2019

4-H AG INNOVATORS EXPERIENCE
PRESENTED BY BAYER

Teen Facilitator Guide



NATIVE BEE CHALLENGE


NATIONAL 4-H COUNCIL

BAYER

IOWA STATE UNIVERSITY
Extension and Outreach

Created by:

Lynne Campbell, STEM Professional Development Specialist, Iowa State University Extension and Outreach
Maya Hayslett, Crop Sciences Youth Education Specialist, Iowa State University Extension and Outreach
Dr. Richard Hellmich, Research Entomologist, USDA, Corn Insects and Crop Genetics Research Unit
Keith Bidne, Insect Rearing Specialist, USDA, Corn Insects and Crop Genetics Research Unit
Ashley St. Clair, Graduate Research Assistant, Ecology and Evolutionary Biology & Entomology, Iowa State University
Randall Cass, Extension Entomologist, Honey Bees and Native Bees, Iowa State University Extension and Outreach
Dave Hunter, Founder and Owner, Crown Bees, Woodinville, WA
Grace Jakes, Student worker, Iowa State University
Nick Oppedal, Student worker, Iowa State University

Map Graphics by:

John Noftsker, Student worker, College of Design, Landscape Architecture, Iowa State University
Haley Mougin, Student worker, College of Design, Landscape Architecture, Iowa State University
Wenlin Wlyang, Student worker, College of Design, Landscape Architecture, Iowa State University

Reviewed by:

Beth Bunkers, Associate Educator, Iowa State University Extension and Outreach, Sioux and O'Brien Counties
Mary Wilkins, Youth Outreach Coordinator, Iowa State University Extension and Outreach, Story County
Lauren Britton, Youth Outreach Coordinator, Iowa State University Extension and Outreach, Boone County
Leah Feltz, Youth Outreach Coordinator, Iowa State University Extension and Outreach, Hamilton County
Bekah Beall, Naturalist, Story County Conservation, Iowa
Alicia Vasto, Executive Director, Iowa Conservation Education Coalition
Royce Bitzer, Research Associate, USDA, Corn Insects and Crop Genetics Research Unit

Native Bee Photo credits:

Dr. Joseph Wilson, Associate Professor, Biology Department, Utah State University

Iowa State University Leadership:

Dr. Chad Higgins, Senior Director, Iowa State University Extension and Outreach

4-H AG INNOVATORS EXPERIENCE
PRESENTED BY BAYER

NATIVE BEE CHALLENGE

What's Inside?

Overview

4-H AG INNOVATORS EXPERIENCE
PRESENTED BY **BAYER**

The 4-H Ag Innovators Experience (AIE) has an agricultural emphasis that incorporates teamwork, communication, workforce development and Science, Technology, Engineering, and Mathematics (STEM) skills. This challenge will focus on the importance of biodiversity, specifically as it relates to native bees and their role in plant pollination. Native bees include bumble bees, sweat bees, mason bees, squash bees, leafcutter bees, and several other types of bees that are native to the United States. Many of the foods we eat are pollinated by native and non-native (introduced) bees. The focus of the 2019 Ag Innovators Experience is understanding the life of native bees, their role in maintaining our food supply, and learning how we can "bee" part of the solution by increasing awareness of native bees.

Of the earth's 250,000 flowering plants, 80% require pollination and 75% of the fruits, vegetables, and nuts we consume rely on insect pollination. Of the many types of organisms that contribute to pollination, bees are the most important. The iconic honey bee is the bee most people recognize. Many people, however, do not know there are more than 20,000 species of bees worldwide. About 4,000 of these bee species live in the United States. Native bees come in a wide array of shapes, sizes, and colors with different life cycles, geographical distributions, seasons of activity, nests, and flower preferences. They are truly fascinating!

Did you know?

The largest North American bee is a species of Xylocopa (/zile-low-COPE-uh/) a type of carpenter bee, whose body is as large as a U.S. quarter. The smallest North American bee is a species of Perdita (/per-DIH-tuh/), known as the fairy bee – on the same quarter this bee would just about cover George Washington's nose.

photo credit for Dr. Joseph Wilson

Why the Native Bee Challenge?

Health of bees is a public concern because bees are important pollinators that contribute to our food supply. Honey bees receive most of the "buzz" in the news, but little attention is given to native bee species. Honey bees were transported to North America by European settlers in the early 1600s, and therefore are not native bees. The importance of honey bees as pollinators, specifically in agriculture, is well established. Yet, some native bee species are as efficient or more efficient than honey bees at pollinating crops such as apples, pumpkins, tomatoes, cherries, blueberries, and cranberries.

The transformation of landscapes across the United States into agricultural fields and urban areas has significantly decreased habitat for native bees. Even though much of the Midwestern landscape consists of row crops, a remarkably diverse community of bees occurs in or near these agricultural ecosystems. Many bee species gather pollen and nectar, and use crops as nesting resources. Some bees may even contribute to pollination of row crops.

Current research focuses on understanding how native bees contribute to agriculture and how establishing habitat increases biodiversity. Incorporating diverse habitats with many types of flowering plants into agricultural ecosystems provides forage and nesting areas not only for bees, but for other animals as well. These cutting-edge studies demonstrate how applying scientific and engineering principles can help solve real-world problems.

The 4-H AIE Native Bee Challenge teaches youth about the abundance and diversity of native bees as well as the vital role they play in food production and ecosystems. Youth will learn that everyone can contribute to increasing pollinator habitats and providing structures for bee nests in agricultural and urban landscapes. Native Bee Challenge is designed for multiple 4-H delivery modes that include: summer day camps, residential camps, 4-H club meetings, summer reading programs, afterschool programs, special events, and K-12 school programs. Activities are aligned with Next Generation Science Standards (NGSS).

Key messages:

Native bees are important pollinators.

- Types of native bees
- Life cycles of native bees

Native bees impact our food supply and have an economic impact on agriculture.

- Process of pollination
- Importance of native bee pollination to food crops
- Economic significance of pollinators to agriculture

Enhancing habitat for native bees benefits pollinators and other organisms, which in turn promotes broader biodiversity.

- Challenges impact native bees.
- Increasing the bee population helps crops and flowering plants
- Promoting biodiversity by improving habitat (both natural and artificial)

What Makes a Bee a Bee?

People often confuse bees, wasps and flies. Bees evolved from wasps and developed the ability to use plant protein from pollen as food for their young. Wasps typically use animal protein, while flies use a variety of protein sources for their larval development. All three of these insects can be found on flowers because all three need carbohydrates from the flower's nectar to provide daily energy.

In addition, bees are characterized by their branched hairs that allow them to collect pollen. These specialized hairs make bees more effective pollinators because they usually transfer more pollen between flowers compared to other pollinators such as butterflies, moths, flies, beetles, and even birds and bats.

Is it or isn't it a bee?

Bee

- Usually very hairy with branched hairs
- Four wings
- Long, elbowed antennae
- Legs broad and hairy
- Pollen on legs or abdomen
- Can sting
- Feed young plant protein

Photo Courtesy of Lance Cheung, USDA,

Wasps

- Usually less hairy or not at all
- Four wings
- Long antennae
- Legs narrow and not hairy
- No pollen
- Can sting
- Feed young animal protein

Photo Courtesy of Jerry Payne, USDA

Flies

- Usually less hairy or not at all
- Two wings
- Short antennae
- Legs narrow and not hairy
- No pollen
- Cannot sting
- Young eat a variety of protein sources

Bees and wasps both have the ability to sting but flies do not. Many wasps sting to immobilize their prey, while bees sting as a form of defense. This defensive behavior varies between species. Some bee species are more likely to sting than others. Solitary native bees are less likely to sting because they do not defend large nests. Thus, solitary bees are sometimes known as gentle bees.

Did you know?

Only female bees have the ability to sting because the stinger is actually a modified egg laying organ (ovipositor) with an associated venom sac.

photo courtesy of USGS

Native Bees

Many people probably have seen native bees and did not realize it. Native bees are common visitors to flowers in yards and often build nests around our homes. Native bees come in a wide array of shapes, sizes, and colors with different life cycles, geographical distributions, seasons of activity, nests, and flower preferences.

Key message:

Native bees are important pollinators.

- Types of native bees
- Life cycles of native bees

Types of native bees

While all bees have branched hairs, some females have pollen transport hairs that are stiff and feathery, called scopae (singular scopa \'skōpə\); plural scopae \ -ō,pē \).

Each family of bees collects pollen in specific ways depending on location of the scopae. The majority of native bees collect pollen with scopae on the hind legs with the exception of the family Megachilidae (/meg-uh-KILE-e-dae/) who specialize in collecting pollen on the underside of the abdomen. The Apidae (/AP-i-dae/) family includes bumble bees and honey bees that carry pollen in corbiculae (/kawr-BIK-yuh-lae/), which are highly developed pollen storage structures on the hind legs.

Seven families of bees around the world

Scientific family name	Examples
Apidae	Squash, long-horn, carpenter, bumble, mason, leafcutter, resin bees and honey bees
Halictidae	Sweat and alkali bees
Megachilidae	Mason, leafcutter and resin bees
Andrenidae	Mining and burrowing bees
Colletidae	Plasterer, polyester and cellophane bees
Melittidae	Melittid bees
Stenotritidae	Stenotritid bees (native only in Australia)

Some species of native bees are yellow and black, but most native bees come in a variety of colors, including metallic green, blue, and gold.

Sweat Bee, Halictidae

Bumble Bee, Apidae

Leafcutter Bee, Megachilidae

Squash Bee, Apidae

Mason Bee, Megachilidae

Permission to use photos from Joseph Wilson, Associate Professor, Utah State Univeristy

Bees are social or solitary

Native bees are either solitary, highly social or somewhere in between. Highly social native bees, like bumble bees, live in colonies with many individuals and have a division of labor, one reproductive queen, and overlapping generations. The majority of native bees (85%) are solitary, meaning they nest alone and have only one generation at a time. Most female solitary bees build and care for their nests without assistance from other bees. A native bee nest contains many chambers for larval development. Females bring pollen and nectar to these chambers where they slowly form a food ball. An egg is laid on top of this ball, then the chamber is closed. The egg hatches, the larva develops on the provisioned food, and a new bee emerges the following year.

Let's compare social to solitary bees

Highly Social	Solitary
Honey bees and bumble bees	Most native bees
Live in colonies	Nest alone
Queen lays eggs, workers do all other tasks	Females lay eggs and do all tasks
Raise their young	Lay eggs in nest but do not care for young
Overlapping generations in a season	Usually single generation in a season

Where do native bees live?

Most native bees, about 70%, build their nests underground. For example, bumble bees often establish colonies in abandoned rodent burrows, while sweat bees dig tunnels in packed earth. Other native bees use hollow stems or holes in trees, usually left by beetles. Carpenter bees use their powerful jaws to make holes in wood. Cavity-nesting bees are commonly found in stems of trees, shrubs, and grasses.

Pupae in carpenter bee nest pictured left

Did you know?

Some highly specialized bees called masked bees (Hylaeus /hi-LEE-us/) do not have external scopae. They swallow pollen, carry it back to the nest, and regurgitate it into a nest cell.

photo courtesy of Stephen Cresswell

How far do native bees fly?

Depending on a bee's size, they may have the ability to travel long distances. Large-bodied bees like bumble bees have strong, highly developed flight muscles and can travel up to eight miles looking for food and nest sites. Many small native bees travel up to half a mile to find appropriate food sources and then make their nest near the food source. Once nesting begins, most small native bees rarely travel beyond 100 meters from their nests.

Life cycles of native bees

Native bees have a complete life cycle, meaning they go through egg, larval, pupal, and adult life stages. The time of year these stages occur and the number of generations can vary among species. Most native bees overwinter in the ground or in cavities as pupae, emerging the following season as adults ready to continue their life cycle. One exception are bumble bees that overwinter as adult queens in leaf litter or loose soil.

Life cycle of a solitary ground-nesting native sweat bee in the family Halictidae

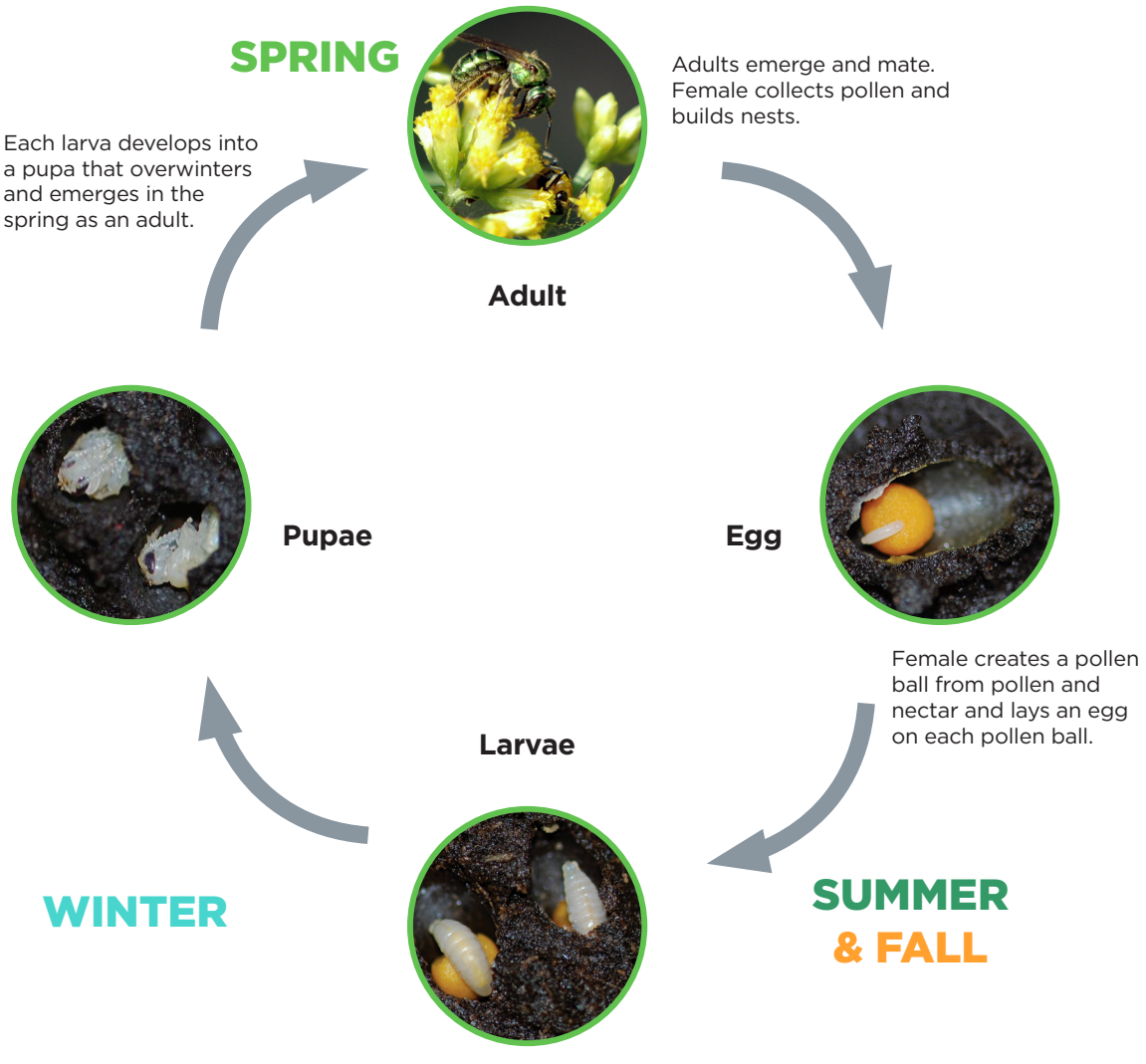


photo credits: Roberta Gibson

Native Bees & Pollination

Key message:

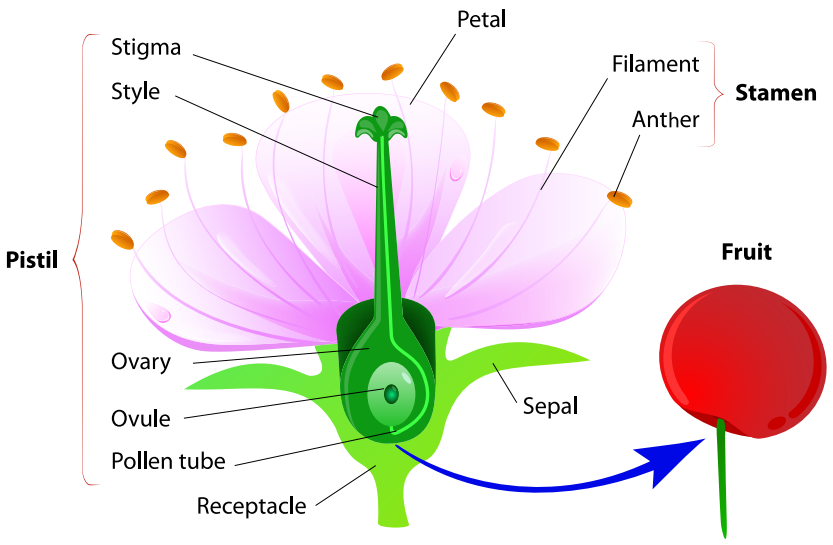
Native bees impact our food supply and have an economic impact on agriculture.

- Process of pollination
- Native bees are important to pollination of food crops
- Pollinators are economically significant for agriculture

What is pollination?

All living organisms create offspring for the next generation. Most plants accomplish this by producing seeds that grow into new plants. Seeds are produced only after flowers are pollinated. Pollination is the process of transferring pollen from the male anther of a flower to the female stigma of a flower. When pollen is transported to the stigma, the pollen grain forms a tube that grows through the style and ovary to fertilize the ovule. A fertilized ovule is the new seed that can grow into a new plant. Often seeds produced from pollination are found inside fruit. Some seeds are large like those found in cherries or peaches, while others are small like those found on strawberries or in kiwi.

BASIC FLOWER STRUCTURE



Did you know?

A strawberry flower needs to be completely pollinated so that each stigma receives one pollen grain that results in one seed. If not all stigmas are pollinated, the result is misshapen fruit.

How is pollen transported from one flower to another?

Many plants like grasses rely on wind to transport pollen, but most flowers rely on pollinators. The coevolution of plants and pollinators is truly fascinating and remarkable. Pollinators receive a reward, usually nectar, pollen or both, in exchange for carrying pollen from one plant to another, which results in fertilization and seed production.

Types of pollination

Self-pollination

Sour cherry flowers

Pollen from the anther lands on the stigma of the same flower or a flower on the same plant.

Self-pollination

Buzz-pollination

A special type of self-pollination that is enhanced by a bumble bee physically buzzing using distinctive high-frequency vibrations to dislodge pollen.

Cross-pollination

Apple flowers

Pollen from the anther of a flower is transferred to the stigma of a flower on a different plant of the same species.

Separate male and female flowers

Pumpkin flowers

Pollen from the anther of a male flower is transferred to the stigma of a female flower of the same species.

Why do bees visit flowers?

Bees visit flower blossoms to collect nectar and pollen. They consume nectar, a sugary liquid that flowers produce to attract pollinators. Nectar is a source of energy and is the primary food for adult bees. Bees also collect pollen, either actively or passively, usually while collecting nectar. Some bees visit flowers such as tomato blossoms only to collect pollen. Pollen adheres to hairs on the bee's legs and abdomen as it brushes up against the anthers. The bee then transports nectar and pollen back to the nest. Honey bees and bumble bees moisten the pollen with nectar and pack it into their corbiculae. Most native bees typically dry pack pollen on scopae under their abdomens or on their hind legs. All adult and larval bees consume pollen as a source of protein, fat, and other nutrients. Back at the nest, the female bee removes and mixes the pollen and nectar to make a food ball for one of her young. Consistency of the food ball ranges from pasty to soupy, depending on the bee species. She repeats this multiple times, once for each egg she lays.

Flowers also benefit from these bee visits. When a bee visits multiple flowers, pollen grains brush off onto the sticky stigmas of recipient flowers. If the plant species match, then the pollen grains fertilize the ovules and become the seeds in a developing fruit. Pollen contains male gametes, while ovules contain female gametes. When transporting pollen between different individual plants of the same species, bees help distribute genes among plants. This results in a greater variety of traits in the offspring and increases genetic diversity of the plant population. Both bees and plants benefit from this mutualistic relationship.

How do native bees contribute to food production?

Pollination by bees contributes to healthy and productive plant communities, provides food for wildlife, and serves an important role in crop production. Annually, bees contribute over $14 billion in crop production in the United States and between $200 and $600 billion worldwide.

Honey bees are the most commonly used commercial pollinator, but native bees that are used commercially, such as bumble bees, alfalfa leafcutter bees, and mason bees, contribute over $4 billion to agricultural pollination each year. Research demonstrates that native bees nearly double the yield for a variety of crops, such as cherry and alfalfa. Native bees also can increase almond production by 1.2 times, and strawberries by 1.5 times. Orchard owners often use honey bees to pollinate pear and apple trees but research shows that native bees are, in some cases, superior pollinators.

Did you know?

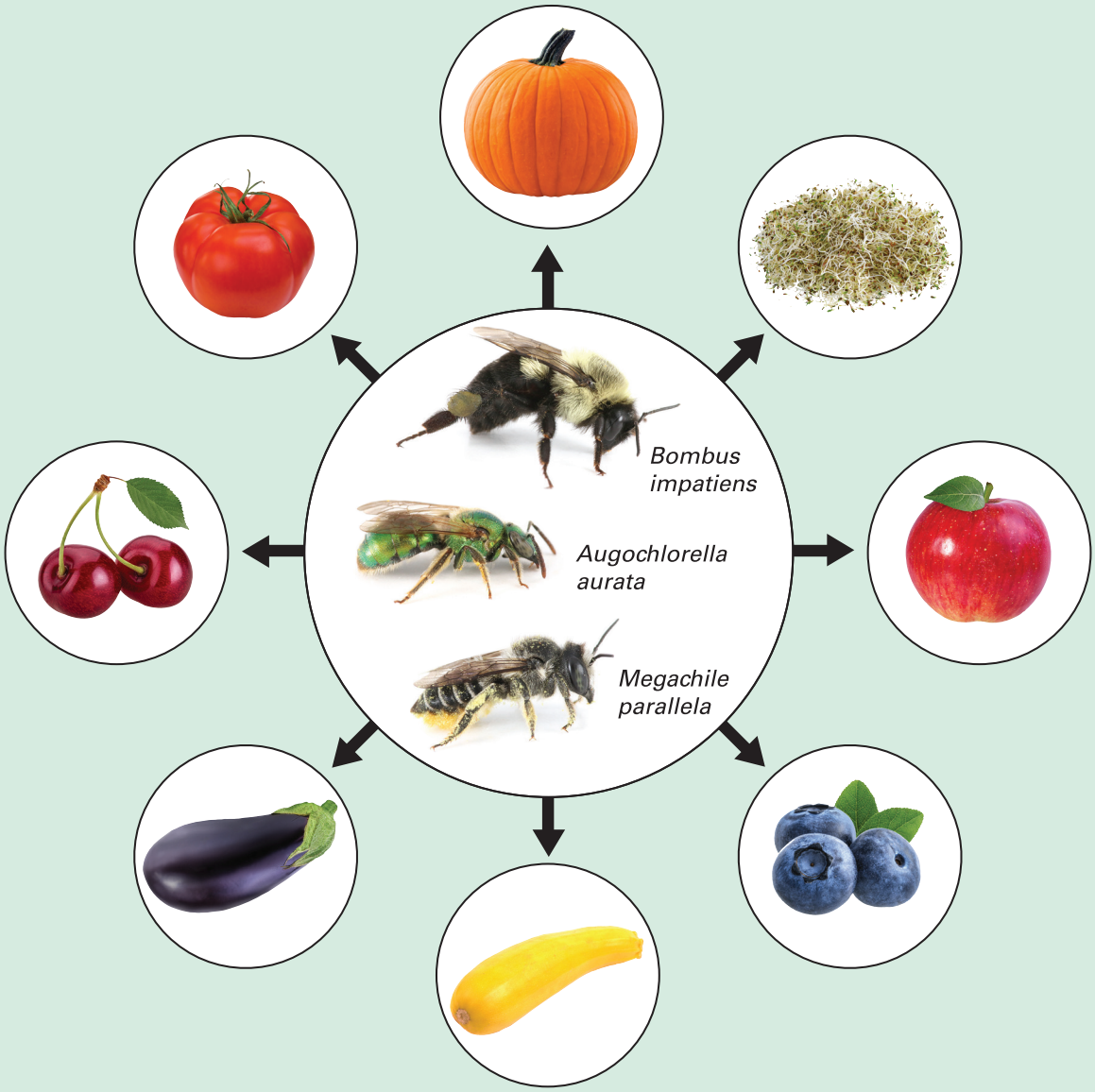
The southeastern blueberry bee can visit as many as 50,000 blueberry flowers in her short lifespan, resulting in the pollination of over 6,000 ripe blueberries. That is over $20 worth of blueberries per bee!

Photos Courtesy of the USDA Hannah Burrack

Field trials also have shown increased yields in squash, beans, peas, and many other crops when native bees are present. Tomatoes are a crop with no nectar reward, but bumble bees are still attracted to the pollen. Bumble bees, if contained within a greenhouse and supplied with nectar, can improve tomato production through a process called buzz pollination, or sonication. During this process, bumble bees beat their wings at a higher frequency, which results in the release of more pollen and increases the number of tomato flowers pollinated. Many foods that are eaten daily are pollinated by native bees. The diagram below focuses on three common native bees and their possible contributions to production of food that we eat.

Not all bees make great candidates for commercial pollination. Solitary ground-nesting bees are not used commercially because their nests are hard to duplicate and it is difficult to maintain enough bare land to support nesting. However, bumble bees and many cavity nesters, such as mason bees, are excellent candidates for commercial pollination because they are commonly attracted to artificial nests and can be easily transported.

Native bees are important pollinators of flowers and trees in both natural and artificial habitats. These habitats provide many ecological benefits. For example, trees provide shelter for animals and insects, while flowers produce seeds for mammals and birds.



Graphic created by Iowa State University Agriculture and Natural Resources Communications Team

Challenges to the Native Bee Population

Key message:

Enhancing habitat for native bees benefits pollinators and other organisms, which in turn promotes broader biodiversity.

- Challenges impact native bees
- Increasing the bee population helps crops and flowering plants
- Promoting biodiversity by improving habitat (both natural and artificial)

Threats to Native Bee Survival

The Midwest is home to several imperiled bee species such as the rusty patched bumble bee, which was recently listed as an endangered species in the United States. Many factors affect bee health and can lead to bee losses and reduced populations. In general, bee threats fall into four categories: habitat loss, diseases and parasites, climate change, and pesticide exposure.

Habitat loss

Habitat for bees includes flowers for nectar and pollen, and places for bees to build nests. Preserving bee populations requires several types of flowers that provide nectar and pollen from early spring to late fall to accommodate different types of bees. Preserving native bees also requires providing nesting resources, which varies from open ground to multiple types of pithy stemmed plants. Improving habitat increases bee populations and often enhances species biodiversity. In general, low-diversity habitats such as mowed lawns and agricultural fields do not support many bees. Manicured lawns with non-flowering grasses and no bare spots, have few if any places for bees to establish nests, forage for food, or both. Habitats with high diversity, on the other hand, provide flowering and nesting resources that can support many types of bees that occur at different times of the season.

Diseases and parasites

Although diseases in native bees are not as well studied as in honey bees, research has shown that native bees are susceptible to several diseases including those spread by honey bees. One way to avoid disease is to maintain plentiful habitat for native bees and to replace cavities (straws) in artificial nests at least every two years.

Photo courtesy of @Jacquie Hartwright

Diseases are sometimes spread by bees visiting flowers. If a diseased bee visits a flower, that bee could leave a virus, mite, or a fungus in the flower for other bees that visit the same flower. For example, Deformed Wing Virus is a disease that is passed from adult bees to bee larvae. This transmission is similar to the flu virus being transmitted by person not washing their hands and leaving the flu virus on a door handle for another person to acquire when they touch the door handle.

Climate change

Climate change may impact specialist species of bees that rely on resources from one type of plant. Often the relationship between plants and insect pollinators is dependent on seasonal timing of blooms. Changes in climate may impact seasonal bee-flower interactions. Bees that are generalists should be more adaptable to changes that occur as the result of climate change, but even they could have challenges with locating foraging resources.

Pesticide exposure

Most insecticides are toxic to bees and some herbicides impact non-targeted flowering plants in and around crop fields. Any effort to reduce the exposure of pesticides is encouraged, both in agricultural and urban areas.

How can we help the native bee population?

Planting foraging habitat for bees

A key component of a good bee nesting environment is the availability of nectar and pollen from flowers. Generally speaking, bees benefit from a variety of flowers because each type of flower provides different nutrients. Native bees often prefer to forage on flowers of native plants, which are better adapted to the climate and are more likely to thrive than non-native plants. In general, a diverse array of plants, native and non-native, should be considered; however, non-native plants that are "invasive" or "weedy" should be avoided.

Since the activity of each native bee species varies throughout the year, it is important to plant a variety of flowers with varying blooming periods to ensure food sources for bees are available from early spring into fall. A diversity of flowering plants also is important since native bees have anatomical differences that influence the type of flowers they visit. For example, some native bees (Apidae) have long tongues that are better suited for collecting nectar from flowers with long tubes, while other native bees (all other families) have short tongues that are better for foraging on more open flowers with easily accessible nectar.

In agriculture, there are multiple ways for farmers to increase pollinator habitat and increase abundance of native bees on their land. Providing pollinator habitat around cultivated crops can increase foraging and nesting resources for bees. All types of underutilized land can be used to establish habitats that are beneficial for bees, other pollinators, monarch butterflies, and wildlife, which increases biodiversity without reducing food production. A greater biodiversity of bees can lead to increased pollination of plants, including crops. Native bees help increase crop yields by increasing successful pollination of farm and orchard crops. Specific practices can help farmers.

1. Conservation Reserve Program (CRP) is a government program in which farmers are paid to take land out of crop production and plant environmentally beneficial plants. These areas could be planted into pollinator habitat.
2. Strips of prairie plants can be planted strategically in fields or edges of fields to reduce soil erosion and increase biodiversity. Similarly, native flowering plants could be planted in fallow land or near non-productive lands near crops.
3. Farmers can develop crop rotation plans that include flowering cover crops, such as clover and alfalfa, that not only provide bees with forage but also improve soil fertility.

Reducing risk of pesticide exposure

There are many ways to reduce the risk of pesticide exposure to bees and help preserve native bee populations:

1. Integrated pest management (IPM) is an important approach that allows pesticide applicators to find a balance that minimizes pesticide use and maximizes insect or weed control, while protecting crop yields, maximizing profits and reducing costs.
2. In agriculture and backyard gardening alike, it is important to read pesticide labels. In many cases, the exposure of bees to pesticides can be reduced by reading the pesticide label and closely following its instructions.
3. Commercial agricultural producers can reduce impacts to bees by applying pesticide at dusk when bees are less likely to be foraging and by avoiding spraying on windy days. Exposure also can be reduced by controlling application rates and droplet size of pesticides so that pesticide spray does not land on nearby flowers.
4. Most lawns are manicured and have only one type of plant (grass) and few flowers, which reduces biodiversity. In lawns and gardens, pesticide use can be reduced or eliminated by growing pollinator habitat, which requires less maintenance.

Providing nesting habitat for bees

Native bees will nest near sites where they forage. Once they have established nests, bees will not travel very far. The smallest bees may only travel a few hundred feet from their nests. Since most native bees are ground nesting, the ideal site for these bees is a bare patch of ground with full sun and well-drained soil. Some native bees prefer flat ground to dig their nests while others prefer to nest in vertical banks of ground or berms. Entrances to bee nest tunnels often look like ant hills with small piles of soil surrounding round holes. The best sites are areas that are not tilled and have very little traffic from vehicles or people.

Ground nesting native bee nests.
photo courtesy of the USDA Hannah Burrack

Holes of the ground-nesting squash bee
photo courtesy of T'ai Roulston, University of Virginia

To increase nesting habitat for stem-nesting bees, there are many plants from which to choose. These plants include agave, cup plant, sunflowers, yucca, and pithy-stemmed plants like raspberry, blackberry, and elderberry.

Finally, nesting habitat can be increased by constructing artificial nests for cavity-nesting bees. Wooden trays with holes in a "bee house" or bundles of stems or cardboard tubes can be tied together or set in a PVC pipe to create an inviting nesting "hotel" for solitary bees.

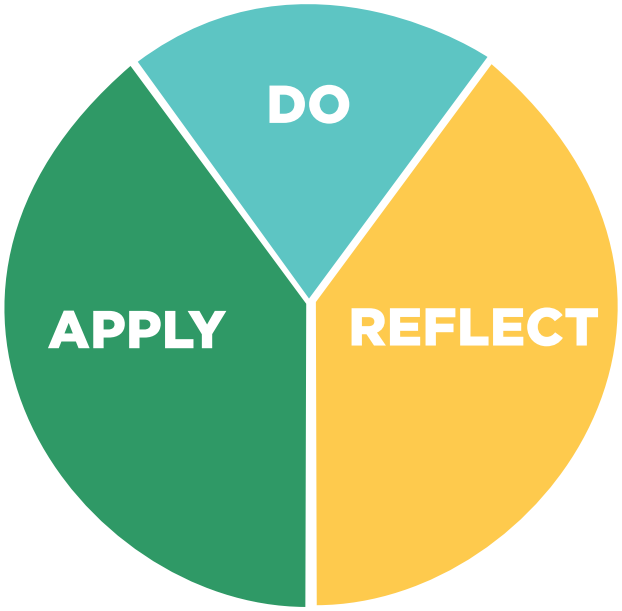
Facilitator Preparation

Experiential Learning Model

DO

1. Experience: Youth engage in hands-on educational learning experiences.

Youth explore ways to increase biodiversity so that bees and other pollinators have access to food and nesting sites and habitat is available for other animals.



REFLECT

2. Share:
Youth describe their observations and reflections.
Each team shares results from the experience and draws a conclusion based on findings.

3. Process:
Ask youth to identify themes, problems, and opportunities.
Facilitators will lead both small and large group discussions as as youth consider the reflection questions. Youth discuss findings and identify patterns they notice during the experience.

APPLY

4. Generalize:
Ask youth to connect key learning to real life experience.
Youth share their learning and identify how new learning can be utilized in real life scenarios. Youth will build a native bee nest and take it home to increase native bee habitat in their community. Youth will recognize that bees can be added to increase pollination and profitability of agricultural land.

5. Apply:
Ask youth how they will use what they learned in similar/different situations. Youth will use what is learned to participate in action beyond the experience. Youth can use the native bee nest that they built to participate in a nationwide citizen science project in collaboration with CrownBees. Youth can also seek ways to increase pollinator habitat to the environment to increase bee population specifically and increase biodiversity by providing food and shelter for other organisms such as songbirds, honey bees, butterflies, and other wildlife.

Ages and Stages of Youth Participants

Certain characteristics are common to children at each age level. Although children differ in the rate at which they develop, the order of the stages does not vary. Some needs and interests are universal to all children in order to ensure successful development; however, it is important to remember that every child is unique and special in his or her own right.

Age appropriateness refers to how a program matches its educational offerings with the predictable sequences of growth and change that occur in children. Each stage is distinct, characterized by abilities, attitudes, and priorities that are different from those of preceding and subsequent stages.

Below are the typical characteristics of youth that are important for teen leaders to understand when they are engaged with youth during implementation of the Native Bee Challenge.

Characteristics of Grades 3-5 (ages 9-11)	Implication and application
Usually work best when work is presented in small pieces.	Need simple and short directions.
Need guidance from adults to stay at a task to achieve their best performance.	Work closely with the groups to keep them on task.
Enjoy cooperation.	Encourage youth to work together to do the tasks.
Have limited decision-making ability.	Need to know steps of the task (will need adult guidance).

Characteristics of Grades 6-8 (ages 12-14)	Implication and application
Desire a sense of independence, yet they want and need assistance.	Encourage youth to work with adults and older teens to complete learning experiences and apprenticing.
Are ready for in-depth, longer learning experiences.	Encourage deeper exploration of leadership roles. Encourage more detailed recordkeeping of leadership experiences.
May avoid difficult tasks.	Help youth choose tasks at which they can succeed. Encourage them to participate in all tasks. Assist youth in eliminating their fears. Help them succeed in solving and participating in difficult tasks.
Gain skills in social relations with peers and adults.	Provide opportunities for interaction with peers and adults. Provide activities that would foster social interaction.

Source: Adapted from Iowa State University Extension and Outreach, Publication VI950902, December 2006

Getting Organized

One kit reaches 24 youth, or six teams of four. Items listed in green are NOT included in the 4-H Native Bee Challenge kit. The complexity of the models can be increased for older youth or simplified for younger youth.

Materials for Native Bee Model

- ☐ Clear plastic spoons (30)
- ☐ Tape and double face tape
- ☐ Bee Image Sheet (6 of each image: leafcutter, mason, bumble, squash and sweat bee)
- ☐ Sets of Five Bee Cards (6 sets/kit)

Materials for Flower and Pollen Models

- ☐ Flower cards - Apple (4), Cherry (4),Tomato (4), Pumpkin (4), Prairie Plants (2)
- ☐ Foam cones to represent pistil (18/kit)
- ☐ Glue dot strips for stigma (2 sheets/kit)
- ☐ 1 oz cups to represent anther (80/kit)
- ☐ Wood craft sticks to represent filament (80/kit)
- ☐ Petri plates (9/kit)
- ☐ Small containers with lid to store sequins (8)
- ☐ Red 5mm sequins to represent nectar (1 pkg)
- ☐ Colored 8mm sequins to represent flower pollen (1 pkg/color)
  - ☐ Light Pink
  - ☐ Silver
  - ☐ Light Blue
  - ☐ Brown
  - ☐ Purple
  - ☐ Dark Pink
  - ☐ Iridescent
  - ☐ Dark Blue

- ☐ Toilet paper tubes or small cups for the nest (24/kit)
- ☐ Yellow, green and brown tissue or construction paper for nest partitions (optional)
- ☐ Apples, cherries, tomato for snacks to make a healthy snack connection (optional)

Materials for Map Challenge

- ☐ 11x17 Magnetic Challenge Map & Icon Sheet (6/kit)
- ☐ Characteristics of Bee (reproducible)
- ☐ Challenge Map with Habitat Icons Key
- ☐ Challenge Map with Bee Icons Key

Apple flower model

Tomato flower model

Flower and Pollen Models Reference Chart

Flower Picture	Pollen color of model	Type of pollination
Apple 	Light pink / Dark pink	cross-pollination
Cherry(sour) 	Silver / Iridescent	self-pollination
Pumpkin   male female	Gold	male and female flowers
Tomato 	Light blue / Dark blue	buzz pollination
Prairie Plants  Purple Coneflower  Wild Bergamot  New England Aster  Goldenrod	Purple	additional nectar and pollen sources

Facilitating the Activity

Overview

The 4-H AIE Native Bee Challenge introduces youth to native bees as important pollinators and explores the relationship of native bees to agriculture, the food we eat, and biodiversity in general. The use of modeling builds understanding of the process of pollination, role of pollinators in our food supply, and importance of creating habitat for native bees that also benefits other organisms. Working in teams, youth "operate as" bees as they navigate to plants to gather nectar and pollen to live and grow.

During the Native Bee Challenge, youth apply the concepts from the pollination model to a second model where they add bees and habitat to a landscape to increase biodiversity and profitability of the land. Each team makes a proposal that is compared to a key. Each team receives Bee Bucks based on how much the value of land in and near the community is increased based on their recommendation.

Key Messages

As the facilitator of this experience, you will help youth understand:

Native bees are important pollinators.

- Types of native bees
- Life cycles of native bee

Native bees impact our food supply and have an economic impact on agriculture.

- Process of pollination
- Importance of native bee pollination to food crops
- Economic significance of pollinators to agriculture

Enhancing habitat for native bees benefits pollinators and other organisms, which in turn promotes broader biodiversity.

- Challenges impact native bees
- Increasing the bee population helps crops and flowering plants
- Promoting biodiversity by improving habitat (both natural and artificial)

Model of Pollination

Pollination is an important process that leads to the development of seeds. This process also results in the production of foods we eat such as fruits and nuts. In this activity youth will explore the process and results of pollination and its connection to our food supply.

Youth will create a model of pollination that includes five types of bees and four types of flowers. In the model each type of flower will have different colors of pollen. Youth will explore a variety of scenarios with different types of solitary bees (mason, leafcutter, sweat and squash bees) and one type of social bee (bumble bee).

Native Bee Challenge Pollination Model

Setting Up the Activity

- ☐ Set out 2 of each flower photo (apple, pumpkin, tomato, cherry) and one prairie flower.
- ☐ Set out a model with each flower photo. For female pumpkin flower, do not use anthers. For male pumpkin flower, do not use stigma. You will only have one flower for prairie.
- ☐ Place sequins that represent pollen in each anthers (cups) according to the color identified and only when the flowers are in bloom.
- ☐ Place red sequins that represents nectar in the petri plates for all flowers except tomatoes.
- ☐ Give each youth a bee card and corresponding spoons with squash, leafcutter, mason, sweat and bumble bees.
- ☐ Give each youth a toilet paper roll or cup to represent the bee nest. Ask youth to write their name on the nest.

DO

Presenting Pollination Activity to Participants

Leader script: Read italics script as youth participate in the activity. Leader performs the actions in bold.

For this activity you are bees visiting a produce farm. The farm grows apples, cherries, pumpkins and tomatoes ***(show pictures of flowers that correspond with each crop)****.*

When we look at a flower we usually notice the petals, however, a flower has many parts and is important for a plant's life cycle. Each flower can make a seed, but to make a seed the flower needs to be pollinated. This means a pollen grain needs to land on a stigma.

Pollen grains are held on the anthers. Each flower usually has one stigma ***(represented by the foam cone)*** *and several anthers. Apple, cherry and tomato flowers each have one stigma and 5 anthers in each flower* ***(show model)****.*

Pumpkin plants have separate male and female flowers. What do you notice about those flowers? That means some pumpkin flowers will have anthers and some pumpkin flowers have stigma only.

For this activity you will be a mason bee, a leafcutter bee, a squash bee, a sweat bee or a bumble bee, gathering pollen and nectar (refer youth to their bee card).

Mason bees are active in the spring and good at pollinating spring fruit crops like apples. Mason bees are solitary bees. Each of you are gathering food for you and your young. You are active in the spring.

Bee	Time of year	Flowers
Mason bee	Spring	Generalist
Bumble bee	Spring, summer	Specialist (tomato), generalist
Sweat bee	Summer	Generalist
Leafcutter bee	Summer	Generalist
Squash bee	Summer	Specialist (pumpkin)

Leafcutter bees, sweat bees, and squash bees are active in the summer and are solitary bees. You are active in the summer. Bumble bees are social bees and active all season. You are active in the spring and summer.
The toilet paper roll represents your nest. Mason bees, leafcutter bees and squash bees live on their own, so place your nest where you are seated and return to your nest once you visit a flower.
Bumble bees live together, so place your nests all together in one spot. That will be the nest you return to after visiting a flower.

Each bee needs to collect pollen and nectar from the flowers and take both back to the nest. When your bee visits a flower, you need to touch the stigma, anther, and collect nectar. When back at the nest, you remove the pollen and nectar placing it in the nest.

Spring Pollination

It is spring at the farm. That means the apple and cherry flowers are in bloom and the mason bees and bumble bees are flying around. Spring prairie plants are also in bloom. Every bee who is active in the spring can now "fly" to locate a flower. Only mason and bumble bees should collect pollen and nectar in the spring.

Youth Action: Youth representing bumble bees and mason bees only go collect pollen and nectar and return to their nest to deposit pollen and nectar.

Optional: If time permits, add partitions to the nest for your eggs.

- Bumble bees – yellow representing wax pot
- Mason bees – brown representing clay material between larvae
- Leafcutter bees – green representing leaf circles
- Sweat bees – brown representing mud door of the chamber
- Squash bees - brown representing mud door of the chamber

Summer Pollination

Now it is summer. The apple and cherry trees are done blooming. ***(remove sequins from apple and cherry anthers)*** *Tomato and squash flowers are now blooming* ***(add additional pollen colors).***

Mason bees are not as active, so mason bees will not be flying now. However, leafcutter, squash, sweat, and bumble bees are active.

Pumpkin flowers now have open blooms and are easy to access. Tomato flowers have their pollen inside the anther making it more difficult to collect.

Bumble bees are strong enough to get the pollen out of the flower, but leafcutter bees are not. So, leafcutter, sweat bees and squash bees cannot get pollen from the tomato flowers.

Youth Action: Youth representing leafcutter, squash, sweat, and bumble bees go collect pollen and nectar and return to their nest to deposit pollen and nectar.

REFLECT

Discuss pollination (for the plant) and food collection (for the bee) with participants.
Let's look at the apple flowers. Apple flowers cannot pollinate themselves. They are often cross-pollinated. That means that you need to have two different types of apple trees for them to be pollinated. In this activity the bright pink pollen was from one type of apple tree and the light pink was from another. So, the flowers that have bright pink pollen need to have light pink pollen on their stigma and the flowers that have light pink pollen need to have bright pink pollen on their stigma.

Let's look at the sour cherry flowers. The sour cherry flowers can pollinate themselves. This is called self-pollination. That means either color of pollen will result in cherry fruit.

Let's look at the other flowers.
Did you notice anything different about the pumpkin flowers? They had different types of structures in the middle. Pumpkin have male and female flowers. The female pumpkin flower needs to have gold pollen to make a pumpkin.

Did you notice anything unique about the tomato flowers? Tomato plants have either light or dark blue pollen or both. While tomatoes can self-pollinate, bumble bees use buzz pollination to increase pollination of the tomato flowers. This results in more tomatoes.

DO

Have participants return to a flower that they visited to collect nectar and pollen. Ask them to collect data on flower pollination collection to determine how many flowers are successfully pollinated. **Suggest creating a data table like the one to the right.**

Crop Type	Flower 1	Flower 2
Apple	Yes / no	Yes / no
Cherry	Yes / no	Yes / no
Pumpkin	Yes / no	Yes / no
Tomato	Yes / no	Yes / no

How many flowers were pollinated?

How many fruit will form out of the 9 (or 18) flowers? (The number of flowers depends on the number in group)

Optional: Have the fruit (apples, cherries, squash or pumpkins, and tomatoes) available.
Connect to Healthy Living /Pick A Better Snack.

Did you end up with pollen at your nest? How about nectar? Count how much pollen you collected at your nest. How many flowers did you visit? Record your findings and share on a Flower Pollination data table.

Flower Pollination Blank Data Table

Bee type	Pollen Types	Number of Flower Types Visted	Number of Flowers Pollinated?
Bumble bee			
Leafcutter bee			
Mason bee			
Squash bee			
Sweat bee			

Ask participants to share their findings. See the data table below for maximum number of flower types visited.

Flower Pollination Key Data Table

Bee type	Pollen Types	Number of Flower Types Visted	How many flowers were pollinated?
Bumble bee	Could have all	5 types of plants	Number will vary
Leafcutter bee	Apple, cherry, pumpkin, prairie plants	4 types of plants	Number will vary
Mason bee	Apple, cherry, prairie plants	3 types of plants	Number will vary
Squash bee	pumpkin and prairie plants	2 types of plants	Number will vary
Sweat bee	Apple, cherry, pumpkin, prairie plants	4 types of plants	Number will vary

REFLECT

Engage youth participants with these questions.

What strategy did you use to collect pollen and nectar? How well did it work? Some youth will go fast to visit many flowers.

What would you do differently next time? Youth suggest other strategies.

How well did the bees pollinate the flowers? Refer to data collection tables.

Why is it important to have the flowers at a farm pollinated? Without pollination there will not be fruit to harvest.

What could be done on this farm to help all types of bees? Increase habitat for nests and food sources. Add artificial bee nests.

What are the advantages of being a social bee? Solitary bee? Social bees share work and resources. Solitary bees can take advantage of resources for themselves, and when they are finished providing for the nest, their work is done.

What are the disadvantages of a social bee? Solitary bee? Social bees need to provide continued care of the nest and colony. Workers do not have opportunity to reproduce. Solitary bees don't have other bees to help raise their young.

What could be done at a vegetable farm to increase pollination? Increase the population of bees to improve pollination. Increase habitat for bees to collect nectar and pollen after fruit and crop flowers have bloomed. Provide sustained habitat suitable for nesting.

Summarizing Pollination

How does pollination happen? Emphasize mutualism between the bee and flower. Both plant and bee benefit.

Why do bees visit flowers? Emphasize gathering nectar and pollen for themselves and the next generation.

How does the plant benefit? Emphasize that pollination results in the certain types of food production including fruits and nuts.

Native Bee Challenge Flower and Bee Morphology (optional)

The focus of this activity is the concept of co-evolution, specifically the relationship between flower structure and the length of a bee's tongue.

Preparation

- ☐ Use flower pictures or tape flower petals to the tube of rolled construction paper, 6"and 8" tall, making some flowers short and other flowers tall.
- ☐ Fill tube area half full of pompoms.
- ☐ Cut some straws or skewer sticks in half; leave others long.
- ☐ Tape a piece of hook & loop fastener to straw ends.

DO

Some participants will be short-tongued bees, and some will be long-tongued bees. Each bee will visit both the short and the tall shaped flowers with their straw to extract pompoms (representing nectar) with the hook and loop fastener end of the straw. The straw represents the bee's tongue and the participants are the bees.

Some native bees have long tongues while other bees have short tongues. Some flowers also have long corolla tubes, while others have short corolla tubes.

This model demonstrates how both specialist and generalist bees can pollinate different types of flowers, which in some cases leads to specific pollinator-plant co-evolution.

Those with the long straw (long-tongued bees) can collect nectar and pollen from both short- and long-corolla-tubed flowers representing a more generalist type bee; the short-tongued bees are only able to successfully obtain nectar and pollen from short-corolla-tubed flowers.

This model illustrates the diversity in both bee and flower anatomy and the necessity for a diversity of bees to successfully pollinate the diverse array of flower types.

REFLECT

Engage youth participants with these questions.

How does the anatomy of a bee impact their ability to eat? Long-tongued bees can get nectar from a variety of flower shapes. Short-tongued bees cannot get nectar from flowers with long corolla tubes.

How does this relate to the anatomy of a flower? The flower anatomy will determine which bees collect nectar from the flowers. The more flowers that are visited results in more flower that are pollinated.

What impact does this have on the diversity of bees? Long-tongued bees can collect nectar from both short- and long-corolla-tubed flowers representing a more generalist type bee; short-tongued bees are only able to successfully obtain nectar from short style flowers and thus would be more specialists. Generalists can access to more flowers, thus would have a greater chance at survival.

What impact does tongue length have on biodiversity in general?

Bees and flowers co-evolve together in different ways, which results in increased biodiversity.

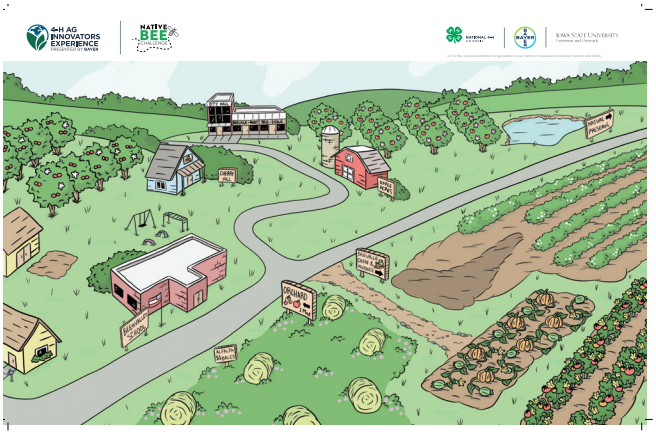
Native Bee Challenge Map Activity

APPLY

You are part of a team asked to make recommendations to a community task force about ways to increase food production and biodiversity. Your team is comprised of four to six stakeholders: farmer, orchard owner, city planner, home owner, school administrator, and parks commissioner. At an upcoming Beeville City Council meeting, your team will share its recommendations about where to add habitat and native bees that would help increase the value of the land. Team members will need to justify their recommendations.

Hand out magnetic map and icons to each team, and randomly assign a stakeholder role to each team member. If less than six youth working together, use the first four roles. The city planner should then consider the needs of the school administrator and/or parks commissioner. Review the icon descriptions, Bee Cards and stakeholder roles with the youth but do not share too much information.

Native Bee Challenge Map and Icon Sheet



Native Bee Challenge Map Icon Descriptions

Icon	Graphic	Description
Tomato (square)		Vegetable gardens with tomato plants
Coneflower (square)		Flower gardens that have a variety of native plants that bloom throughout the season
Pollinator habitat (square)		Prairie habitat and/or CRP land, these icons can be placed together to cover a larger area
Pollinator habitat (long)		Prairie habitat and/or CRP land that cover larger areas of land such as prairie strips
Native bees (5)		Five different native bees added to locations on the map

Roles of Stakeholders:

1) Farmer - Interested in increased crop production and profits.

2) Orchard Owner - Interested in increased crop production and profits.

3) City Planner - Works with businesses, private land owners, and government agencies to increase pollinator habitats.

4) Home Owner - Have small gardens where they grow food to supplement what they purchase from stores.

5) School Administrator- Provides youth a learning environment that helps students understand nature and become informed decision makers.

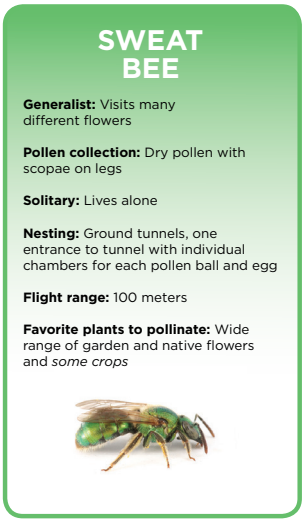
6) Parks Commissioner - Makes decisions about the management of city parks and nature preserves.

*Consult your **Bee Cards** and **Bee Characteristics Chart** to help make decisions. Consider the time of year, crop pollination needs, blooming season of crops, foraging needs of bees, and flight ranges of bees. Specific locations on the map are labeled to help you identify where icons can be added, for example, Orchard sign reads 1 mile to provide scale, Nature Preserve represents a public area.*

Allow each team to collectively identify and place icons on the map at locations to increase value, as well as to increase the foraging and nesting locations for native bees. Ask older youth to consider integrated pest management. Each team then shares their proposed recommendations and justifications. Recommendations can be compared to other teams and to the **Challenge Map Key**. Agreement with the key maps should be a strong consideration; however, alternative solutions are possible. Not all icons have to be used.

Award **Bee Bucks** to each team based on how much their recommendations will increase the value of the land. You will need to print 42 pages of Bee Bucks to cover possible scenarios
(6 teams x 7 sheets).

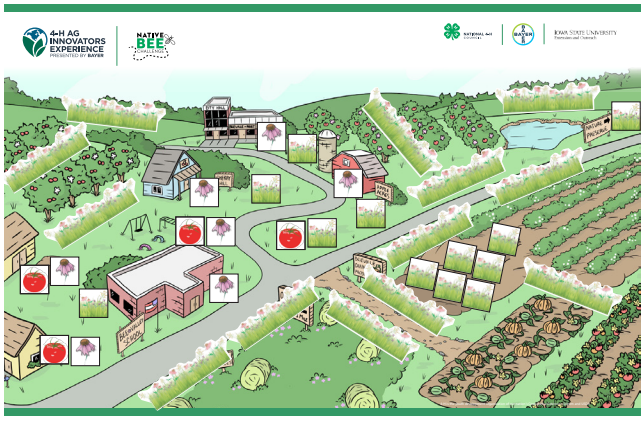
One of five Bee Cards



Sample of Bee Bucks

Challenge Map Keys

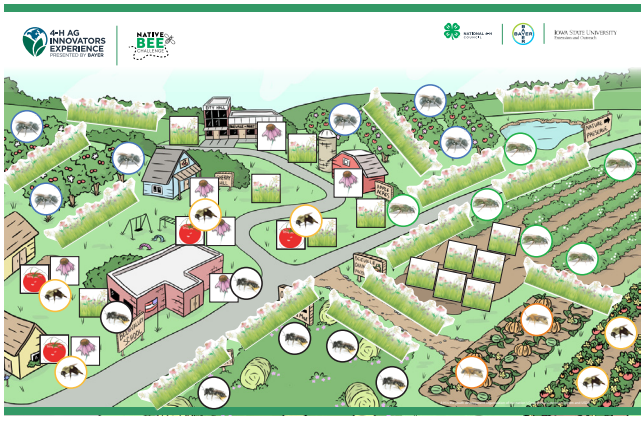
Challenge Map Key with Habitat Icons



Scoring based on Challenge Map Key with Habitat Icons

Habitat Icons	Locations	Quantity
Pollinator habitat (long)	Prairie strips that are large narrow areas along fields, near orchards, along roads, and in nature preserve	13
Pollinator habitat (square)	CRP in unproductive part of soybean field	6
Pollinator habitat (square)	Prairie habitat in open spaces near school, city hall, and near orchards	6
Tomato	Vegetable gardens near homes, school, and community garden	4
Coneflower	Flower gardens near homes, businesses, and school	8
Total		37

Challenge Map Key with Bee Icons



Scoring based on Challenge Map Key with Bee Icons

Bee Icons	Locations	Quantity
Mason bees	Apple Orchard	3
Mason bees	Cherry Orchard	3
Squash bees	Pumpkin field	3
Bumble bees	Tomato field	2
Bumble bees	Vegtable garden	4
Leafcutter bees	Alfalfa field	3
All bees except squash bees	Flower garden	5
Sweat bees	Soybean field (emerging research)	4
Total		27

REFLECT

Engage youth participants with these questions.

Do all flowers need pollination?
Yes, but not all flowers are pollinated by insects. However, insect pollination is important for many of the foods that we eat including fruits, nuts, and berries.

What do you notice about the difference between the number of bees in town and on the farm?
There are often more bees around the farm because it is likely to have more undisturbed areas where bees can build their nests and forage.

Why is it important to have flowers at a farm pollinated?
Many food crops require or benefit from insect pollination. Farmers need pollination to increase crop production for some crops. Note: Corn is wind pollinated and does not need insects for pollination. Soybeans are self-pollinated but may benefit from insect pollination. Other crops such as alfalfa (for seeds) and fruit crops need insect pollination.

Would you expect the farmer to need more bees than a homeowner?
More bees are needed in fields or orchards as there are more blossoms that need to be pollinated. This results in increased food production for the farmer (especially in orchards). There is also more nectar and pollen available for the bees.

Where would you expect most commercial native bees to be placed?
Native bees could be placed near the orchards (mason bees), tomato fields (bumble bees) and alfalfa fields (leafcutter bees). Squash bees and sweat bees are ground nesting and are not used as commercial bees because they cannot easily be transported from one location to another.

What could be done on this farm to help all five types of bees?
Grow plants that provide nectar and pollen for bees at the right time. Provide natural habitat or man-made nests for tube-nesting bees, and bare, undisturbed ground for ground-nesting bees. Promote a healthier environment for bees by using fewer pesticides.

Beyond crop production, what are possible benefits of using commercial native bees?
Besides crop pollination, Bees pollinate other plants. Many of which provide ecosystem services such homes and food for animals. These plants also help reduce soil erosion and nutrient runoff into waterways.

Which location(s) would likely benefit most by having prairie strips?
Farms would benefit from prairie strips, especially around and within fields/orchards. Prairie strips provide food and nesting locations for bees and other animals. Bees also help pollinate crops at specific times for example, apples in the spring, pumpkins in the summer, etc. There is emerging research that suggests native bees also can increase soybean yields.

Photo courtesy of Larry Stone


Photo courtesy of Lynn Betts

Which locations on the map tend to have more season-long pollen available?
Locations where there are a variety flowers, such as parks and home gardens, nature preserve, roadsides with prairie strips, and farms with multiple crops and prairie strips that bloom from spring through summer.

What are some reasons why each stakeholder cares about adding flowers or bees?
Leader note: Possible reasons stakeholder groups are willing to add habitat and native bees.

Farmer: A farmer is interested in increased crop production and profits. More food is produced due to increased pollination. Leafcutter bees help pollinate alfalfa fields; bumble bees increase tomato production at produce farms.

Orchard Owner: An orchard owner is interested in increased crop production and profits. More fruit is produced due to increased pollination. Mason bees can be managed to help pollinate orchards to increase fruit production.

City Planner: The city planner works with businesses, private land owners, and government agencies to increase pollinator habitats. City planners are interested in creating green spaces at businesses, government locations, and public places such as community gardens and city parks. The city could adopt an "edible landscaping" approach in community gardens, city parks, right of ways, etc.

Home Owner: Home owners have small gardens where they grow food to supplement what they purchase from stores. Home owners are interested in producing as much high-quality food as possible from their gardens. By increasing native bees, more flowers in their garden are pollinated resulting in more tomatoes, fruits and berries.

School Administrator: The school administrator provides youth a learning environment that helps students understand nature and become informed decision makers. School administrators are interested in involving students in the establishment of school gardens and outdoor classrooms. Sustainable landscaping on school grounds provides benefits by decreasing time and money used for maintenance of the grounds. Long-term goals are preparing students to appreciate biodiversity and make more informed decisions about the environment.

Parks Commissioner: The park commissioner makes decisions about the management of city parks and nature preserves. The parks commissioner is interested in increasing pollinator habitat in city parks and nature preserves to increase habitat for wildlife including native bees. Because pollinator habitat typically has flowers that bloom during the spring, summer and fall, these natural areas provide opportunities for foraging throughout the typical 6-week active period of adult native bees. Parks also serve as recreational areas for citizens to spend time outdoors enjoying nature.

Native Bee Nest

APPLY

Native bees living in habitats disturbed by urban landscapes and agriculture often struggle to find suitable places to nest and quality habitat to collect pollen and nectar. By building and placing bee nests around homes, businesses, in parks and on farms, we can increase the availability of habitat for bees to nest. Each participant builds a native bee nest to take home. If time is short, the participants can build the nest at home.

Step 1: Organize materials

The following items are needed to build one nest:

- ☐ 1 PVC Pipe (approximately 8″ long)
- ☐ 1 PVC Pipe End Cap
- ☐ 14 nest tubes from Crown Bees (multiple sizes)
- ☐ Clay/mud
- ☐ 1 rubber band to hold tubes together
- ☐ Sticks, as needed, to secure nest tubes
- ☐ 1 plastic tie or wire (approximately 10-12″ long)
- ☐ Sticker labeled with unique tracking number from Crown Bees network
- ☐ Instructions from **www.crownbees.com/4-H** regarding sticker placement and ID registration.

DO

Step 2: Construct the nest

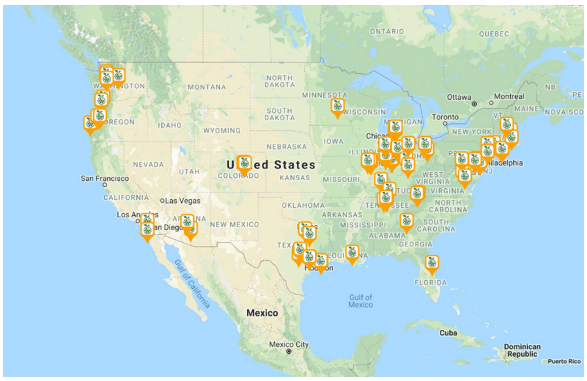
- Follow the directions on the following page.

Step 3: Location and hanging of nest

- Secure the native bee nest to a stout branch or fixed location where it will not be disturbed or move with the wind. The bees need to be able to find the nest as they fly through the area. Choose a location where the nest will receive as much sunlight as possible through the year. Avoid areas where leaves would block sunlight. Position nest with opening sloped slightly downward to prevent rain from entering.

Step 4: Register nest with Crown Bees Native Bee Network

- Youth may participate in a citizen-science project where they contribute information about their native bee nest through the Native Bee Network at Crown Bees. Each bee nest will have a sticker with a unique number that can be registered with this network at **https://crownbees.com/4-H**. Additional details are available online.

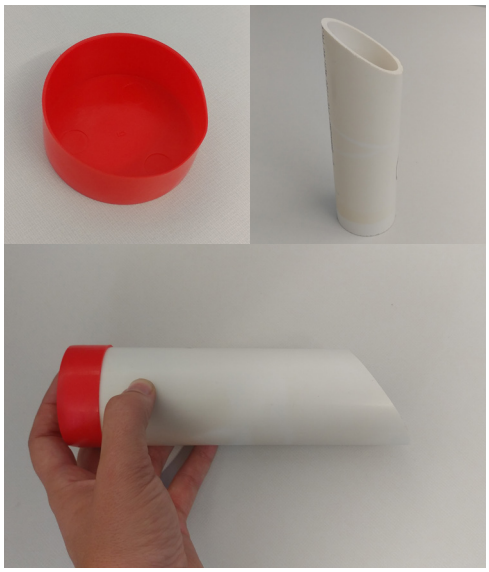


The Crown Bees Native Bee program maps cavity-nesting bee species across North America.

Example of bee nest label

1 Gather all the required materials.

2 Place the PVC end cap onto the flat end of the PVC pipe.

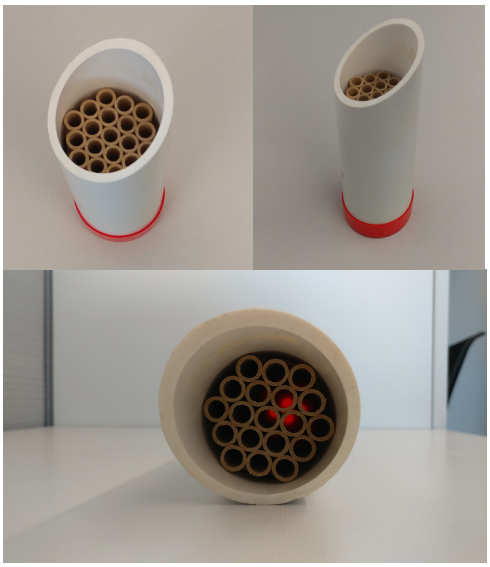


3 Roll out the clay so that it is about ¼ inch thick. Push each tube into the clay so that it creates a hole when it is pulled out.

4 Gather the nesting tubes into a bundle and bind them with the rubber band.

5 Place the bundle of nesting tubes into the PVC pipe.

6 Make sure the nesting tubes are pushed to the back of pipe. Sticks can be added to fill gaps so tubes do not fall out. Overhang in front protects nest from rain and other elements.



Leafcutter Bee

Leafcutter Bee

Leafcutter Bee

Mason Bee

Mason Bee

Mason Bee

Bumble Bee

Bumble Bee

Bumble Bee

Squash Bee

Squash Bee

Squash Bee

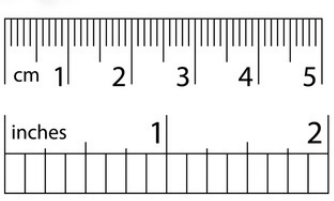
Sweat Bee

Sweat Bee

Sweat Bee

Characteristics of Bees

	Social or Solitary	Flight Range	Bee body size (mm)	How bees carry pollen	Flight Activity	Nesting Location	Specialized Flowers
Honey Bee *Apis* spp. /A-pus/	social	1-5 miles	12-16 mm	corbiculate hind legs	spring, summer, fall	man-made hives, tree hollows and cavities in walls	generalist
Bumble Bee *Bombus* spp. /BOMB-bus/	social	1-8 miles	19-38 mm	hairy body, corbiculate hind legs	spring, summer, fall	small cavities above or below ground	generalist
Mason Bee *Osmia* spp. /OZ-me-yuh/	solitary	100 meters	5-13 mm	hairy body	spring, summer	reeds, twigs, tubular cavities	generalist
Leafcutter Bee *Megachile* spp. /meg-uh-KILE-e/	solitary	100 meters	5-24 mm	hairy body, abdomen	summer	reeds, twigs, tubular cavities	generalist
Squash Bee *Peponapis* spp. /pep-o-NAY-pus/	solitary	100 meters	11-14 mm	hairy body, hind leg	summer, fall	ground	specialist
Sweat Bee *Halictus* spp. /hah-LICK-tuss/ and Lasioglossum spp. /laz-e-o-GLOSS-um/	solitary/ social	.5 mile	3-10 mm	hairy body, hind leg	spring, summer	ground	generalist



1 mile = 1.6 kilometers

100 meters = 328 feet

Native Bee Challenge Map Scorecard

HABITAT ICONS	Potential Locations for Placement	Quantity	Bee Buck Earned
Pollinator habitat (long)	Prairie strips that are large narrow areas along fields, near orchards, along roads, and in nature preserve		
Pollinator habitat (square)	CRP in unproductive part of soybean field. Prairie habitat in open spaces near school, city hall, and near orchards		
Tomato	Vegetable gardens near homes, school, and community garden		
Coneflower	Flower gardens near homes, businesses, and school		
Total			

BEE ICONS	Potential Locations for Placement	Quantity	Bee Buck Earned
Mason bees	Apple orchard		
Mason bees	Cherry orchard		
Squash bees	Pumpkin field		
Bumble bees	Tomato field, Vegtable garden		
Leafcutter bees	Alfalfa field		
All bees except squash bees	Flower garden		
Sweat bees	Soybean field (emerging research)		
Total			

Next Generation Science Standards

Grade level	NGSS Performance Expectations
Grade 3	**3-LS4-3** Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive, less well, and some cannot survive at all. **3-LS4-4** Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change
Grade 4	**4-LS1-2** Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to information in different ways.
Grade 5	**5-LS2-1** Develop and use a model to describe how the movement of matter among plants, animals, decomposers, and the environment. **5-ESS3-1** Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
Engineering 3-5	**3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
Middle School (Grades 6-8)	**MS-LS3-2** Develop and us a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. **MS-LS2-1** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. **MS-LS2-4** Construct and an argument supported by empirical evidence that changes to physical or biological components of and ecosystem affect populations. **MS-LS2-5** Evaluate competing design solutions for maintaining biodiversity and ecosystem services. **MS-ESS3-3** Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.
Engineering 6-8	**MS-ETS1-1** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Grade levels	NGSS Practice 2 Developing and Using Models
Grades 3-5	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Identify limitations of models • Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. • Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. • Develop and/or use models to describe and/or predict phenomena. • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. • Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.
Grades 6-8	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Evaluate limitations of a model for a proposed object or tool. • Develop or modify a model— based on evidence – to match what happens if a variable or component of a system is changed. • Use and/or develop a model of simple systems with uncertain and less predictable factors. • Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. • Develop and/or use a model to predict and/or describe phenomena. • Develop a model to describe unobservable mechanisms. • Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

4-H AG INNOVATORS EXPERIENCE
PRESENTED BY BAYER

Youth Participant Evaluation Survey

NATIVE BEE CHALLENGE

Dear Participant:
You are being given this survey because you are part of a 4-H program or project, and we are surveying young people like you to learn about your experiences.

- **This survey is voluntary.** If you do not want to fill out the survey, you do not need to. However, we hope you will take a few minutes to fill it out because your answers are important.
- **This survey is private.** No one at your school, home, or 4-H program or project will see your answers. Please answer all of the questions as honestly as you can. If you are uncomfortable answering a question, you may leave it blank.
- **This is NOT a test.** There are no right or wrong answers, and your answers will not affect your participation or place in the program in any way.

Thank you for your help!

Section 1: Native Bee Challenge

Please select one response to each of the five statements below regarding your experiences in the Native Bee Challenge.

1. I think it was important to work in a group to complete the Native Bee Challenge.

☐ Yes ☐ Kind of ☐ No

2. My teammates and I used good communication to complete the Challenge.

☐ Yes ☐ Kind of ☐ No

3. After completing the Challenge, I understand that protecting pollinators and increasing their habitat is important to our food supply.

☐ Yes ☐ Kind of ☐ No

4. I am more interested in science and agriculture after participating in the Challenge.

☐ Yes ☐ Kind of ☐ No

5. After completing the Challenge, I have a better understanding of how science and engineering help solve real life problems.

☐ Yes ☐ Kind of ☐ No

Section II: Tell Us About Yourself

1. How old are you? _____
(age in years)

2. Which of the following describes your gender?
(Check one box.)

☐ Female ☐ Male ☐ I don't want to say

3. Which of the following best describes your race? (Check each box that applies to you.)

☐ Asian
☐ Black or African American
☐ Hispanic or Latino
☐ Native America
☐ Native Hawaiian or Other Pacific Islander
☐ White or Caucasian
☐ More than one race
☐ I don't know

4. Which of the following best describes the primary place where you live?
(Check one box.)

☐ Farm
☐ Rural (non-farm residence, pop. <10,000)
☐ Town or City (pop. 10,000-50,000)
☐ Suburb of a City (pop. >50,000)
☐ City (pop.>50,000)

Reproducible

Bayer is a global enterprise with core competencies in the Life Science fields of health care and agriculture. Its products and services are designed to benefit people and improve their quality of life. As population continues to increase and access to land and water for agriculture decreases, Bayer remains focused on enabling farmers to produce more from their land while conserving the world's natural resources. Bayer is supporting the 4-H Ag Innovators Experience because today's participants will provide tomorrow's foundation for a prosperous, knowledgeable, and innovative agricultural workforce.

Visit **www.advancingtogether.com** for more information, and follow us on Twitter **@bayer4crops.com.**

Thank you notes should be addressed to:

Jessica Rommel
Business Communications Manager
Bayer, E4227S
800 N. Lindbergh Blvd.,
St. Louis, MO 63167

I pledge my HEAD to clearer thinking,

my HEART to greater loyalty,

my HANDS to larger service,

and my HEALTH to better living,

for my club, my community, my country

and my world.