



MISSION BOTANICA

CORRESPONDING LESSONS

<i>Fruit Dissection</i>	2
<i>See Inside a Seed</i>	7
<i>Seed Germinator</i>	13
<i>Flower Structure</i>	20
<i>Flower Dissection</i>	25
<i>Looking at Leaves</i>	31
<i>Let's Pollinate (with Cheetos)</i>	34
<i>Build a Forest</i>	39
<i>Designer Plants</i>	41
<i>What Plants Give Us</i>	42
<i>Tree Stewardship</i>	45
<i>Design a Garden</i>	49



Science Snack

Fruit Dissection

Cut into fruits to discover their shared structures, and how they hint at their past lives as flowers.



Grade Band: **Grades 3-5, Grades 6-8, Grades 9-12**

Subject **Biology: Anatomy and Physiology**

Activity Tags: **plant, botany, reproduction, Fruit, flower, dissection**

Next Generation Science Standards **Structure and Function**

LS1 LS3

Investigate shared structures of fruits, and their role in reproduction. Each botanical fruit develops from a flower, and contains the next generation of the plant. Dissect a few fruits to understand the structures they share, and their role in plant reproduction.



Tools and Materials

- Assortment of botanical fruits (for example: apples, berries, figs, plums, corn, fava or green beans, pea pods, cucumbers, peppers, pomegranates)
- Knife
- Cutting board
- Hand lens or dissecting microscope
- Paper and pencil for drawing and recording
- Optional: Flower (preferably a simple flower like a gladiola or Alstromeria, not shown)

Assembly

None needed.

To Do and Notice

Examine your assortment of fruits. Some might not seem like fruits to you, but many things we commonly call vegetables are defined by botanists as fruits.

What do your fruits have in common? Do you notice any similarities among the structures on the outsides of the fruits? Draw or describe these structures.

Cut each fruit in half (or for beans or corn, open up the pod or ear) and examine its insides with a hand lens. Do you notice similar structures inside the different fruits? What kinds of symmetry can you find in these structures? Try cutting a half in half again to get a closer look. Count or estimate how many seeds your fruit has. Draw or describe what you notice.

If you have a flower, carefully examine its structures. Cut the flower in half lengthwise (or do a complete dissection, as described in the [Flower Dissection Science Snack](#)). Do you notice any similarities between the structures of the flower and those of the fruit?

What's Going On?

Some of your fruits may have structures left over from their past lives as flowers. For example, pea pods, peppers (first photo below), and other fruits retain the stem and *sepals*—the leaflike structures surrounding the flower's petals. If you look closely at some fruits, you can often find the remnants of the flower's sex organs. The multiple dried filaments on the bottom of an apple or the top of a pomegranate or strawberry (second photo below) are former *stamens*, the structures that carry pollen. The single filament at the bottom of a pepper or a pea pod, and

the filaments on every bump of a raspberry (third photo below), are former *stigmas*, structures connected to the ovary. (Click on photos to enlarge.)



The shape of a fruit and the arrangement of its seeds can give you clues about the structure of the flower it came from. For example, a fruit with radial symmetry and radially arranged seeds, like an orange or an apple, grew from radially symmetrical flowers. And a fruit with many seeds came from a flower with many ovules.

Some fruits retain even more dramatic forms of their flowery past: corn, for example, contains long strands of silk. Each kernel of corn is a former ovule attached to its own strand of silk. When corn is fertilized, pollen containing the sperm cells lands on the tip of each silk strand, then travels down the silk to fertilize the ovule inside the husk. And the “baby corn” you buy in the grocery store are unfertilized ovules.

Teaching Tips

Although dissecting fruits alone is a valuable exercise, connecting the structures found in fruits to those found in flowers can help students to better understand the reproductive cycles of plants and the diverse adaptations that have made flowering plants so successful. By dissecting many types of fruit, students notice that seeds are the common structures. The fruit dissection can be followed by [dissecting a seed](#) to observe the baby plant inside.

If it's possible to get extra fruits for your class, students can cut the same type of fruit in different directions. For example, an apple can be cut through the equator and through the stem and the bottom. This makes it easier for students to visualize the internal structures.

Providing too much vocabulary in the introduction to this activity typically interferes with students' ability to make their own observations. Before giving them terms for botanical structures, let students notice and use their own language to describe what they see, and let them reason about the connections between the structures they notice.

Drawing can help focus their observations. Ask students to notice and draw the structures outside and inside the fruits, and the similarities between fruit structures and flower structures. Ask them how they would argue from this evidence that fruits are related to flowers.

It's often difficult to distinguish between the remnants of stamens and stigmas on the outsides of fruits. Ask your students to reason based on their observations—they might notice that stamens are more numerous than stigmas, for example, or notice the presence of dried *anthers*, the pollen-containing structures of a stamen.

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Science Snack

See Inside a Seed

Examine the baby plants inside the seeds we eat.



Grade Band: Grades 3-5, Grades 6-8, Grades 9-12, Grades K-2

Subject **Biology:** Anatomy and Physiology Ecology **Chemistry:**
Food and Cooking

Activity Tags: plant, seed, edible, nature, development,
photosynthesis

Next Generation Science Standards **CCCs:** Cause and Effect
Energy And Matter Structure and Function Stability and Change **LS:**

LS1

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Examine the baby plants inside the seeds we eat.

Soaked in water, dried beans spring to life. Learn your way around a legume as you explore the various structures that protect and feed a developing plant embryo.



Tools and Materials

- A handful of dried beans (lima, kidney, or other large beans work well)
- Cup or small bowl
- Water
- Hand lens
- Optional: paper and pencil for sketching

Assembly

1. Set aside a few dry beans for later comparison and place the rest in a cup or bowl.
2. Cover the beans with water and let them soak for 12 to 24 hours.

To Do and Notice

Take the beans out of the water and compare them to the dried beans. Using the hand lens, examine the outsides of the beans. What do you notice?

Gently remove the soft outer coating of a soaked bean. Break the inside of the bean in half lengthwise, and use the hand lens to look closely at the shapes, colors, and structures inside. If you'd like, focus your observations by drawing what you see.

What's Going On?

A bean is actually a seed that contains the embryo of a future plant. The embryo is packaged with a food source to use during its early stages of growth, and is covered with a protective seed coat. Soaking the bean in water activates germination of the seed, and the embryo inside begins to grow and unfold.

When you removed the seed coat, you probably noticed a small, white, root-like structure sticking out from one side of the bean. This structure, called the radicle, is the future root of the plant.

When you split the bean open, you may notice tiny white leaves on the end of the radicle. These are the first true leaves of the bean plant.

The bulk of the inside of the bean is the cotyledon, or seed leaf. Each bean contains two cotyledons that separate when you split apart the bean. When the bean sprouts, the cotyledons turn green and have the appearance of leaves (hence their alternate name, seed leaves), but they're actually not (yet) photosynthetic. Filled with stored starches,

fats, and proteins, the cotyledon supplies energy to the developing embryo during the early stages of its growth. Later, once the embryo has used the food stored in the cotyledon, the plant will begin to make its own food through photosynthesis, which occurs in both the seed leaves and the true leaves.

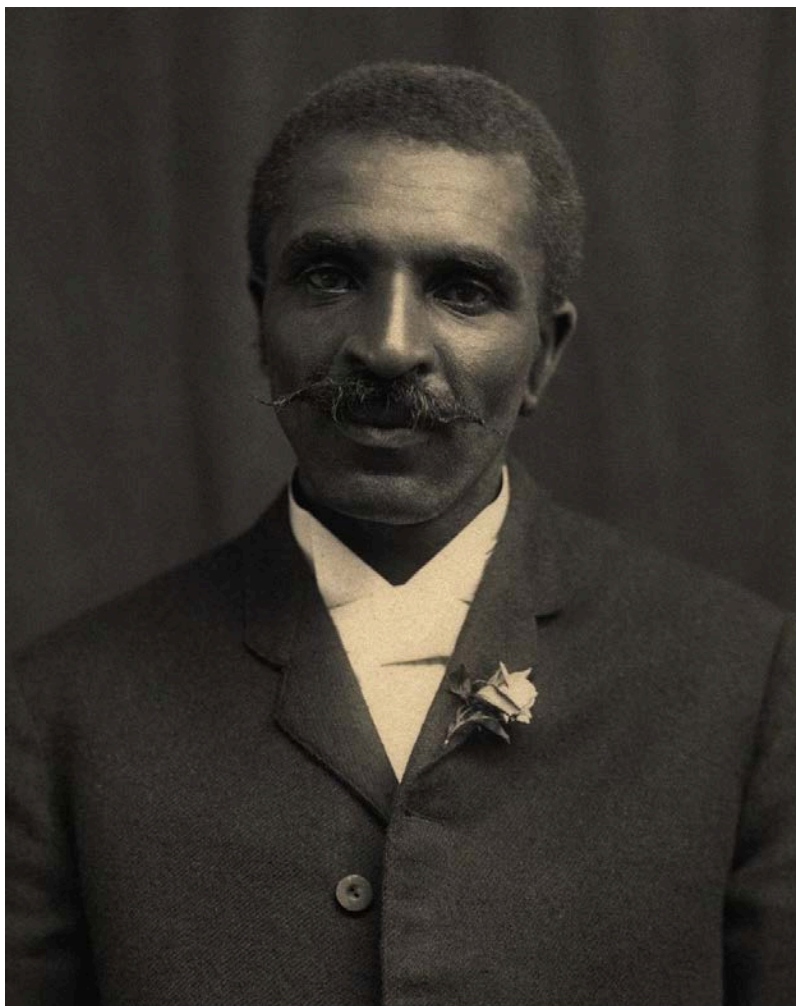
Going Further

To continue watching your bean plants develop, put a few soaked beans on a wet paper towel in a covered container or sealed plastic bag. Compare the structures that emerge to those you saw in the bean embryo. What emerges first from the sprouting bean? Can you tell the difference between the cotyledon and the true leaves?

Try examining the insides of other seeds, especially those you might find in your kitchen. Rice, corn, wheat, peas, peanuts, and almonds are all seeds. Do they look similar to beans?

You'll find that corn, rice, and wheat don't easily split into two halves, as the bean did, and the embryo may be smaller. These plants, called monocots, have one small cotyledon, and store the majority of their embryo's food in a structure called the endosperm. Like the beans you examined here, peas, almonds, and peanuts are all dicots.

This Science Snack is part of a [collection](#) that highlights Black artists, scientists, inventors, and thinkers whose work aids or expands our understanding of the phenomena explored in the Snack.



Source: Tuskegee University Archives/Museum

George Washington Carver (1864–1943), pictured above, was an agricultural scientist, inventor, and professor. Carver applied his knowledge of soil chemistry to help save the cotton farms that were failing in the South. He realized that years of growing cotton had depleted the soil, and by growing nitrogen-fixing plants like peanuts, soybeans, and sweet potatoes, the soil could be restored. Not only did crop rotation produce more cotton, but also a bonus of surplus peanuts. Carver developed over 300 uses for peanuts. Born a slave who became a professor, he was remembered for his peanuts after testifying before Congress on behalf of the peanut industry. Carver was the first African American to earn a Bachelor of Science degree. In this Science Snack, you can explore the parts of a seed and learn what helps it grow.

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Science Snack

Seed Germinator

Watch the life of a plant embryo unfold.



Grade Band: **Grades 3-5, Grades 6-8, Grades 9-12, Grades K-2**

Subject **Biology:** Anatomy and Physiology Ecology

Activity Tags: **plant, seed, nature, botany, development**

Next Generation Science Standards **CCCs:** Energy And
Matter Structure and Function Stability and Change **LS:** LS1 LS2 **ESS:**
ESS2 EPCs: EPC2

Watch the life of a plant embryo unfold.

What goes on underground when seeds are sprouting? Make yourself a window into the process of plant development.



Tools and Materials

- Quick-germinating seeds, such as radish or Wisconsin Fast Plants®
- Water
- Paper towel or coffee filter
- Scissors
- Pencil
- Large petri dish with lid, or an old CD case with clear sides (if you're using a CD case, open it and remove the plastic insert that holds the CD, being careful not to break the case)
- Lidless, straight-sided plastic container wide enough to set the petri dish or CD case inside, on its edge, as shown in the photo
- Two rubber bands big enough to fit around the open container

- Metric ruler with millimeter markings
- Magnifying glass

Assembly

1. Soak the seeds overnight in water.
2. Set aside the top of the petri dish, or open the CD case. Cut the paper towel (or coffee filter) to fit inside.
3. With a ruler and pencil, draw a straight line across the middle of the paper towel. Lay the marked-up paper in the bottom of the dish (or inside the CD case) so the line sits horizontally across the center. If you're using a CD case, be sure the hinged edge is at the top or side (not bottom).
4. Pour a little water into the dish to wet the paper towel. Smooth out any bubbles and tip out any extra water not absorbed by the paper. Later, when you stand the dish on its edge, the wet paper should remain stuck to the inside of the dish or CD case.
5. Place 6 to 10 seeds on the paper towel, evenly spaced along the reference line. Then put the lid on the petri dish, or close the CD case.
6. Stretch the rubber bands, set close to one another, around the center of the straight-sided plastic container (see photo below). Stand the petri dish (or CD case) between the rubber bands, and adjust the setup so it's secure, standing on edge, upright in the container. With gentle handling, the seeds should stick to the moistened paper towel. If they move, put them back in their places on the line.



7. Pour water into the container to a depth of about 1 inch (2 to 3 cm). The water should seep into the petri dish or CD case and

contact the paper towel, keeping it moist as the seedlings begin to sprout.

8. Put your seed germinator in a warm place (room temperature or slightly higher), away from direct sunlight.

To Do and Notice

Check on your seeds once or twice a day, and notice what changes or emerges (see photo below). (It's fine to open the seed germinator; just handle it carefully so the seeds don't move.) Do shoots with green tips emerge first, or do white roots emerge first? Do each seed's roots and shoots sprout in the same direction, or in different directions? Use a magnifying glass to examine the growing structures in more detail. How do they change over time?

Measure the growth of the roots and shoots over time. You may want to collect data to graph average root length vs. time, and average shoot length vs. time. (Note that it's helpful to measure time in total elapsed hours, rather than days.) Which grows faster, the shoots or the roots?



What's Going On?

Inside a seed is the embryo of a plant, plus a food source for that embryo, all contained within a protective seed coat. Here, you can observe seed germination, in which the embryo begins to digest the food and grow into a seedling. While this process usually happens in soil, the key component for germination is water.

At appropriate temperatures, most seeds begin their germination by absorbing water through a tiny hole in the seed coat. The moisture starts the metabolic processes of the embryo that's contained within the seed. When hydrated by absorption of water, enzymes in the seed are activated. They begin digesting the food stored inside to generate energy for the embryo's growth.

The developing root emerges from the seed first. As the root grows longer and thicker, it develops tiny root hairs, which help the developing plant take up water and nutrients. Shoots with pale-green leaflike structures emerge after the roots. Eventually, these leaves will turn a deeper green color and begin to photosynthesize, capturing and storing light energy and carbon dioxide from the air.

Photosynthesis in leaves supplies the plant with the energy and matter it needs to grow. Newly germinated seedlings, however, are not yet photosynthesizing. Instead, in early stages of growth, the embryo digests and assimilates the energy and matter from the food present in the seed. Depending on the type of seed, this food store contains a mixture of proteins, fats, sugars, and starches. This stored food isn't just important to the developing plant embryo; it's also important to human diets. About 45 percent of the calories humans consume globally comes from seed grains like rice, wheat, and corn.

A common misconception is that plants get their mass from soil. In this soil-free experiment, you can prove to yourself that plants don't strictly require soil to grow. In fact, many plants grow very well hydroponically in water cultures, as long as the appropriate nutrients such as nitrogen, phosphorous, and potassium are provided. Your seedlings will eventually need more space than the seed germinator can provide, but given the right lighting conditions, they'll begin to photosynthesize, accumulating mass from the carbon dioxide in the air and the water you provide.

Going Further

This seed germinator makes it easy to design and perform experiments to determine the materials and conditions seeds need in order to germinate and grow. The effects of temperature, light levels, and water conditions (such as pH or salinity), as well as the presence or absence of various nutrients are all factors you can investigate. Experimenting with the position and lighting of the seed germinator can help you determine the conditions necessary for roots to grow down, and for shoots to grow up. Do roots sense gravity? Do they sense light? Or are they affected by other factors?

This Science Snack is part of a [collection](#) that showcases LGBT artists, scientists, inventors and thinkers whose work aids or expands our understanding of the phenomena explored in each Snack.



Jennifer Nemhauser (she/her) is a queer and pansexual biologist. She is a faculty member in the Department of Biology at the University of Washington and studies how plants use signaling networks to change the shapes of their bodies to make the best of particular environments. She hopes that if she can learn how plants control division, growth, differentiation, communication, and death, she can help breed the next generation of more resilient crops. Prior to her faculty position at the University of Washington, she completed her doctoral work in auxin and flower development and post-doctoral work in hormone interactions in seedling development. Jennifer feels as though she expresses her queer identity the most in the ways she works to build a distinctly queer scientific culture within her lab group—an effort that is reflected in the large number of LGBTQIA+ students and postdocs that have found a home there. Make yourself a window into the process of plant development with the Seed Germinator Science Snack.

Teaching Tips

As noted in the What's Going On? section above, this experiment can be used to begin investigating where a plant's mass comes from. To do this, weigh the seeds before you soak them. Allow the seedlings to grow under good light conditions for several days, so they begin to accumulate mass through photosynthesis. Then take them out, let them dry, and check their mass again. Comparing the initial mass of the seeds to the dry mass of the germinated seedlings can help show students that a plant's mass does not come from soil or water.

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FLOWER STRUCTURE & PLANT REPRODUCTION

Content Connections:

Life Science - Plant life cycle

Grade: 4th-8th

Time: 45-60 minutes

Objective: Students will dissect and identify parts of the flowers. They will learn about plant anatomy and be able to demonstrate the mechanism of pollination by examining several types of flowers.

Materials:

- A variety of fresh flowers (the number of flowers depends on how you will divide up students to facilitate this activity)
- Small sharp scissors
- **Anatomy of a Flower** diagram (showing flower structure and function)
- **Taking a Closer Look at Flowers** record sheet, 1 for each type of flower
- Flower anatomy worksheet, 1/participant
- Felt markers
- Recycled materials and craft supplies including tape and glue

Background:

Pollination of a plant occurs when a pollen grain moves from the anther (male part) of a flower to the stigma (female part). This is the first step in a process that produces seeds, fruits, and the next generation of plants. This can happen through self-pollination, wind and water pollination, or through the work of pollinators that move pollen within the flower and from bloom to bloom.

Procedure:

1. Give each participant a copy of a flower anatomy worksheet.
2. Spread fresh flowers out on a table, or place individual flowers in plastic cups. Place one **Taking a Closer Look at Flowers** sheet labeled with the name of the flower with each sample for recording observations.

3. As a group examine the flowers and discuss: What parts of the flower are visible? How are flowers different? How are they similar? Encourage participants to notice and compare flower characteristics such as shape, petals (color, patterns, texture, and number), scent, and whether the flower is composite (composed of many small flowers), like a sunflower, or simple, like a lily.
4. Divide students into groups of 2 or 3 to examine one flower and record their observations on ***Taking a Closer Look at Flowers*** sheet.
5. Have each group dissect their flower with the sharp scissors, carefully laying out the different parts and comparing the real flower to their flower anatomy worksheet. If necessary, identify the basic flower structures using the ***Anatomy of a Flower*** diagram.
6. Have each participant complete ***Taking a Closer Look at Flowers*** sheet to reinforce and/or review the basic structure of a flower.
7. As a whole group or in small groups, look at each dissected flower and the accompanying ***Taking a Closer Look at Flowers*** sheets. If students were given different flowers, ask them to compare and contrast the structures in their flower with those from a neighboring group.
8. Discuss as a group the features they have identified, i.e., floral color, form, scent, and structure in addition to any similarities and differences between different flowers.
9. Using the parts of the dissected flowers, discuss the basic process of pollination using the ***Anatomy of a Flower*** diagram. Depending on the age of your group, focus on the cross-section of the flower and the development of the pollen grain, pollinating agents, and types of pollination.

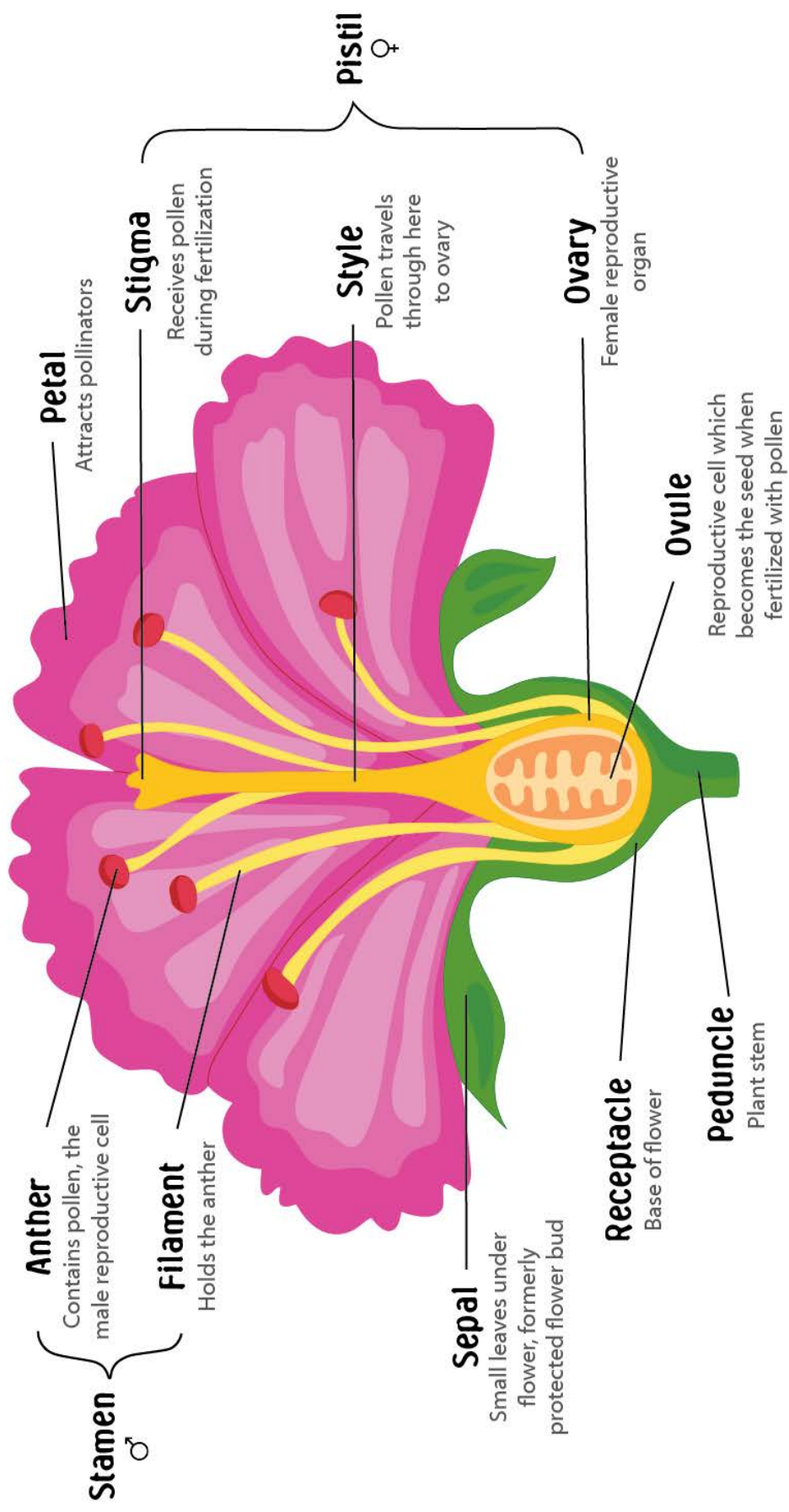
Extension:

To demonstrate understanding, ask students to build a model of a flower with provided materials. Give students a variety of recycled materials and craft supplies, including tape, glue, and scissors. Ask them to build a flower that models the key parts identified in the ***Flower Anatomy*** sheet.

References:

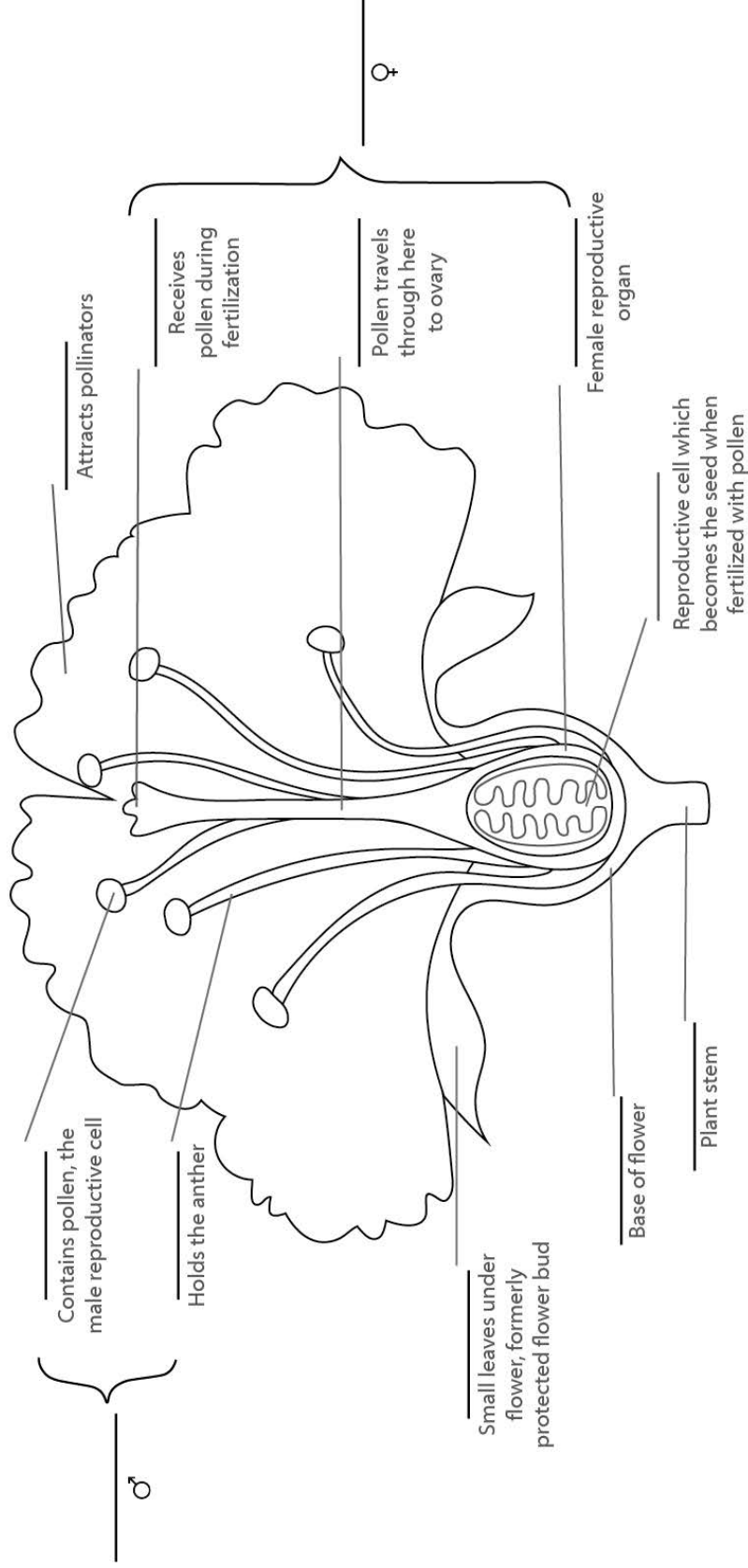
For more information and ideas, visit the NAPPC curriculum guide activity on [Understanding Flower Structure & Plant Reproduction](#), Pg 51.

Anatomy of a Flower



Anatomy of a Flower

Use the word bank to help you fill in the blanks and name the missing parts of the flower



Stamen	Filament	Petal	Anther	Ovary	Style
Pistil	Ovule	Peduncle	Sepal	Stigma	Receptacle

Taking a Closer Look at Flowers

Name of Flower: _____

Describe the parts of the flower. Include number of various parts, size (length or diameter). Colors, patterns, texture (smooth, rough, sticky), and shape. Draw them if you can.

Sepal:

Petals:

Stamens (Anther & Filament):

Pistil (Stigma, Style, & Ovary):

Scent:

What type of pollinator do you predict would pollinate this flower? Why?

If this flower has nectar guides please describe them.

Science Snack

Flower Dissection

Find the sex cells hidden in a bouquet.



Grade Band: **Grades 3-5, Grades 6-8, Grades 9-12**

Subject **Biology: Anatomy and Physiology**

Activity Tags: **plant, reproduction, botany, dissection**

Next Generation Science Standards **Structure and Function**

LS1 LS3

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Dissect a flower to explore plant reproductive structures.

Dissect a flower to explore the form and function of plant reproductive structures.



Tools and Materials

- Flower (a relatively large, simple flower like a lily, Alstroemeria, or gladiolus is a good starting point, but all flowers are interesting)
- Scissors
- Razor blade or scalpel
- Hand lens or dissecting microscope
- Paper and pencil for drawing and recording

Assembly

None needed.

To Do and Notice

Examine your intact flower. What do you notice first about it? What are your senses drawn to? What do you think the function of the structures you notice could be? Notice how the different structures are connected to the stem of the flower. Draw what you see, if it helps you.

Carefully remove the petals from the flower (you can use scissors or gently pull the petals off). You will probably notice that the center of the flower contains long filaments (click to enlarge the photo below). Use the hand lens and/or dissecting microscope to examine the filaments. Do all the filaments look similar to each other, or do they look different? Are they the same from top to bottom? Draw and describe the different structures that you see. What do you think the functions of the different structures you notice might be? How might these structures interact?



Remove the filaments and examine the swollen structure that is left. Use a blade or scalpel to cut it in half, either lengthwise or crosswise (see photo below). (If you have two flowers, cut one lengthwise and one crosswise.) Examine the inside using your hand lens or microscope. What do you notice? What might this be?



What's Going On?

Flowers are the reproductive structures of angiosperms, or flowering plants. While there are lots of different types of flowers with seemingly very different structures, they all have pretty much the same parts—

though sometimes you have to look very closely to notice the similarities.

Flower structures have evolved to maximize the chance of pollination, or fertilization of ovules by sperm cells contained in the pollen. The color, scent, nectar, and shape of a flower all help facilitate pollination through animal pollinators like insects, birds, and bats, or through wind, rain, and other physical phenomena. The colored petals along the outside of the flower advertise its presence to animal pollinators. The petals may be surrounded by green leaflike *sepals*, connected to the stem, or the petals themselves may actually be modified sepals.

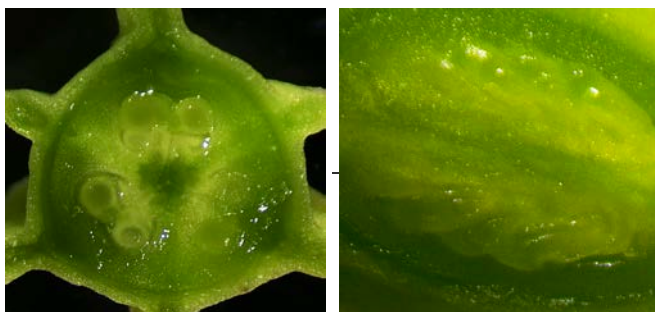
When you removed the petals, you probably noticed a ring of filaments with knobs on top. These are the *stamens*, or sperm-associated part of the flower (the outer filaments in the first and second photos below). The knobs, or *anthers*, on the top of these filaments contain a powdery substance called *pollen* (third photo below) that may come off on your fingers (and can stain your clothes!). This pollen contains the plant sperm. If you examine pollen under a high-powered microscope, you'll see that pollens from different flowers can have very different shapes and colors.



You also probably noticed a filamentous structure that didn't have anthers or pollen—this is called the *pistil* or *carpel*, and it's the structure that catches the pollen (the middle structures in the first and second photos above). The tip of the pistil is called the *stigma* and is often sticky, nubby, or covered in fine hairs, all structures that aid in catching pollen. The base of the pistil is swollen and is called the *ovary*, where the sex cells called *ovules* are found. Ovules are unfertilized, immature seeds. The tube connecting the stigma and the ovary is called the *style*.

When you dissect the ovary in a cross section, you'll see segments containing ovules similar in shape to the inside of an orange (first photo below). These shapes will vary depending on what type of flower you

are dissecting. Dissecting in a longitudinal cut reveals ovules lined up like peas in a pod (second photo below). Indeed, peas are actually mature, fertilized ovules.



Fertilization occurs when a pollinator transfers pollen from the anther of one flower to the stigma of another (flowers often try to avoid self-pollination). The pollen on the stigma forms a tube that travels the length of the inside of the style and contacts an ovule. The nucleus of the pollen sperm then travels down the pollen tube into the ovule and fuses with the female nucleus—that's the fertilization event. The fertilized ovule grows into a seed and the entire ovary ripens into a fruit.

In some types of flowers, you may find stamens but no pistil, or a pistil but no stamens. There's great variety in the way angiosperms organize their sexual organs: many have “perfect” flowers containing both parts, while other species may have sperm-associated structures and ovule-associated structures on separate flowers on the same plant. In other species, an individual plant may have only sperm-associated parts or ovule-associated parts.

Going Further

Dissect other types of flowers, such as sunflowers, iris, or snapdragons, and identify the same parts.

Fruits come from flowers. Try examining fruits (as described in the [Fruit Dissection Science Snack](#)) for the remnants of flower structures.

Teaching Tips

It's easy for students to get overwhelmed at the amount of vocabulary that can be involved in learning about botanical structure and function. For this reason, you may not want to begin a lesson with technical vocabulary. Instead, leave botanical terms for the end of the lesson and encourage students to spend the bulk of their time examining and describing the structures that they notice using their own words, and considering their form and potential functions. You might even consider whether knowing the botanical names of flower parts is truly necessary for your students.

Studying plant reproduction is an excellent way for younger students to learn about sexual reproduction in a hands-on way. Depending on their age and prior knowledge, you can have students draw connections and identify similarities between the sexual structures of a plant and those of a mammal or another animal. For example, sperm sex cells of both plants and animals are numerous, small, and mobile, while eggs/ovules of both plants and animals are fewer in number, larger, and stay in place.

You may want to consider how you use the gendered terms “male” and “female” during the flower dissection, which are commonly applied to flower reproductive parts. While the sex cells of flowers have many similarities to human sex cells, flowers do not have genders, and the use of gendered terms to describe non-human organisms may contribute to the exclusion of trans or gender-nonconforming students by reinforcing ideas about human gender as a naturally binary phenomenon.

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LOOKING AT LEAVES

Content Connections:

Life Science – Structure and function of plants

Grade: 2nd-7th

Time: 45-60 minutes

Objective: Students will learn about plant anatomy and function and demonstrate understanding by identifying parts of leaves.

Materials:

- Green: The Story of Plant Life by Nicola Davies
- Fresh leaves of different varieties, ideally allow students to collect their own leaves outside, but can provide from a grocery store or florist
- Leaf identification key (see Resources)
- Parts of a Leaf guide (see Resources)
- Hand lenses or magnifying glass (optional)
- Paper
- Crayons
- Tape
- Pencil

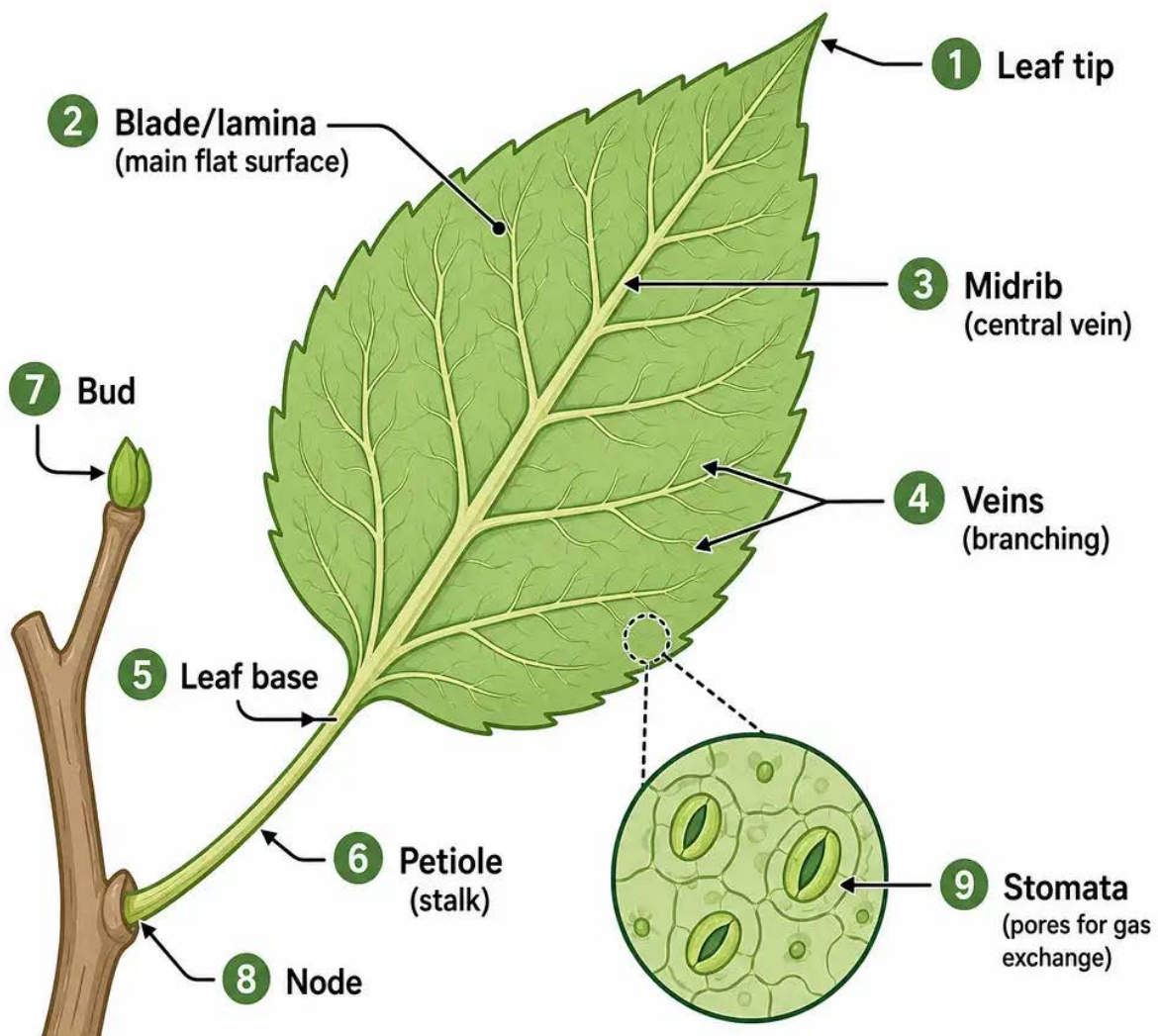
Procedure:

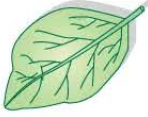
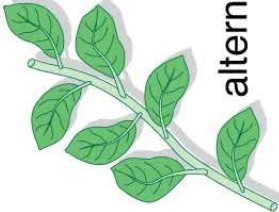
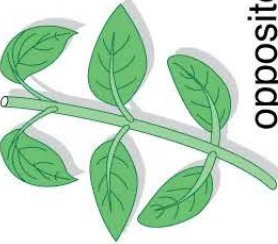
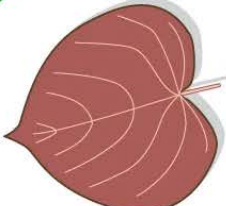
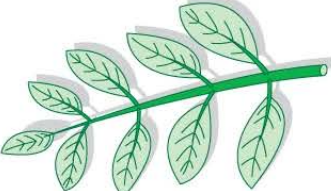
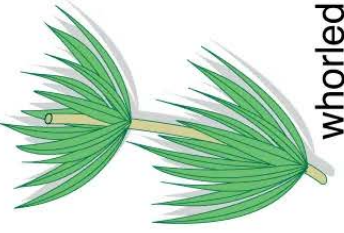
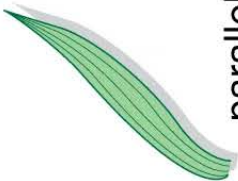
- For younger students, read the beginning of Green: The Story of Plant Life by Nicola Davies. Discuss the importance of leaves (and the color green) for both plants and people.
- Engage students by creating a list of prior knowledge about leaves and plants.
- Time to get up close and personal with leaves! Provide students with a variety of leaves. If possible, let students collect their own leaves outdoors.
- Start by making observations of shape, color, texture, veining, serrations and other structure. Use the botanical vocabulary:
 - Palmate, Pinnate, Lobed, Serrated, Smooth, Compound, Simple, etc.
- (Optional) Provide students hand lenses or magnifying glasses to make up close observations.

- Demonstrate how to make leaf rubbings and provide crayons and paper for students to do the same.
- Tape the leaf beside the rubbing and identify and label the major leaf parts
 - leaf blade, petiole, veins, etc.
- Use the provided Parts of a Leaf diagram to identify leaf structures and ask students to hypothesize the purpose of each structure.
- As an extension, students can identify the type of plant that the leaf came from and conduct research to write a brief natural history summary of the plant.

Resources:

PARTS OF A LEAF



Veins	Shapes	Arrangement	Edges	Arrangement on the Stem
				
netlike				
netlike				
			lobed	whorled
parallel	needle	compound		

LET'S POLLINATE (WITH CHEETOS)

Content Connections:

Life Science - Life cycle of a plant; Mutualisms

Grades: K-5th

Time: 30-60 minutes

Objective: In this lesson, students learn how pollination works by using Cheetos and bee finger puppets to simulate pollen transfer from flower to flower.

Materials:

- Flower print outs
- Crayons
- Black and yellow pipe cleaners or bee cut outs
- Scissors
- Cupcake wrappers
- Cheetos (or other powdery, coated snack)
- **Let's Pollinate** worksheet
- Hand wipes or access to a wash station or bathroom

Engage:

- Read **What Is Pollination?** by Bobbie Kalman

Explore:

- Ask students to recall a list of pollinators that were described in the story.

Explain:

- With the help of the students, summarize the process of pollination. Reiterate that flowers need to exchange pollen in order to be able to make seeds. Since flowers can't move, they need help from pollinators. So deep in their petals, flowers produce a sweet sugary nectar that pollinators like bees, bats, birds, butterflies, and other insects love to eat.

- Remind students that in order for pollination to happen, pollinators need to visit multiple flowers of the same type so that pollen is transferred to the right kind of flower.

Elaborate:

- Tell students that today they are going to act out pollination! Give each student a picture of a flower to color and cut out. Alternatively, teacher can provide students with these already completed.
- Set a cupcake paper in the middle of the flower and fill it with Cheetos.
- Provide students with a bee hand puppet made out of a paper cutout or piper cleaners. This should go on their hands so that the fingers stick out and represent the bees legs.
- Tell students to put on their bee puppets and then eat the Cheetos. If desired, let students fly around the room to other flowers and eat one or two Cheetos at a time. Tell the students to be sure NOT to brush or lick the Cheetos crumbs from their hands!
- When they are finished eating, the bee's feet (student's fingers) should be covered with Cheetos crumbs.
- Wait until everyone has gathered lots of pollen on their legs (Cheetos dust on their fingers), then instruct them to fly to a friend's flower and land on it. Ask them what they notice when they land on a flower. They should leave pollen (Cheetos dust) behind on the flower. Let the students fly around the room and pollinate a few flowers.
- After a few pollination trips, instruct students to wash their hands.

Evaluate:

- Lastly, discuss with the students what they observed using the ***Let's Pollinate!*** worksheet guide discussion and illustrate the sequence of events in pollination.

Reference:

- [Pollination – A Sticky Situation!](#) (New Jersey Agricultural Society).

Let's Pollinate!

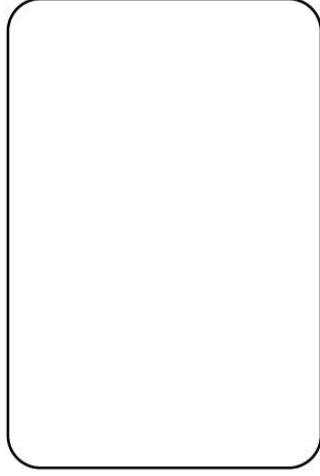
Name: _____

My Cheetos represent...

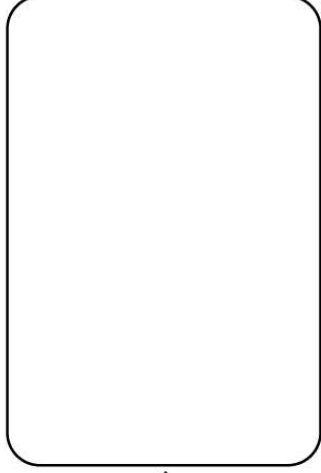
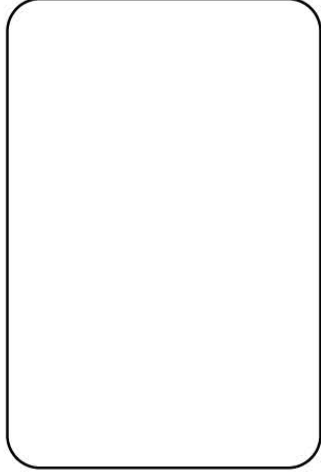
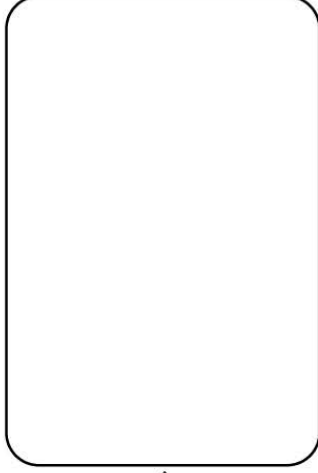
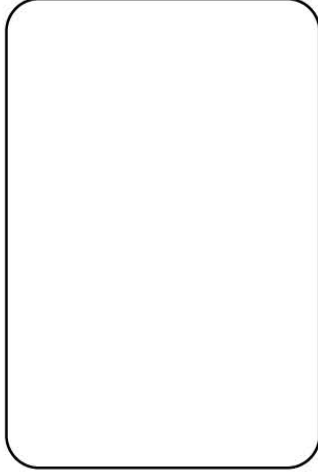
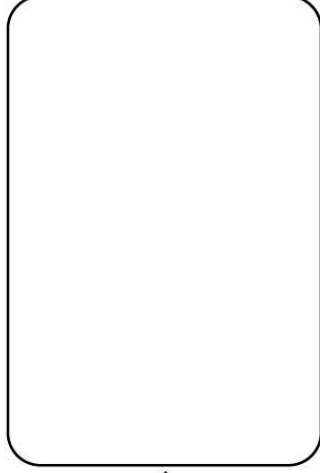
My fingers represent...

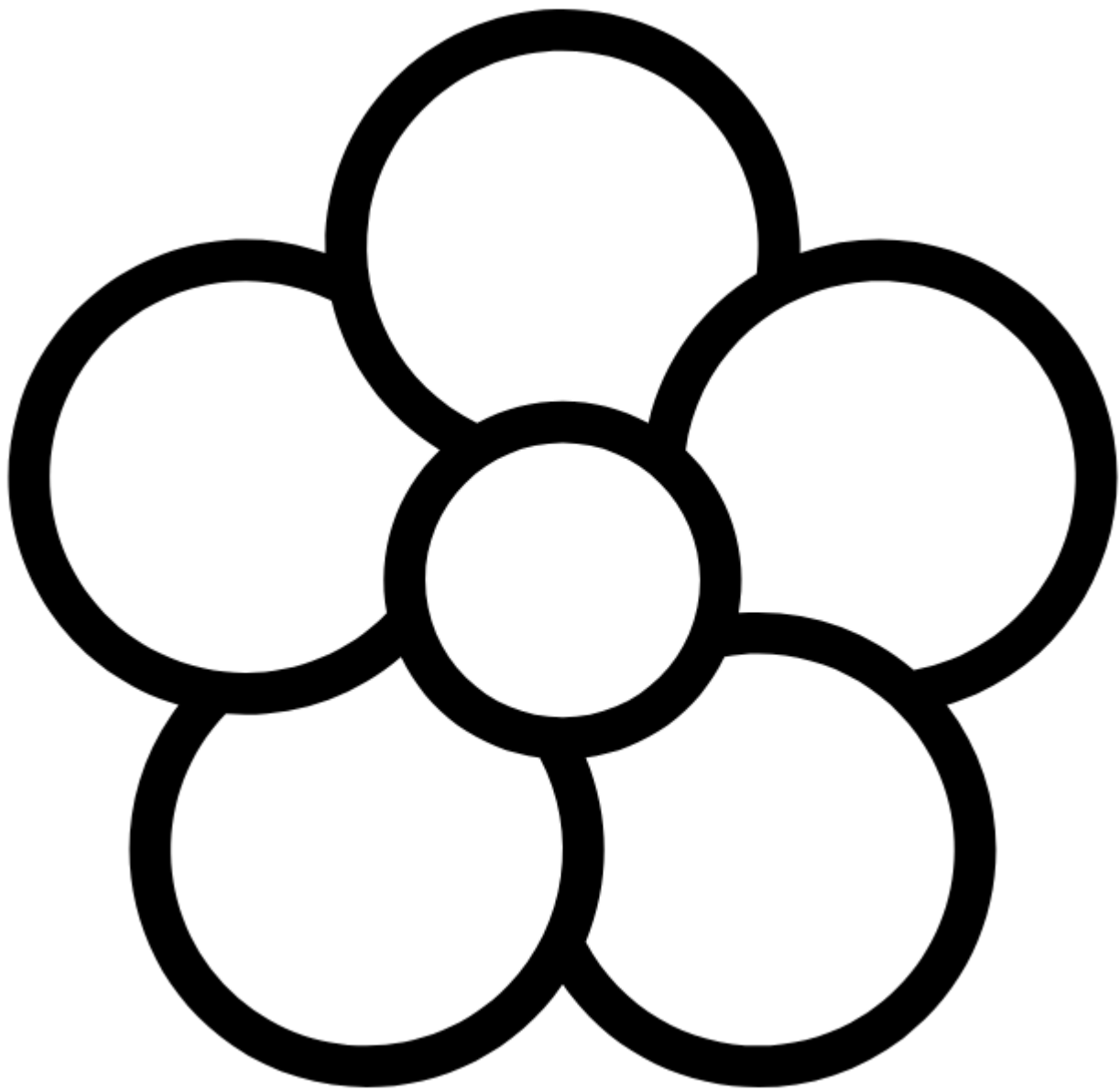
When I touched a friends flower...

Draw your answer

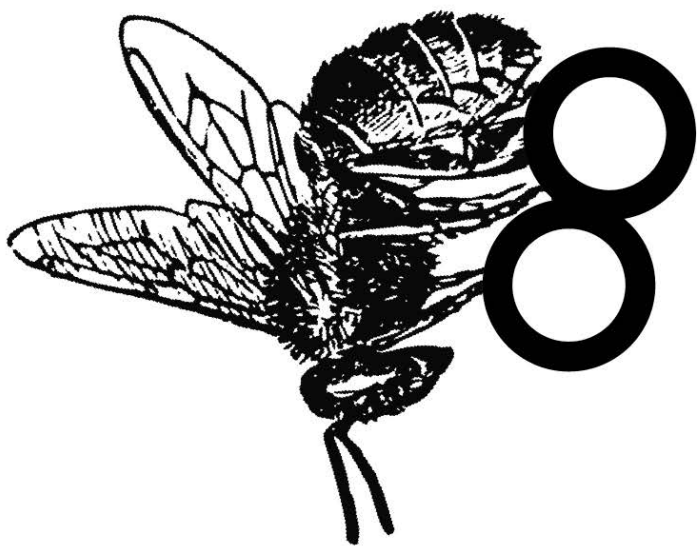
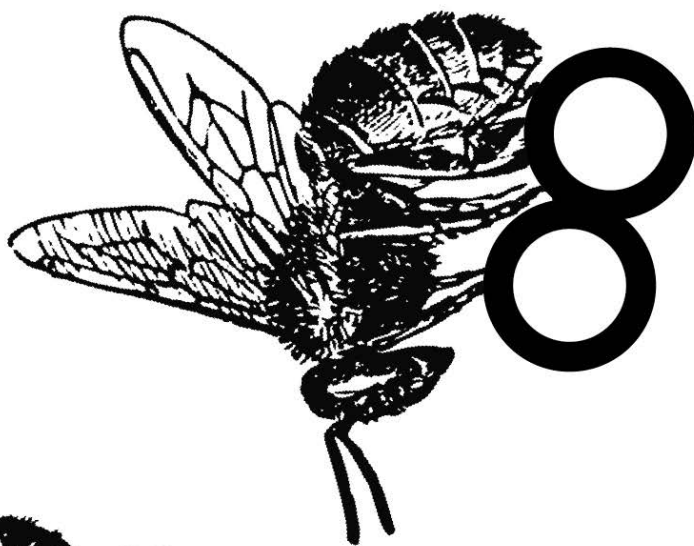
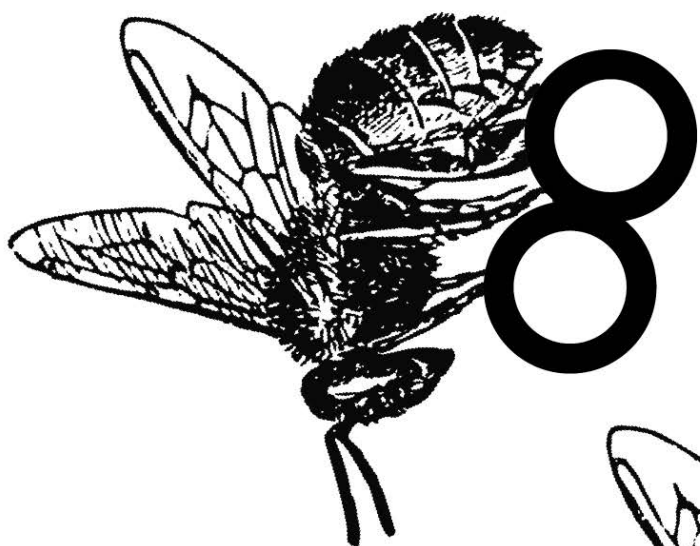


Write your answer





Print out one flower for each student to color and cut out.
Place cupcake wrapper in center.
Fill cupcake wrapper with Cheetos to represent pollen.



Print on cardstock or laminate
Let students color bees
Cut out bee body and inside the
two white circles for fingers

BUILD A FOREST

Content Connections:

Life Science – Structure and function of plants; Ecosystems

Grade: 3rd-5th

Time: 90-120 minutes, can be divided over multiple class periods, or assign diorama construction as homework

Objective: Students will use a KWL chart to collect information from video resources, then create a diorama to demonstrate understanding of the structure of and ecological relationships in forests.

Materials:

- Video projector or TV monitor with Internet access
- Layers of the Forest diagram (see Resources)
- Shoeboxes
- Craft materials (construction paper, tissue paper, pipe cleaners, markers, crayons, colored pencils scissors, tape, glue, hot glue, etc.)

Procedure:

Part 1: Video introduction to layers of the forest

- Before watching the video, ask students to complete a KWL chart about forests. Students should complete the K and W columns by themselves first, then share with a partner. Review the answers as a class to get a sense of what to help students highlight from the video.
- Watch an introductory video about temperate forests (approximately 5 minutes)
 - Layers of a Forest, by Washington's Working Foresters:
<https://www.youtube.com/watch?v=pEipyNr0gw>
 - NOTE: the layers described in this video are different from those described in the lesson above.

Part 2: Forest layers reviewed

- After watching the video, the instructor should draw a profile of the forest on a whiteboard or large piece of paper, or use a projected image on a smart board.
- As a class, ask for student help labeling and describing the layers of the forest on the drawing or image. Additionally, create a list of the plants and animals that live in the forest and match them to the layer in which they most frequently reside.

Part 3: Diorama design

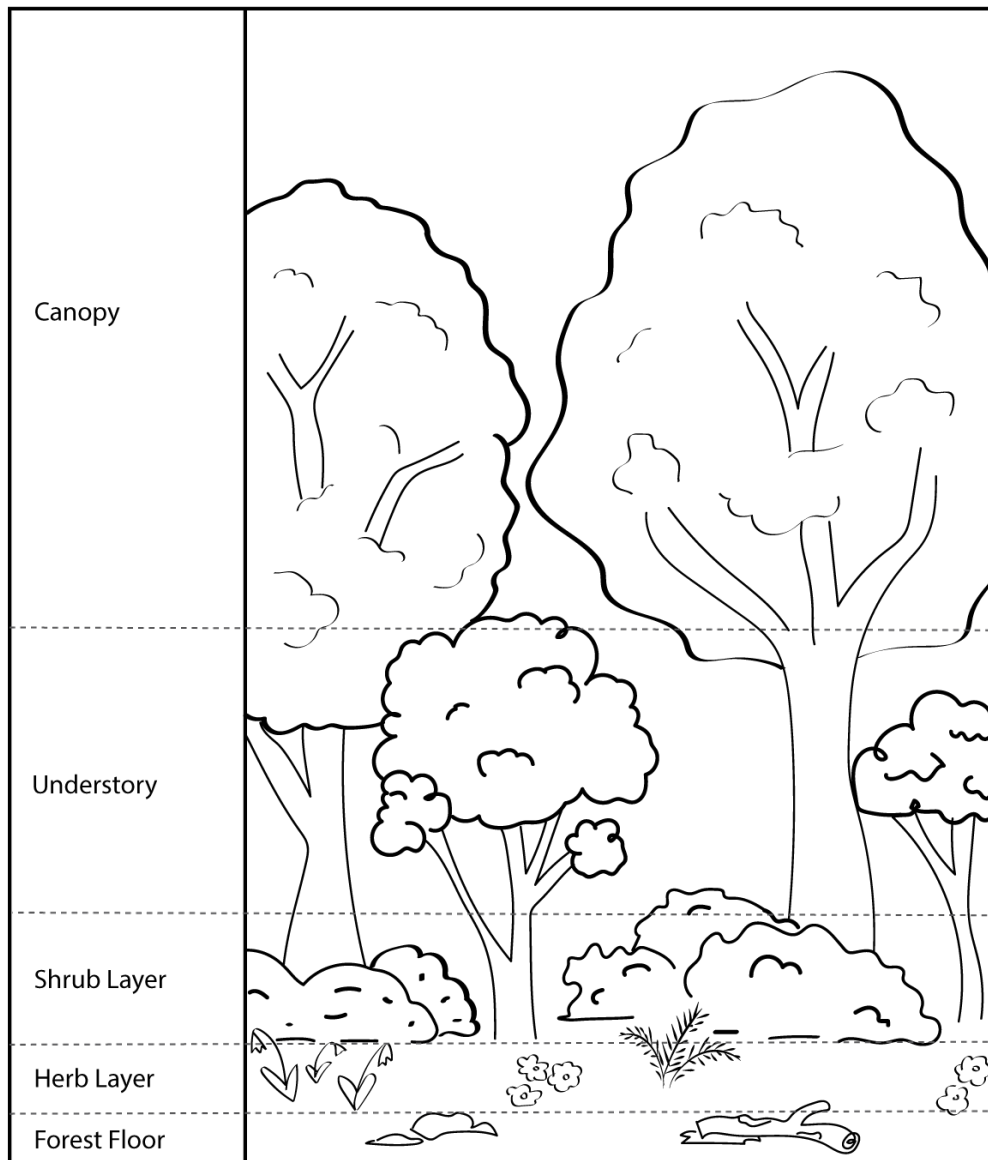
- Provide students with a shoebox and craft materials to build a forest model. Students should label the model to demonstrate understanding of rainforest structure.

Part 4: Animal habitats

- Students can draw and place animals in the model in their correct habitats. If necessary, provide information relating to the needs of each animal so that students can use information to help with placement.

Resources:

LAYERS OF THE FOREST



DESIGNER PLANTS

Content Connections:

Life Science – Structure and function of plants

Grade: 2nd-5th

Time: 45-60 minutes

Objective: Students will develop their understanding of plant adaptations and survival, then apply this understanding to create an imaginary plant of their own.

Materials:

- Plant Adaptations: Shallow Roots, Thick Stalks, and Poison by Andi Diehn
- Paper
- Crayons
- Tape
- Pencil

Procedure:

Part 1: Plant adaptations

- Read: Plant Adaptations: Shallow Roots, Thick Stalks, and Poison by Andi Diehn
- Discuss any surprising observations made while reading. Summarize some of the plant adaptations and hypothesize how these adaptations help the plants survive.

Part 2: Design a plant

- Congratulations! You have just discovered a previously unknown plant in your area.
- Use your imagination to draw what this never-before-seen plant looks like. Consider the following while coming up with your plant.
 - Where does it grow? (sun, shade, in the woods, near water, mountain top, etc.)
 - And how big does it get?
 - What does it look like? (shape and color of leaves and flowers)
 - What is the climate like where it grows? (hot, cold, dry, rainy)
 - What animals try to eat it, and how does it protect itself?
 - Any other unique characteristics that help it survive?
- Share your new discovery with the class

WHAT PLANTS GIVE US

Content Connections:

Life Science – Biodiversity and Humans

Earth Science – Natural Resources

Grade: 2nd-8th

Time: 30-45 minutes

Objective: Students will complete activities that demonstrate human dependence on plants and will be able to list everyday inventions or materials that are directly related to botanical resources.

Materials:

- **2nd-4th grade: Daily Comic**
 - The Reason for a Flower: A Book About Flowers, Pollen, and Seeds (Explore!) by Ruth Heller
 - Paper and drawing/coloring materials
- **5th-8th grade: Biomimicry Activity Stations**
 - **Station 1:** Velcro, sticky seed pods like burrs (pictures or physical examples), hand lens or magnifying glass
 - **Station 2:** Tuscan or Lacinato variety kale leaves, spray bottle with water, hand lens or magnifying glass
 - **Station 3:** Maple seed pods (pictures or physical examples), [Bunny Copter templates](#), scissors, paper clips
 - **Station 4:** Screen with internet to watch a video, [curly party blowers](#)

Procedure:

- **2nd-4th grade**
 - Read the book The Reason for a Flower: A Book About Flowers, Pollen, and Seeds (Explore!) by Ruth Heller

- As a class, create a list of foods and other everyday items from plants that were identified in the book. Discuss whether there was anything missing or anything surprising? Like rubber or medicine?
- Ask students to illustrate a comic strip of their daily routine that highlights items they use that come from plants.
- **5th-8th grade**
 - Complete Biomimicry Activity Stations to explore applications of natural engineering with everyday items inspired by nature.
 - Give students 5-10 minutes at each station to interact with materials and make observations (can vary the number of stations and time at each station depending on student ability and time available)
 - **Station 1: Velcro & other sticky seed pods**
 - Set up: Lay out pieces of hook and loop Velcro as well as burrs or other sticky seed pods and fabric. Let students interact with materials. If possible, provide a hand lens or magnifying glass to allow students to inspect the surfaces of the materials. During debrief, ask students to compare/contrast the burrs and cloth to the hook and loop Velcro. The hooks on the Velcro were inspired by the hooks on the ends of the burrs.
 - **Station 2: Kale & hydrophobic coating**
 - Set up: Set out a big tin foil roasting pan. In the pan, place a couple kale leaves (preferably [Tuscan or lacinato kale](#) with big, full leaves) and a spray bottle with water. Add other types of leaves if desired. Let students spray both the kale leaves and watch what happens to the water. If possible, provide a hand lens or magnifying glass to allow students to inspect the surfaces of the materials. During debrief, ask how would this be useful for humans?
 - **Station 3: Aerodynamics & maple seed pods**
 - Set up: Provide students with [Bunny Copter templates](#), scissors and paper clips. If maple seeds are available, provide those as well. Let students cut out, fold, and test their copters. If time allows, let students experiment with different lengths and sizes of copter blades. During debrief, ask students where this technology occurs in nature and how it would be helpful for humans?
 - **Station 4: Vines & Robotics**
 - **Part 1:** Watch a video of a vining robot
 - [Stanford researchers develop vine-like, growing robot](#)
 - <https://www.youtube.com/watch?v=oRjFFgAZQnk>
 - **Part 2:** Use a [curly party blower](#) to try to grasp small pompoms. Debrief by asking students what surprised them, if anything, about this technology, and how it can be useful to humans.
 - Debrief activity stations using prompts listed above.

Extension Material:

- Ecosystem Services BINGO <https://www.epa.gov/enviroatlas/introduction-ecosystem-services>
- Ecosystem Services that Stick chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.epa.gov/sites/default/files/2018-12/documents/es_lesson_5_stick.pdf

TREE STEWARDSHIP

Content Connections:

Life Science – Biodiversity and Humans

Earth Science – Natural Resources

Language Arts – Key Ideas & Details

Grade: 1st-2nd

Time: 30-45 minutes

Overview: Students will develop an understanding of stewardship by exploring the things that trees give and need things from humans and what humans give and need from trees.

Materials:

- A copy of The Giving Tree by Shel Silverstein (hardcopy, video, or digital)
- Chart paper and markers
- Examples of paper and cardboard products to display to class
- Leaf pattern (provided in Resources)
- Writing and coloring utensils
- Large teacher-made tree for bulletin board (see notes in Prep)

Prep:

Draw a line down the middle of a piece of chart paper to divide it into two columns. Label one column "Giving" and the other "Receiving."

Create a large tree trunk and branches for a display board by cutting out brown paper or color the paper brown. Alternatively, draw a large tree on a big piece of paper.

Procedure:

Part 1: The Giving Tree

- Ask the students what trees give to people and keep track of responses on a piece of chart paper under a header labeled "Giving."

- To explore the ways that trees give to people, read the book The Giving Tree by Shel Silverstein. Choose one of the options below to share the story with your students. If desired and if able, read the story outside under a tree.
 - Teacher reads a paper copy of “The Giving Tree” aloud to the class
 - Class watches a video: <https://www.youtube.com/watch?v=XFQZfeHq9wo>
 - Teacher and/or students read aloud from a projected version of the story as an online slideshare: <https://www.slideshare.net/peneglos/thegivingtree>
 - 12 students volunteer to read parts of the story as a Reader’s Theater activity: <https://www.slideshare.net/joselyn198/the-giving-tree-40608459>

Part 2: The Receiving Tree

- After reading the story, ask students to add any new ideas to the chart of what trees give to people.
- Explain that trees give people a lot, but they also need things in return.
- Ask students what they think trees need to receive, or in other words, what do people need to give trees? Responses can include: sunshine, air, soil, water, space to grow, no pollution. Catalog these responses on the opposite side of the chart paper under the header, “Receiving.”

Part 3: Giving and Receiving together

- Explain to students that there are ways trees can give to us and we can give to trees at the same time. Ask students to think about what paper has to do with trees. If students are stumped, explain that paper comes from trees and there are lots of paper products we get from trees! Hold up examples of tissues, paper towels, cardboard packaging, and other materials made from paper pulp.
- Explain that the more paper and cardboard used, the more trees that need to be cut. Recycled paper products are made from old paper that is remade into new products.
- Ask students why using two sides of paper, recycling paper, and buying recycled paper can help trees. Explain that if we do these things, we can use what trees have to offer, but not use so much that it hurts the trees.

Part 4: Stewardship

- Write the word steward on the board. Explain to students that people who take care of, treat with respect, and do not harm things are stewards of those things. “Tree stewards” are friends to the trees. They take care of and treat the trees with respect so that the trees will be around for a long time.
- Ask students how they can be stewards of trees and add responses to the “Receiving” side of the chart. Responses may include planting new trees, using less products from trees like

cloth napkins rather than paper, reusable lunch box rather than paper bag, reusable cup rather than paper cup.

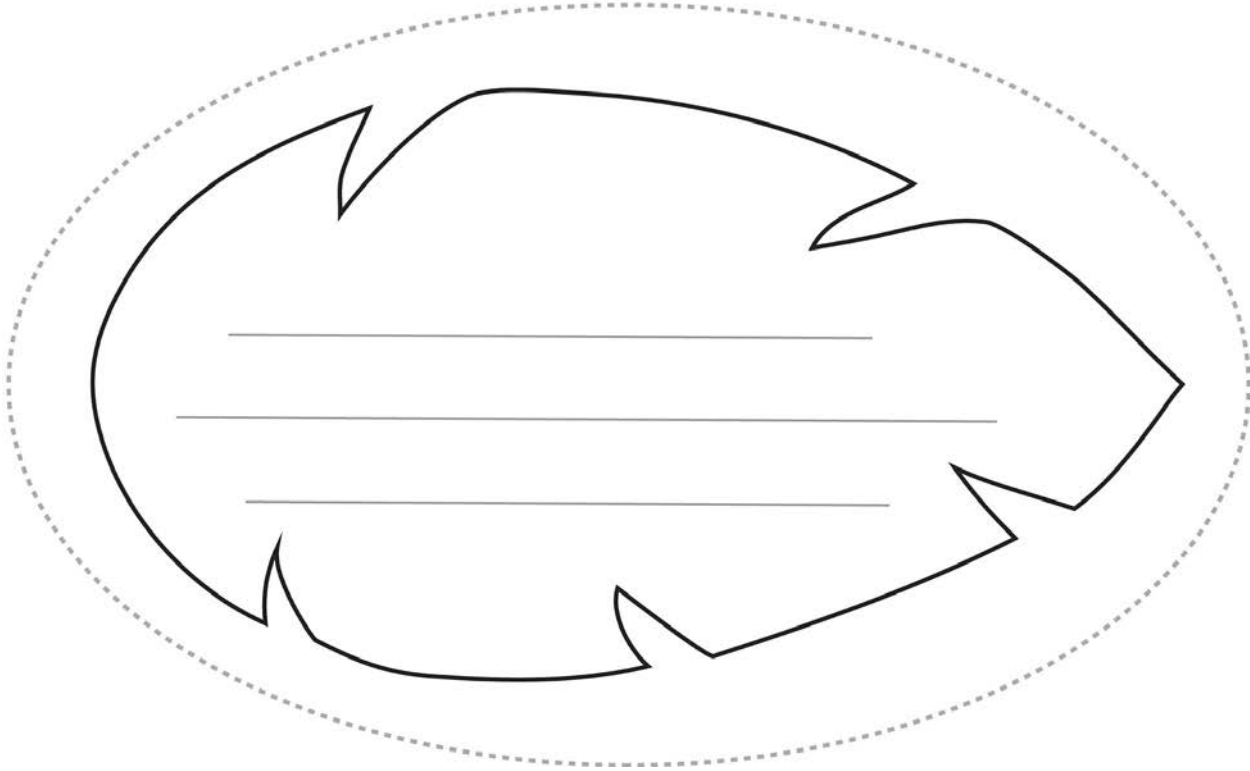
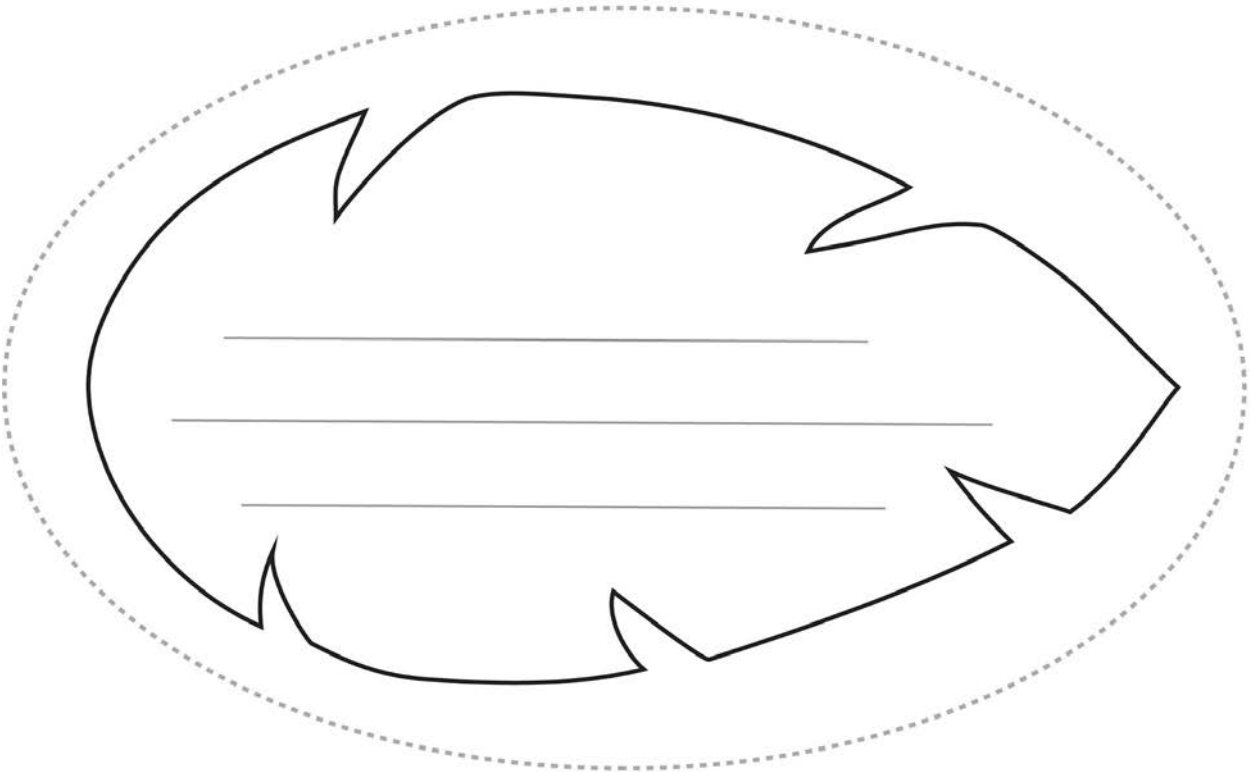
Part 5: Make a Receiving Tree

- Explain that we have now discovered ways people need and can help trees and trees need and can help people.
- To remind us to be good tree stewards, we are going to make our own “Receiving Tree” to keep in the classroom.
- Provide a large tree with trunk and branches cut from brown paper or colored brown, or draw one on paper. If desired, label the parts of the tree.
- Give each student a leaf pattern to cut out, add an illustration and/or sentence, and color. The illustration and sentence should show an example of a way people can give to trees or what trees can receive from people.
- When students are done, have them add their leaves to the tree branches to complete the tree.
 - Alternatively, students can take their leaves home to remind them to be Tree Stewards.

Resources:

- Giving Tree Leaf cut out

Giving Tree Leaf Cut Out



DESIGN A POLLINATOR GARDEN

Content Connections:

Math - Area, Perimeter, Measuring

Engineering - Design a solution to a problem using available tools and resources

Language Arts - Research and application

Visual Arts - Colors and Patterns, functional design

Grades: 2nd-7th

Time: 1-2 hours

Objective: Students will use graph paper to map out a garden plot according to the space requirements of different plants and flower preferences of different types of pollinators.

Materials:

- One-inch graph paper per group
- Pencils
- Flowering plant inventory list or research materials
- Flower Talk: How Plants Use Color to Communicate by Sara C. Levine and illustrated by Masha D'yans

Procedure:

1. Read Flower Talk: How Plants Use Color to Communicate by Sara C. Levine and illustrated by Masha D'yans.
2. Discuss how butterflies and other insects use plants for food and how plants need pollinators for reproduction. Explain that pollinators, especially insects, need special plants at different times in their life cycle.
3. Introduce the project, to plan and design a pollinator friendly garden that will support all types of pollinators throughout the year (Spring-Fall). Discuss with students what things they need to consider and what will they need to do more research on to find out how to best design their garden. Allow students time to research (independently or with materials provided). Questions to consider include:
 - a. What are the types of pollinators?
 - b. What types of flowers does each type of pollinator prefer?
 - c. Do these pollinators need different types of plants at different life stages?

- d. When do each plant's flowers bloom?
 - e. How long does each type of flower bloom?
 - f. How much sunlight does each flowering plant need to grow?
4. If research time is limited, instructor can provide students with a plant inventory sheet that includes a picture of the flower to show shape and color, flower size, bloom time, bloom length, whether it is an annual or perennial, and mature plant size. If desired, alter the provided flowers to match local wildflowers (See attached inventory sheet)
 5. Provide students with one-inch graph paper and explain that on our grid, one inch will equal one foot. Tell students they may use any combination of plants they choose, as long as they follow the space requirements. Give students about 30 minutes to design their gardens with their partners.
 6. Make a career connection with Landscape Architecture. As students are working, Make suggestions as to the garden design, such as choosing colors that blend and making sure all plants are visible (i.e., tall in back, short in front).

Extensions:

- For early elementary students, provide pictures of flowers cut to size and shape that will fit on graph paper. Ask them to fill the space and consider making patterns in the garden.
- Challenge upper elementary students to create a garden that includes other shapes such as circles, triangles, and octagons. Ask students to design a three-dimensional garden that includes fencing, wire cages, or climbing poles.
- Ask older students to create garden maps for younger students who are planting a garden plot, and then have them assist the younger students in following the plan.
- Explore varieties of plants and try planning a pollinator garden for a different environment. How would the garden and flowers change if it were planted in a different part of the world?

References:

New Jersey Agricultural Society: [Making A Garden Map](#)

Clemson Cooperative Extension: ["Bee" A Friend to Pollinators](#)

Design a Garden

Flower Inventory:

Use this list of flowers and their characteristics to help you determine which plants you will put in your garden to attract all types of pollinators all year long!

<i>Flowering Plant</i>	<i>Pollinators Attracted</i>	<i>Bloom Time</i>	<i>Plant spacing when planting</i>	<i>Amount of sunlight</i>
<i>Bluebells</i> 	Bumble Bees, Butterflies	Mid-April through Late-May	6" apart	Partial shade
<i>Phlox</i> 	Butterflies, Moths	April through June	18" apart	Full sun to partial shade
<i>Penstemon</i> 	Bees, Hummingbirds	May through June	24" apart	Full sun to partial shade
<i>Petunia</i> 	Bumble Bees, Butterflies, Hummingbirds	Late-May through August	12" apart	Full sun
<i>Tickseed</i> 	Beetles, Solitary Bees	June through September	24" apart	Full sun

<i>Milkweed</i> 	Butterflies, Moths,	June through August	18" apart	Full sun
<i>Blanketflower</i> 	Bumble Bees, Bees, Flies, Wasps, Butterflies	June-September	18" apart	Full sun
<i>Yarrow</i> 	Beetles, Flies	June through September	18" apart	Full sun to partial shade
<i>Bee Balm</i> 	Bees, Bumble Bees, Butterflies, Moths, Hummingbirds	July through September	18" apart	Full sun
<i>Aster</i> 	Beetles, Flies, Bees	August-October	24" apart	Full sun to partial shade
<i>Goldenrod</i> 	Beetles, Bees, Flies	August through October	36" apart	Full sun

Garden Summary:

My garden will be...

_____ feet by _____ feet, or _____ feet square

In my garden, I will plant...

And will attract...

The first flower to bloom will be _____ (flower) in _____ (month)

The last flower to bloom will be _____ (flower) in _____ (month)