in most cases unsuccessful journey. In areas of limited or no wind, of course, this did not work at all.[5]

Because honeybees are efficient and effective pollinators of plants and flowers, they play a significant role in agricultural systems, increasing crop values each year by more than $15 billion in the United States alone and pollinating more than 80 percent of all cultivated crops.[6] It has often been said that bees are responsible for one out of every three bites of food we eat. Most crops grown for their fruits, such as squash, cucumber, tomato and eggplant, nuts, seeds, cotton, and hay require pollination by insects. The main insect pollinators, by far, are bees.

Honeybees (*Apis mellifera*) are the most economically valuable pollinators of agricultural crops worldwide and are the only bee species kept commercially in the United States. In the United States, bee pollination of agricultural crops is said to account for about one-third of the U.S. diet, and to contribute to the production of a wide range of high-value fruits, vegetables, tree nuts, forage crops, some field crops, and other specialty crops.[7]

A number of agricultural crops are almost totally (90%-100%) dependent on honeybee pollination, including almonds, apples, avocados, blueberries, cranberries, cherries, kiwi fruit, macadamia nuts, asparagus, broccoli, carrots, cauliflower, celery, cucumbers, onions, legume seeds, pumpkins, squash, and sunflowers. Other specialty crops also rely on honeybee pollination but to a lesser degree. These crops include apricot, citrus (oranges, lemons, limes, grapefruit, tangerines, etc.), peaches, pears, nectarines, plums, grapes, brambleberries, strawberries, olives, melon (cantaloupe, watermelon, and honeydew), peanuts, cotton, soybeans, and sugarbeets.[8]

The tasks that honeybees must perform to effectively and efficiently use what is around them are many: recognize the flowers; distinguish between different kinds of flowers; recognize the state of the flower; know how to work the flower effectively with legs and mouth; determine the geographic location of the flower; determine the daily time window in which various flowers produce the most nectar; share the information with other field bees as a messenger in a communication system; receive and understand this information in this communication system of where to find flowers.[9]

Honeybees have the scientific name *Apis mellifera*, which means "honey-carrying bee." They live in colonies of about 50,000 individuals in summer and about 20,000 in winter.[10] Each colony occupies its own hive. Although there are tens of thousands of bees in a colony, there are only three types of bees: workers, drones, and queens.

The workers are the smallest bees, and all worker bees are sterile females. Thousands of them perform chores in the hive. They make honey, clean the hive, feed larvae (baby bees) and build the wax comb where all the bees live. Workers are the only bees that visit the flowers.[11]

Approximately one hundred male bees, or drones, live in each colony and serve only for reproduction, i.e., to mate with the queen. The largest bee is the queen. Each colony has only one queen, easily recognized by the longer abdomen, whose most important function is to lay eggs.[12]

In the summer months, workers live for about six weeks. They may live a bit longer in the winter as they are less active during the colder months. Drones live a bit longer in the summer months - about eight weeks. They generally leave the colony in the Fall and die. A healthy queen may lay for up to four years and lay over one million eggs during that time.

Honeybees survive the winter as a complete colony. The bees collect together in a dense cluster and keep themselves warm by vibrating their wing muscles. They use honey stores as the energy source for this activity.[13]

In the warm weather, a healthy queen lays one thousand to fifteen hundred eggs a day. Her “court” is formed of court bees who guard, clean, and feed her, exclusively with royal jelly, tending to her every need, and providing her with particular attention and care. Drones tend to be lazy, often not even feeding themselves. Worker bees will feed them.[14]

From Egg to Bee

A queen bee lays only a single egg in each comb cell, but up to 200,000 eggs each summer. Like many insects, a honeybee grows in four stages: egg, larva, pupa, and adult. The bee changes dramatically from one stage to the next.

Although all bees develop from the same four stages, the time it takes for each type of bee varies. Queens grow the fastest, in about sixteen days. Workers mature in twenty-one days, and drones in twenty-four days. Female bees develop from fertilized eggs, the larger male bees from unfertilized eggs.[15]

A queen lays a soft, white, oval egg at the bottom of a cell in the comb. In three days, a wormlike form called a larva hatch from the egg. Fed by worker bees, the larva grows much larger. Then the larva spins a cocoon. Inside the cocoon, a pupa develops from the larva. It starts to look more like an insect than a worm. It grows eyes, legs, and wings. Finally, an adult bee chews its way out of the cell.[16]

Stages of growth

Young worker bees constantly care for and feed the young larva. They feed royal jelly to the queen larvae. They feed bee milk to workers and drone larvae for the first three days and beebread after that.

Royal jelly is a milky, yellow syrup that young worker bees secrete from their glands inside their heads. It is high in protein. Bee milk is similar to royal jelly, but it is not as nutritious. It too comes from the glands in the worker bee’s head. Beebread is a mixture of honey and pollen.

During its first day, a larva eats so much that its weight increases five and a half times. For reference, if a child weighed 60 pounds on Monday, by Tuesday he would weigh 330 pounds.[17]

Inside the Hive

The comb is made of thousands of six-sided wax cells, built from wax that they produce from glands. They store honey and pollen in these cells of the comb and use comb cells as a nursery for their young.

Honey cells fill the top and circle the edge of the comb. Bees eat this honey for energy. Pollen cells curve below the honey cells. Pollen is powder taken from flowers that bees eat for protein, which helps their muscles grow stronger. Blood cells, where the worker and drone larvae are raised, are in the lower part of the comb. Queen larvae cups hang at the bottom of the comb.[18]

Honeybees are one of the few species of bees that live together in a colony - even bumblebees, social in the summer, reduce down to a single queen in the winter. They produce as much honey as they can in the summer when the flowers are blooming, to sustain them through the colder season.

In summer, the bees raise several young queens in specially constructed cells and feed them a special diet. Young queens mate only once in their lives, during their nuptial flight, but with many drones. [19]

Honeybees swarm to propagate their colonies. The old queen leaves with a large proportion of individuals from the original hive (need to expand on swarming)

The Body of a Bee

When a worker bee crawls out of her cell, she is already fully grown. Even though she is one-half-inch long and weighs only 1/250 ounce, she contributes more than any other type of bee to the daily survival of the colony.

A honeybee has two kinds of eyes. Two compound eyes with over three thousand lenses each allow the bee to see ultraviolet light which is invisible to the human eye. With their ultraviolet vision, they can see which flowers are full of nectar. Antennae detect scents like a nose does and are used as feelers in the dark. A bee uses her front legs like arms to move flower parts and dust off her antennae. Her middle legs brush the pollen out of the thousands of branched hairs that cover her. Pollen baskets are on the outside of the back legs and are for storing collected pollen.

A bee can fly more than twelve miles an hour, going forward. She can also fly backward and sideways. A honeybee has two pairs of wings that can beat 250 times a second.

Like all insects, a bee has three sets of legs. A worker bee’s body is covered with branched hairs that trap pollen. Beeswax is secreted from the underside of the bee’s abdomen.

A honeybee has two stomachs The honey sac is where a bee stores nectar that will be made into honey. The midgut is where she digests her food.

A honeybee keeps her stinger hidden in the tip of her abdomen until she needs to defend herself or her hive. A worker’s stinger has barbs that prevent the bee from pulling it out from the target. As a result, a worker can only sting once. She flies away and dies because leaving the stinger behind damages her internal organs. [20]

Figure 1: Honeybee side view

Figure 2: Honeybee – top view

House Bee

Worker bees pass through many occupational stages in their lives, for example, as cleaner bees, builder bees, brood care bees, and guard bees. Having reached seniority, they leave the nest as foragers. Brood care is the task of bees living within the hive. Foraging is the task of the bees that fly out of the hive.[21]

For the first three days of her adult life, a worker bee performs chores in the hive. Beekeepers refer to these workers as house bees. House bees clean the hive, feed larvae, build wax comb, store food, and defend the hive against enemies. No bee tells the house bee which chores need to be done. Instead, each bee is guided by an inner clock and does certain chores as she reaches a certain age. When a worker bee is first born, she cleans her cell and the cells around it. At three days old, she now feeds beebread to older drone and worker bee larvae. From about six to eleven days old, workers feed bee milk to the young drone and worker larvae and royal jelly to the queen. In the next several days, the bee's wax glands are most active. Bees may hang from one another so that the wax flows more smoothly from their wax glands. Then, with her jaws, each bee shapes the wax into honeycomb.

Bees that are not making wax store food in the honeycombs. They deposit nectar (which will be made into honey) in the honey cells and pack pollen in the pollen cells.[22]

Field bee

In the summer, during the last three weeks of her life, a worker bee leaves the hive and flies through the fields, meadows, and gardens to visit flowers. The worker has been a house bee and has now become a field bee. She will make about ten journeys a day. Each flight takes about an hour and is within three miles of the bee's hive. The first flight occurs before the dew dries from the flowers in the morning and the final flight of the day ends at sunset. During her trips, she gathers water, bee glue, nectar, and pollen, all of which the colony needs.[23]

Bees collect resin from the buds, fruit, flowers, and leaves of plants to make a caulking resin, called "propolis", which they build into the hive. Humans use propolis from bee- hives for medicinal purposes, such as cold syndrome (upper respiratory tract infections, common cold, and flu-like infections), as well as dermatological preparations useful in wound healing, treatment of burns, and acne.[24]

Water is collected from small puddles and used to thin honey that is too thick. Droplets are placed inside the hive in hot weather. The bees fan the water which cools the hive as it evaporates. Bee glue sap, collected from flower buds, is stored in the bee's pollen basket and used to seal cracks and varnish the inside walls of the hive. Bees gather nectar, the sweet juice from the flowers, and make it into honey. She sits still on the flower and uses her tongue to suck up the nectar. As she visits the flower and crawls around, pollen sticks to her antennae and branched hairs. She then hovers over the flower and brushes the pollen into the pollen baskets on her hind legs.[25]

How Bees Make Honey

Making honey requires field bees and house bees. A field bee collects the nectar, and returns to the hive, where the house bees take over the process. With her ultraviolet vision, field bees see dark shapes that indicate which flowers are rich in nectar. She lands on the flower's petals and searches with her antennae for the sweet-smelling nectar. The field bee sucks up the nectar but does not digest it. When the field bee returns to the hive, she transfers the nectar to the house bee, who spreads the droplet of nectar on the roof of the honey cell where the nectar begins to dry. During the next couple of days, other house bees fan their wings over the honeycomb. Fanning evaporates the moisture in the nectar, which is 80% water. Honey is only 19% water. In the final step, other house bees cap the honey cells with a thin layer of wax. Inside, the thickened nectar ages and becomes honey. To make one pound of honey, a colony of bees collects nectar from over a million flowers![26]

Honeybees communicate with one another through various chemical and tactile signals. The dance language is an important part of their communication system.[27]

Field bees show other field bees flowers are by dancing on their honeycomb in their hive. After the field bee has given the nectar to the house bee, she begins to walk rapidly in a circular pattern. Other bees gather and touch the dancing field bee with their antennae. By smelling the dancing bee, the other bees can tell what type of flowers she has visited. By feeling her movement, they can learn how far away the flowers are, and sometimes their location. There are several bee dances, but the most common ones are the round dance and the waggle dance. The round dance says "Flowers are close the hive" or less than one hundred yards away. The bee circles in one direction, then turns around and circles back in the other direction. The waggle dance says "Let me draw you a map, the flowers are further away" or at least one hundred yards away. The bee dances a half circle in one direction, turns, and runs straight while wagging her tail. Then she dances a half circle in the other direction. This elaborate dance shows both location and distance of the flowers, so the bees know exactly where to fly.[28]

The honeybee is the most important agent in the maintenance of flowering plant diversity.[29]

The biology of bee colonies and many flowering plants are tightly interwoven. Bee colonies produce daughter colonies with young queens carrying the female germ cells. Flowering plants produce fruit containing seeds. The uninterrupted flow of material and energy from the flowers to the bee colony enables the continuous replacement of the members of the hive, and thereby an "eternal colony" that brings forth a perpetual stream of daughter colonies.[30]

Colony Collapse Disorder

Colony Collapse Disorder is the phenomenon that occurs when the majority of worker bees in a colony disappear and leave behind a queen, plenty of food, and a few nurse bees to care for the remaining immature bees and the queen. (EPA) Starting in the last three months of 2006, what seemed a new phenomenon began to occur based on reports of an “alarming” number of bee colony losses and die-offs along the East Coast. By the end of 2006, beekeepers on the West Coast also began to report “unprecedented” losses. Estimates indicated that beekeepers in 35 states were affected.[31]

Discovering a Problem

During the winter of 2006-2007, some beekeepers began to report unusually high losses of 30-90 percent of their hives. As many as 50 percent of all affected colonies demonstrated symptoms inconsistent with any known causes of honeybee death: (1) sudden loss of a colony’s worker bee population with very few dead bees found near the colony, (2) the queen and brood (young) remained, and the colonies had relatively abundant honey and pollen reserves.

But hives cannot sustain themselves without worker bees and would eventually die. This combination of events resulting in the loss of a bee colony has been called Colony Collapse Disorder.[32]

What followed was global concern over a new phenomenon. Scientists realized that it was not just the US that was losing its honeybees, but that similar problems had manifested all over the world. To make things worse, areas were also losing many populations of wild bees too. Losing bees can have tragic consequences. Bees are pollinators for about one-third of the plants we eat, a service that has been valued at as much as $168 billion worldwide.

Dead Bees Don’t Necessarily Mean CCD

Honeybee colony losses are not uncommon. A recent report by the National Research Council (NRC) documents extensive literature on honeybee population losses due to bee pests, parasites, pathogens, and disease. Most notable are declines due to two parasitic mites, the so-called vampire mite (*Varroa destructor*) and the tracheal mite (*Acarapis woodi*), and also colony declines due to the bacterial pathogen *Paenibacillus larvae*. Other reasons for bee colony declines reported by the NRC include competition between native and introduced bees, pathogen spillover effects, habitat loss, invasive plant species that reduce nectar- and pollen-producing vegetation, bee genetics, and pesticides, among other factors.[33]

Certain pesticides are harmful to bees. That’s why we require instructions for protecting bees on the labels of pesticides that are known to be particularly harmful to bees. This is one of many reasons why everyone must read and follow pesticide label instructions. When most or all of the bees in a hive are killed by overexposure to a pesticide, this is considered a bee-kill incident resulting from acute pesticide poisoning. But acute pesticide poisoning of a hive is very different from CCD and is almost always avoidable.

Several incidents of acute poisoning of honeybees have been covered in the popular media in recent years, but sometimes these incidents are mistakenly associated with CCD. A common element of acute pesticide poisoning of bees is, literally, a pile of dead bees outside the hive entrance. With CCD, there are very few if any dead bees near the hive. Piles of dead bees indicate that the incident is not colony collapse disorder.

Heavily diseased colonies can also exhibit large numbers of dead bees near the hive.

Though agricultural records from more than a century ago note occasional bee “disappearances” and “dwindling” colonies in some years, it is uncertain whether the colonies had the same combination of factors associated with CCD. What we do know from the data from beekeepers for 2014/2015 is that, while colony loss from CCD has declined, colony loss is still a concern.[34]

Do We Understand Why?

The good news is that there has been plenty of progress in the past decade in understanding the mystery of Colony Collapse Disorder. The bad news is that we now recognize it as a complex problem with many causes, although that doesn’t mean it is unsolvable.

For all bees, foraging on flowers is a hard life. It is energetically and cognitively demanding; bees have to travel large distances to collect pollen and nectar from sometimes hard-to-find flowers and return it all to the nest. To do this they need finely tuned senses, spatial awareness, learning, and memory.

Anything that damages such skills can make bees struggle to find food, or even get lost while trying to forage. A bee that cannot find food and make it home again is as good as dead. Because of this, bee populations are very vulnerable to what are called “sublethal stressors” – factors that don’t kill the bees directly but can hamper their behavior.[35]

If all bees died it may not be a total extinction event for humans, but it would be a disaster for our planet. We would see a domino-like effect as many plants started to just disappear one by one, and all animal species would start to struggle to find food.

Herbivores, who depend on certain plant species, would be affected first. They would simply become extinct if those plants ceased to exist because bees were no longer pollinating them.

The animals that fed on those animals would be the next to starve and face extinction... and so on as each link in our natural food chain broke down. The price of food and medicines would become out of control, leading to an economic disaster.

Lastly, without bees, there would obviously be no honey! We would be losing one of the healthiest, most versatile, and most natural food products available. One of our favorite baking and cooking products would be gone and beekeepers would have no bees to look after. We would miss the honey in skin remedies, shampoos, and other cosmetic products. Beeswax would also no longer exist.

It's almost impossible to overstate how much bees play an essential role in the global food supply and the natural balance of the planet. It's essential not just for us that bees survive, but for every living thing on the planet.[37]

Teaching Strategies

Experiential Learning: The major strategy for this unit is to engage the students in hands-on learning. I want them to be actively participating as inquisitive scientists and engineers. The honeybee body design and hive activities are designed to be exploratory for the students, so that they are engaged in the enjoyment of the inquiry and design as well as the process.

Differentiated Instruction: The students will use a variety of approaches, working sometimes individually and sometimes in small groups, determined by the complexity of the activity. Because these are young children with variance in levels and background, guidance, and pacing are adjusted to ensure that all students are engaged and active throughout the learning experiences. Students will have opportunities to work with a variety of peers as they explore design ideas using various materials.

Cooperative Learning: The students will be given opportunities to work in cooperative groups to complete assignments and activities. This strategy will allow students to work collaboratively taking on various roles necessary to complete the experiments and journal work, with a focus on success for all.

Classroom Activities

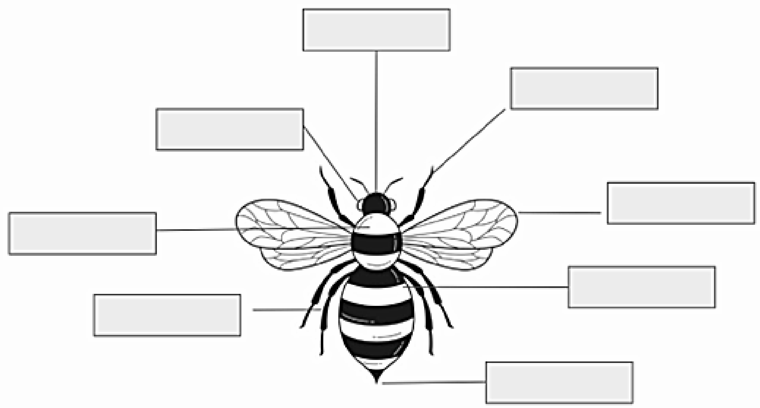
Activity One: Honeybee Body Structure / Staying Healthy

Objective: Students will be introduced to interdependent relationships between animals, plants, and their environment.

Materials: read-aloud book - *Please Please the Bees,* copies of bee labeling activity, pencils scissors, glue

Begin the unit by reading *Please Please the Bees* by Gerald Kelley. This will introduce the unit with a fundamental foundation of biodiversity, recognizing that bees, the bear, and the flowers all work together to support each other. Discuss the connections the students discover in the story.

Introduce the body of a bee by showing the video, *Little Science Lab: Busy Buzzing Bees #1 - Bee Body Parts,* or one similar. This eight-minute video shows students each part of a bee and teaches the correct terms and vocabulary. They will then complete the labeling activity.



Example bee drawing for labeling body parts

eyes	head	wings	antennae
legs	thorax	abdomen	stinger

Activity Two: Honeycomb Models

Objective: Students will create a model of a honeycomb and understand the purpose of its design.

Materials: Yellow hexagon pattern blocks, ping pong balls, yellow paint, paintbrush, black permanent marker, glue, scissors, white construction paper, cardboard tubes (cut into 1” sections), black pipe cleaners cut in 2” pieces

In groups of two, have students use pattern blocks to design a beehive flat on their tables. Have them ensure that the edges are touching, and the honeycomb is all connected. With this design as an example, the student can now create their own.

This next set of steps should be modeled by the teacher before students work on their own:

In groups of two, have the students start by building the beehive. First, have them fold the rings in half. Then, unfold and fold in half again until the ring has a hexagonal shape. They don’t need to be perfect.

Once the rings are all folded, the students can pick two, add a dot of glue to connect them and they will continue building out until their beehive is the desired shape and size.

To make the bees, you can purchase yellow ping pong balls or other similarly sized balls. Students can paint them yellow. Once dry, have them draw a circle for the face using the black permanent marker. They can add eyes, a nose, and a mouth. They can then draw black rings around the ping pong balls for the bees’ stripes and add a small triangle on the side opposite the face. This is the bee’s stinger. Fold the small pipe cleaner piece into a ‘v’ shape and glue it to the bee’s face for his antenna. They will then cut out two oval shapes from white construction paper. Fold the wing on the tab and add a drop of glue. Attach it to the bee.

The honeycomb sections can be connected and displayed on a bulletin board.

Activity Three: Honeybee Dances / Where are the Flowers?

Objective: Students will learn that movement is a method bees use to communicate called a "waggle dance."

Materials: a variety of artificial flowers

Introduce the "waggle dance" that bees use to communicate where to find nectar. Because they cannot talk, they use movement as a form of communication. Use the video to show a bee, who has just returned to the hive, telling others where to head out to find the flowers they need: *Honeybee Dance Language* (https://www.youtube.com/watch?v=1lhVBNQ-Ik8).

Hide different silk flowers somewhere in your room. Explain to children that bees communicate with each other using a dance. If a bee finds a source of food, the bee will fly back to the hive and tell the other bees how to find the flower. Choose one child to pretend to be a bee and instruct the child how to find the flower. Use gestures to indicate forward, to the right, to the left, behind, above, under, etc. Then let the child go and find the flower and show it to the group. Repeat this activity for other students. With practice, the students will be able to direct their classmates to find flowers they have hidden.

Activity Four: Bee Box Shelters

Materials: tin soup or bean can, large plastic bottles, or small milk cartons from school; art supplies to decorate the can; sheets of 8 ½ x 11" scrap paper, scissors, pencils, tape, glue, toilet paper rolls, twigs from outside, string

Clean and completely dry the interior of a used tin can or milk carton. Have students decorate with items, such as stickers, paint, construction paper, or colorful tape. Cut each piece of scrap paper in half, making sure each piece is a bit shorter than the can or box when you hold them up horizontally.

Have students roll a piece of scrap paper around a pencil. Make sure they roll it five or six times so the tube being created is a little thick. After rolling the paper, help them tape it closed and wiggle it gently off the pencil. This should be repeated until each student has about 30 rolls. Some rolls can be a bit longer or shorter than others as long as they all measure at least six inches.

Students now over the bottom of the can or box with glue and stick the toilet paper roll inside. The roll will help keep the thinner tubes stay snug in the can. Once the toilet paper roll is in, students then place the thinner tubes in the roll, making sure the tubes don't get squished, otherwise, the bees won't be able to fit inside. Twigs are used in the open spaces around the toilet paper roll, breaking them so they don't stick out from the can.

Once the rolls and twigs are in the can, students can tie two pieces of string around the can: one near the top and one near the bottom. Each piece of string should be long enough to wrap around the can twice with enough left over to allow the can to hang about 8 to 12 inches from a tree branch. Bee shelters should be located in sunny areas. Tie the bee home to a branch. It may take a little while for the bees to find the shelter. Return to check the bee home a few times a week to see if anyone has moved in.

Activity Five: Build a Bee Garden

Materials: outdoor planting containers; variety of small flowering plants and/or seeds; plant name labels, like popsicle sticks; permanent markers

Create a container garden to include flowers that attract bees, such as Black-eyed Susans, lantana, and zinnias, and herbs such as lavender, basil, and sage. Have students write on plant labels to keep track of the plants included in the project. Place the containers in an area that is sunny and visually accessible so that students can observe any bee activity that they may generate. Students can keep track of which flowers are visited by the bees.

Additional activities:

Use paints and pens and create pieces of artwork for the bulletin boards

Create a collage, using dried flowers you know the bees like, and mount it onto the wall.

Try a version of encaustic art.

Have a bee-themed fancy-dress party.

Make a bee-themed, hanging mobile.

Invent a dance to the tune: *The Flight of the Bumblebee*

Resources

Barton, Bethany. *Give Bees a Chance*, Puffin Books, Reprint edition, July 2, 2019

Benyus, Janine M. *Biomimicry: Innovation Inspired by Nature*. New York, NY: Perennial, 2009. This book gives information about bees in a fun way, as well as dispelling fears of bees. The graphics are useful for teaching visual literacy.

Buchmann, Stephen*. Letters From the Hive: An Intimate History of Bees, Honey, and Humankind*. Paw Prints, 2008. The author is an amateur beekeeper and founder of The Bee Works, an environmental company.

Burns, Alex. *Beekeeping for Beginners: A Simple Guide to Keeping Bees in Your Yard and Garden, Using Top Bar Hives, Langstroth Hive, and Warre Hive. Caring for Your ... and Thriving Beehive. Buzzing with Success!*, Independent Publisher, May 1, 2023. Many tips and practical advice for both in both an urban and country landscape.

Connecticut Beekeepers Association. https://www.ctbees.org/. This website offers a forum for beekeepers in Connecticut to share information and ideas.

EPA. https://www.epa.gov/pollinator-protection/colony-collapse-disorder. Comprehensive presentation of the disorder, its consequences, and what is being done to support bee health.

“How You Can Help Save the Bees, One Hive at a Time | Noah Wilson-Rich.” YouTube, April 10, 2019. https://www.youtube.com/watch?v=WlFsUeYzezk.

Jackson, Tom. *Bees: Heroes of the Garden*, Amber Books, July 6, 2021. Extensive collection of photographs explaining how bees live and function communally.

Johnson, Renée. Honeybee colony collapse disorder § (2010).
https://cursa.ihmc.us/rid=1JJM69DXL-27XB9CC-12CF/bees.pdf.

Jukes, Helen. *A Honeybee Heart Has Five Openings: A Year of Keeping Bees*. Ithaca, NY: Comstock Publishing Associates, an imprint of Cornell University Press, 2022. The author combined factual honeybee information along with her personal story of first-time beekeeping.

Just Bee Honey. "What Would Happen If Bees Became Extinct?" *Just Bee Honey*, February 12, 2021.
https://justbeehoney.co.uk/blogs/just-bee-honey-blog/what-would-happen-if-all-bees-died.

Klein, Simon and Andrew Barron. "Ten Years after the Crisis, What Is Happening to the World's Bees?" *The Conversation*,
https://theconversation.com/ten-years-after-the-crisis-what-is-happening-to-the-worlds-bees-77164.

Louv, Richard. *Last Child in the Woods: Saving our Children from Nature-Deficit Disorder*. Chapel Hill, NC: Algonquin Books of Chapel Hill, 2005. The book's intent is to illustrate the impacts of too little time spent in nature and what to do to get more nature in kids' lives and make inner cities more accommodating to natural activities.

MacDonald, Rebecca and James MacDonald. *I Am a Bee: A Book About Bees for Kids* (I Am Learning: Educational Series for Kids), House of Lore Publishing, October 15, 2019. The writing is simple with plenty of information and illustrations that are descriptive in themselves.

Micucci, Charles. *The Life and Times of the Honeybee*. Houghton Mifflin, 1998. Easy enough for kindergarteners to understand with beautiful pictures.

"Protecting Bees, Building Habitat, and Strengthening Communities Together," *The Bee Conservancy*, February 28, 2023. https://thebeeconservancy.org. A nonprofit organization dedicated to protecting bees.

"More than Honey - Official Film Website." http://morethanhoneyfilm.com/.

Rodgers, Paul. "Einstein and the Bees. Should You Worry?" *Forbes*, May 28, 2015.
https://www.forbes.com/sites/paulrodgers/2014/09/09/einstein-and-the-bees-should-you-worry/.

Seeley, Thomas. *The Lives of Bees: The Untold Story of the Honeybee in the Wild*, Thomas Seeley, Princeton University Press, May 28, 2019. The author, a world authority on honeybees, sheds light on why wild honeybees are still thriving while those living in managed colonies are in crisis.

Shah, Anup. "Why Is Biodiversity Important? Who Cares?" *Global Issues*.
https://www.globalissues.org/article/170/why-is-biodiversity-important-who-cares.

Tautz, Jürgen. *The Buzz About Bees: Biology of a Superorganism*. Berlin: Springer, 2011.

Woolley-Barker, Tamsin. The Biomimicry Manual: What Can the Honeybee Teach a Designer?, *Inhabitat*.
https://inhabitat.com/the-biomimicry-manual-what-can-the-honeybee-teach-designers-about-insulation-elasticity-and-flight/.

Appendix on Implementing District Standards

Kindergarten Next Generation State Standards:

Interdependent Relationships in Ecosystems: Animals, Plants, and Their Environment

K-LS1-1 Use observations to describe patterns of what plants and animals (including humans) need to survive. The story of Please Please the Bees will introduce the concept of interdependency of bees and their environment. Students will be able to describe the connections between the flowers, the bees, and the bear. The students will understand that the bees communicate with each other in a variety of ways, but specifically use the waggle dance to direct each other to good locations to find nectar.

K-ESS2-2 Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. The character Benedict, the bear, realizes that he needs to change the conditions of his yard to meet the needs of the bees, and once they return, they will again make honey for him to enjoy. Students will recognize that the bear's efforts have made a difference in supporting everyone's needs.

K-ESS3-1 Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live. Students will construct a bee shelter, using their understanding of the design that is most ideal for helping. Bees create a new hive.

Endnotes

[1] Louv, Richard. *Last Child in the Woods: Saving our Children from Nature-Deficit Disorder*

[2] Seeley, Thomas. *The Lives of Bees: The Untold Story of the Honey Bee in the Wild*

[3] Tautz, Jürgen. *The Buzz About Bees: Biology of a Superorganism, 57*

[4] Tautz, 57

[5] Tautz, 53

[6] The Bee Conservancy

[7] Johnson, Renée. Honeybee colony collapse disorder, 3

[8] Johnson, 2

[9] Tautz, 72-73

[10] Tautz, 12-13

[11] Tautz,16

[12] Tautz,16-17)

[13] Tautz, 25

[14] Micucci, Charles. *The Life and Times of the Honeybee*

[15] Tautz, 18-19

[16] Micucci,

[17] Micucci,

[18] Tautz, 14

[19] Tautz, 23

[20] Micucci, 10-11

[21] Tautz, 20-21

[22] Micucci, 12-13

[23] Micucci, 14-15

[24] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3872021/

[25] Micucci, 15

[26] Micucci, 16

[27] Tautz, 22

[28] Micucci, 18-19

[29] Tautz, 29

[30] Tautz, 51

[31] Johnson, 3

[32] EPA. https://www.epa.gov/pollinator-protection/colony-collapse-disorder.

[33] Johnson, 5

[34] EPA

[35] Klein, Simon and Andrew Barron. “Ten Years after the Crisis, What Is Happening to the World’s Bees?” *The Conversation*

[36] Just Bee Honey. “What Would Happen If Bees Became Extinct?” *Just Bee Honey*, February 12, 2021.