Pollinators

In this unit we are learning about our good garden friends the pollinators. Who are the pollinators? Bees, hummingbirds, moths, bats, butterflies, flies, and beetles are a few notable representatives. Pollinators are animals that help many flowering plants produce their seeds and thus ensure the continued existence of millions of plant species, and in turn, of most animal species, including humans. In each module, we will dig into a different pollination-focused topic and provide instructions for engaging, hands-on lessons and activities. By the end of the unit we hope your young gardeners will understand the intricate relationship between pollinators and flowering plants and also learn to love, respect, and appreciate these hard-working animals.

Module 1: What is Pollination?

Learning Objectives:

In this module, kids will learn:

- The common parts of a flower
- How flowers make seeds
- Why many flowers need help from pollinators to make their seeds

Materials Needed for this module:

Activity 1: Introduction to the Parts of a Flower

- Fantastic Flowers Reading Page (end of lesson)
- Anatomy of a Flower Coloring Page (end of lesson)
- Crayons, colored pencils, or markers

Activity 2: Make Your Own Flower

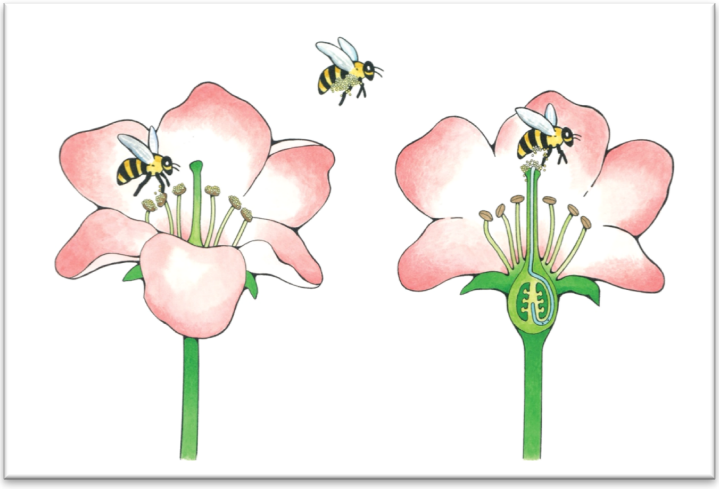
- Plastic cup(s)
- Modeling clay or playdough
  (Try your hand at making no-bake homemade playdough (https://www.pbs.org/parents/crafts-and-experiments/no-bake-playdough-recipe) or traditional homemade playdough (https://www.pbs.org/parents/crafts-and-experiments/rainbow-playdough) from PBS Kids for Parents
- Construction paper
- Crayons, colored pencils, or markers
- Chenille sticks, pipe cleaners, or straws
- Pompoms, cotton balls, or tissue paper
- Tape
- (Note: Feel free to substitute any of the above supplies if needed. You'll find more suggestions after Activity 2, below.)

Activity 3: **Dissect a Flower**

- Flower Dissection Handout (optional, end of lesson)
- A sample flower
- Hand lens or magnifying glass (optional)
- Tweezers (optional)

Introduction

Flowering plants have a distinctive way of making seeds. Their flowers make pollen in parts called stamens. To create a seed, the pollen must be transported and joined with egg cells that are located in parts called pistils. This process is called pollination. Sometimes the pistils and stamen are in the same flower and sometimes the pollen from one flower must be moved to the pistil of another flower. Since pollen does not have wings or feet, it needs help moving from one place to the other. Some flowers rely on the wind or water to help make pollination happen. Other flowers rely on small animals called pollinators to transport their pollen from flower to flower as demonstrated in the illustration below.

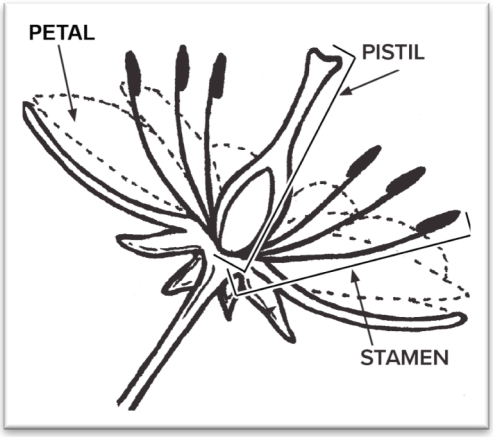


Let's look more in depth at the parts of the flower and the pollination process.

The pistil is made up of multiple parts: a platform called the stigma and the thin stalk that holds it up, called the style. The stigma is often sticky so it can trap pollen. At the base of the style is the ovary, which may or may not be visible. Inside the ovary are the ovules, which contain the eggs.

Pollination occurs when the pollen transfers from the stamen to the pistil. Once there, it will grow a tiny pollen tube down the style into the ovary, where the eggs are located. This part of the process is called fertilization. Fertilized eggs grow into tiny embryos, which then develop into seeds. *You can vary the amount of detail you share about this process with your child or students depending on their age.*

Other important flower parts are the petals and sepals. In addition to surrounding and protecting the seed-making parts, the petals of flowers that need pollinators to help them transport the pollen are often brightly colored or patterned to attract the pollinators (birds, bees, and other insects). Some are broad and flat to provide good "landing pads." Wind-pollinated flowers, such as those of corn and oak trees, on the other hand, usually have inconspicuous petals, if any. Sepals are green leafy structures surrounding the petals, which initially protected the developing bud.



Activities and Lessons

Activity 1: Introduction to the Parts of a Flower

1. Together or independently, read the Fantastic Flowers Handout. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Next, color the Anatomy of the Flower coloring page. Encourage kids to create different color combinations and patterns that they think would help their flower attract pollinators. Give them an opportunity to explain their choices.

3. Finally, if possible, take your coloring page outside and go for a flower hunt in your yard or local green space. Without picking the flowers (remember they are hard at work making seeds!) see if you can identify the sepals, petals, pistil, and stamen. Extra bonus if you can find some pollen or visiting pollinators too!

Activity 2: Make Your Own Flower

1. Ask kids to cut out flower petals from construction paper and decorate them with different patterns. Attach your petals to the edge of a small plastic cup with tape so that they hang down the outside of the cup.

2. Next, create your pistil and stamens using chenille sticks. It is common for flowers to have just one pistil and multiple stamens; however, you can leave that up to your child if you wish. To make the pistil, shape the chenille stick so that the top looks like a landing pad or a loop. To make the stamen, wrap small pompoms around the top.

3. Place a piece of modeling clay or playdough in the bottom of your cup and then poke the bare ends of the pistil and stamens into it.

4. If you want to take this activity further, name your flower and then encourage kids to also create their own pollinator to help with pollination.

Note: These are just suggested materials, but feel free to use anything you have on hand. For example, you can use straws instead of chenille sticks or ball up pieces of paper or tissue instead of using pompoms.

Activity 3: Dissect a Flower

1. In this module, kids have learned about the important work flowers are doing by making the seeds. However, in this activity we are going to sacrifice one or two flowers for the sake of science. Begin by obtaining one or two flowers to dissect. If cut flowers are available to you from a grocery store or florist, look for alstroemeria flowers — they make great dissection subjects because they have very large, recognizable plant parts. (Lily flowers also work, but they are generally more expensive, and please note that they are poisonous for humans and animals.) You may also be able to find flowers from your garden or other shrubs or trees in your yard. If you must look beyond your own space, please make sure to obtain permission before picking them.

2. Give kids a copy of the Flower Dissection Handout. Go over the different parts of the plant that you will be looking for with your child.

3. Very carefully, remove the flower petals. If available, you could use tweezers for this job and add in some fine motor skills practice (and kids find it fun), but you could also just use your fingers. Have kids take a close look at the petals. If you have a hand lens or magnifying glass available, take a look at the petals for additional details, such as texture, shine, tiny hairs, color patterns, etc. Count the number of petals and record that information on the chart on the Handout. If you want extend your math learning, you could also have your kids measure the petals.

4. Next, count the number of stamens and carefully remove one of them. (See Note, below.) Look carefully for pollen at the top. Try gently tapping the anther against a piece of white paper to see if any pollen comes loose. Use your hand lens or magnifying glass, if available, to examine the stamen.

5. Finally, count the pistils. (See Note, below.) Describe the top "landing pad." Does it look shiny or wet? Gently touch it — is it sticky? Look at it through a magnifying glass or hand lens if available. As the very last step, see if you can very gently pull apart the ovary at the bottom and see seeds beginning to develop.

Note: What if you do not find any stamen or pistils in your sample flower? There are some plants that produce pistils and stamens on separate flowers; that is, some flowers have only stamens, some have only pistils. A common example of this phenomenon is the squash family (squash, cucumbers, watermelons). There are even some plants, such as holly shrubs — some plants only produce flowers with stamens, and other plants only produce flowers with pistils. This is why not all holly plants will get holly berries on them. Only the holly shrubs that have flowers with pistils (which contain the ovaries) will develop holly berries (seeds).

6. As a last and optional step, to document your work, you can tape your parts onto your handout for later review. If supply allows, you could also repeat this process with another type of flower and compare your findings.

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books

The Reason for a Flower by Ruth Heller
Beautiful illustrations and simple text provide an overview of the purpose of flowers in the plant world.

The Flower Garden by Eve Bunting
A delightful book about a young girl who plants a flower garden for her mother's birthday.

Videos

Time Lapse Videos posted by Seed Your Future:
https://www.seedyourfuture.org/plantflix
Seed Your Future has gathered a great collection of plant-focused time-lapse videos. Make sure to check out The Beauty of Pollination by Moving Art™, Watch Flowers Bloom Before Your Eyes, Beautiful Cacti Bloom Before Your Eyes, and Cherry Blossom 4K Timelapse.

Identifying Parts of a Flower from the Art Lady Channel:
https://www.youtube.com/watch?v=ZQAnJ8lCFc8

Daffodil Flower Dissection from QLab:
https://www.youtube.com/watch?v=MSAVKlyZh6o

Additional Related KidsGardening Lessons and Activities to Try

Pressed Flowers and Leaves
https://kidsgardening.org/resources/garden-activities-pressed-flowers-and-leaves/

Flower and Leaf Prints
https://kidsgardening.org/resources/garden-activities-leaf-and-flower-prints/

Edible Flowers
https://kidsgardening.org/resources/growing-guide-edible-flowers/

Petal Attraction
https://kidsgardening.org/resources/lesson-plans-petal-attraction/

State Flowers
https://kidsgardening.org/resources/lesson-plan-state-flowers/

Pollinators

Lessons to Grow By, Pollinators Module 1 Reading Page

Fantastic Flowers

Roses are red, violets are blue, we love flowers, how about you?

Do you have a favorite flower? What color is it? Where do you find it? Why is it special to you?

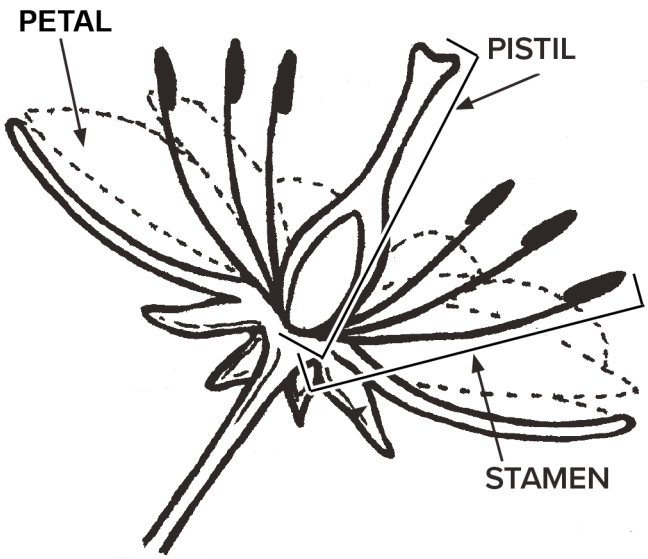
Flowers can be found in many different sizes, shapes, and colors. They can be as small as a penny or as big as a dinner plate. Their petals come in every color of the rainbow – red, orange, yellow, green, blue, purple, and also brown, black, and white. Some of them give off a wonderful scent too (although not all of them – some of them actually are kind of stinky). Most times we see notice them in spring, summer, and fall, but in places where it is warmer, you might find some during the winter months too.

Think back to the plants you have seen around your school or home. Do they all have flowers on them? The answer is no. Most plants have flowers, but there are some that do not. There are also some plants, especially some of our bigger trees that have small flowers that you may not recognize as flowers at all.

So why do plants have flowers? How do they help the plant? Flowers have one very important job to do. Their job is to make seeds. Seeds grow into new plants and ensure that we have plenty of plants living in our environment. Plants are an important source of oxygen, food, and shelter, and without them animals would not be able to survive on this planet.

Even though flowers on different plants do not look like each other, they are actually made up of the same parts including:

- Petals: The often-colorful structures that surround the seed making parts.
- Stamens: The parts that make pollen, small grain-like cells that are often yellow in color.
- Pistil: The parts where the seeds actually grow.



To make the seeds, the pollen from the stamens must be moved to the pistil. Sometimes the pollen moves from the stamens to the pistil on the same flower and sometimes it moves from the stamens on one flower to the pistils on another flower. In some cases, the pollen moves with the help of wind or water. Other times, animals like bees or butterflies help move the pollen from plant to plant. This process is called pollination.

Flowers have many features to encourage pollinators to help them move pollen. At the base of the pistil of some types of flowers, pollinators can find sweet nectar to eat. Some pollinators also eat some of the pollen too. The bright colors and eye-catching patterns on petals also help flowers attract pollinators.

From sunflowers to petunias, next time you stop to admire a beautiful flower, remember that it is hard at work!

Reading Comprehension Questions

1. True or false: Flowers come in different sizes, shapes and colors.

2. True or false: All plants have flowers.

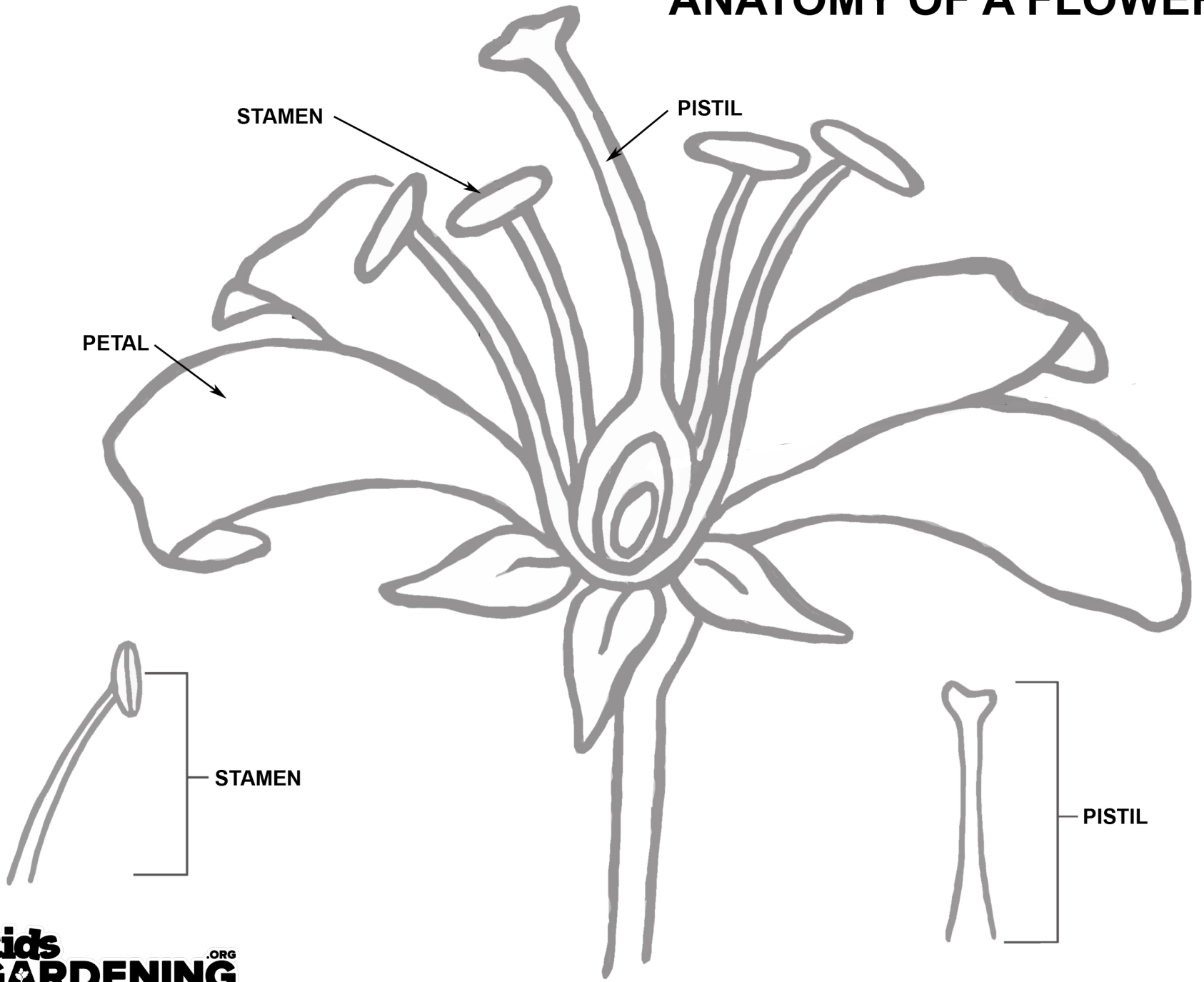
3. What is the main job of a flower?

4. Which of the following is not a name of a common part of a flower:

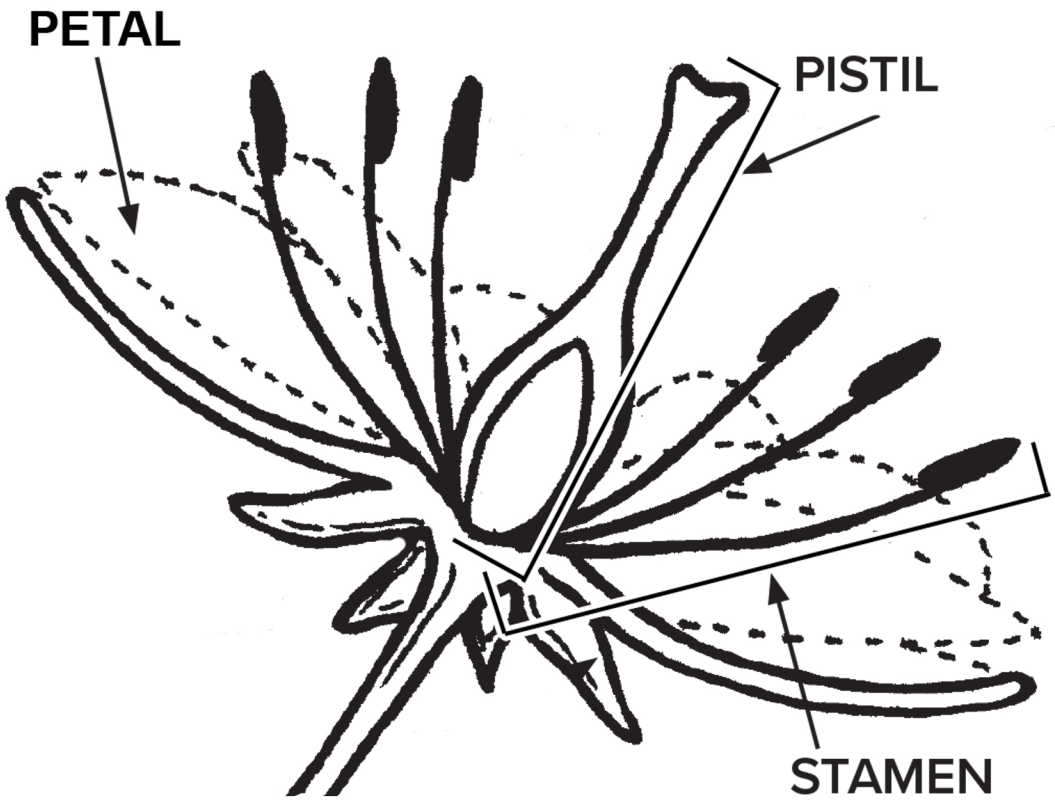
    Pistil
    Antennae
    Petals
    Stamen

5. What word do we use to describe how pollen moves from one flower part to another flower part?

ANATOMY OF A FLOWER



kids GARDENING .ORG
HELPING YOUNG MINDS GROW



Flower Part	Number	Additional Observations
Petals		
Pistil(s)		
Stamen(s)		

Additional Notes:

kidsGARDENING.ORG

LESSONS TO GROW BY

Pollinators

In this unit we are learning about our good garden friends the pollinators. Who are the pollinators? Bees, hummingbirds, moths, bats, butterflies, flies, and beetles are a few notable representatives. Pollinators are animals that help many flowering plants produce their seeds and thus ensure the continued existence of millions of plant species, and in turn, of most animal species, including humans. In each module, we will dig into a different pollination-focused topic and provide instructions for engaging, hands-on lessons and activities. By the end of the unit we hope your young gardeners will understand the intricate relationship between pollinators and flowering plants and also learn to love, respect, and appreciate these hard-working animals.

Module 2: Who are the pollinators?

Learning Objectives

In this module, kids will:

- learn how to identify common pollinators
- discover why different pollinators are attracted to different kinds of flowers
- sharpen their observation skills

Materials Needed

Activity 1:

- Blooming Café Reading Page (end of lesson)
- Pollinator/Flower Profile Cards (end of lesson)
- Crayons, colored pencils or markers

Activity 2:

- Pollinator Scavenger Hunt Printout (end of lesson)
- Crayons, pencils, and pens
- Clipboard (optional)

Activity 3:

- Writing paper, journal, or Pollinator Journal (end of lesson)
- Pencil or pen
- Field guides or access to digital identification tools
- Clipboard (optional)
- Camera (optional)

Introduction

Although bees are the best-known and most widespread pollinators, other kinds of animals, including wasps, beetles, flies, butterflies, moths, birds, and bats act as pollinators for various kinds of flowers. Over millions of years, many flowers and pollinators have adapted together and developed special relationships. For example, a pollinator may have an adaptation that allows it to detect the colors or scents of a certain flower, so it's able to recognize it as a valuable source of nectar and pollen. Another type of pollinator may have evolved special structures, such as an extra-long tongue, so it can reach the nectar deep inside a tubular bloom. These special adaptations give the pollinators advantages over their less fortunate kin, and they pass the adaptations on to their offspring. Over many generations these traits have become well established in pollinator populations. Meanwhile flowers have also evolved, giving rise to specific characteristics or adaptations that attract particular pollinators.

To compete for the attention of pollinators, flowers have come up with creative methods to entice creatures to their sugar-filled nectar and protein- and vitamin-rich pollen. In exchange, the unsuspecting creatures unintentionally act as messengers, delivering pollen between blooms that would otherwise never touch. The amazing diversity of flowers results from their unique adaptations to lure a range of pollinators (or to ensure that wind or, more rarely, water carries pollen). Every aspect of a flower, from the designs on its petals to the timing of its bloom, is vital to its pollination strategy. Below are examples of flower characteristics that attract some common pollinators:

Pollinator Flower Preferences

Pollinators	Flower Preferences
Bees **Did you know?** There are about 4,000 species of native bees in the U.S. ranging in length from less than 1/8" to more than 1". Most of these bees are solitary nesters. Unlike the non-native (but now naturalized) hive-building honeybees, solitary native bees have no hive to defend and are unlikely to sting!	Yellow, blue, purple flowers. There are hundreds of types of bees that come in a variety of sizes and have a range of flower preferences. They can't see red, but are attracted to some red flowers, such as bee balm, that reflect ultraviolet light. Small bees, which have short tongues, prefer packed clusters of tiny flowers (e.g., saliva, alyssum, lilacs, phlox, butterfly weed, aromatic herbs). They like flowers with a good supply of nectar and pollen. They use the nectar to make honey, and they also store pollen in their honeycombs to use as an alternate food source.

Butterflies	Red, orange, yellow, pink, blue flowers. They need to land before feeding, so prefer flat-topped flower clusters (e.g., Joe Pye weed, calendula, butterfly weed, yarrow, daisy, zinnia) in a sunny location. They like flowers with lots of nectar available. Just as important, butterflies also seek out specific plants on which to lay their eggs, so that when the eggs hatch the larvae (caterpillars) have a ready food source. Different butterfly species need different plants for their larvae, including milkweed, aster, lupine, thistle, fennel, violets, hollyhock, black-eyed Susan.
Moths	Light-colored and white flowers. Most moths are active at night, so they prefer plants that open at dusk such as evening primrose and moonflowers. They like flowers with lots of nectar available and tend to be attracted to flowers that give off a strong sweet scent.
Pollinating beetles	Dull white and green flowers. Since they do not all fly (or at least fly well), beetles prefer wide-open, bowl-shaped flowers that they can sit in, such as magnolia, aster, sunflower, and rose. They like flowers that have lots of pollen to eat. They may also eat the petals and other plant parts.
Flies	Green, purple, brown, white, or cream flowers. They have short tongues, so prefer simple, bowl shapes. Pollen is an important food source for them. They are attracted to flowers that give off foul odors, such as trillium and western skunk cabbage.
Hummingbirds	Red, orange, purple/red flowers. Their long beaks fit well into tubular flowers with lots of nectar. Nectar is their main food source and so they search out flowers with an ample supply (e.g., honeysuckle, sage, fuchsia, jewelweed, fireweed, cardinal flower, bee balm, nasturtium, century plant). No landing areas are needed since they hover while feeding.
Bats (Pollinating bats are found primarily in the Southwest)	White and light-colored flowers. Bats prefer large, night-blooming flowers with strong fruity odors (e.g., many types of cacti). They like flowers with lots of nectar available.

Activity 1: Pollinator/Flower Profile Cards

1. Read the Blooming Café reading page independently or together. Complete the reading comprehension questions and then talk about the special relationships between plants and pollinators and the characteristics of each that support the dependence on each other. You can use the introductory information for additional details to share.

2. Print out the Pollinator/Flower profile cards and play a matching game with your kids to talk about how different pollinators are attracted to different types of flowers. If you have a larger number of kids playing, you can give each child a flower or pollinator card and then give them time to find a partner with the matching pollinator or flower card. Make as many copies as you need so that each child has their own card. Alternatively, if you are playing with just one or two kids, you can turn the cards over and play the game as a memory matching game.

Here are the answers to the pollinator-flower matches:
Magnolia – Beetle
Monarda – Hummingbird
Moonflower – Moth
Saguaro – Bat
Snapdragon – Bee
Trillium – Fly

Zinnia – Butterfly

3. As an optional extension to this activity, have the kids color the cards, keeping in mind the information in the introduction about the colors and patterns that each of the pollinators tends to be attracted to.

Activity 2: Pollinator Scavenger Hunt

1. Go on a pollinator scavenger hunt. Use the scavenger hunt worksheet or create your own to help you find pollinators in your garden or in a local green space. This activity is best done in the spring through the fall as it is hard to find flowers and pollinators during winter months.

2. A few optional adaptations to this activity:
   - To add to the fun, you can turn it into a game to see who can find the most pollinators and pollinator-attracting flowers.

   - Go on multiple pollinator hunts at different times of the day using a different worksheet each time, and then compare your results. Make sure to record the time of your observations at the top of your sheet before you start. Do you notice any differences in what pollinators you find or what flowers are open at different times of the day? You could also record temperature or weather conditions and look for patterns. Repeat more than once for best observations. You could also track over many months and look for seasonal differences. Graph your results to practice additional math and science skills.

Activity 3: Start a Pollinator Journal

1. Take your young explorer's observation skills to the next level by starting your own pollinator journal. You can create your own with notebook or even scrap paper stapled together, you can use a composition book, or you can also print out the KidsGardening Pollinator Journal included at the end of this lesson.

2. To get started, set aside some chore-free time to **explore your garden or a nearby green space.** For maximum enjoyment, select days with comfortable weather and a relaxed schedule. As with the scavenger hunt, you can also try visiting at different times of the day to see of time, temperature, and sunlight impact your garden visitors.

Before heading outside, **set the stage with a few ground rules and tips:**
- Respect all life in the garden.
- Observe living creatures with your eyes, not your hands.
- Write down or draw as many details as possible.

Younger observers may want to rely on drawings. For older children, encourage them to take written observations and more extensive notes. This activity can be a way to help sharpen their science and writing skills. If tools are available, you can also encourage them to take photos that they can later add to their journals and/or use to create a digital journal or collage.

3. Either while you are outside or when you return home, use resource materials to help you identify any pollinators you do not already know. There are a number of printed field guides that can be purchased or checked out from a local library. There is also a growing body of online identification guides available. Here are a few digital resources you may want to check out:
   - Bee Identification Guides from the Pollinator Partnership: https://www.pollinator.org/bee-guides

- Seek by iNaturalist created by California Academy of Sciences and National Geographic: https://www.inaturalist.org/pages/seek_app
- Citizen Scientist Pollinator Monitoring Guide by The Xerces Society for Invertebrate Conservation at the University of California at Berkeley: https://xerces.org/sites/default/files/2018-05/11-010_01_XercesSoc_Citizen-Science-Monitoring-Guide_California_web.pdf

There are many, many more online resources available. Your state's land grant university's entomology department is often a great place to look for information about insects specific to your area. Make sure to match your identification activities to the interest and developmental level of your kids. For example, identifying a bee as a bee or a beetle as a beetle may be more than enough for younger children (and not require a field guide), but older students may want to take on the challenge of identifying the specific species of bee found.

4. Want to expand on this activity further? Encourage your kids to conduct a pollinator inventory to deepen their understanding about how many pollinators are out there at work. This can be as simple as keeping a tally in a chart in your journal of the different pollinators you see or as involved as participating in an organized wildlife inventory.

There are a number of organizations that offer regional and nationally planned inventories which are usually conducted to support conservation efforts and awareness. In addition to increasing their knowledge, participating in an organized inventory can be a fun way for kids to connect with others and feel like they are making a difference. Here are a few inventory opportunities you may want to explore (note that not all of these are specific to pollinators):

- iNaturalist from the California Academy of Sciences and National Geographic: https://www.inaturalist.org/ (conduct a search of community projects to see if there are any in your area)
- Monarch Watch: https://www.monarchwatch.org/
- October Big Day (Bird count): https://ebird.org/octoberbigday
- The Great Backyard Bird Count (February): http://gbbc.birdcount.org/
- The Lost Ladybug Project: http://www.lostladybug.org/
- Journey North (monitors a variety of migratory animals): https://journeynorth.org/

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books

The Reason for a Flower by Ruth Heller
Beautiful illustrations and simple text provide an overview of the purpose of flowers in the plant world.

Bea's Bees by Katherine Pryor
Follow Bea as she learns what kind of flowers bees like and their other habitat needs.

The Flower Alphabet Book by Jerry Pallotta and Leslie Evans
This book shows the diversity of flowers found in all different colors, shapes and sizes.

Videos

Slo-Mo Footage of a Bumble Bee Dislodging Pollen from the Smithsonian Channel:
https://www.youtube.com/watch?v=J7q9Kn1rhRc

The Beauty of Pollination from Moving Art(TM):
https://www.youtube.com/watch?v=MQiszdkOwuU&t

Pollination: Trading for Food for Fertilization from Cornell University's Naturalist Outreach Series
https://www.youtube.com/watch?v=Lu7AjOvznh8

Additional Related KidsGardening Lessons and Activities to Try

Petal Attraction:
https://kidsgardening.org/resources/lesson-plans-petal-attraction/

Wonderful Wildflowers:
https://kidsgardening.org/resources/lesson-plan-wonderful-wildflowers/

Imperfect Flowers: A Design for Genetic Diversity:
https://kidsgardening.org/resources/lesson-plan-imperfect-flowers/

Insect Safari:
https://kidsgardening.org/resources/lesson-plans-insect-safari/

Bug Hunt:
https://kidsgardening.org/resources/garden-activities-bug-hunt/

Wildlife Inventory:
https://kidsgardening.org/resources/garden-activities-wildlife-inventory/

Plant Families for Pollinators:
https://kidsgardening.org/resources/digging-deeper-plant-families-for-pollinators/

Planting a Flower Clock:
https://kidsgardening.org/resources/garden-activities-planting-a-flower-clock/

Flower Adaptations to Lure Pollinators:
https://kidsgardening.org/resources/garden-how-to-flower-adaptations/

Blooming Cafés

Reading page for Pollinators Module 2: Who are the pollinators?

Do you have a favorite food? What do you like about it? Do you like the way it looks? Do you like the way it smells? Or is your favorite thing about it the way it tastes? Did you know that just like you, pollinators have favorite foods too?

Pollinators are animals like bees and butterflies that help plants move pollen from one flower to another flower. This helps them make their fruit and seeds. Pollinators need flowers too. Flowers provide pollinators with food. Pollinators drink the sugar-filled nectar and eat the protein- and vitamin-rich pollen that flowers make.

Since there are lots of blooming plants out there, how does a plant make sure that pollinators will visit their flowers and move their pollen?

Think about some of the ways restaurants and grocery stores get you to buy food products. Do they put it in a pretty package? Do they make sure it smells good? Are they open during the hours you are awake and hungry?

In addition to the nectar and pollen they make, flowers have developed special traits to help attract pollinators to them, such as the colors, patterns, and shapes of their petals, the time of day they are open, and even the smell they give off. These traits act like advertisements to encourage pollinators to come visit them. Here are some examples of pollinators and their favorite flowers:

Bees like yellow, blue and purple flowers. Because they have small tongues for sipping nectar, they like tiny flowers that grow in groups best.

Butterflies like bright colors, so they're attracted to red, orange, yellow, pink, and blue flowers. They like to sit on the flower while they drink the nectar, so they like flowers that have a wide top that can serve as a landing pad.

Moths and **bats** are out looking for food at night. They are attracted to white and light-colored flowers that smell sweet and fruity.

Beetles do not always fly much, so they like bowl-shaped flowers that they can crawl around and sit in. Sometimes they eat the petals and other flower parts too!

Hummingbirds are really attracted to the color red, and their long beaks fit well in tube-shaped flowers. They use a lot of energy flying so they also look for flowers that have lots of nectar to drink.

Flies like green, purple, brown and white flowers. They also like flowers that give off stinky odors that smell like rotting meat. Yuck!

So next time you notice a pretty flower or take a moment to smell its scent, remember that there is purpose behind these appealing qualities. Just like a cool box design or a prize inside might get you to try a breakfast cereal, the flower is working hard to get the pollinator to try their nectar and pollen so that without knowing it, they also help the flower make its seeds.

Reading Comprehension Questions

1. How do pollinators help plants?
    A. They water plants.
    B. They provide plants with food.
    C. They move pollen from one flower to another flower.
    D. None of the above.

2. How do flowers help pollinators?
    A. They provide them with shelter.
    B. They provide them with food.
    C. They look pretty.
    D. Flowers do not help pollinators.

3. What traits of flowers help them attract the attention of pollinators?
    A. Scent
    B. Color of petals
    C. Shape of the flower
    D. Pollen and nectar available
    E. All of the above

4. True or false, pollinators have favorite flowers?

5. Cactus plants have white flowers that smell sweet and bloom at night. What kind of pollinators do you think would be attracted to a cactus flower?

BAT

I feed on nectar.

I like fruity fragrances.

I am active at night.

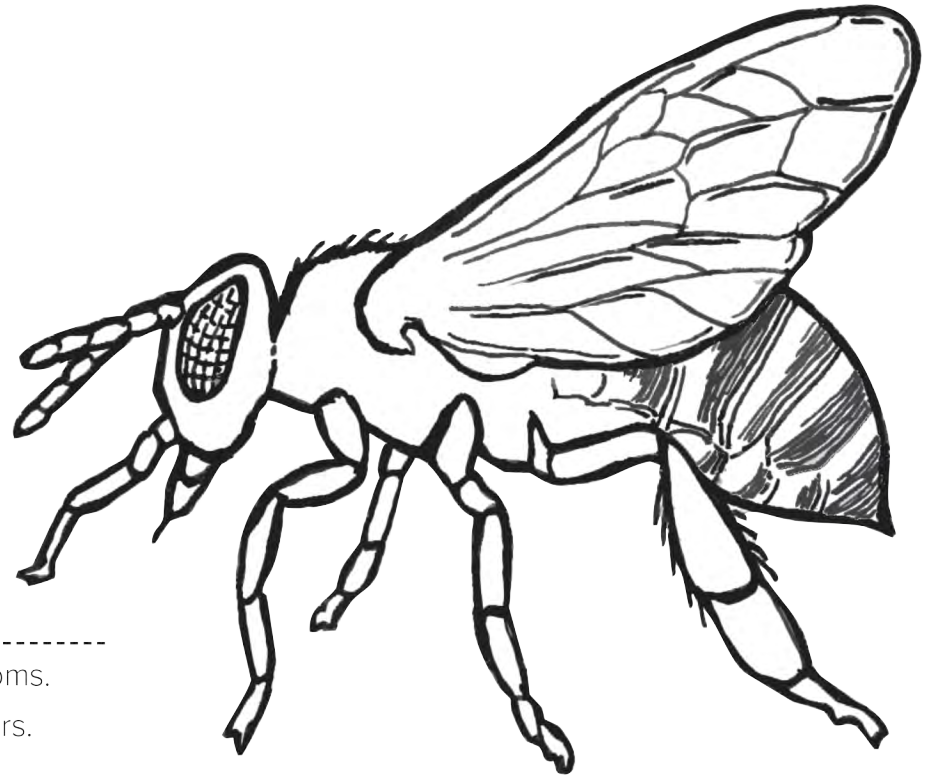
SAGUARO

I blossom at night.

I have white petals.

I smell like over-ripe melons.

I have lots of nectar to offer.



BEE

I like sweet-smelling blossoms.

I like clusters of small flowers.

I eat nectar and pollen.

I like having a place to land while I eat.

SNAPDRAGON

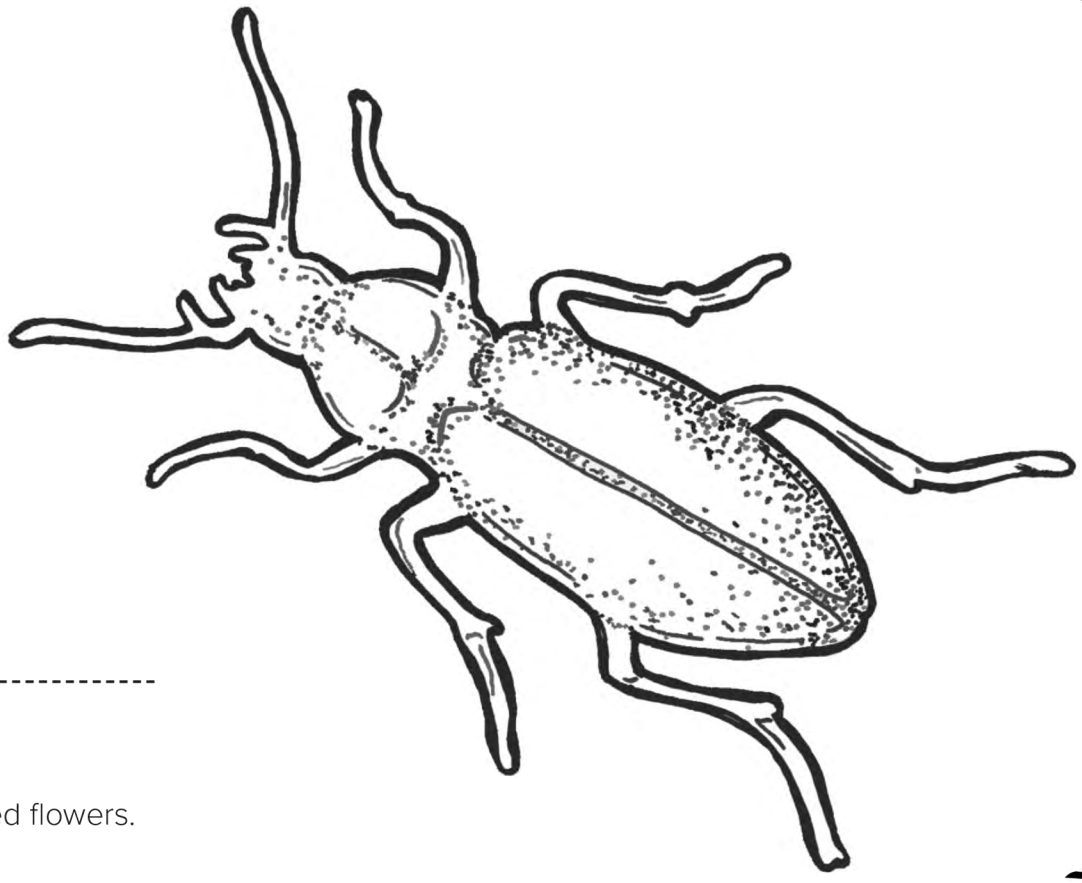
My flowers have handy landing pads.

I smell sweet.

I have lots of small blossoms.

My flowers come in many colors.

kids GARDENING .ORG
HELPING YOUNG MINDS GROW

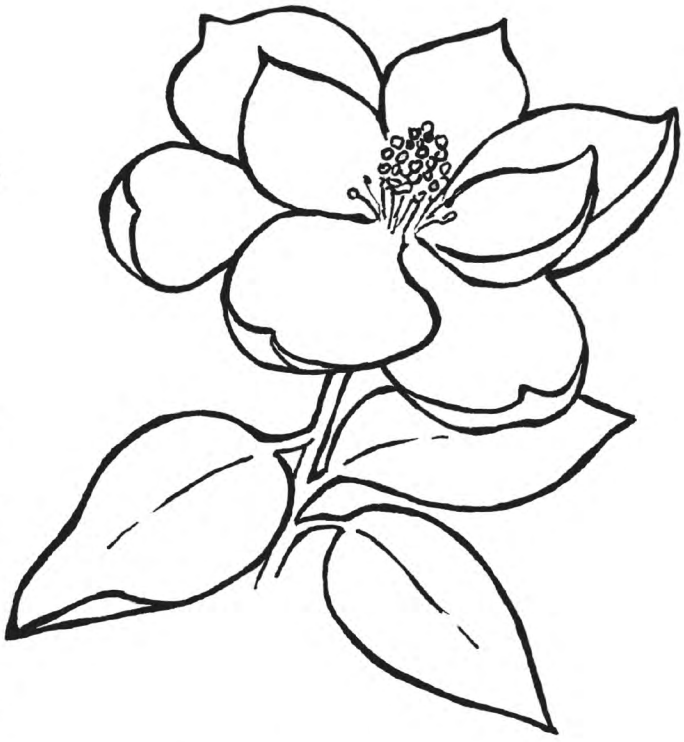


BEETLE

I eat lots of pollen.

I like white flowers.

I like, open, bowl-shaped flowers.



MAGNOLIA

I'm bowl-shaped.

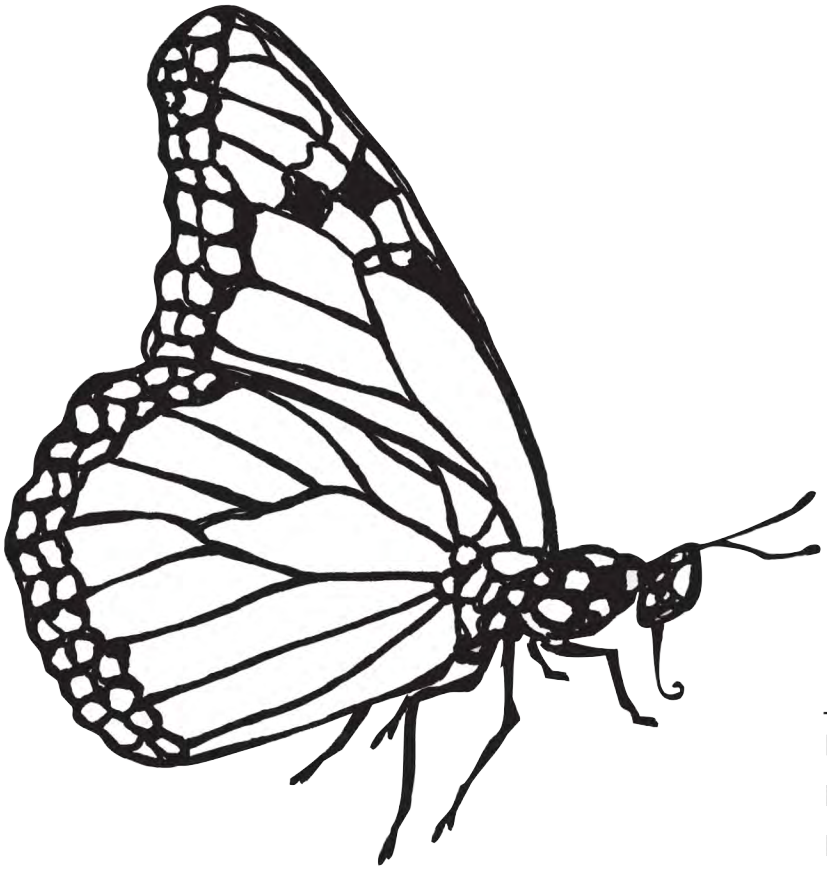
My petals are white.

I open during the day.

I have lots of pollen to offer.

kids GARDENING .ORG
HELPING YOUNG MINDS GROW

Lessons to Grow By

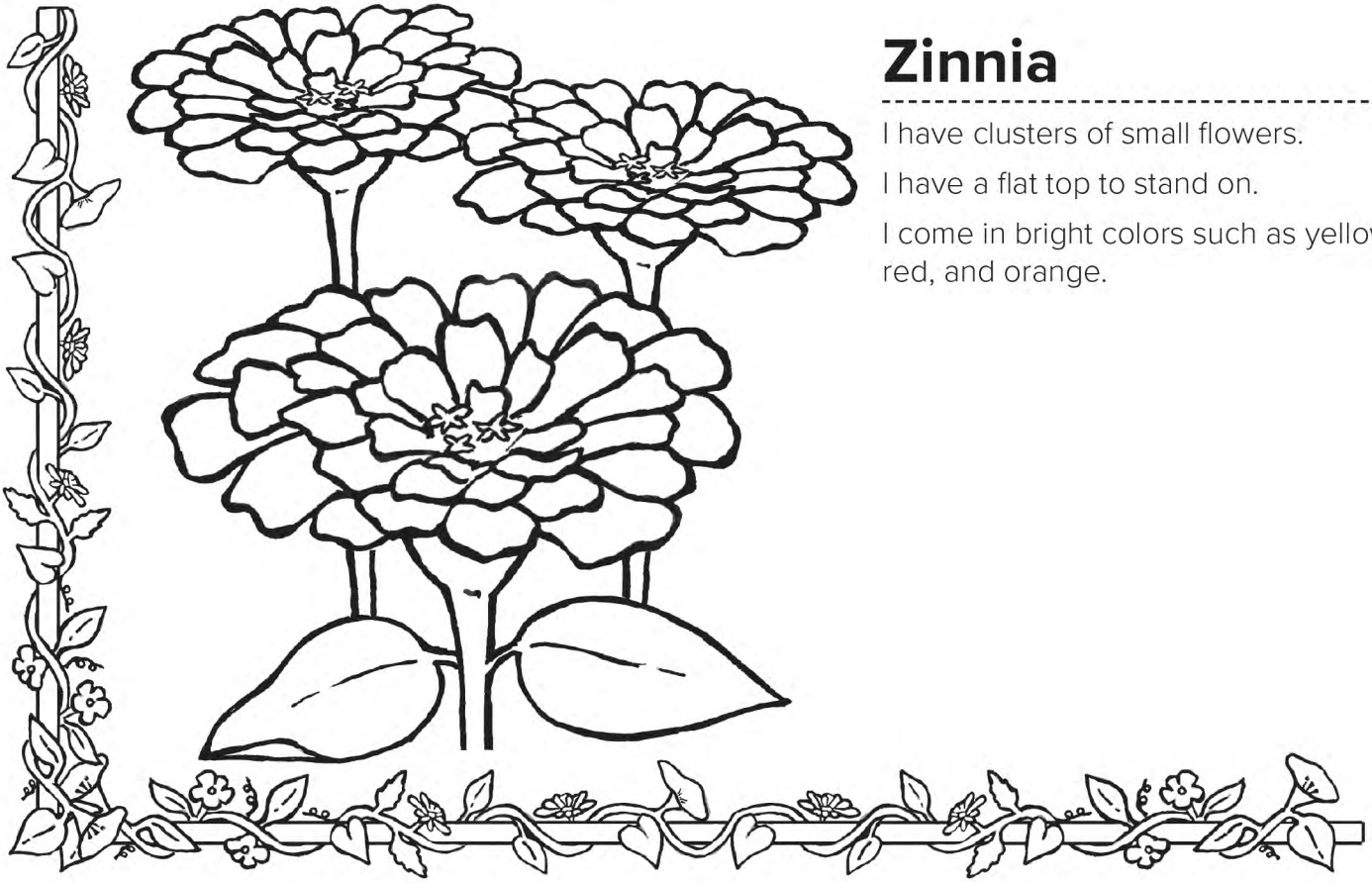


BUTTERFLY

I'm attracted to bright flowers.

Nectar is my main food.

I need a place to stand while I eat.



Zinnia

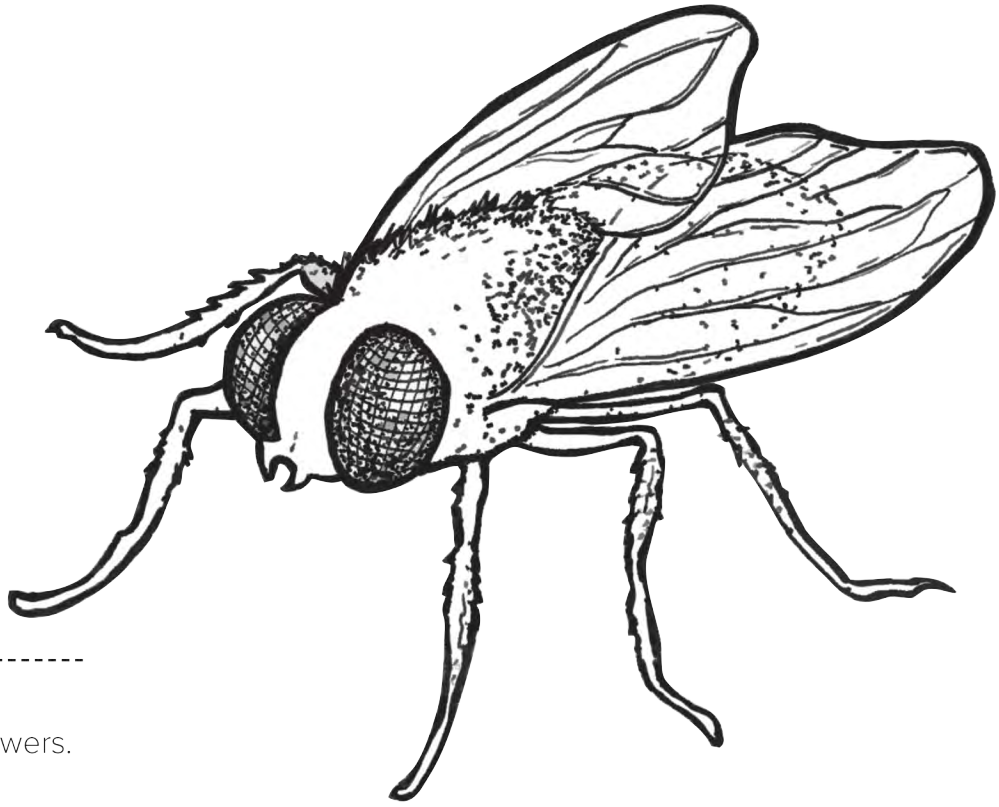
I have clusters of small flowers.

I have a flat top to stand on.

I come in bright colors such as yellow, red, and orange.

kids GARDENING .ORG
HELPING YOUNG MINDS GROW

Lessons to Grow By

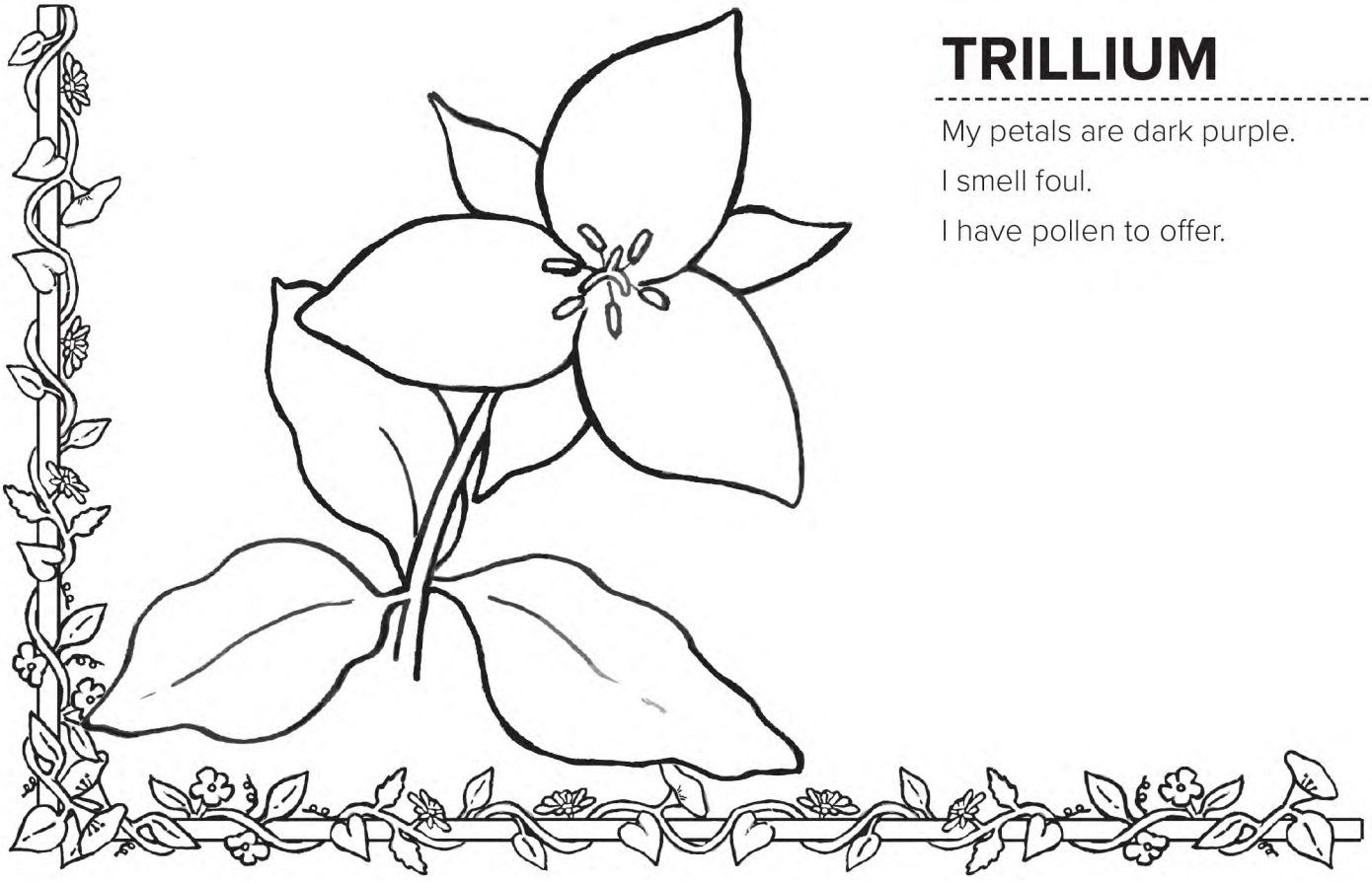


FLY

I eat pollen.

I like dark or pale-colored flowers.

I'm attracted to foul odors.



TRILLIUM

My petals are dark purple.

I smell foul.

I have pollen to offer.

kids GARDENING .ORG
HELPING YOUNG MINDS GROW

Lessons to Grow By

HUMMINGBIRD

I hover to eat.

My main food is nectar.

I like red and purple flowers.

I'm attracted to tube-shaped flowers.

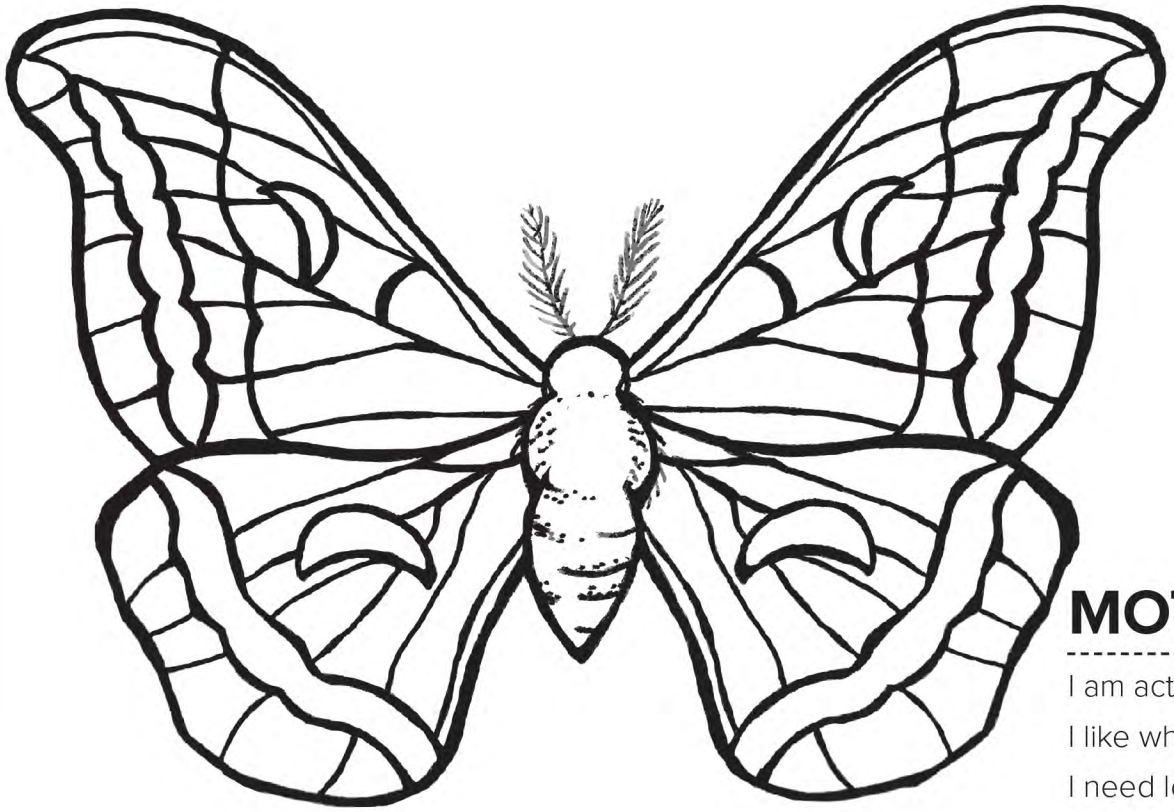
MONARDA

My petals are tubeshaped.

I have lots of nectar.

My petals are bright red or purple.

kids GARDENING .ORG
HELPING YOUNG MINDS GROW

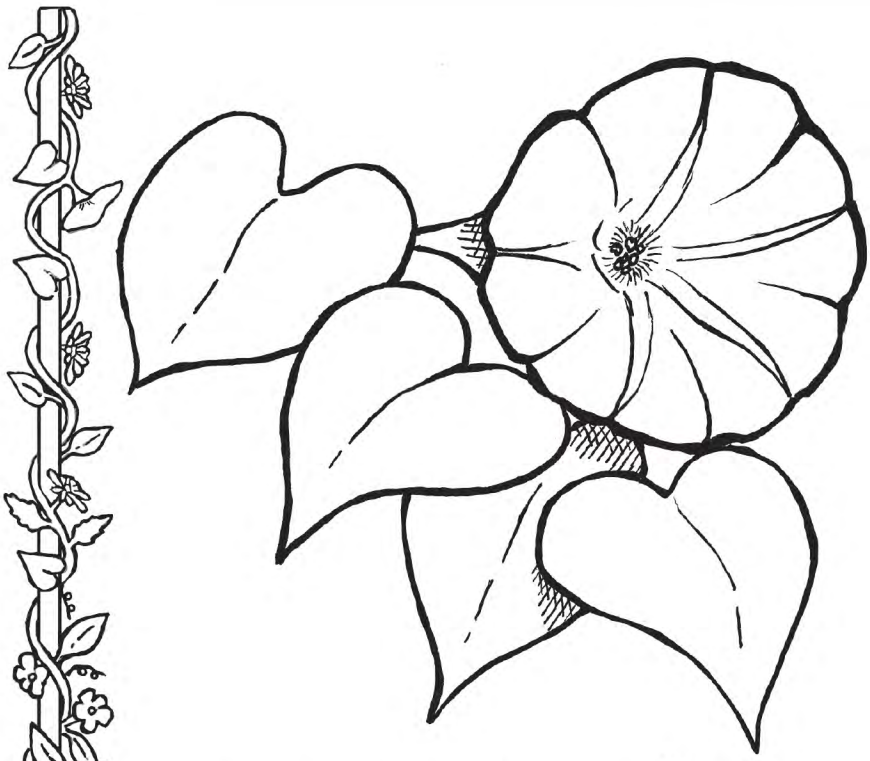


MOTH

I am active at night.

I like white flowers.

I need lots of nectar.



MOONFLOWER

My flowers open at night.

My petals are white.

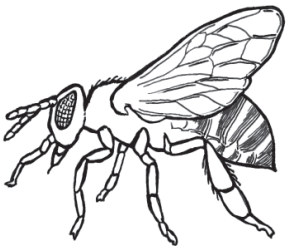
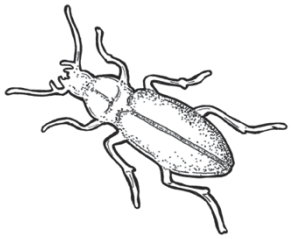
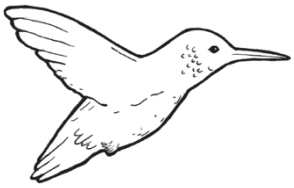
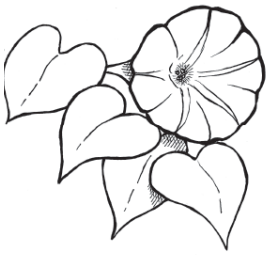
I have nectar to offer.

kids GARDENING .ORG
HELPING YOUNG MINDS GROW

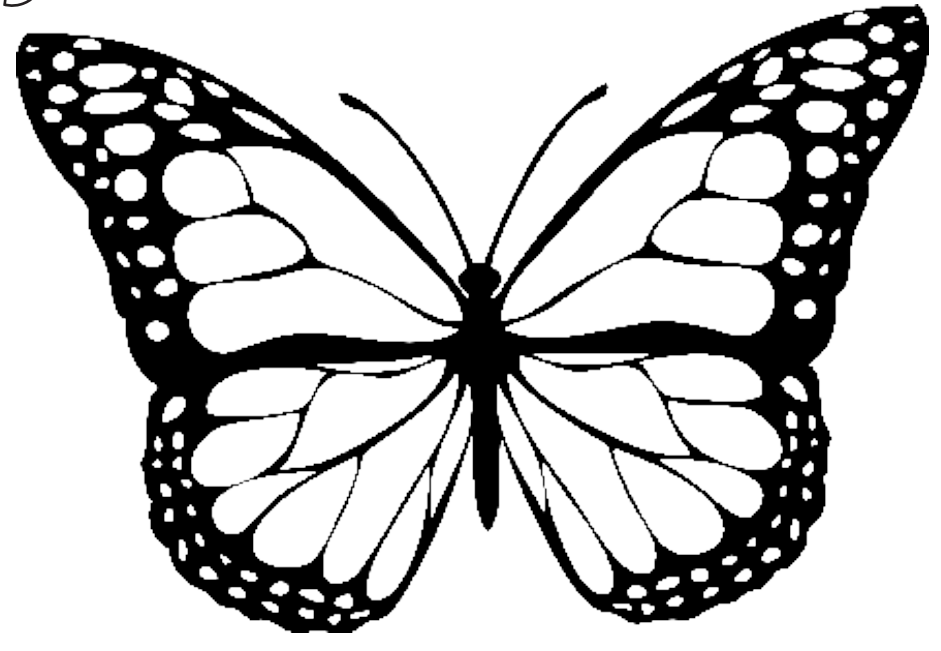
Lessons to Grow By

Pollinator Scavenger Hunt

How many of these pollinators or flower shapes can you find?

 Tube-shaped flower	 Caterpillar	 Bee	 Beetle
 Bat	 Flower with sweet scent	 Bowl-shaped flower	 Moth
 Hummingbird	 Flower that blooms at night	 Leaves eaten by caterpillars	 Flat-topped flowers
 Clusters of small flowers	 Butterfly	 Flowers that stink	 Fly

My Pollinator Journal

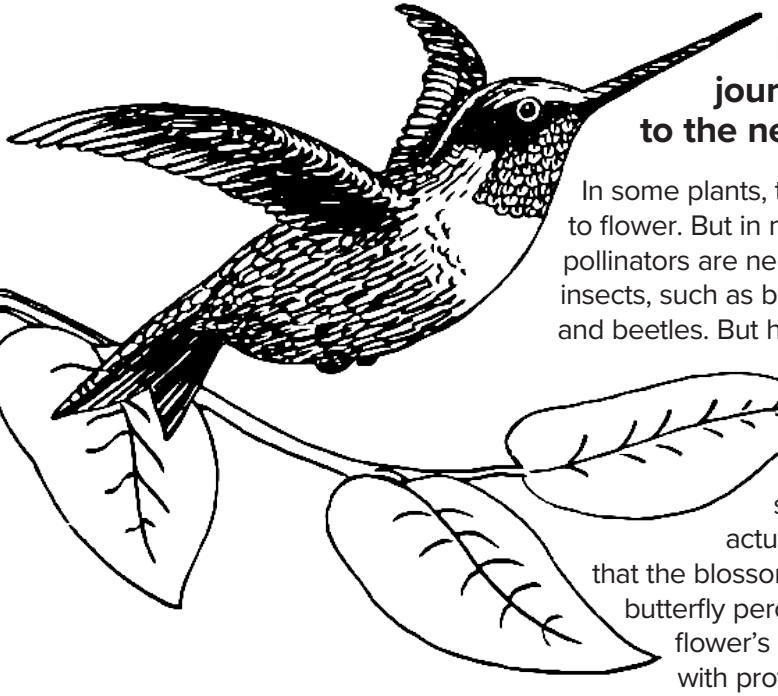


NAME

kids GARDENING .ORG
HELPING YOUNG MINDS GROW

It Takes Two – What are Pollinators?

A garden full of flowers is a beautiful sight! You might think that flowers exist just to please our eyes, but their real goal in life is to create more plants. In order for many plants to produce the seeds that grow into new plants, pollen from the male parts of one flower needs to be carried to the female parts of another flower. This transfer of pollen is called **pollination.**

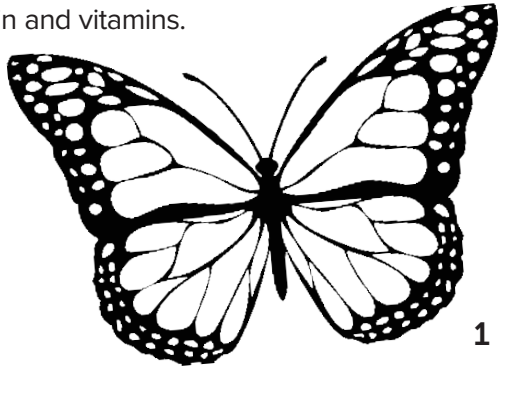


How does the pollen make its journey from one flower to the next?

In some plants, the wind helps move pollen from flower to flower. But in many plants, living creatures called pollinators are needed to do the job. Many pollinators are insects, such as bees, wasps, flies, butterflies, moths, ants, and beetles. But hummingbirds and even bats act as pollinators for some plants!

While we enjoy the beauty and fragrance of flowers, their strong scents and brightly colored petals are actually used to attract pollinators, signaling that the blossoms are a source of food. When you see a butterfly perched on flower, it's there to sip from the flower's nectar – a sweet substance jam-packed with protein and vitamins.

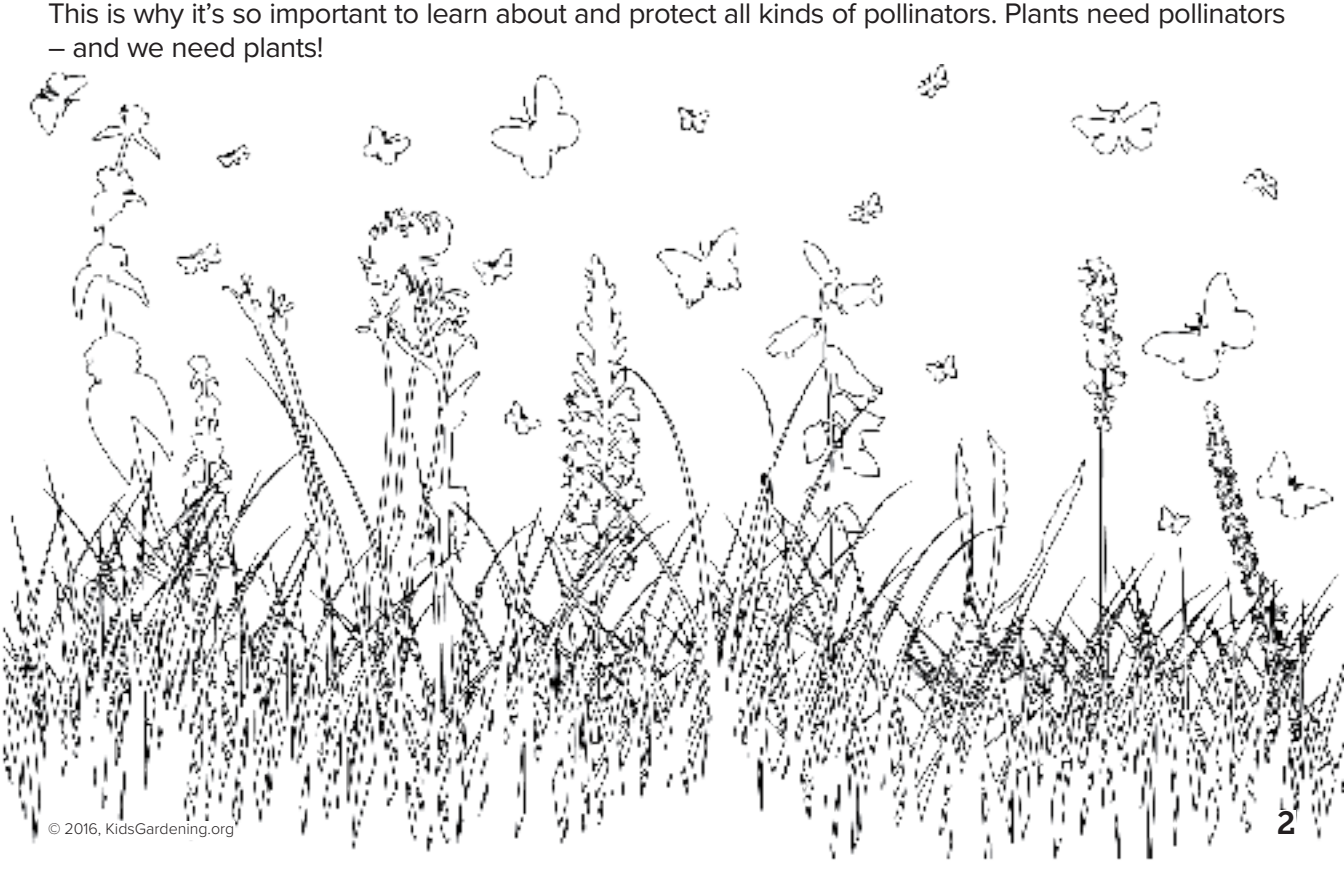
A bee foraging on a flower may be eating nectar or protein -rich pollen, or collecting it to feed to developing baby bees back in the hive.



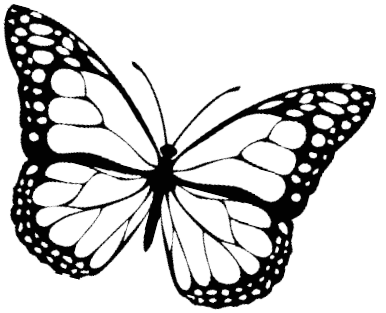
As they move about on flowers, pollinators pick up some of the powdery pollen on their bodies and carry it with them to the next flower they visit, in the process helping the plants as the plants help them. It's a win-win situation!

Pollinators are also important to us, for without their help we wouldn't be able to enjoy many of the foods we eat. Without pollinators, we'd miss out on foods like apples, cucumbers, almonds, and strawberries, which come from plants after they've been pollinated. We'd also lose many food plants that are grown from seed, like beans, melons, cabbage, and carrots, since without pollination they can't produce seeds to grow more plants. And that cotton shirt you're wearing would have to go too – cotton plants need pollination to produce the fibers used to make cloth.

This is why it's so important to learn about and protect all kinds of pollinators. Plants need pollinators – and we need plants!



Types of Pollinators



BUTTERFLIES

- Brightly colored wings
- Fly during the day
- Attracted to flowers with bright red, orange, yellow, pink, or blue petals
- Attracted to flowers with petals arranged to form a flat “landing pad” they can sit on to feed

MOTHS

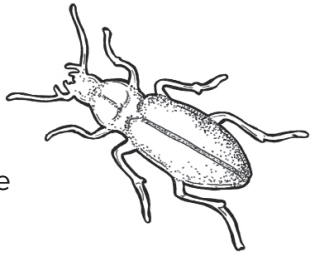
- Wings not colorful
- Most fly at night
- Attracted to flowers with white or light-colored petals

Both butterflies and moths have a mouthpart called a proboscis. It looks like a coiled up drinking straw. When these insects eat, the proboscis uncoils, allowing them to reach nectar deep within flowers to sip up. As they reach for the nectar, butterflies and moths collect pollen on their bodies, carrying it to a different part of same flower or to a new flower, pollinating the flower in the process.

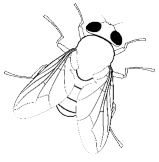
BEES

- Most important pollinators
- A single “busy bee” can visit up to 240 flowers in one trip
- Collect nectar and pollen from sweet-smelling, brightly colored flowers
- Nectar and pollen are carried back to nest to feed the next generation of bees
- Nectar also used to make honey that’s stored in the nest

BEETLES



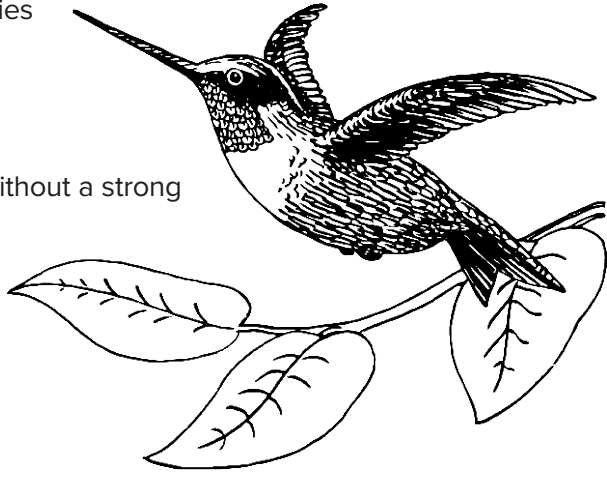
- Usually visit white or green flowers with a strong, fruity odor
- These clumsy flyers typically pollinate flowers with an open bowl shape, like magnolia blossoms
- Beetles may feed on petals or other flower parts as they pollinate blossoms



FLIES

- Attracted to odors that don't appeal to human noses
- Pollinate flowers that have brown, purple, or green flowers that smell like decaying meat or "poop" (yuck!), like skunk cabbage
- Pollen sticks to flies hairy bodies

HUMMINGBIRDS



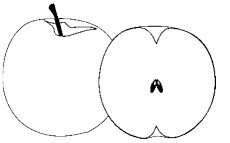
- Most common bird pollinator in the United States
- Able to hover in one place to feed on a flower
- Attracted to long, tube-like, red or orange flowers without a strong scent, like bee balm
- Feed by inserting long beak and brush-like tongue deep into flower to sip nectar
- Hummingbird collects pollen on its forehead as it feeds, transferring pollen as it moves from flower to flower

BATS

- Most pollinating bats live in tropical areas and pollinate crops such as figs, guava, avocados, and wild bananas
- Night-flying bats are attracted to white or light colored flowers with a strong smell
- Pollinating bats have long snouts and bristly tongues that help them collect nectar to eat
- Bats get dusted with pollen as they feed on flower nectar, transferring it as they move from flower to flower

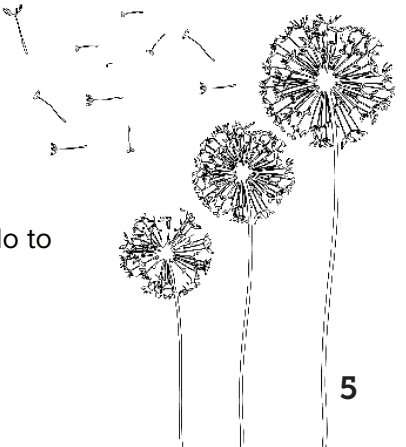
Pollinators Need Our Help!

Imagine a world without apples for snacks or pumpkins at Halloween time. Imagine not having any carrot seeds to grow new carrots. These are just a few of things you'd have to live without if pollinators didn't exist. Plants depend on pollinators and humans depend on plants. In fact, it's estimated that about one-third of the crops we rely on for food depend on pollinators!



Now here's the scary part: many pollinators are in danger of disappearing! How is this possible? Throughout history, humans have changed the way the land is used. Our activities, from building to modern farming practices, have disturbed the habitat that pollinators depend on for survival.
One way to help pollinators is to protect and restore the land that can be used to grow the plants that pollinators depend on for food. You've heard the saying, "Think globally, act locally." Well, here's your chance! Listed below are a few things you can do to help the pollinators in your part of the world.

- Create a pollinator-friendly garden. Pollinators use plants as food sources and nesting sites. Make sure the garden has plenty of native plants that will support the pollinators that are found in your area. Also remember to include some plants that will be in flower from spring to fall to feed pollinators all season long. Also include plants that will feed every stage of their life cycle. For example, while monarch butterfly adults will sip nectar from many kinds of flowers, their caterpillars will feed only on milkweed plants.
- Fill a birdbath or other shallow container with water and place it in the garden. In addition to water, pollinators need water to survive.
- Create a bulletin board or newsletter at school to educate other students about the importance of pollinators and what people can do to help them survive.
- Encourage your parents to allow dandelions and red clover to grow in your yard.



What's Buzzing in My Garden?

Spend 30 minutes in your garden keeping track of the number of pollinators that visit different colored flowers. Record your observations in this chart.

	Red	Orange	Yellow	Green	Blue	Purple	Pink	White
Bee								
Butterfly								
Beetle								
Fly								
Hummingbird								

What can you learn from your observations?

What pollinator did you see the most? _____

The least? _____

Did some pollinators visit only flowers of one color? _____

Which pollinators? _____

Which colors? _____

Did some pollinators visit many different colored flowers? _____

Which pollinators? _____

What colors? _____

GARDEN SOUVENIRS

Pollinator Observation

Observe and record the pollinators that you see in your school garden or backyard!

Date: _____ **Time:** _____ **Place:** _____

Weather: _____

Observations: _____

_____

_____

_____

_____

Draw what you see

Date: _____ **Time:** _____ **Place:** _____

Weather: _____

Observations: _____

_____

_____

_____

_____

Draw what you see

Date: _____ **Time:** _____ **Place:** _____

Weather: _____

Observations: _____

_____

_____

_____

_____

Draw what you see

Date: _____ **Time:** _____ **Place:** _____

Weather: _____

Observations: _____

_____

_____

_____

_____

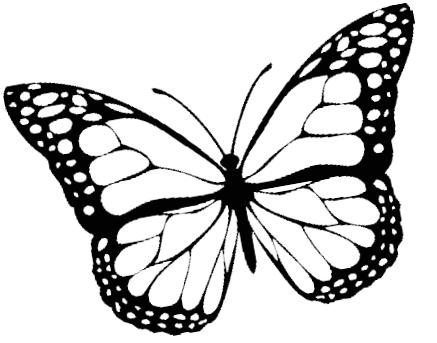
Draw what you see

Pollinator Word Search

O	B	D	M	B	X	K	H	O	Z	U	S	O	V	U
P	Y	K	K	M	O	T	H	T	R	E	G	T	O	E
O	K	I	C	G	V	U	H	Q	S	P	O	D	S	W
L	P	D	V	D	S	F	D	R	B	G	R	U	E	F
L	C	P	L	H	X	Q	M	S	H	I	O	E	J	J
E	K	B	O	Y	Z	E	X	O	B	N	B	I	Y	X
N	U	B	U	L	L	Y	A	G	N	A	U	Z	Y	C
I	C	F	W	T	L	M	N	S	B	A	T	D	U	A
K	E	O	Z	K	T	I	M	X	U	P	R	J	H	F
H	C	M	Q	I	M	E	N	I	J	M	H	C	Z	L
S	Q	A	D	M	L	A	R	A	C	F	A	J	H	O
F	F	Q	U	T	W	J	A	F	T	R	E	E	Z	W
K	J	H	E	F	L	Y	G	Y	L	I	L	L	U	E
A	D	E	V	G	F	F	T	B	X	Y	O	N	U	R
T	B	Q	S	F	W	A	F	T	D	C	P	N	E	F

BEE
BUTTERFLY
BAT
MOTH
BEETLE
FLY

HUMMINGBIRD
FLOWER
POLLEN
POLLINATION
MONARCH



kidsGARDENING.ORG

LESSONS TO GROW BY

Pollinators

In this unit we are learning about our good garden friends the pollinators. Who are the pollinators? Bees, hummingbirds, moths, bats, butterflies, flies, and beetles are a few notable representatives. Pollinators are animals that help many flowering plants produce their seeds and thus ensure the continued existence of millions of plant species, and in turn, of most animal species, including humans. In each module, we will dig into a different pollination-focused topic and provide instructions for engaging, hands-on lessons and activities. By the end of the unit we hope your young gardeners will understand the intricate relationship between pollinators and flowering plants and also learn to love, respect, and appreciate these hard-working animals.

Module 3: Why do we need pollinators?

Learning Objectives

In this module, kids will:

- Discover why seeds are so important
- Investigate some of the common fruits and vegetables we eat that rely on pollinators
- Explore all of the ways plants are important in our environment

Materials Needed:

- Activity 1: What Do Seeds Do?
  - Dried beans from the soup aisle or bulk bins at the grocery store
  - Paper towels
  - Plastic sandwich bag
  - Assortment of common fruits and vegetables with seeds (optional)
  - Small disposable cups or cartons (optional)
  - Potting soil (optional)

- Activity 2: Pollinators Fill My Plate
  - Making Seeds Reading Page (end of lesson)
  - Old magazines, seed catalogs, or newspaper grocery store ads
  - Craft paper

- Glue stick
- Fruits and vegetables for snack (optional)
- Pollinator Food Diary (optional, end of lesson)

- Activity 3: Plants Run Our World
  - Sticky notes or stickers or
  - Paper, clipboard and pencil or
  - Digital camera/ phone with a camera

Introduction

More than 150 of our common food crops, from avocados to zucchini, rely on pollinators to move pollen among flowers to facilitate fertilization, which ultimately leads to the development of fruits and seeds. Pollination by bees, hummingbirds, moths, bats, butterflies, flies, and beetles ensures the continued existence of millions of plant species, and in turn, of most animal species, including humans – in fact, one of every three mouthfuls of our food depends on them. The following list from the Pollinator Partnership* includes common fruits and vegetables that rely on pollinators:

Fruit: Apples, bananas, blackberries, blueberries, cherries, figs, grapes, grapefruit, kiwi fruit, mango, melons, peach, pear, raspberries, strawberries

Nuts: Almonds, cashews, coconuts

Vegetables: Avocados, beets, broccoli, cabbage, carrots, cauliflower, cucumbers, onion, potatoes, pumpkin, squash, zucchini

Seeds: Flax, sesame, sunflowers

Additional Favorite Treats: Chocolate, coffee, vanilla, sugarcane, tea

Pollinators also help pollinate plants that are important sources of food for wildlife of all sizes, from birds to bears. Their impact goes far beyond edible crops too. Pollinators help produce the seeds of many other plants that play important roles in keeping our ecosystem healthy and habitable for all life.

*https://www.pollinator.org/list-of-pollinated-food

Activity 1: What Do Seeds Do?

1. Each seed contains a tiny baby plant. Plants do not live forever, so they need seeds to grow more plants that will replace them when they die. In this activity, kids will plant seeds to confirm that seeds do in fact make new plants.

2. Give kids a chance to look at an assortment of seeds. Some of the easiest and least expensive seeds to plant are dried bean seeds that are available in bags in the soup aisle of your grocery store. Ask them to use some of their senses to explore the seeds. What do they look like? What do they feel like? What do they smell like?

If you have multiple kinds of bean seeds, sort them by their characteristics. You can place them order by size, compare weight, or group them by color and pattern.

Ask kids to create a hypothesis about what they think seeds do. What is their purpose?

3. Plant your seeds. Many seeds, including dry bean seeds, do not need soil to start growing. Moisten a paper towel and then fold it to fit inside of a plastic sandwich bag. Place a few dried bean seeds inside

and seal the bag. If you want to speed up the growing process, soak your bean seeds in water for a few hours before placing them in the plastic bag.

4. Put the bag in a warm spot and within a couple of days your seeds will germinate and you will be able to see roots and stems develop. Review your hypothesis. What is the purpose of a seed? Why is that important?

5. An alternative to planting bean seeds, you can also gather an assortment of fruits and vegetables* from your garden, farmer's market, or grocery store that contain seeds and experiment planting your harvested seeds instead.

**Note: Many of our vegetables are by botanical classification actually fruits, such as tomatoes, squash, and peppers. They are commonly called vegetables because they are consumed as part of a meal or savory dish. The term fruit is used to describe produce that is sweet and consumed as a dessert or snack.*

Although you can try placing them in a bag with a moist paper towel as described above, many of these seeds will be more successful if planted in potting soil and a container. You can use repurposed plastic cups or milk cartons with holes punched in the bottom for your container. Moisten your soil, place in the container and then plant your seeds.

You will have mixed success with seeds collected this way because we harvest some fruits and vegetables to eat before the seeds are fully developed. (By the time the seeds are ready, the fruit/vegetable may be too ripe for us to eat.) Some seeds you may want to try: watermelon, citrus, peppers, pumpkin and avocados.

6. Connect your seed-planting activity to pollinators. Remind kids that pollinators help plants make fruit and seeds by carrying pollen from one flower to another flower. Without the help of pollinators many plants would not be able to make seeds, which means they would not be able to make new plants, and they would eventually disappear from our planet.

Check out the KidsGardening article on Seed Viewers, https://kidsgardening.org/resources/garden-activities-seed-viewer, for an additional idea for growing your seeds using a clear plastic cup and paper towels.

Activity 2: Pollinators Fill My Plate

1. Read the Making Seeds Reading Page together or independently. Answer and discuss the reading comprehension questions. From this reading page, what did we learn about why pollinators are so important?

2. Review the list of fruits and vegetables that rely on pollinators to make their fruit and seeds. Cut out pictures of some of these pollinator-dependent products from old magazines, seed catalogs, or the grocery store ads from old newspapers. Make a collage on a piece of craft paper of fruit and vegetables we are able to enjoy because of the hard work of pollinators.

If resources are available, you can laminate this collage or place it in between sheets of contact paper to use it as a placemat.

3. You can expand on this activity by making a pollinator-supplied snack that includes ingredients that pollinators helped produce. Your snack can be as simple as apple slices, or you can also use this opportunity to practice math skills with a more elaborate recipe. Here are a few great websites you may want to check out for recipe ideas:

ChopChop Family: https://www.chopchopfamily.org/recipes/

Cooking Matters: http://cookingmatters.org/recipes

Common Bytes: https://www.commonbytes.org/#!/recipes

4. Another possible follow-up to continue to grow your young gardeners' awareness about the importance of pollinators to our diet is to keep a Pollinator Food Diary. Ask them to record the foods they eat each day that can be tracked back to the hard work of pollinators. A sample diary worksheet is included at the end of the lesson.

Activity 3: Plants Run Our World

1. Let's think beyond our plates! We rely on a host of plant-made products to meet our basic needs, and plants serve an indispensible role in our ecosystem, too. Plants are the producers at the bottom of every food chain due to their amazing ability to transform the energy of the sun into food (carbohydrates) through photosynthesis. They are also key to air, water, and soil health. There literally would be no life on this planet without plants. How is that for being important? If plants are so important, discuss how this relates to pollinators. Why would it be critical to have a secure way to make new plants?

2. Let's go on a plant product hunt. Ask your kids to look around their classroom or home and identify products that are derived from plants. There are a couple of different ways to do this depending on the resources available and skills you would like to practice. If you would like to hone writing skills, give each child a piece of paper, a clipboard and a writing utensil and have them list out all of the plant products they see on their hunt. If you want to make it feel more like a game, give each child a pack of sticky notes or stickers and have them label each plant-derived product they identify and then go back and count how many they found. Finally, if you want to make your hunt more visual, you can ask them to take photos or drawings of the products they find. They can follow this up by turning their drawings/photos into a slide presentation or journal entry page that could be shared with others.

Some items they may find on their hunt include:

- Foods: Grains, vegetables, and fruits
- Spices and herbs: Cinnamon, pepper, vanilla, mint, etc.
- Special treats: Tea, coffee, sugar, chocolate
- Cooking oil
- Animal food/birdseed
- Medicines (aspirin)
- Fabric (cotton, linen)
- Natural ropes
- Lumber/building materials
- Furniture (wooden)
- Rubber
- Cork
- Bamboo
- Fuel
- Wood for fireplaces
- Paper of all kinds
- Cardboard
- Oxygen (air)

3. It won't take long for kids to see how plants and plant products surround them. Take this activity a step further and ask them, what does the importance of plants in our lives mean for the importance of pollinators?

As explained in this week's reading page, not all plants rely on pollinators to make their seeds. Large trees and grass plants tend to rely on wind to move their pollen around. However, most smaller plants, including the fruits and vegetables we eat, rely on the hard work of pollinators. And so do many of the understory plants in wooded areas which are the main food source for wild animals (understory plants do not get exposed to as much wind movement because it is blocked by the bigger trees). Pollinator-aided seed production is also attributed to additional benefits. Pollination by pollinators is considered more efficient than wind pollination. Also, pollen transfer between plants can lead to more diversity in the offspring.

4. Extend your exploration by taking kids on a plant walk in your garden, yard, or a local greenspace and predict which plants you think are pollinated by pollinators and which rely on wind or water for pollination. Use the plants' characteristics, such as flower shape or overall plant shape and size, as a clue. Are the flowers bright and colorful so they look like they might attract pollinators? Are the flowers small, numerous, and drooping from stems so they look like they would easily be picked up by the wind? Are the plants shorter and blocked from the wind by taller trees? Are the flowers in a meadow where wind moves freely? If flowers are present on the plant, do you see any pollinator activity? When you return home or to the classroom, an Internet search can be used to help you confirm your predictions.

Digging Deeper

You can use the following resources to dig deeper into this module's lessons.

Books

A Seed is Sleepy by Dianna Hutts Aston
A beautiful overview all about seeds.

The Giving Tree by Shel Silverstein
A classic tale illustrating the many ways trees contribute to our lives.

The Great Kapok Tree: A Tale of the Amazon Rain Forest by Lynne Cherry
With vivid illustrations, this book demonstrates how all life in an ecosystem works together and also highlights the importance of plants.

Videos

Time Lapse of a Bean Plant from GPhase: https://www.youtube.com/watch?v=w77zPAtVTuI

Sunflower Growing Time Lapse from Green Timelapse: https://www.youtube.com/watch?v=VolHs1sFrZM

Timelapse of Sunflower from Seed to Flower from Mortrek: https://www.youtube.com/watch?v=Z-iPp6yn0hw

Big Green Seed Scavenger Hunt with Elisa and Little Green Chefs Rainbow Spinach Summer Rolls: https://biggreen.org/teaching-in-your-garden/video-library/

Dr. Seuss' The Lorax movie trailer from Movieclips Trailers: https://www.youtube.com/watch?v=1bHdzTUNw-4

Additional Related KidsGardening Lessons and Activities to Try

Pollinator Celebration Meal: https://kidsgardening.org/resources/garden-activities-pollinator-celebration-meal/

Photosynthesis Runs the World: https://kidsgardening.org/resources/lesson-plan-photosynthesis/

Petal Attraction: https://kidsgardening.org/resources/lesson-plans-petal-attraction/

Plant Families for Pollinators: https://kidsgardening.org/resources/digging-deeper-plant-families-for-pollinators/

Flower Adaptations to Lure Pollinators: https://kidsgardening.org/resources/garden-how-to-flower-adaptations/

Choosing Flowers to Attract a Diversity of Pollinators: https://kidsgardening.org/resources/digging-deeper-welcome-pollinators/

Pollinator Journal: https://kidsgardening.org/resources/garden-activities-pollinator-journal/

Making Seeds

Lessons to Grow By – Pollinators Reading Page

Have you ever seen seeds inside of a piece of fruit like an apple, orange, or watermelon? What about inside of a vegetable like a cucumber, tomato, or squash? What do those little things do?

Although it may be hard to imagine, inside each seed is a very tiny baby plant. When the seed is exposed to the right conditions, which often include warm temperatures and moisture, then the new plant will start to grow. Why are seeds so important?

Most of the plants growing on Earth today depend on seeds to make new plants to replace themselves when they die. There are many different kinds of plants and some have developed other ways to make more plants. However, most rely on seeds to ensure their survival.

To make seeds (usually inside of fruits), many plants need the help of pollinators. Pollinators are animals that carry pollen from one flower to another flower, resulting in the growth of fruit and seeds. Some plants will not produce any seeds without the help of pollinators. Apple trees will not grow apples (and apple seeds) without the help of pollinators. Other plants may be able to make some fruit and seeds without the help pollinators because their pollen will move with the wind or rain too, but they can make a lot more if pollinators help them out. Orange trees can grow oranges (and orange seeds) without the help of pollinators, but they will make a lot more oranges if there are pollinators to help them. Some plants do not need pollinators to help them make seeds at all. Grass and corn plants get help from the wind to move their pollen.

Here is a list of some of our common edible crops that get help from pollinators to make their fruits and seeds:

Fruit: Apples, bananas, blackberries, blueberries, cherries, figs, grapes, grapefruit, kiwi fruit, mango, melons, peach, pear, raspberries, strawberries

Nuts: Almonds, cashews, coconuts

Vegetables: Avocados, beets, broccoli, cabbage, carrots, cauliflower, cucumbers, onion, potatoes, pumpkin, squash, zucchini

Seeds: Flax, sesame, sunflowers

Additional Favorite Treats: Chocolate, coffee, vanilla, sugarcane, tea

Do you see anything you like to eat on the list? Just think, without pollinators helping these plants make seeds you may not be able to enjoy this tasty and healthy treat.

You might look at the list and see that not all of the things on the list are fruits that we eat. Carrots are the roots of the plant, so why should we care if they make fruit and seeds when we just want to eat their roots? Although we may dig up carrots to eat their crunchy roots, gardeners and farmers also leave some of the carrots in the ground so they can make flowers and eventually make new seeds. Without some of the carrot plants being left in the garden to make new seeds, we would not be able to grow more carrots.

In addition to the foods we eat, pollinators help make seeds for plants and trees that make oxygen for our air, give us wood for building our homes, and keep our soil healthy and water clean. Pollinators are very important to our lives. Have you thanked a pollinator today?

Reading Comprehension Questions:

1. Pollinators help plants make:
    A. Leaves
    B. Roots
    C. Stems
    D. Fruit and seeds

2. True or false, all plants need pollinators to help them make seeds:
    True
    False

3. In what ways do plants help people?
    A. They provide food for us.
    B. The provide oxygen for our air.
    C. They provide wood for our homes.
    D. They keep our soil and water healthy.
    E. All of the above.

4. True or false, pollinators only help plants. They are not important for people.
    True
    False

5. List a fruit or vegetable that is grown with the help of pollinators that you like to eat:

Pollinator Food Diary

Date/Meal	Menu Item	Top 3 Ingredients in Menu Item	Does this menu item or ingredient rely on pollinators?

LESSONS TO GROW BY

Pollinators

In this unit we are learning about our good garden friends the pollinators. Who are the pollinators? Bees, hummingbirds, moths, bats, butterflies, flies, and beetles are a few notable representatives. Pollinators are animals that help many flowering plants produce their seeds and thus ensure the continued existence of millions of plant species, and in turn, of most animal species, including humans. In each module, we will dig into a different pollination-focused topic and provide instructions for engaging, hands-on lessons and activities. By the end of the unit we hope your young gardeners will understand the intricate relationship between pollinators and flowering plants and also learn to love, respect, and appreciate these hard-working animals.

Module 4: How can we protect pollinators?

Learning Objectives:
In this module, kids will:

- Learn about native pollinators and their habitat needs
- Discover reasons why pollinator populations are decreasing
- Explore ways they can help pollinators

Materials Needed:

Activity 1: Be the Bee

- Helping our Pollinator Friends Reading Page (end of lesson)
- Chart paper
- Marker
- Timer
- Be the Bee Game Supplies:
  - Simple version: buckets or boxes, paper, and tape (optional: Styrofoam balls or pompoms)
  - Elaborate version: 2-liter bottles, 20-oz. bottles, 6" wooden dowels, Styrofoam balls, construction paper, tape, yellow paint, glitter, 8 oz. drinking cups, turkey basters or water droppers
  - Extend the fun with a DIY bee costume (optional): headband, pipe cleaners, easel paper or large brown paper bag, lunch bag, string, markers

Activity 2: Design a Pollinator Garden

- Drawing paper
- Graph paper (optional)
- Pencils, colored pencils, crayons, or markers
- Old seed catalogs or garden magazines (optional)

Activity 3: Spread the Word

- Poster board and markers or
- Paper and pencils or
- Smart phone or digital camera
- Clay (optional)
- Compost or potting soil (optional)
- Wildflower seeds (optional)

Introduction

Researchers have documented a decline in the populations of many different pollinators, such as bees, over the last few decades. They have linked this decrease in numbers to several factors, including:

- Loss of habitat, resulting in decreasing food supply and disruption of nesting sites due to land development
- Pollution of air, water, and soil
- Misuse of chemicals, such as pesticides, that impacts not only pest insects who are usually their targets but also beneficial insects such as pollinators
- Disease and parasite problems
- Climate change

The good news to share with kids is that there are some very practical ways we can help pollinators in our daily lives. Here are a few ideas:

- Plant a diversity of plants that bloom throughout the growing season at home, school, or community centers. This will provide a continuous supply of pollen and nectar for pollinators.
- Plant native plants that provide shelter and a food source for pollinators in all stages of their life cycles.
- Leave areas of uncut grass or wildflowers to provide shelter for pollinators.
- Avoid using pesticides and herbicides.
- Spread the word to others! Teach your community about the importance of pollinators.

Planting a pollinator garden is a great first step for any family or school. You don't need a lot of space to start a pollinator garden. Even a few containers or buckets of flowers can attract hungry bees and butterflies. To design a pollinator garden, it is important to provide for basic needs of wildlife in your plan— food, water, shelter, and places to rear young. Here are some ideas of what you might want to include:

Food sources (host plants): Pollinating insects in their adult stages generally thrive on flower nectar and/or pollen. Good plants for pollinators include: aromatic herbs (coriander, catnip, mint, parsley, lavender), annual flowers (marigold, phlox, bachelor's button, zinnia, cosmos, salvia), and perennials (bee balm, Shasta daisy, iris, coneflower, lobelia, delphinium). Try to plant a combination that ensures something is blooming at all times during the growing season.

Some insects' larval stages have a penchant for plant leaves. For example, monarch butterfly larvae rely on milkweed foliage; swallowtail butterfly larvae happily munch on parsley and dill.

Another option is to allow a section of your schoolyard to revert to wild grasses, weeds, and wildflowers (e.g., milkweed and Queen Anne's lace).

Water: Butterflies will gather and sip at shallow pools, mud puddles, and birdbaths; bees and wasps can use mud as a home-building material. Mud puddles also provide important minerals for some pollinators.

Sites and materials for nesting and overwintering: Leave cut plant stems exposed, place flowerpots with drainage holes bottom-up on the ground, leave twigs and brush in small piles, create mud puddles, or put out short pieces of string, yarn, or other light fibers. Students can even build nesting structures for certain types of bees and bats.

Another important consideration: Do not use pesticides and herbicides in or around your pollinator garden. Even organic pesticides derived from plants and microbes can be harmful to pollinators as well as pests. Herbicides may wipe out key plants (weeds) that are important food plants for pollinators. Help prevent pest problems by growing a variety of different plants. Diverse plantings are less likely to have severe pest infestations and are more likely to attract pest insects' natural enemies: predatory insects and birds. If certain plants are continually plagued with pests, replace them with less susceptible species or varieties.

Activity 1: Be the Bee

1. Together or independently, read the Helping Our Pollinator Friends reading page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Play **Be the Bee**. In Be the Bee, kids pretend to be bees collecting pollen from flowers to take to their hive to feed their young. By altering the number of bees, the movement of the bees, and the number of flowers available, you can demonstrate how environmental and population changes can impact the work of pollinators.

3. Set up the game. Props can be very simple or more elaborate if you have the time and interest.

For a very simple set up:

Simple version supplies: buckets or boxes, paper, and tape (optional: Styrofoam balls or pompoms)

Instructions: Collect 5 to 10 boxes or buckets (or other similar containers). Assign one box/bucket to represent the hive and then decorate the others to represent flowers. Crunch up paper into balls to represent pollen (yellow construction paper works well, but you can use other paper if that is not available). You can also use Styrofoam or pompom balls if available.

For an elaborate set up:

Elaborate version supplies: 2-liter bottles, 20-oz. bottles, 6" wooden dowels (or other sticks), Styrofoam balls, construction paper, tape, yellow paint, glitter, 8 oz. drinking cups, turkey basters or water droppers

Instructions: If you have the time and interest to create a more elaborate set up for your game (making the props for the game could be a separate extension activity) here are some ideas to jazz it up:

Make each flower

- Cut the top off a 2-liter bottle. Cut construction paper into petal shapes and attach them with tape in ring around the edge of the bottle to make it look like a flower. (You can use different colors and patterns of petals for each flower if you really want to get fancy*.)
- Place a 20 oz. bottle in the middle of the 2-liter bottle to represent the flower's pistil. If you want to have your 'bees' collect nectar too, they can fill these with water.
- Push each Styrofoam ball securely on to a dowel. Holding the dowels (like a lollipop on a stick), paint the Styrofoam balls with yellow paint. While the paint is still wet, sprinkle balls with glitter. *This addition is completely optional, but it gives you the opportunity to explore how bees spread pollen unintentionally.***

- Place the ball-topped wooden dowels in the cut-off soda bottle. These represent the flower's stamens with the ball and glitter serving as the pollen that will be collected in the game.

Create a honeycomb for the hive:
Attach six 8 oz. plastic drinking cups to each other with tape. Although the size of the honeycomb can vary, using at least 7 cups will provide enough to give it a "honeycomb" look. Place the honeycomb at your home base or "hive" for your student bees.

Extend the fun: Make a DIY bee costume (optional)
Supplies: headband, pipe cleaners, easel paper or large brown paper bag, lunch bag, string, markers

Instructions for bee costumes: Make antenna by attaching pipe cleaners to headbands. Next, let students decorate a piece of easel paper to serve as wings. After they finish coloring the paper, use a 12" piece of string to cinch the paper in the middle, dividing it into two wings. Then use two 24" pieces of string to make loops for the students' arms so they can wear their wings: At the cinched-up section of the wings, attach the two pieces of string at their middles, so that two pairs of 12" strings hang down on each side. Holding the wings in place on the child's back, bring each pair of strings over and under the child's shoulder. Then tie the strings together in front to hold the wings securely in place. As an addition, you can also use small paper bags and additional string to create "pollen sacs" to attach to their legs. If you plan to have kids collect "nectar" as well, pass out turkey basters or water droppers. These represent a bee's proboscis — its long, slender tongue that is used like a straw to suck up nectar from a flower.

4. Once your props are ready, set your flowers around a large room or yard to represent. Place your pollen in approximately equal numbers in each container. Then place your hive a moderate distance away from your flowers.

5. Play the game. Tell your group that they are going to be "bees" and when the timer starts, they need to go out and collect pollen grains (yellow paper, pompoms or Styrofoam balls) one at a time and bring

them back to the hive (also your starting line). You can encourage wing flapping and buzzing to add to the fun.

6. For the first round, give them 30 seconds and at the end of that time count how much pollen they collected and record the results on a piece of chart paper.

7. Return the pollen to the flowers at their original location. Follow up with a few more rounds demonstrating different factors that may impact pollinator populations. You can choose from the following situations (in any order) or devise your own:

> To demonstrate loss of habitat: Explain that a new housing development has been constructed in your bees' habitat and remove half of the flowers from the game. Once again give your bees 30 seconds to collect as much pollen as they can. Add your new count to your chart.
>
> To demonstrate disease and parasite problems: Inform your bees that your hive has been infected with varroa mites. These tiny mites attack the bees and weaken them. If left untreated, the mites can lead to the death of the full colony. Ask half of your bees to sit down and not participate in the next round. Give the remaining bees 30 seconds to collect pollen, but ask that they walk instead of run from the flowers back to the hive. After 30 seconds, record the amount of pollen collected. You can repeat this with the other half of the group, who were "impacted by mites," so that all kids get to actively participate in the round.
>
> To demonstrate misuse of chemicals: Tell your bees that a local homeowner treated their flowerbeds with a pesticide which killed half of your colony. Ask half of your group to sit down and then give the remaining bees 30 seconds to collect pollen. Add your results to the chart. You can repeat this round a second time, switching which half of the kids were impacted by the pesticides so that all kids get to actively participate in this round.

8. Compare the results of each round of the “Be the Bee” Game. Talk about each of the scenarios and discuss how they impacted the bees and the amount of pollen they were able to collect. Discuss what kind of impact decreasing pollinator populations might have on our environment and food systems.

* If you took the time to decorate your flower petals using different colors or patterns, you may also want to discuss if they found themselves visiting some flowers first. Ask, Were their certain colors or patterns that caught your eye in the garden? In nature, for example, bees are attracted to yellow, blue, and purple flowers. Explain to kids that the reason flowers have developed interesting colors, patterns, shapes, and smells is to attract pollinators.

** Glitter Pollen Extension – If you chose to create a more elaborate set up for the game and use glitter on your pollen balls, make sure to take time at the end of the game to have children look around and see where you they find glitter. (Hint – the glitter should be everywhere.) Have them examine the “pistils” from the “flowers.” Do they see any glitter inside the 20-oz. soda bottles? Can they find glitter on their hands and clothes? The glitter in bottles represents pollen that made it onto a stigma and pollinated the flower. Use this example to emphasize how the bees help with pollination even though that is not their true objective.

Activity 2: Design a Pollinator Garden

1. Look around your yard, school grounds or a community greenspace and find a place you think would make a great spot for a pollinator garden. It should be in a location that receives at least six hours of full sun each day and does not get trampled on regularly. Remind them a pollinator garden can be as small as a 5-gallon bucket on porch or as big as a meadow.

2. Next, research pollinator species native to your region. Find out what specific plants and habitat features these creatures need to thrive and reproduce. In general, the greater variety of plant types you have (trees, shrubs, perennials, annual flowers, and herbs), the more pollinators you'll attract. Since pollinators have different needs during different life cycle stages, maintaining plant diversity will also make your site more of a full-service oasis. Pollinator.org offers free Ecoregional Planting Guides available at http://pollinator.org/guides that are an excellent resource to begin your search.

Younger kids are very visual, so obtaining a wildflower seed catalog or even browsing an online seed or plant catalog can be a great way to get them engaged in planning.

Make a list of plants you could plant to help attract and support your native pollinators. Remember to include plants needed in all stages of a pollinator's life. For example, monarch butterfly larvae (caterpillars) feed exclusively on milkweed.

Consider the following when creating your plant list:

- Use as many plants native to your region as possible. Native plants have evolved closely with native creatures and are well-suited to meet their needs. In fact, some pollinator species are entirely dependent on the availability of certain native plants. (Your state's agency of natural resources and/or conservation and native plant societies are excellent resources to tap. They may also have Web sites that offer plant lists and habitat information.)

  *Native Plant Note: Never dig plants from the wild unless the area is slated for destruction and development and you have permission from the landowner. The best source for native plants is a local nursery or native plant association that offer plants that have been grown, not gathered.

- Choose a range of flower shapes and sizes to suit the feeding preferences of a variety of pollinators.

- Include a variety of flowers that bloom throughout the season. By doing so, you will accommodate different pollinators' preferences and provide a sequence of pollen and nectar sources throughout different life cycle stages. For instance, flowering shrubs and trees tend to blossom early in the season, providing nectar or pollen when other food is scarce.

3. Draw up a plan. This can be a simple sketch from a bird's eye view with plants represented as circles of different sizes, or you can challenge older kids to draft a plan to scale. (Graph paper is very helpful if you want to introduce the concept of drawing to scale.) At the end of this packet you can find a plan for a butterfly and hummingbird garden you can share with them for inspiration. Younger kids may enjoy making more of a collage by cutting out pictures of plants from a seed catalog or magazine as shown in the picture below.

Activity 3: Spread the Word

1. Learning about pollinators and creating awareness about how important they are in our world is an important step towards motivating people to protect them. Challenge your kids to think of something they can do to share the knowledge they have gained by completing the Lessons to Grow By activities with friends, family members and neighbors. Here are a few ideas:

Create a Poster or Brochure

Create a poster or brochure to share with family and friends, at school or at home. They can sharing a broad message by creating a poster highlighting all the fruits and vegetables we love that rely on pollinators for the cafeteria, or a brochure all about how to start your own pollinator garden to give out to neighbors. Alternatively, they could choose to focus in on specific story, such as a pollinator of the month for a local library display.

Write a Letter or Article

They can write a citizen action article asking your school, local park, or community center to leave a small portion of their property wild and un-mowed to provide habitat for pollinators. If every citizen and business owner let a portion of their property grow wild and un-mowed, it would help create a connecting corridor of plants to provide habitats for the wild and native bees and other pollinators that are in trouble. Or perhaps they could write an article for their school's monthly newsletter or create a pollinator fact section for your community's website.

Share through Social Media

With the help of parents and guardians, use a smart phone or digital camera to inspire people through pictures. Share pictures of pollinators at work. Spotlight local native plants that look beautiful and support pollinators. Highlight delicious-looking meals that use a pollinator-dependent harvest.

2. Looking for a more hands-on garden activity? Make seed balls full of wildflower seeds to give away. Seed balls are small bundles of seeds, clay, and soil or compost designed to promote easy planting. Although seed balls have been around since ancient times, they were rediscovered in the 1930s by the Guerilla Gardening movement as a way to covertly introduce vegetation by simply tossing the seed balls (or, on a large scale, dropping them from an airplane). They are still used today to re-vegetate areas burned by wildfires. On a small scale, seed balls are fun to make and offer an inexpensive way to sow native plants and flowers.

Wildflowers are good choice of seeds for seed balls because in nature they are self-planted and their seedlings are hardy, requiring little care. Seeds of native wildflowers work especially well because they are adapted for your climate, and they also provide a food source for local pollinators. Check out the KidsGardening article at: https://kidsgardening.org/garden-activities-seed-balls/ for full instructions.

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books:

Bea's Bees by Katherine Pryor: Follow Bea as she learns about bees and works to make her a community a place they feel welcomed.

Errol's Garden by Gillian Hibbs: In this book Errol learns he does not need a yard to have a garden.

The Thing About Bees: A Love Letter by Shabazz Larkin: A poetic book about why we need bees.

Videos:

Why Protect Pollinators? From the California Academy of Sciences:
https://www.youtube.com/watch?v=p8uxJnNteNY

National Pollinator Week from the US Department of Interior:
https://www.youtube.com/watch?v=9W5myGZCxoQ

Why Bees Matter? From the Food and Agriculture Organization of the UN:
https://www.youtube.com/watch?v=oUq6qRZfjlw

Additional Related KidsGardening Lessons and Activities to Try:

Plant a Butterfly Garden:
https://kidsgardening.org/resources/garden-activities-plant-a-butterfly-garden/

Pollinator Celebration Meal:
https://kidsgardening.org/resources/garden-activities-pollinator-celebration-meal/

Create a Butterfly Puddle:
https://kidsgardening.org/resources/garden-activities-create-a-butterfly-puddle/

Pollinator Journal:
https://kidsgardening.org/resources/garden-activities-pollinator-journal/

The Pollinator Patch:
https://kidsgardening.org/resources/garden-activities-pollinator-patch/

Hooked on Hummingbirds:
https://kidsgardening.org/resources/garden-activities-hooked-on-hummingbirds/

Wonderful Wildflowers:
https://kidsgardening.org/resources/lesson-plan-wonderful-wildflowers/

Pollinator Jeopardy:
https://kidsgardening.org/resources/lesson-plan-pollinator-jeopardy/

Helping our Pollinator Friends

Reading page for Module 4: How can we help pollinators?

Pollinators help us in so many ways. As they gather nectar and pollen for their diet, they move pollen from one flower to another flower. This process, called pollination, helps plants make their seeds. New seeds mean new plants! New plants mean we will continue to be surrounded by these amazing green living things that make oxygen for our air, provide food for our tables, give us shelter, and help keep our soil healthy and our water clean. We need plants and so we need pollinators!

Scientists who study pollinators have noticed that the numbers of pollinators in our ecosystems are decreasing. They think this is due to a number of reasons, including:

- Pollinators are losing their homes! When we clear natural spaces to build houses, businesses, and roads, we are kicking them out of their homes and taking away their food sources. Pollinators need space to build nests and also lots of flowering plants to collect food from.

- Pollution is not good for pollinators! Many of our actions change the chemicals in the air, water, and soil and that can hurt pollinators.

- When we kill what we consider bad insects and pests, we can kill good ones too! Sometimes humans apply sprays called pesticides to kill insects that are damaging our favorite garden plants, crops, or lawn areas and these chemicals can also hurt the pollinators in our environment — even if they are not the insects we are trying to remove.

- Just like us, pollinators can get sick! Although different than the ones that hurt us, pollinators can catch viruses and be impacted by bacteria and parasites just like people.

- Weather is changing. When weather changes over long periods of time it is called climate change. Our planet is experiencing changes in average temperatures and rainfall. This is impacting where many of our pollinators can live and the timing of their life cycles.

Pollinators are in trouble and if things don't change, plants that rely on pollinators to make their seeds are going to be in trouble too. The good news is that we can help. Here are some examples of ways people can help:

- Add lots of different kinds of blooming plants to your yard. Make sure there are flowers available to be a food source for pollinators from spring through fall. Local pollinators especially like plants that are native to your area.

- Encourage people in your community to leave areas of uncut grass and wildflower patches at homes, in local parks, and in other greenspaces. This will provide homes and food for pollinators. Remember that some pollinators like butterflies might have specific types of plants that they need when they are in their caterpillar forms too.

- Encourage grownups to avoid using pesticides that may hurt our pollinator friends by accident.

- Finally, spread the word! Find ways to teach others about how important pollinators are in our world.

As much as pollinators do for us each day, we need to make sure to remember to help them too!

Reading Comprehension Questions

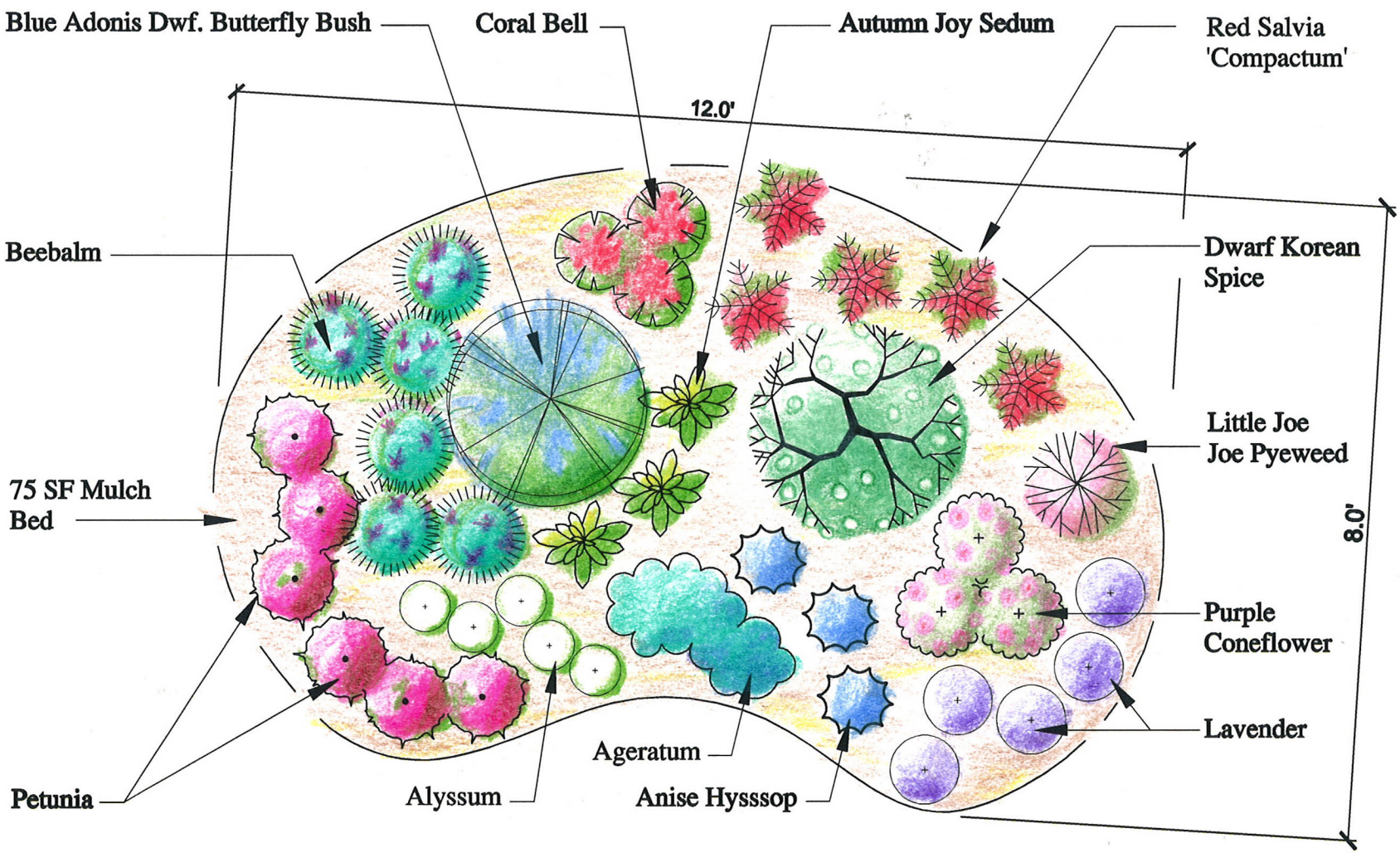
1. List one of the reasons pollinators are important to humans:

2. The numbers of pollinators in our world is:
    A. Increasing
    B. Decreasing
    C. Staying the same

3. Which of the following is not a reason pollinator population numbers are changing:
    A. Pollution
    B. Loss of habitat
    C. Pesticides
    D. They are being eaten by birds and other predators in larger numbers
    E. Disease

4. Why do pollinators need to be able to visit plants with flowers from spring until fall?
    A. For nectar
    B. For pollen
    C. Because they need to eat through the whole growing season
    D. All of the above

5. How can you help pollinators? List one of the ideas suggested in the reading page or come up with a new idea of your own.



Butterfly + Hummingbird Garden

Design by: Susan Littlefield, Horticulture Editor and Paul Simon, Landscape Architect

Scale: 1/2" = 1'-0" Feet

0' 1' 2' 3' 4'

NATIONAL Gardening Association

Tel: (802) 863-5251 Web: www.garden.org

THE NATIONAL GARDENING ASSOCIATION

kidsGARDENING.ORG

LESSONS TO GROW BY

Plant Parts

In this unit we are investigating important botany basics by studying plant parts. Take a look around your yard or a nearby green space and you will most likely notice a great diversity of plants. From tall trees with woody stems to the soft, creeping grass along the ground, plants can be found in a wide variety of colors, shapes, and sizes. Despite their differences in appearance, plants share a common set of parts. Learning about how the different parts function is essential to exploring plant growth and development. This foundational knowledge also contributes to our understanding how to care for the plants in our gardens and environment.

Module 1: Roots

Learning Objectives

In this module kids will:

- Learn about the function and structure of roots
- Investigate the water-absorbing capabilities of roots
- Explore plant roots we eat

Materials Needed:

Activity 1: Root Observation

- Root for Roots reading page
- Example of a plant with a taproot [possible examples: carrots (with leaves), beets (with leaves), dandelion, pine tree seeding]
- Example of a plant with fibrous roots (possible examples: lettuce, grass, most annual bedding plants)
- Root Observation Worksheet
- Ruler
- Magnifying glass (optional, but highly recommended)
- Ball of string (optional)

Activity 2: Watering Experiment

- Two (or more) small plants of any type in containers
- Plastic bag(s) or plastic film

- Tape
- Watering can
- Spray bottle
- Watering Experiment Observation Worksheet

Activity 3: Roots We Eat

- My Vegetable Cooking Guide Worksheet
- Recipe book or online recipe website
- Index Cards (optional)
- Root vegetables (such as carrots, beets, radishes, turnips, or sweet potatoes) (optional)

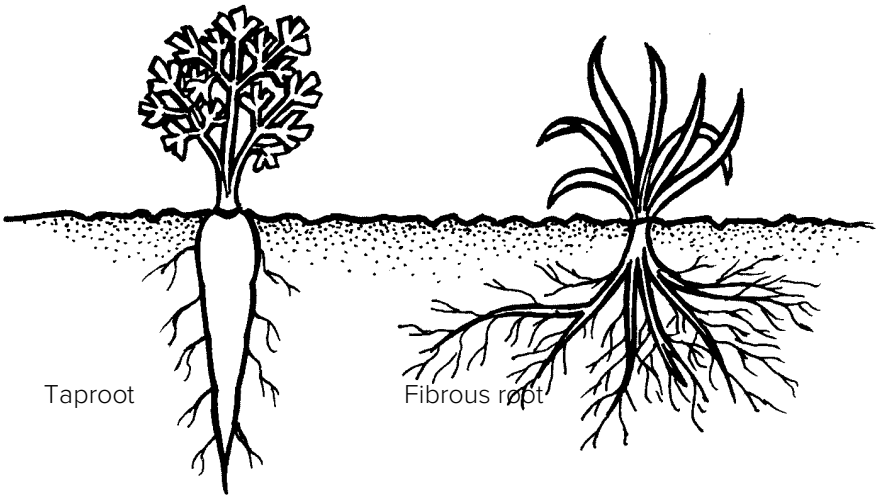
Introduction

It is the job of roots to absorb the water and nutrients a plant needs to grow and thrive. They also provide support for the plant and anchor it in the soil.

As a seed germinates, the first part to emerge is the primary root. It is the initial anchor for the plant and begins to absorb water and minerals so the shoot can develop. From that point, root development takes one of two directions depending on the plant.

Some plants have a one main root called a taproot with just a few smaller secondary roots. Reaching deep into the soil, these long, strong roots pull up nutrients from far below the surface. Dandelions are a common example of a plant with a taproot. In some plants, taproots are specialized to also be a storage site for starches and sugars. Common examples of taproots with this capability include carrots, radishes and beets.

Other types of plants have a fibrous root system — a network of small- to medium-sized roots that spread wide in the soil. Fibrous roots play an important role in soil stabilization and, even though they are not as deep as taproots, they may reach far beyond the footprint of the plant above ground. Grass plants are great examples of fibrous roots to study. One scientist measured all the roots of a single rye plant and found that if they were laid end to end in a line, their length would total 387 miles!



Both taproots and fibrous roots are covered in tiny root hairs that perform much of the water and nutrient absorption. They are very fragile, which is one of the reasons why it is important to be gentle when planting new plants and digging around established plants.

Along with their contributions to the plant, the network of roots is an important part of the soil ecosystem. Roots help break down rock to build soil and also prevent soil from eroding in the rain and wind. As plant roots grow through cracks in rocks, they break off tiny pieces of rock, which assists in the long, slow process of soil formation. Some roots even produce substances that help dissolve rocks. When living, roots aerate and loosen soil, and provide tunnels for burrowing insects and animals. When dead and decomposed, they contribute to the rich humus in the soil. The extensive

network of roots and root hairs also create a strong hold on soil particles. They keep soil from eroding away in ice, water, and wind.

Activity 1: Root Observation

1. Together or independently, read the Root for Roots reading page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. To build on the reading page, obtain at least one example of a taproot and one fibrous root for kids to compare. Possible taproot examples include carrots or beets from the grocery store (select ones that still have their leaves so your kids can picture what they look like when growing in the garden) and dandelions (a common weed found in lawns across the country; make sure to dig deep to get the full root). Although their root growth may change to a fibrous root system over time, many trees also start their lives with a taproot. If you can find tree seedlings in areas you do not want them (such as in flower pots or vegetable garden beds) you can pull them up for observation.

For your fibrous root example, most grass plants have fibrous roots and can be readily found in yards and greenspaces across the country. Lettuce plants also provide really nice examples of fibrous roots, as do most annual bedding plants.

Gather a copy of the Root Observation Worksheet, a ruler, and, a magnifying glass (if available).

3. Very, very gently, remove the soil from the roots. If the soil is dry, you may be able to shake and/or carefully brush it off. If the soil is moist, swish the roots in a basin of water to wash away the soil, then allow to dry. Have kids measure the roots and then draw a picture of them on the Observation Worksheet. If you have a magnifying glass, have them look for the root hairs.

4. Talk about the differences between the two different kinds of roots. Ask kids to list some of the benefits of each kind of root. To spark discussion, ask: Are there some environments that one type of root might be better suited to than another? Do you think soil depth influences plant roots? What about space availability?

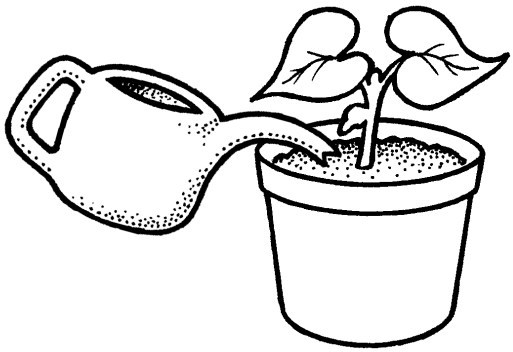
5. As an extension to this activity, share that the roots of a plant may extend much further below ground than the leaves extend above ground. A mature tree's root system may extend out two to three times farther from the trunk of the tree than the canopy. To visualize this, use a ball of string to measure the length from a trunk to the edge of the tree's canopy (a radius). Have one person stand at the trunk and hold the end of the string and then have a second person walk to the edge of the canopy in a straight line. You can measure the length if you wish. Then have the person at the edge of the canopy pivot, and have the person at the trunk walk away from the tree in the same line that same distance. Repeat again. Wow, that is a lot of roots!

Activity 2: Watering Experiment

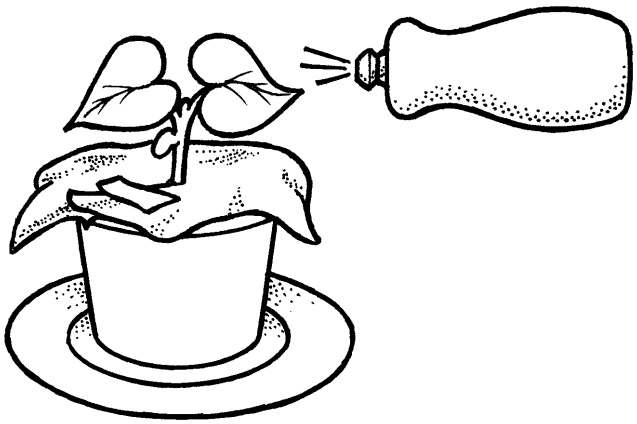
We have told you that taking in water for the plant is one of the most important jobs of the roots. In this activity, kids help set up a simple experiment to test if that is true.

1. Obtain at least two plants in containers. The kind of plant used can vary; houseplants or outdoor bedding/landscape plants will both work. However, you want to pick out two of the same kind of plant and also try to find two that are approximately the same size. If you do not have access to established plants, you can also start a few bean seeds (from the dry bean aisle at the grocery store) in small pots of soil or even in a cup with wet paper towels, and then perform this experiment after giving them a couple of weeks to establish roots and a few leaves.

3. Start by making sure the growing media in the containers is equally moist. Next, cover the top of one of the pots around the stem with a secure layer of plastic film so that the soil will not get wet.



Watering the roots of the plant



Spraying water on the leaves of plant while soil is covered in plastic

4. Over the next couple of weeks, water the soil of the plant without plastic using a traditional watering can or water bottle. Water the plant with the plastic covering the soil by spraying the leaves directly with a spray bottle. Use the Watering Experiment Worksheet to track your observations.

5. After a couple of weeks, compare your results. The time it will take to see a difference between the two watering techniques will vary depending on the type of plants you chose and how long it takes for the plastic-covered plant to run out of water in its existing soil. At the end of your observations ask kids, Did our experiment prove that plants take in water through their roots? Why or why not? How can we apply this information in our garden?

Activity 3: Roots We Eat

Because some roots store sugar and starches for plants, many are sweet and nutritious food sources for humans and other animals. Sweet potatoes, carrots, beets, turnips, and radishes are some of our common vegetables that are actually plant food storage roots. The root of the tropical plant cassava is used to make tapioca and although not as common in the United States, it is a food staple in many tropical countries. Another root crop of note is the sugar beet; between 55% and 60% of the sugar produced in the US comes from the roots of sugar beets.

1. Make a list of all of the common roots that we eat. Your list may include: carrots, sweet potatoes, beets, turnips, parsnips, and radishes. A couple of less common root vegetables you may brainstorm include cassava, rutabaga, and jicama. If possible, let kids join you on your next trip to the grocery store or farmer's market and see if they can spot the root vegetables.

2. Talk about and research some of the nutritional benefits of eating root crops. You can use the Nutrition Information for Raw Vegetables Chart from the USDA to get you started at: https://www.fda.gov/food/food-labeling-nutrition/nutrition-information-raw-vegetables

California's Department of Public Health offers a comprehensive set of Harvest of the Month newsletters for educators and families that provides excellent resources to dig deeper into the root crops available at: https://harvestofthemonth.cdph.ca.gov/Pages/Downloads.aspx

3. Create your own Root Vegetable Cooking Guide featuring one or more of the vegetables you explored in Step 2. You can use the My Vegetable Cooking Guide worksheet or just use index cards and draw a picture of the vegetable on one side and record some of the facts you discovered about that root crop on the other side.

4. Search through recipe books and online recipe websites to find recipes to go with your root vegetable worksheets, noting which ones sound most appealing to your kids. Print out or write down recipes you would like to try on index cards or recipe cards and attach them to your cooking guide page. Here are a few cooking website you may want to explore:

ChopChop Family: https://www.chopchopfamily.org/recipes/

Cooking Matters: https://cookingmatters.org/recipe-finder/

Common Bytes: https://www.commonbytes.org/#!/recipes

4. If possible, sample some of fresh root crops raw or in salads and also give some of the recipes you found a try. Your kids might just discover their new favorite vegetable!

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books

What do Roots Do? by Kathleen Kudlinski
A beautifully illustrated book, sharing all about roots through rhymes.

Up in the Garden and Down in the Dirt by Kate Messner
A look at what happens above and below the ground in the garden.

Oliver's Vegetables by Vivian French
Journey with Oliver as he tries to find French fries in his grandfather's garden.

Videos

Bean Time Lapse from GPhase: https://www.youtube.com/watch?v=w77zPAtVTuI&t=17s

Erosion and Soil from Funsciencedemos: https://www.youtube.com/watch?v=im4HVXMGI68

How to Make Roots Salad and Roots We Eat Lab Investigation Demo from Big Green's Video Library: https://biggreen.org/edresources/video-library/

Roots with Chris from Green Our Planet's Virtual Academy:
https://www.youtube.com/watch?v=4U_jquOzT7g

Additional Related KidsGardening Lessons and Activities to Try

Fruit and Vegetable Art: https://kidsgardening.org/resources/garden-activities-fruit-and-vegetable-art/

Plant a Snack Garden: https://kidsgardening.org/garden-activities-plant-a-snack-garden/

Plant Parts Salad: https://kidsgardening.org/resources/garden-activities-plant-parts-salad/

Kitchen Scrap Gardening: https://kidsgardening.org/resources/garden-activities-kitchen-scrap-gardening/

Seed Viewer: https://kidsgardening.org/resources/garden-activities-seed-viewer/

Soil Art: https://kidsgardening.org/resources/garden-activities-soil-art/

Room to Grow: https://kidsgardening.org/resources/lesson-plan-room-to-grow/

Exploring Oliver's Vegetables: https://kidsgardening.org/resources/lesson-plan-exploring-olivers-vegetables/

Root for Roots

Lessons to Grow By – Plants Parts - Module 1 Reading Page

Solve this riddle: I live underground. I absorb water. I keep my plant's stems standing tall. What am I?

Answer: Roots!

Although most of the time we can't see a plant's roots because they are hidden underground, they are very important for the plant. Here are some of the jobs they do:

- Roots take in the water and nutrients that are needed by the plant. Nutrients are like vitamins for people and are used for healthy growth. Without water, plant cells would dry out and die. Plants need both water and nutrients to help them make food in their leaves.

- Roots hold plants in the soil so they can grow tall to reach sunlight. Roots also keep them from being blown away in the wind.

- Roots help keep the soil in place, too. Without roots, soil would wash away every time it rained. Think about what a muddy mess that would be!

What do roots look like? Plant roots can grow in two different ways. If you get a chance to look at a plant's roots, you will find that they are usually white or off-white in color and they may remind you of string or noodles. We call this type of root system fibrous. Fibrous roots spread out as wide as they can to help the plant stay anchored. In many cases the roots of a plant spread out much farther underground than the leaves of the plant spread out above ground. If you are looking for an example, the grass plants found in most lawns will most likely have fibrous roots.

Other plants make one big root that grows deep into the soil. We call these taproots. Some taproots get very thick and some even come in a variety of colors. A few examples of chunky roots that come in bright colors are ones that we eat, such as carrot, beet and radish roots. Other common plants with taproots include dandelions and pine trees.

Both taproots and fibrous roots have an important feature that is so small we can't always see it without a magnifying glass to help. Roots are covered in tiny structures which scientists call root hairs because they look like people's hair. These root hairs are actually doing a lot of the work when it comes to absorbing water and nutrients. They are very fragile which is why we have to be careful when we are planting new plants and digging around existing plants in the garden.

Since we can't always see them, we may forget about a plant's roots, but they are very important. In order for a plant to be happy and growing well above ground, it must have happy roots growing well below ground!

Root for Roots
Reading Comprehension Questions:

1. True or false: Plant roots usually grow underground.

2. Which of the following is not a job of roots:

A. Taking in water
B. Anchoring the plant
C. Making food
D. Taking in nutrients
E. Keeping soil in place

3. List the two different types of roots commonly found in plants:

4. Root hairs:

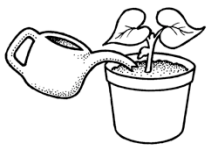
A. Cover the outside of the roots
B. Are so small you might need a magnifying glass to see them
C. Are the site on the root where most of the water is absorbed
D. Look like hair
E. All of the above

5. Name a plant root that we eat:

Root Observation Worksheet

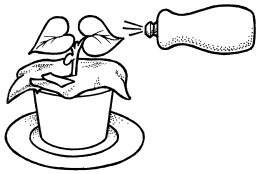
Root System	Tap Root	Fibrous Root
Plant collected		
How tall are the roots?		
How wide are the roots?		
Draw the roots.		
Do you see any root hairs?		
Do you think this root would be a good anchor for the plant? Why or why not?		

Watering Experiment Observation Worksheet



Pot 1: Water with watering can. Do not cover the soil with plastic.

Date	Appearance of Plant in Pot 1 (no plastic)	Sketch of plant in Pot 1 (no plastic)	Additional Observations



Pot 2: Water with spray bottle. Cover the soil with plastic.

Date	Appearance of Plant in Pot 2 (plastic)	Sketch of plant in Pot 2 (plastic)	Additional Observations

My Vegetable Cooking Guide

Vegetable name:

Other names for this vegetable:

Draw a picture of your vegetable below.

What parts of the plant do we eat?

- ☐ Root
- ☐ Stem
- ☐ Leaf
- ☐ Fruit
- ☐ Flower
- ☐ Seed

Nutritional information

Serving Size:

Calories:

Fiber:

Vitamin A:

Vitamin C:

Calcium:

Iron:

Growing season

- ☐ Spring
- ☐ Summer
- ☐ Fall
- ☐ Winter

Harvest time

- ☐ Spring
- ☐ Summer
- ☐ Fall
- ☐ Winter

How to Clean:

How to Eat:

- ☐ Raw
- ☐ Cooked

Recipe Ideas to Try:

LESSONS TO GROW BY

Plant Parts

In this unit, we are investigating important botany basics by studying plant parts. Take a look around your yard or a nearby green space and you will most likely notice a great diversity of plants. From tall trees with woody stems to the soft, creeping grass along the ground, plants can be found in a wide variety of colors, shapes, and sizes. Despite their differences in appearance, plants share a common set of parts. Learning about how the different parts function is essential to exploring plant growth and development. This foundational knowledge also contributes to our understanding of how to care for the plants in our gardens and environment.

Module 2: Stems

Learning Objectives

This week kids will:

- Learn about the functions of stems
- Compare the two main types of internal stem structures
- Explore different stem adaptations

Materials Needed:

Activity 1: Stems in Action

- Sensational Stems Reading Page
- Cup or jar
- Celery stem(s) with leaves*
- Water
- Food coloring (blue or red work best)
- Stems in Action Worksheet
- White carnation(s) (optional)

*Celery is actually a leaf petiole or "leaf stalk/stem" rather than a true stem, but it works great for this experiment

Activity 2: Inside a Stem

- Stem Cross Section Worksheet
- Straws (2 different colors, 5 of each would be best)

- Tape
- Modeling clay, Play-Doh®, or homemade "play-dough"*
- Tree Cross Section Worksheet
- Tree cookies/slices (thin cross-sections of branches available at craft stores; optional)

*Try your hand at making no-bake homemade play-dough (https://www.pbs.org/parents/crafts-and-experiments/no-bake-playdough-recipe) or traditional homemade play-dough (https://www.pbs.org/parents/crafts-and-experiments/rainbow-playdough) from PBS Kids for Parents.

Activity 3: Stem Scavenger Hunt

- Stem Scavenger Hunt Worksheet
- White paper
- Crayons

Introduction

Stems contain the plant's internal transport system. Inside the stems, water and dissolved nutrients absorbed by plant roots are moved up to the leaves where plants make their food. Once food is produced, it moves through the stems from the leaves to the rest of the plant and back to the roots. These separate functions are conducted through two types of cells.

Xylem (ZIE-lem) cells transport the water and dissolved nutrients.

Phloem (FLOW-em) cells transport the food made by the plant.

These cells are organized into tissues that serve as the plant's vascular system. For older students, you may want to compare them to the veins and arteries of people. For younger students, it may be helpful to think of them as a system of tubes or straws.

Water movement. Older students may also be interested to learn more about how water moves up the plant against the force of gravity. This feat is accomplished through a combination of factors. Water moving into the roots pushes water upward into the stem. Water molecules cohere to one another, forcing the water column further upward, and they adhere to the sides of the conducting tissue. In addition, transpiration, which is the evaporation of water through leaf openings, actually pulls the water column upward. So water is being pushed and pulled up through the plant at the same time. In some plants and in some conditions, water can move through stems as fast as 30" per minute.

Structural support. Stems complete a second very important function for plants. They are also tasked with providing structural support for the plant, allowing them to grow tall to reach the light their leaves need for food production. By lifting them off the ground, they are also keeping plant leaves from being trampled on and in some cases eaten.

Stems come in a variety of shapes and sizes. Some are soft and flexible. Most annual plants fit into this category. Larger, longer-lived plants like shrubs and trees generally have harder, woody stems. They may have special adaptations to help protect them, such as thorns. In the case of vining plants, the stems may have adaptations that allow them to cling to objects or other plants using features like tendrils, as well as the ability to make aerial roots. Some stems are short at maturity — for example those of the common dandelion. Others are tall like the trunks of a magnolia or oak tree.

In addition to the difference in the outward appearance of the different types of stems, the arrangement of the components inside of the stem also varies. Flowering plants are divided into two subclasses: monocotyledons (monocots) and dicotyledons (dicots). They get their names based on how many seed leaves first sprout out of their seeds.

Monocots, such as grasses and corn, have one seed leaf.

Dicots, which encompass a very diverse grouping of plants including woody, flowering trees, have two seed leaves that emerge from the seedling.

Monocots and dicots also have differing stem structures. Monocots usually have the xylem and phloem scattered throughout the stem in bundles. A cross-section of a bamboo plant may allow you to see this with a hand lens or magnifying glass. Dicots have their xylem and phloem arranged in rings.

Although young children may not be quite ready to fully explore this level of detail, the reason this is important is that the ringed nature of dicots plays a role in understanding tree rings and why tree trunks and branches get wider and wider each year. In activity number 2, we will explore the two different types of arrangements of vascular tissue in stems (the xylem and phloem) and introduce the idea that trees grow wider and wider each year in addition to getting taller. We do not specifically introduce monocots and dicots, but if you have older kids, this is something you can dig into a little deeper. For younger kids just knowing that there are two ways that stems can be organized on the inside and grow on the outside is more than enough information.

Potatoes, an example of a below-ground stem

Finally, one last consideration of note: Most stems are located above the ground, but not all. There are some plants that have modified stems that grow below ground and typically serve as food storage sites. Irish potatoes are an example of below-ground stems, along with true bulbs like onions and tulips. (Fun plant-part trivia: Irish potatoes are stems and sweet potatoes are roots.) Some plants have horizontal stems called rhizomes that help the plant spread as it grows. Irises are common examples of plants with rhizomes. Strawberries also have horizontal stems; however, they grow above-ground and are referred to as stolons.

Activity 1: Stems in Action

1. Together or independently, read the Sensational Stems Reading Page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Next, set up an experiment to watch stems in action. A classic plant activity is to place celery stalks in a jar (or jars) of water with a few drops of food coloring added (red or blue work best). Botanically, celery is actually a leaf petiole or "leaf stem" rather than a true stem, but its structure and the some what transparent nature of celery allow you be able to see the colored water rise through its vascular tissue and into the leaves. For best results, make sure you have fresh celery samples with leaves still attached and cut the end of the celery before placing in the colored water. Also make sure to place your celery in a warm location — if it's too cold, water will not be pulled up through to the leaves.

3. Have kids use the Stems in Action Worksheet to track their observations for one week. Each day, have them measure how far up the stem they can see the color change and record the measurement.

4. You can make changes to the experiment to test out the impact of different variables on the movement of water. Try different colors of food coloring. Try placing the celery in rooms with different temperatures (or even place one sample in the refrigerator). Try placing jars in full sun and others in the dark. Try placing one outdoors and another indoors.

5. White carnations are a fun alternative for this activity. Although the carnations' stems are opaque so you will not be able to see the color rise on the stem, the color will slowly appear on the petals. If you place stems in different colors of water, you can make your own rainbow bouquet. See the KidsGardening activity, Make a Rainbow Bouquet (https://kidsgardening.org/resources/garden-activities-make-a-rainbow-bouquet/) for complete instructions.

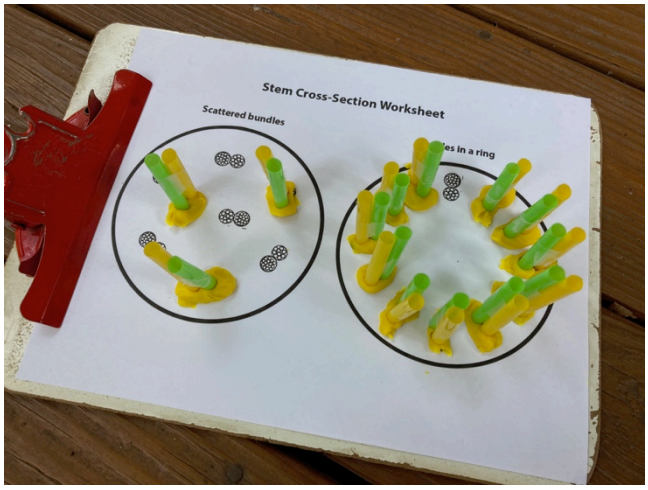
Activity 2: Inside a Stem

1. Water and dissolved nutrients travel up from the roots to the leaves in cells called xylem. The food the leaves produces moves around the plant in cells called phloem. Xylem and phloem cells are structured into tissues that create tubes running throughout the plant. Show kids two different colors of straws and explain that with this activity they are going to represent the xylem and the phloem in a plant. Cut about five straws into pieces of equal size that approximately 2" long.

2. Xylem and phloem are often bundled together. Tape one xylem straw and one phloem straw together and repeat to form 20 bundles.

2. Explain to kids that if you cut stems into slices to view a cross-section, you would find there are two main ways that xylem and phloem bundles are arranged inside of the stem. In some plants, the bundles are scattered throughout the stem. In other plants, the bundles are arranged in a ring. Use the Cross Section of the Stem Worksheet to explain the two types of arrangements.

3. Now make your Cross-Section of a Stem Worksheet into a 3D model. (See photo at right.) Place your worksheet on a flat surface and add a round, ½" thick slab of clay where indicated. Next, using the diagram as a guide, insert your homemade vascular bundles upright into the clay as indicated. Hopefully this model will help kids better visualize the inside of a stem.



4. Common plants that have scattered bundles include lilies, bamboo, grasses, and palm trees. If you can find a sample of bamboo, you can make a cross-section and use a hand lens or magnifying glass to look for the bundles.

5. Common plants with rings of bundles inside are plants that have woody stems. Cut a cross section of a larger tree limb or look at the inside of a tree stump. You can also find pre-cut tree “cookies” (cross-sections of tree branches) at craft stores if you do not have a way to make your own. Ask kids what they see. If real samples aren't available you can use the Tree Cross Section Worksheet.

6. Explain that the rings inside of the tree reflect the arrangement and growth of the xylem and phloem. As shrubs and trees grow, they keep making more xylem and phloem bundles around the outer edge. The newest xylem and phloem cells are doing the most of the transporting work. The older xylem can be found in the center of the tree. It no longer moves as much fluid as the newer bundles that are on the outside, but serves more as storage.

Since the tree is constantly growing and adding new cells to the outer edge of the stem, it gets wider and wider each year. During the spring and early summer when there is lots of rain and temperatures are warm, the tree grows really fast and the cells are really big. Cells made during the early growing season appear as the lighter-colored rings. During the late summer and early fall, the tree grows very slowly and the cells are small and tightly packed. The darker rings represent the cells that are produced late months of the growing season.

7. Because you can distinguish between those cells grown in the early growing season and those in the late growing season, we can count the rings to find out how old a tree is. Look at the Tree Cross Section Worksheet. A pair of one white ring and one dark ring represents one year. How old is this tree?

Answer: 11 years old

7. Look at the worksheet closer. Do you see how some rings are bigger than others? In years where there is a lot of rain and temperatures are good, the tree will grow a lot and the rings will be wider. In years where there is little rain or harsh temperatures the rings will be thinner. So looking at tree rings is also like a history book. It can tells us about environmental conditions over the years that the tree has been alive.

8. If you are able to find real samples, have kids practice counting the years and making observations about the growing conditions based on the size of the rings.

Activity 3: Stem Scavenger Hunt

1. Stems come in a variety of shapes, sizes, and textures. They also have evolved various adaptations, such as thorns to deter hungry animals, and tendrils and aerial roots to help plants climb. Go on a nature walk in a local greenspace or garden and challenge kids to observe different types of stems. They can record their observations in a journal (in writing or through drawings), by taking photographs, or you can use the Stem Scavenger Hunt page.

2. The bark of trees of different species varies. To help kids observe and explore the textures, have them make bark rubbings. To make a bark rubbing, place a piece of white paper over the bark and use a crayon or piece of charcoal turned sideways to gently capture the texture on the paper. If possible, label each rubbing with the type of tree name and later discuss the differences and similarities you find.

Digging Deeper

You can use the following resources to dig deeper into this module's lessons.

Books and Additional Resources:

- *Tell Me, Tree* by Gail Gibbons
  A wonderful introduction to trees for young gardeners

- *Tops and Bottoms* by Janet Stevens
  Learn about tops, bottoms and middles in the garden with Bear and Hare

- Tree rings provide snapshots of Earth's past climate by Jessica Stoller-Conrad & NASA's Climate Kids: https://climate.nasa.gov/news/2540/tree-rings-provide-snapshots-of-earths-past-climate/

Videos

- The Color-Changing Celery Experiment by SciShow Kids: https://www.youtube.com/watch?v=Klug9Foou3s
- How Do I Tap a Maple Tree from The University of Maine: https://www.youtube.com/watch?v=o6B_5Qz_gpc
- PBS Learning Media's Think Garden - Plant Structure: https://www.pbslearningmedia.org/resource/5dea21b4-6c92-46ff-982c-8650f9429c01/think-garden-plant-structure/

Additional Related KidsGardening Lessons and Activities to Try

- Exploring Tree Rings: https://kidsgardening.org/resources/lesson-plan-tree-rings/
- Make New Plants and Keep the Old: https://kidsgardening.org/resources/lesson-plans-asexual-propagation/
- Kohlrabi: https://kidsgardening.org/resources/growing-guide-kohlrabi/
- Bulb Botany: https://kidsgardening.org/resources/lesson-plans-bulb-botany/
- Fruit and Vegetable Art: https://kidsgardening.org/resources/garden-activities-fruit-and-vegetable-art/
- Plant Parts Salad: https://kidsgardening.org/resources/garden-activities-plant-parts-salad/
- Kitchen Scrap Gardening: https://kidsgardening.org/resources/garden-activities-kitchen-scrap-gardening/
- Exploring Oliver's Vegetables: https://kidsgardening.org/resources/lesson-plan-exploring-olivers-vegetables/

Sensational Stems

Lessons to Grow By - Plant Parts - Module 2 Reading Page

What do sugar, paper, cinnamon, rubber, and maple syrup all have in common? They all come from plant stems!

Stems are the part of the plant between the root and the leaves. Stems give plants their structure. Their support allows plants to grow off the ground and reach towards the sunlight. Holding plants up can also help prevent them from being stepped on by large animals (like people).

The stems do another important job. They contain the plant's transport system. Inside the stems, water and dissolved nutrients that are absorbed from the soil by plant roots are moved up to the leaves. They are carried up the plant in special parts called xylem (ZIE-lem) cells. Once in the leaves the water and nutrients are used by the plant to make food. After the food it made, it is then moved from the leaves by the stems to the rest of the plant. The food is moved around through the stems in special parts called phloem (FLOW-em) cells.

Stems come in all different shapes and sizes. Some plants have short stems like the dandelions in your yard. Other plants have really big stems like the trunks of big oak or pine trees. Some stems are green and flexible and you can break them easily. Other stems are hard and covered in bark and you need a chainsaw to cut through them. Some stems have special features, like thorns, to protect the plant. Most stems are found above ground, but there are even some special stems that grow below ground and they help store food for the plant. Irish potatoes and "true bulbs" like tulips and onions are all classified by scientists as stems.

In addition to being important to the plant, stems are also important to people. A lot of useful products in our world come from plant stems. Here are some examples:

Sugar. Approximately 40 to 45% of our sugar is made from the stems of sugarcane plants. (Some sugar comes from beet roots.) Can you think of all of the treats that could not be made without sugar?

Maple Syrup. Maple syrup is made by boiling the sap of maple trees. Can you imagine pancakes and waffles without maple syrup?

Paper. We make paper from the stems of lots of different kinds of trees. What would be missing without paper? No books or newspapers (or homework!).

Lumber. Do you live in a home or go to school in a building that is made from lumber? Are you sitting on furniture made from wood right now?

Rubber. Rubber is harvested from the sap of the rubber tree and is one of the materials needed to make car tires. How much walking would you do without cars?

Medicine. Some medicines are made from stems. Aspirin was originally made from the bark of willow trees and is important for helping us feel better when we are sick or in pain.

Food. Stems provide us with food, too. Asparagus, broccoli, bamboo shoots, kohlrabi, and Irish potatoes are a few examples. (Fun Plant Fact: Irish potatoes are stems, but sweet potatoes are roots). Cinnamon is from the bark of trees and is a tasty spice added to many recipes. Who loves cinnamon rolls?

Whether short or tall, flexible or rigid, green or covered in wood, stems are sensational.

Reading Comprehension Questions

1. What do stems do for a plant?

A. They move water from the roots to the leaves.
B. The move food from the leaves to the roots.
C. They help the plant reach sunlight.
D. They help protect the plant.
E. All of the above.

2. What is the name of the special cells that help move water from the roots to the leaves:

3. What is the name of the special cells that help move food from the leaves to the rest of the plant:

4. Name an example of a plant that has bark on its stem:

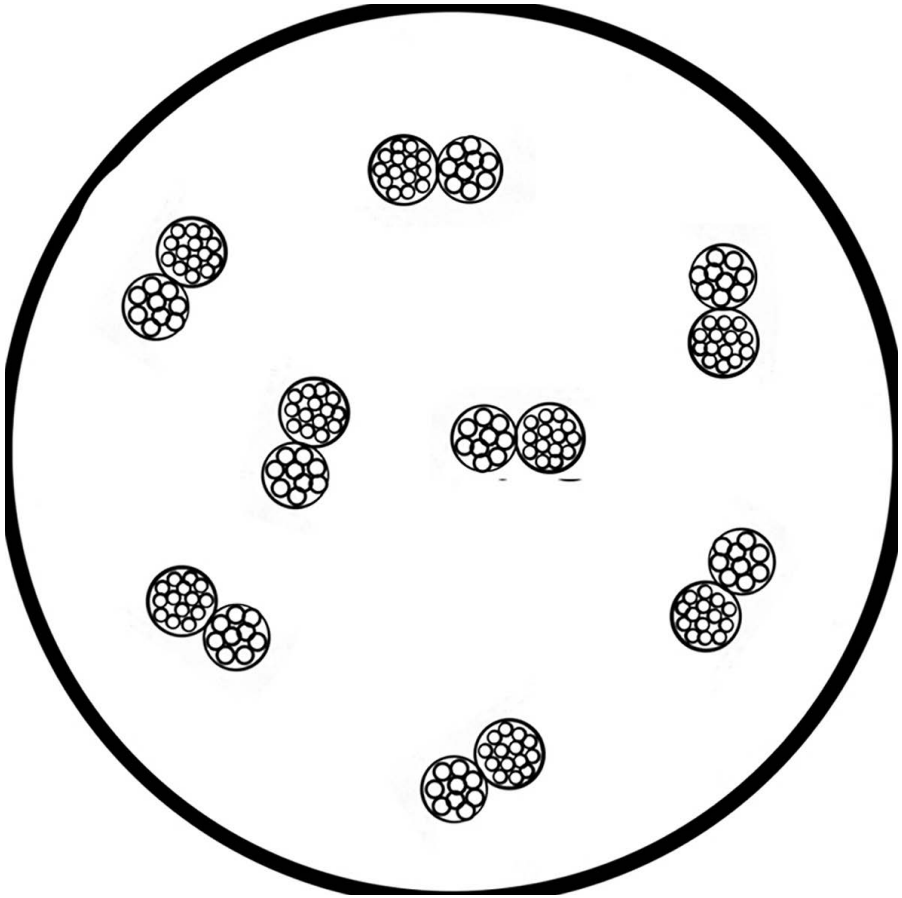
5. List one product made from stems that you would not want to live without and say why:

Stems in Action Worksheet

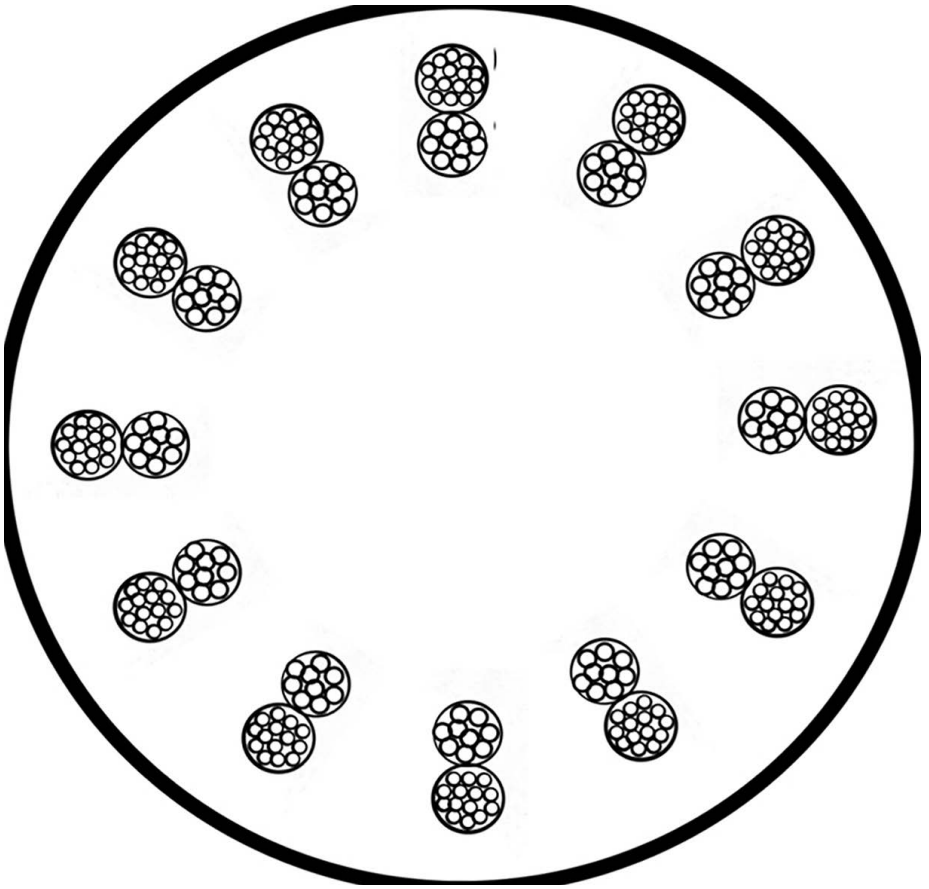
Sample #	Date Placed in Jar	Color of Dye Added	Environmental Conditions (light, temperature, etc.)	Measurement					
				Day 2	Day 3	Day 4	Day 5	Day 6	Day 7

Stem Cross-Section Worksheet

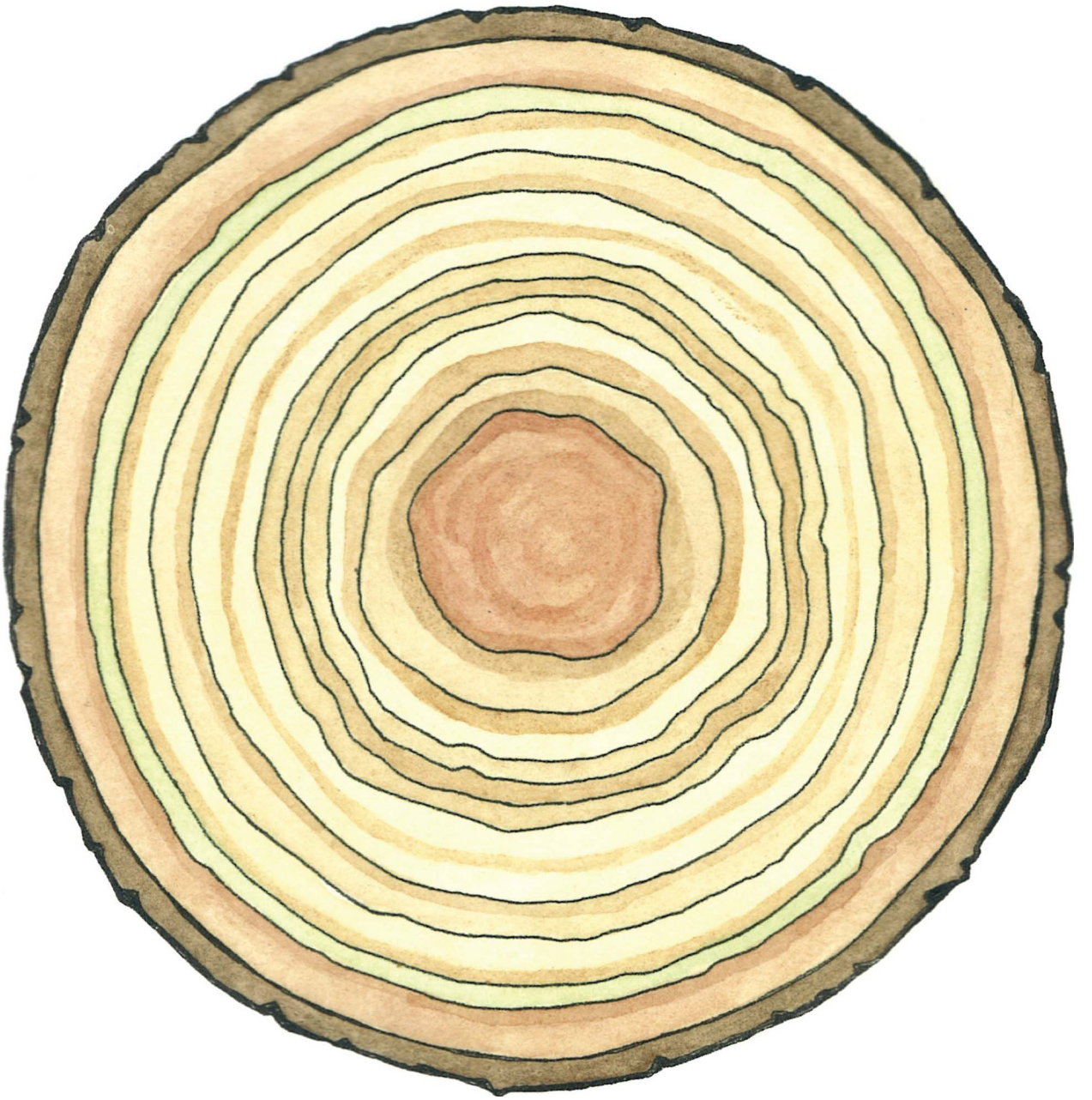
Scattered bundles



Bundles in a ring



Tree Cross Section Worksheet



Books In Bloom: Tell Me, Tree: All about Trees for Kids

Stem Scavenger Hunt

Find a stem that:

- ☐ is green
- ☐ is covered in smooth bark
- ☐ is covered in rough bark
- ☐ is a vine
- ☐ has tendrils to help it climb
- ☐ is edible (may want to look in your kitchen)
- ☐ smells good
- ☐ is flexible or bendy
- ☐ has thorns
- ☐ is soft
- ☐ is scratchy
- ☐ is tall
- ☐ is short
- ☐ is skinner than your finger
- ☐ is so big you can't reach all the way around it

kidsGARDENING.ORG

LESSONS TO GROW BY

Plant Parts

In this unit, we are investigating important botany basics by studying plant parts. Take a look around your yard or a nearby green space and you will most likely notice a great diversity of plants. From tall trees with woody stems to the soft, creeping grass along the ground, plants can be found in a wide variety of colors, shapes, and sizes. Despite their differences in appearance, plants share a common set of parts. Learning about how the different parts function is essential to exploring plant growth and development. This foundational knowledge also contributes to our understanding of how to care for the plants in our gardens and environment.

Module 3: Leaves

Learning Objectives:

Kids will explore the questions:

- What is photosynthesis and why is it so important?
- Why do leaves change color in the fall? What other ways do leaf adaptations help plants to survive in their environment?
- How can the characteristics of leaves help us identify plants?

Materials Needed:

Activity 1: Photosynthesis

- Leaves Support Life Reading Page
- Where's the Plant? Worksheet

Activity 2: Deciduous Versus Evergreen Leaves

- Examples of deciduous leaves
- Examples of evergreen leaves
- Leaf Comparison Worksheet

Activity 3: Leaf Characteristics

- Common Leaf Characteristics worksheet
- Plant journal or Leaf Characteristics Data worksheet
- Digital camera (optional)
- App, online or printed tree identification guide

Introduction

Plant leaves might just be the most underappreciated essential workers on the planet. It is inside the leaves where plants perform the amazing feat of turning water, carbon dioxide, and energy from the sun into the food energy that all living things rely on for survival. Plus, as a bonus byproduct, this process also puts oxygen back into the air for us to breathe. Pretty amazing stuff! Check out the KidsGardening article Photosynthesis Runs the World: https://kidsgardening.org/resources/lesson-plan-photosynthesis/ for a more extensive description of photosynthesis.

Another cool thing about leaves is their wide diversity of sizes, shapes, colors, and textures. From the fine, tough needles of a pine tree to the delicate, intricate designs of a thin Japanese maple leaf to the thick, waxy leaves of philodendron, it is hard to believe they all represent the same plant part. Many of the differences found in leaves reveal how the plants have evolved to adapt to their environment. Here are some examples:

Large leaves. Many plant species that live on the forest floor or in the understory have large leaves that maximize the surface area for catching what little sunlight filters down to their level. The more shade you grow them in, the larger their leaves will be.

Thick, fleshy leaves. Some leaves, like those on succulent plants, have the ability to store water, helping them survive conditions of infrequent and/or scarce water availability.

Needles. The waxy coating and thin shape of the needles of evergreen plants like pine trees help them survive winter conditions. The waxy coating prevents water loss in cold winds and the shape helps snow slide off rather than accumulate.

Drip tips. Many tropical plants have leaves with pointy tips and waxy surfaces that help water slide off quickly. These help prevent water buildup that could lead to decay and mold. Ficus, philodendron, and monstera leaves provide good examples.

Yuck factor. Some leaves have characteristics that discourage animals from eating them, such as poisonous compounds, scratchy textures, and pungent smells.

These are just a few examples of leaf characteristics that contribute to plant survival. Studying leaves can be a fun way to talk about adaptations of organisms in response to environmental conditions. Comparing evergreen and deciduous leaves can be a good place to start exploring adaptations because samples are usually readily available.

Some plants have adapted to the cold temperatures of winter by dropping their leaves and going dormant for the season. These plants are categorized as deciduous plants. Deciduous plants lose their leaves in the fall and essentialy go dormant during the winter, often putting on a spectacular show of fall color first. Alternatively, evergreen plants with needles, including the pine tree described above, have adaptations that help them survive winter conditions. Depending on where you live in the world, the winter conditions may or may not be that harsh and so adaptations of evergreen plants also vary greatly. For example, evergreen trees on the top of a mountain will need to be better adapted for snow and harsh winds, so you will find more trees with thin and scaly leaves like pine trees and other conifers. However, an evergreen tree in the South may just need to have slightly thicker leaves with a waxy coating for extra protection during winter months. It is important to note that even evergreen plants lose their oldest leaves each year, too, but they form their new leaves before they drop the old ones (hence they are ever/always green).

As you explore this adaptation, you can also investigate the always-intriguing question, why do the leaves on deciduous trees, such as maples, change color? The answer is that most plant leaves appear to us in varying shades of green because they contain lots of a plant pigment called chlorophyll. Chlorophyll isn't the only pigment contained in plant foliage, but it dominates. However, come autumn, as the growing season winds down, the amount of chlorophyll in the leaves begins to decrease. No

longer dominating the scene, the scarcity of chlorophyll allows the yellow and orange carotenoid pigments that are found in the leaves to take center stage. Other pigments that make a showing in fall are the anthocyanins which are deep red pigments. Depending on the amounts of these other pigments, the result is a display of leaf colors that ranges from bright red to purple. Uncover more details about in the KidsGardening article Fall Foliage: Why Leaves Change Colors: https://kidsgardening.org/resources/digging-deeper-why-leaves-change-colors/

In addition to telling us about how a plant survives, leaf characteristics are also an important feature to help us identify plants. Although a well-trained plant enthusiastic can identify plants based on its shape, structure, or bark characteristics, most of us rely on leaf and/or flower appearance for a positive identification. In activity 3 below, we describe some of the common characteristics of leaves and send you on a nature walk to try your hand at plant identification.

Activity 1: Photosynthesis

1. Together or independently, read the Leaves Support Life Reading Page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Next, use the Where's the Plant? worksheet to follow the origins of your favorite foods or meals. How many levels or steps does it take to get to a plant?

Activity Extension: If your kids are ready to look beyond the basics of photosynthesis providing food energy and oxygen to living things, you can broaden your view and help them explore the importance of photosynthesis in the carbon cycle. When plants take in carbon dioxide for photosynthesis, they decrease the amount of carbon in the air and then the carbon gets stored in the plant as a carbohydrate. In addition to being used and stored in the plant, they also move excess carbohydrates out of the roots, returning carbon to the soil. Therefore, photosynthesis is a key process for keeping the balance of carbon in our air, soil, and water throughout our ecosystem. Learn more in the lesson Soil-Air Connection: https://kidsgardening.org/resources/lesson-plan-soil-air-connection/ and/or check out the US Department of Energy's Global Carbon Cycle graphic at: https://www.carboncyclescience.us/what-is-carbon-cycle#CarbonCycle

Activity 2: Deciduous Versus Evergreen Leaves

1. Use the introduction above to explain to your kids the difference between deciduous and evergreen plants. Here are some characteristics to share:

Deciduous Plants	Evergreen Plants
Lose leaves during the fall. May also lose leaves in times of drought or other stress.	Do not lose their leaves all at one time. Will have new leaves present before old leaves drop.
Leaves tend to be broad and flat.	Tend to have adaptations for water retention and protection against wind and cold temperatures such as a needle shape, thicker leaves, or a waxy coating.
Plants remain dormant in the winter.	Plants slow their growth dramatically but don't go fully dormant.

Please note that these terms are used primarily with woody plants (plants with bark on their stems) such as trees and shrubs. Herbaceous plants (those that do not have bark) are usually characterized as either annuals or perennials. Annual plants will die at the end of a growing season and they will not grow back again from that same plant (although some will drop seeds and come back from seed each year). Perennials return each year. The leaves and above ground growth of perennial plants will also die back at the end of the growing season; however, their roots remain alive during the winter and their top growth will return in the spring.

2. Take a walk in your yard or at a near by natural area and look for examples of different kinds of plant leaves representing a variety of shapes, sizes, colors, and textures on the trees and shrubs you see.

3. Use the Leaf Comparison Worksheet to make observations about the differences and similarities between the leaves you find. As a last step in the observation process, have your child make a prediction whether they think the plant is deciduous or evergreen.

4. Confirm their hypothesis. You may know the answer just from observations you have made in past seasons. If you are not sure, you can use the tips in Activity 3 to help identify the plant and then research whether it is classified as deciduous or evergreen.

5. Look for other examples of leaf characteristics might help a plant survive, such as succulents that store water or large leaves in shaded areas. A tour through the indoor houseplant section at a garden center will provide lots of additional opportunities to note different leaf adaptations.

Activity 3: Leaf Characteristics

1. Plant leaves are a key feature to help identify the plant. They are also a great way to study shapes and patterns in the natural world, enriching science knowledge while also inspiring both artistic and mathematical thinking. Leaves come in a wide variety of shapes, sizes, arrangement patterns, and textures. Learning how to observe leaf characteristic similarities and differences helps us identify plants and also understand how they are grouped into families.

These following are common characteristics of plant leaves (see the Common Leaf Characteristics handout for line drawings of each).

Leaf Category

- Needle-like leaves
- Scaly leaves
- Broadleaf or flat leaves

Leaf Structure

- Simple: Each leaf is made up of one blade attached to a stem
- Compound: Each leaf is made up of several smaller leaflets. The leaflets can be joined at one based and called palmately compound or spread out along a stem and called pinnately compound

Leaf Arrangement on the Stem

- Opposite: Leaves are positioned on the stems opposite of each other
- Alternate: Leaves are staggered on the stem (not opposite of each other)
- Whorled: Three or more leaves are attached to the stem at about the same place

Common Leaf Shapes

- Elliptical
- Oval
- Oblong
- Ovate
- Linear
- Lanceolate
- Deltoid
- Cordate
- Leaf Margins
- Entire
- Toothed
- Lobed

Leaf Venation

- Palmate: Veins appear to originate from a common spot at the base of the leaf
- Pinnate: Leaf has one central vein down the middle with more spreading out along the sides of the central vein
- Parallel: Veins run parallel to each other

2. Take a walk in a school garden, schoolyard or a local natural area. You can choose to identify plants while out in the field or take digital photos and/or samples to identify inside. (If you collect samples, please make sure not to damage the plant in the process.) If you decided to identify using photos, take several photos of each plant:

- closeup shots of individual leaves
- pictures of a stem showing the leaf arrangement
- picture of the entire plant to note plant shape

3. Use the Common Leaf Characteristic handout to help you describe: leaf category, leaf shape, leaf structure, leaf margins, leaf venation, and leaf arrangement. Record your answers in your plant journal (include a sketch of the leaf) or on the Leaf Characteristics Data Collection Worksheet.

4. Next, use a field guide to help you identify your plant. There are a number of printed field guides that can be purchased or checked out from a local library. There is also a growing body of online identification guides available. The Arbor Day Foundation's What Tree is That?™ online guide is a handy resource that might be helpful; find it at: https://www.arborday.org/trees/whattree/. There are also a number of ID Apps like Seek by iNaturalist from California Academy of Sciences and National Geographic: https://www.inaturalist.org/pages/seek_app.

5. After kids identify a number of plants, reflect on the process. Ask questions like, Was identifying your plant easier or harder than you thought it would be? What characteristics did you find most useful in helping you to identify your plants? Do you think leaves are good tools to use for identification? Why or why not?

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books and Additional Resources:

Why Do Leaves Change Color? by Betsy Maestro

Leaf Man by Lois Ehlert

Seek by iNaturalist from California Academy of Sciences and National Geographic: https://www.inaturalist.org/pages/seek_app.

Videos:

National Geographic Definitions in the Field: Photosynthesis:
https://www.nationalgeographic.org/video/definitions-field-photosynthesis/

National Geographic Definitions in the Field: Chlorophyll:
https://www.nationalgeographic.org/video/definitions-field-chlorophyll/

Travel Deep Inside a Leaf from the California Academy of Sciences:
https://www.youtube.com/watch?v=pwymX2LxnQs

Trees Can Dance From The Magic of Nature by Artur Homan
https://www.youtube.com/watch?v=qImPJo6Nc9I&t=43s

Additional Related KidsGardening Lessons and Activities to Try:

Photosynthesis Runs the World:
https://kidsgardening.org/resources/lesson-plan-photosynthesis/

Fall Foliage: Why Leaves Change Colors:
https://kidsgardening.org/resources/digging-deeper-why-leaves-change-colors/

Photographing Shapes and Patterns in Nature:
https://kidsgardening.org/resources/lesson-plan-photographing-shapes-and-patterns-in-nature/

Tropical Rainforests:
https://kidsgardening.org/resources/lesson-plan-tropical-rainforests/

Indoor Greening:
https://kidsgardening.org/resources/lesson-plans-indoor-greening/

Lettuce Be Healthy:
https://kidsgardening.org/resources/lesson-plans-lettuce-be-healthy/

Let There Be Light:
https://kidsgardening.org/resources/lesson-plan-let-there-be-light/

Fruit and Vegetable Art:
https://kidsgardening.org/resources/garden-activities-fruit-and-vegetable-art/

Plant Parts Salad:
https://kidsgardening.org/resources/garden-activities-plant-parts-salad/

Kitchen Scrap Gardening:
https://kidsgardening.org/resources/garden-activities-kitchen-scrap-gardening/

Exploring Oliver's Vegetables:
https://kidsgardening.org/resources/lesson-plan-exploring-olivers-vegetables/

Leaves Support Life

Lessons to Grow By - Plant Parts - Leaves Reading Page

Skinny pine needles, wide palm fronds, yummy salad greens — leaves can be found in many different sizes, shapes, and colors. Some plants have leaves year-round while others lose their leaves during winter months (many times turning beautiful colors before they fall). However, they all have one thing in common: they make the food and release the oxygen that all other living things need to survive. Without plants — and specifically plant leaves — all other creatures, including people, would disappear.

Plants have the special ability to make their own food through a process with a very long named: photosynthesis (foe-toe-SIN-the-sis). Here is a simple look at how plants make food through this process:

1. Plants take in water from their roots and move it up into their leaves.

2. Plants take in carbon dioxide, which is in the air all around us, through tiny little holes in the leaves. These tiny holes are called **stomata**.

3. Plants catch energy from sunlight with special structures in their leaves called **chloroplasts** (CLOR-oh-plasts). Chloroplasts contain chlorophyll (CLOR-oh-fill), a natural substance found only in plants that makes most leaves look green.

4. The water and carbon dioxide that the plant took in through their roots and leaves are drawn into the cholorplasts.

5. When placed in light and with the help of the chlorophyll in the cholorplasts, plants can make new things from the water and the carbon dioxide. They make food and release oxygen.

6. The oxygen is released back into the air through those tiny holes, the stomata, for living things to breathe.

7. The food plants make is also known by another long name – **carbohydrates** (car-bo HIE-drates). They move this food throughout the plant and use it to grow and stay healthy. Animals and other living things eat plants, so they can get energy from plant food too.

As you can see, through photosynthesis, plants make food not only for themselves, but for all other living creatures too. Photosynthesis is not just a big word, it is also a really big deal in our world. The food produced in the leaves supports all life on our planet.

You might be thinking, but I don't eat only plants, I think I can live without them. Let's look at a favorite dish – a cheeseburger. Here is a list of all the ingredients and where they come from:

Hamburger meat: Hamburger meat is made from cows and cows eat grass, which is a plant.

Buns: Buns are made from grains, which are plants.

Cheese: Cheese is made from milk, which is made by cows. Cows eat grass, which is a plant.

Lettuce, tomatoes, pickles and ketchup: All made from plants.

Throw in some French fries or potato chips (from potatoes, which is a plant) and you have a plant-fueled meal.

Try tracing back other foods you eat that are not plants. Can you figure out how they eventually link back to food from plants?

The next time you take a look at a leaf, think about how important those little green things are for us. Use your imagination to picture factories inside turning sunlight into food and oxygen. As you eat a meal or take a deep breath, don't forget to thank a plant!

Reading Comprehension Questions:

1. True or false: All plant leaves look alike.

2. What is the name of the process inside of a plant that makes the plant food?

3. Which of the following ingredients are needed for plants to make food:

    A. Water
    B. Flour
    C. Chlorophyll
    D. Carbon dioxide
    E. Chocolate

4. True or false: All living creatures rely on plants for food.

5. Like the hamburger example in the reading, list your favorite meal and then make a chart showing how the main ingredients link back to plants:

Where's the Plant? Worksheet

Food Item	Main Ingredients	Comes From	Comes From	Comes From	# of Levels to Plants
Ex. mac and cheese	1. pasta	wheat			1
	2. cheese	milk	cows	grass	3

Leaf Comparison Worksheet

Sketch your leaf or attach a sample if possible.	What does the leaf feel like? Is it smooth or rough? Is it the same on both sides? Does it have a waxy coating?	How thick is the leaf? Does it feel like it would tear easily?	What is the shape of the leaf? Do you think the shape helps the plant in extreme weather?	Do you think this leaf is evergreen or deciduous?	Were you right?

Common Leaf Characteristics

Leaf Category

Needle-like | Scaly | Broadleaf

Leaf Margins

Entire | Toothed | Lobed

Leaf Structure

Simple

Compound

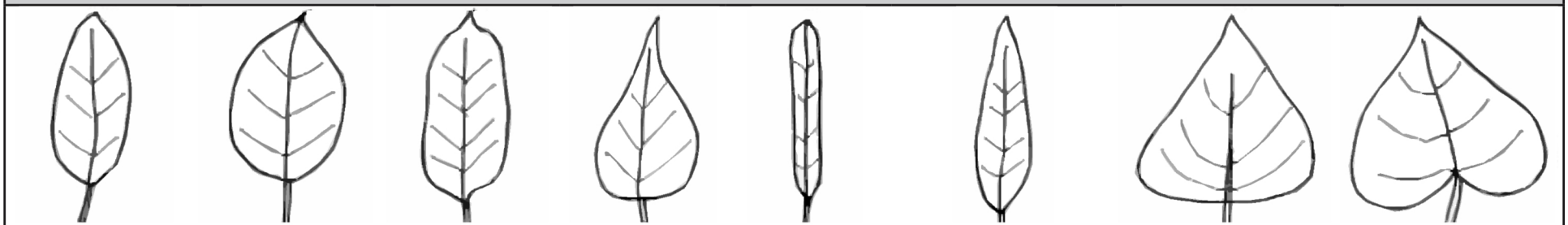
Leaf Arrangement on Stem

Opposite | Alternate | Whorled

Leaf Venation

Palmate | Pinnate | Parallel

Leaf Shapes



Elliptical | Oval | Oblong | Ovate | Linear | Lanceolate (lance-shaped) | Deltoid (triangular) | Cordate (heart-shaped)

Leaf Characteristics Data Collection Worksheet

Sketch your leaf or attach a sample if possible	Leaf Category	Leaf Structure	Leaf Venation	Leaf Arrangement	Plant Identification

kidsGARDENING.ORG

LESSONS TO GROW BY

Plant Parts

In this unit, we are investigating important botany basics by studying plant parts. Take a look around your yard or a nearby green space and you will most likely notice a great diversity of plants. From tall trees with woody stems to the soft, creeping grass along the ground, plants can be found in a wide variety of colors, shapes, and sizes. Despite their differences in appearance, plants share a common set of parts. Learning about how the different parts function is essential to exploring plant growth and development. This foundational knowledge also contributes to our understanding of how to care for the plants in our gardens and environment.

Module 4: Sporangia, Cones, and Flowers

Learning Objectives:

In this module, kids will explore the different parts of plants whose purpose it is to help them make new plants through seeds and spores including:

- Sporangia: Plants like ferns and horsetail make new plants by producing spores in parts called sporangia.
- Cones: Found on plants like pine trees, cycads, and ginkgo trees, cones are structures that contain pollen and seeds.
- Flowers: Most of the plants in our world today make their seeds inside flowers, with the seeds surrounded by fruit at maturity.

Materials Needed:

Activity 1: Sporangia – Fabulous Ferns

- Making New Plants Reading Page
- Fern leaves from outside or from the grocery store
- Hand lens (optional)

Activity 2: Cones - Pine Cone Exploration

- Pine cone samples
- Parts of a Pine Cone Worksheet
- Pine Cone Observation Worksheet
- 1 cup peanut butter or sunflower butter (optional)
- ½ cup songbird seed (optional)
- A mixing bowl (optional)
- Rubber spatula (optional)
- Cookie sheet (optional)
- Wax paper (optional)
- Thin ribbon or string (optional)

Activity 3: Flowers – Wind- vs. Animal-Pollinated Flowers

- Anatomy of a Flower Coloring Page
- A variety of flowers to observe (Try to include both animal- pollinated flowers (most colorful flowers) and wind-pollinated flowers (such as grasses))
- Flower Comparisons handout

Introduction

Just like animals, plants have evolved over time. One of the major changes in plants has been the development of different structures or plant parts they use to reproduce; that is, to produce offspring and create their next generation. The first land plants were spore-bearing plants. Relatives of present-day plants such as horsetails and ferns, they did not make true seeds but rather produced new plants via spores in structures known as sporangia (spore-ANN-gee-uh). Gymnosperms (JIM-no-sperms) were the next major group of plants to evolve. They produced true seeds in cone-like structures. After that came the angiosperms (ANN-gee-oh-sperms)— plants with "true flowers" that produce seeds within protected ovaries that developed into fruits. The ability to make seeds in flowers and be protected by fruit at maturity proved to be very advantageous for the plants' survival and distribution, so much so that now they're the most abundant type of plant on the Earth.

By studying various types of fossils, scientists have pieced together the following record of the appearance of terrestrial (land) plants:

Era	Period	Million Years Ago (mya)	Plant Life on Land
Precambrian		3800? to 543	
Paleozoic		543 to 248	The first land plants appeared, including mosses, horsetails (~400 mya), and ferns (~350 mya).
Mesozoic	Triassic	248 to 206	
	Jurassic	206 to 144	First seed-bearing plants emerged, including conifers such as bald cypress, ginkgos, and cycads (~200 mya)
	Cretaceous	144 to 65	True flowering plants appeared, including magnolias and palms (~140 mya)
Cenozoic		65 to present	

(Dates provided by the Geologic Time Scale from the Geological Society of America.)

Here is a brief overview of these three categories of plants along with the structures and processes they use to make new plants:

Spore-Bearing Plants

Spore-bearing plants do not have true seeds, but instead reproduce through spores in alternating generations. Ferns and horsetail are well-known plants in this category today.

The life cycle of spore-bearing plants varies significantly from the cycles of other common garden plants. Their life cycles have two distinct generations. Using ferns as an example, the part of the cycle easily observed is the development of the green fronds or leaves. On the undersides of delicate fronds, microscopic, dust-like spores are encased in structures called sporangia. Clusters of sporangia called sori (SORE-ee) are the scale-like bumps one can see on the underside of the fronds. (Note that not all spore-bearing plants group their sporangia into sori.) When the sori turn brown (in natural settings, this is typically after midsummer), they are ripe and ready to release spores. If you use a hand lens to look closely at sori, you may see some that are ragged looking; these have probably already opened and released their spores.

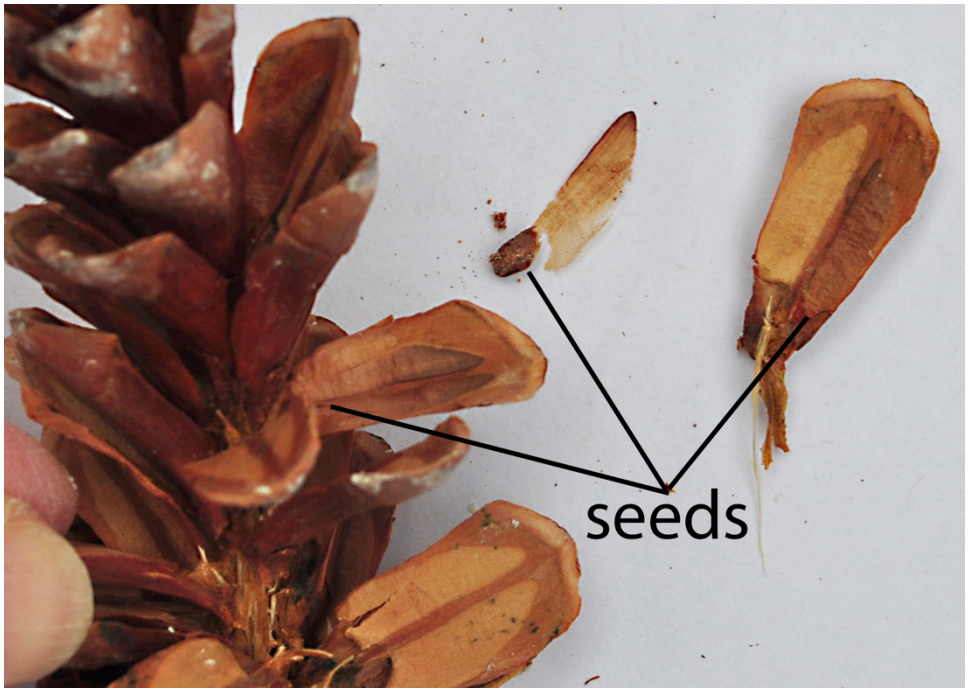
The fern spores fall to the ground and sprout when temperature and moisture conditions are right. But instead of producing fronds like they came from, spores develop into small, green, heart-shaped plants known as prothallia (pro-THALL-ee-uh). In this generation, reproductive organs form on the prothallia to produce features similar to the pollen and ovaries in seed-bearing plants, which combine with the help of moisture to form new spores. It's easy to miss this part cycle because prothallia are tiny and lie close to the ground. When these new spores are released, they grow into the familiar frond-bearing fern plant.

For more information check out KidsGardening articles Growing Baby Ferns at: https://kidsgardening.org/resources/garden-activities-growing-baby-ferns/ and Prehistoric Plants at: https://kidsgardening.org/resources/lesson-plan-prehistoric-plants/.

Cone-Bearing Plants: Gymnosperms

Gymnosperms produce true seeds in cone-like structures. Gymnosperms actually have two different kinds of cones. One type of cone produces pollen. These cones are usually smaller and not as showy. They may not be on the plant for long periods of time and they release their pollen, usually in mass quantities, coating surfaces in a blanket of yellow. The tiny pollen grains travel on the breeze and are caught by the second kind of cone, the seed-making cone. This seed-making cones may stay on the tree for up to 10 years, with a wide variation in the amount of time it takes for seeds to develop. On pine trees, a common gymnosperm found in landscapes across the country, the seed-producing cones are the ones that have the traditional appearance we associate with pine cones.

The word gymnosperm means “naked seed,” pointing out the fact that the seeds aren't covered with an ovary (fruit at maturity). Instead, the seeds are found at the base of the scales on the cone. Although they are not surrounded by fruit, the scales do provide some protection for the seeds, and the scales have the ability to open and close depending on environmental conditions. The scales prevent the seeds from dropping from the trees until they are mature and conditions are right for germination.

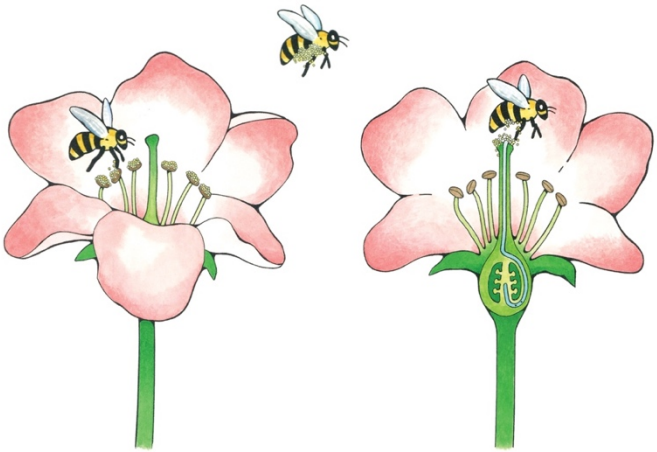


Plants that produce cones are commonly called conifers. Pine trees are types of conifers, and they are some of the more common gymnosperms found in our landscapes. Most conifers are evergreens with scaly and/or needle-like leaves. Some species are rugged enough to thrive in harsh environments, like on the top of mountains.

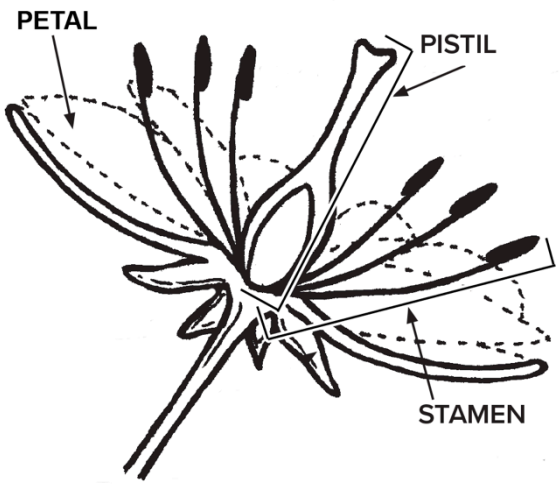
However not all gymnosperms are evergreen. Bald cypress and dawn redwood are deciduous conifers; they drop their needle-like leaves every fall. Gingkos are also gymnosperms; however, they have flat, fan-shaped leaves, are deciduous, and produce small pollen cones. Cycads are gymnosperms native to tropical and subtropic regions; they are evergreen with palm-like leaves and central cones.

Flowering Plants: Angiosperms

Angiosperms are flowering plants. Angiosperms produce seeds in ovaries found inside of flowers. The ovaries develop into fruit as the seeds mature. This advanced packaging can serve as protection for the seeds and also aids in distribution of the seeds. Both of these features are enhancements beneficial to overall survival of the species.



Although flowers come in lots of different shapes, sizes and colors, they all have similar parts. Flowers make pollen in parts called stamens. To create a seed, the pollen must be transported and joined with egg cells that are located in parts called pistils. The pollen is transported by animals (including insects and birds) or wind, depending on the type of plant. This process is called pollination. In depth materials about pollination and pollinators are available in the Lessons to Grow By Pollinator Unit.



Let's look more in depth at the parts of the flower and the pollination process because it's the most common way for plants to reproduce. The pistil is made up of multiple parts: a platform called the stigma and the thin stalk that holds it up, called the style. The stigma is often sticky so it can trap pollen. At the base of the style is the ovary, which may or may not be visible. Inside the ovary are the ovules, which contain the eggs.

Pollination occurs when the pollen transfers from the stamen to the pistil. Once there, it will grow a tiny pollen tube down the style into the ovary, where the eggs are located. Fertilization occurs when the sperm cell inside the pollen tube joins with an egg cell. Fertilized eggs grow into tiny embryos, which then develop into seeds. You can vary the amount of detail you share about this process with your child or students depending on their age.

Other important flower parts are the petals and sepals. In addition to surrounding and protecting the seed-making parts, some plants' flower petals act as beacons. Flowers that need pollinators to help them transport pollen are often brightly colored or patterned to attract the pollinators (usually birds, bees, and other insects). Some petals are arranged so that the flowers are broad and flat to provide good "landing pads." Wind-pollinated flowers, such as those of corn and oak trees, on the other hand, usually have inconspicuous petals, if any. Sepals are green leafy structures surrounding the petals, which initially protected the developing bud.

Although angiosperms were last on the scene in terms of evolution, it is estimated that 80% of the plants on Earth today are flowering plants.

Activity 1: Fabulous Ferns

Ferns were once the primary vegetation covering the Earth! The ancient species were probably similar to tree ferns, now found only in some tropical regions. These dominant plants of the dinosaur era decomposed to become a major component of coal deposits, an important energy source for us today.

The ability of ferns to adapt and evolve has resulted in more than 12,000 known living species growing in climates from the tundra to the tropics. Some of the earliest species include the maidenhair ferns (Adiantum species), lady ferns (Athyrium species), and autumn fern (Dryopteris erythrosora). Fern leaves, called fronds, grow from rhizomes (underground stem structures that grow just below the soil surface). Ferns range in size and shape from low, mounding ground covers to the tree ferns mentioned above. Most ferns grow in woodlands and are well adapted to shady beds, and some thrive in indoor plantings.

1. Together or independently, read the Making New Plants reading page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Use the background information found in the introduction to share how plants like ferns develop spores in sporangia to make new plants. Next, go on a hunt for fern sporangia/sori.

Fern spores are located on sporangia and the sporangia are clustered into sori that look like round bumps on the undersides of fern fronds. Sporangia/sori are most likely to appear on outdoor ferns from spring through summer (houseplant ferns may develop them at different times). Mature spores are dark colored, look firm and slightly fuzzy, and rub off easily onto your fingers.

If you don't access to an area with outdoor ferns or it is the wrong time of the year to find spores in your area, you can also very often find sori on leatherleaf ferns available at local florist and grocery stores. Leatherleaf fern is the most commonly used greenery in flower arrangements. The leaves may have sori in different stages of development. If you find leatherleaf fern leaves where the sori are present but not yet mature, place the stems in water and keep them in a warm location, and they may continue to mature for you.

3. Once you find sporangia/sori, allow kids to observe. What do they look like? What do they feel like? Were they hard to find? Are the ones you found mature? Can you see spores? If spores are present, talk about how they are different than seeds. Look at them through a hand lens if possible.

Extend the Activity: There are two ways to extend this activity. If you are able to collect fern spores, you can actually try to plant them to grow new ferns. Find full instructions at Growing Baby Ferns at: https://kidsgardening.org/resources/garden-activities-growing-baby-ferns/.

If growing ferns from spores sounds too complicated, you can also explore ferns by collecting leaves from different types of ferns and pressing them to make your own herbarium sheets. Attach a pressed leaf to a sheet and make notes about the plant's characteristics such color, habitat, size, shape, and so on. Kids can also use pressed ferns to create artwork such as note cards, bookmarks, and hanging ornaments. And since ferns are plants that date from the Mesozoic Era, they may want to include dinosaurs in their art, too! For instructions on pressing plant leaves, check out Pressed Flowers and Leaves at https://kidsgardening.org/resources/garden-activities-pressed-flowers-and-leaves/.

Activity 2: Pine Cone Exploration

1. A common decoration, pine cones are an easily recognized plant feature. However, most kids probably do not know that the pine cone is the structure pine trees use for making new seeds. Collect pine cones from the ground of your yard or natural area for kids to observe. Please note that in addition to being a home for seeds, they may also be a home for insects, so you may want to place them in a sealed plastic bag in your freezer for a few days before bringing them in. (Or conduct your explorations outside.)

2. Use the Parts of Pine Cones Worksheet as you inspect your collected pine cones. Are your cones pollen-producing cones or seed-making cones? Did you find different sizes and shapes of pine cones? How are they the same? How are they different? You can use the Pine Cone Observation Worksheet as a guide.

Be careful when handling the cones and scales. Many of the scales have sharp edges or end points. Ask kids why they think that would be a beneficial trait. It is a way to help protect the seeds from hungry animals. Carefully remove a few scales to see what you find underneath. Possibly seeds. Please note you may not find seeds inside of the pine cones that are collected from the ground since they might have released their seeds before being detached from the branch and/or have been eaten by animals.

3. As a last step, use your pine cones to help you identify what kind of pine tree they came from. You can use a printed tree ID guide or one of the many online identification tools available. Having examples of the needle bundles may also be useful for your search (the length of the needles and the number of needles in each bundle is an important ID tool also). The American Conifer Society offers an extensive online resource about pine trees at: https://conifersociety.org/conifers/pinus/.

Extend the Activity: Want to have some fun with your leftover pine cones? Make seed-encrusted pine cone ornaments to hang in your yard for the birds.

Materials Needed:

- Dried pine cones
- 1 cup peanut butter or sunflower butter
- ½ cup songbird seed (plus additional seed for sprinkling)
- Mixing bowl
- Rubber spatula
- Cookie sheet
- Wax paper
- Thin ribbon or string

Instructions:

- Attach a 10" length of ribbon to the top of the pine cone.
- In a mixing bowl add the peanut butter or sunflower butter and songbird seed, and then mix with the rubber spatula until combined.
- Place the cones on the wax paper-lined cookie sheet, and use the spatula to liberally cover them with the seeds.
- Once the cones are covered, add an additional sprinkling of seeds to their surfaces.
- Freeze the ornaments until firm and ready to hang. Store them in a cool place before hanging.

Activity 3: Wind- vs. Animal-Pollinated Flowers

1. Use the Anatomy of a Flower Coloring Page to introduce kids to the different parts of the flower. Explain that some flowers have all of these parts in one flower, but others may only have a pistil or a stamen. Note that although they have the same function, the parts may look very different on different flowers.

2. Use the background information in the Introduction to explain that in order to make seeds, the pollen that is produced in the stamen must be moved from the stamen to the pistil. There are a couple of ways this can happen. It can be moved by wind or water (usually wind). Or it can be moved with the help of pollinators, which include insects, birds, and other animals. Share the following characteristics of wind- versus animal-pollinated flowers:

Wind Pollinated Flowers	Animal-Pollinated Flowers
Small, numerous flowers	Flower size ranges from small (and if small they are usually found in clusters) to quite large
Petals are usually small and/or not present	Most have showy petals in a variety of colors
Stamen and pistils easy to access	Stamen and pistils often surrounded by petals
Usually no scent	May give off a scent – some pleasant, some not pleasant
Pistil(s) may not have nectar	Flowers have nectar
Abundant small, dust-like pollen grains	Pollen grains larger/thicker and sometimes sticky

3. Observe a variety of flowers in your garden or local green space or collect a sampling of wind-pollinated and animal-pollinated flowers for your kids to observe indoors. Use the Flower Comparison Worksheet to note the characteristics of each flower and make a hypothesis about whether they are pollinated by wind or by animals. Conduct research to discover if your predictions are correct.

Extend the Activity: Additional flower-related activities can be found in Module 1 of the Pollinator Unit of Lessons to Grow By including instructions for dissecting a flower and making your own flower.

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books and Additional Resources

The Reason for a Flower by Ruth Heller

The Little Pine Cone by Ella Syfers Schenck and Chris Bauman

Fun Facts about Pine Cones from Michigan State University Extension:
https://www.canr.msu.edu/news/fun_facts_about_pine_cones

American Conifer Society's Conifer Database:
https://conifersociety.org/

Videos

National Geographic Time-Lapse: Watch Flowers Bloom Before Your Eyes:
https://www.youtube.com/watch?v=LjCzPp-MK48

Identifying Parts of a Flower from the Art Lady Channel:
https://www.youtube.com/watch?v=ZQAnJ8ICFc8

Daffodil Flower Dissection from QLab: https://www.youtube.com/watch?v=MSAVKlyZh6o

What is a Pine cone? From BayerUS: https://www.youtube.com/watch?v=fxrMDZV0HWQ

Additional Related KidsGardening Lessons and Activities to Try

Prehistoric Plants: https://kidsgardening.org/resources/lesson-plan-prehistoric-plants/

Growing Baby Ferns at: https://kidsgardening.org/resources/garden-activities-growing-baby-ferns/

Pressed Flowers and Leaves: https://kidsgardening.org/garden-activities-pressed-flowers-and-leaves/

Leaf and Flower Prints: https://kidsgardening.org/resources/garden-activities-pressed-flowers-and-leaves/

Petal Attraction: https://kidsgardening.org/resources/lesson-plans-petal-attraction/

The Pollinator Patch: https://kidsgardening.org/resources/garden-activities-pollinator-patch/

Making New Plants

Lesson to Grow By - Plant Parts Reading Page

All living things have ways to make more of themselves. Birds lay eggs, mammals have babies, and most plants make seeds.

Our green plant friends come in many different sizes, shapes, and colors so it should not surprise you that they also have many different ways to make new plants, too. Here are three ways living plants make new plants:

1. Plants make seeds inside of flowers.

A majority of plants in our world make flowers. Although we enjoy flowers because they are colorful and sometimes smell good too, the reason plants have flowers is to make fruit and seeds. Many of these fruits become tasty treats for us like apples, oranges, and avocados. However, it is the seeds that are prizes for the plant — the fruits are just packages to protect them. Inside those little seeds are tiny new plants.

2. Plants make seeds inside of cones.

Have you ever seen a flower on a pine tree? Not all plants make flowers and fruits. There are some plants that make their seeds inside cones instead. The cones are usually made up of scales that help protect the seeds growing in the middle. Pine trees and other conifers that stay green all year round are the most common cone-making plants, but there are a few others too.

3. Some plants make spores instead of seeds.

There is a third type of plant that does not even make true seeds; they make new plants by making spores. Spores are tiny and really hard to see. Spores are made in plant parts called sporangia (spore-ANN-gee-uh). Ferns are common plants that make new plants using spores.

What do all these plants have in common? All three have roots, stems, and leaves, too. Also in common, they all make their own food through the process of photosynthesis. However, they get the chance to be unique when it comes to how they make seeds and spores. Flowers, cones, and sporangia are all very important plant parts because they make sure we will always have new plants in our world.

Reading Comprehension Questions

1. True or false: All plants make seeds.

2. Select the plant parts that make seeds:

- ☐ Cones
- ☐ Leaves
- ☐ Flowers
- ☐ Roots
- ☐ Stems
- ☐ Sporangia

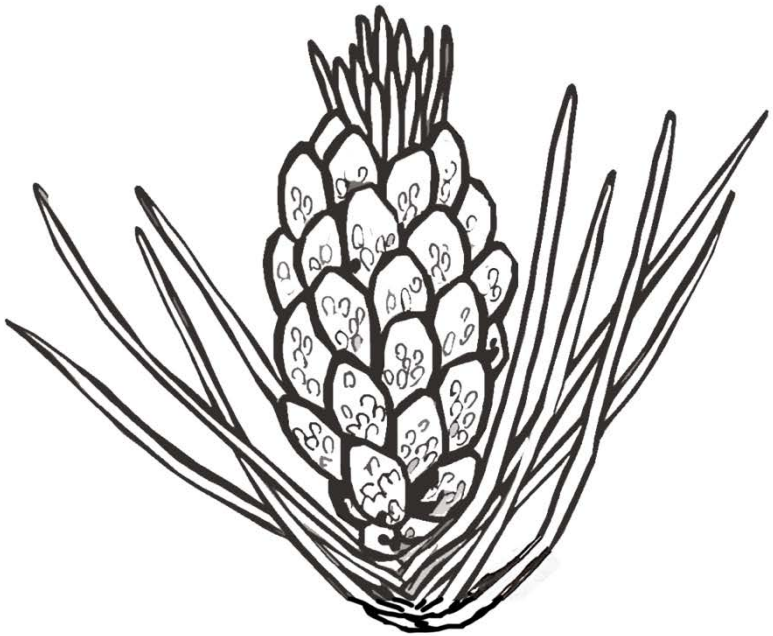
3. What do fern plants make that helps them make new plants:

- ☐ Fruit
- ☐ Seeds
- ☐ Flowers
- ☐ Spores
- ☐ None of the above

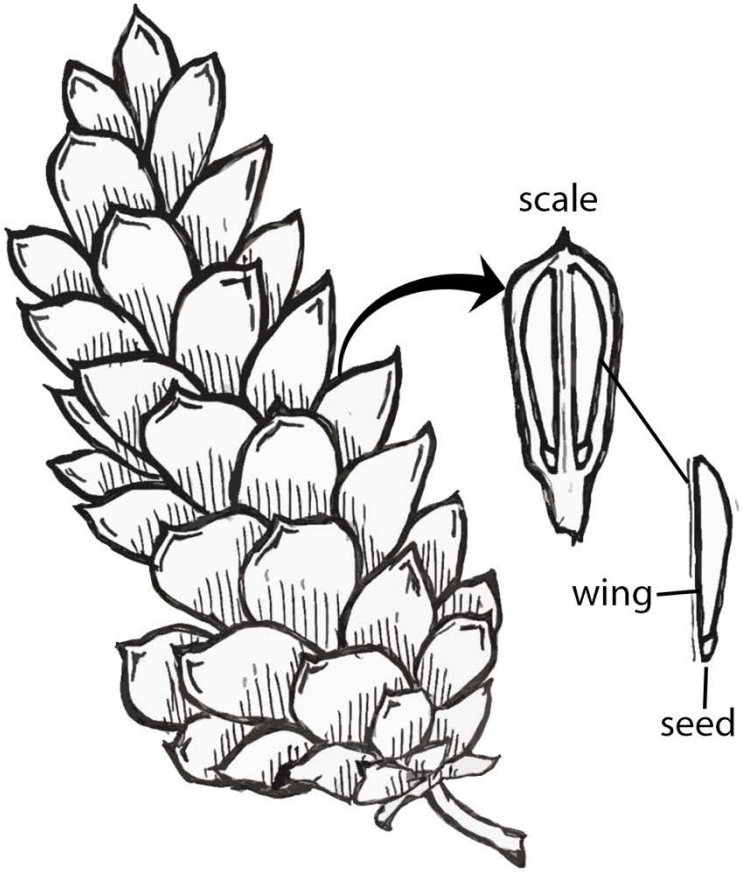
4. Why do plants make seeds?

5. What do flowers make to help protect seeds? Give an example.

Parts of Pine Cone Worksheet



Pollen-producing pine cone

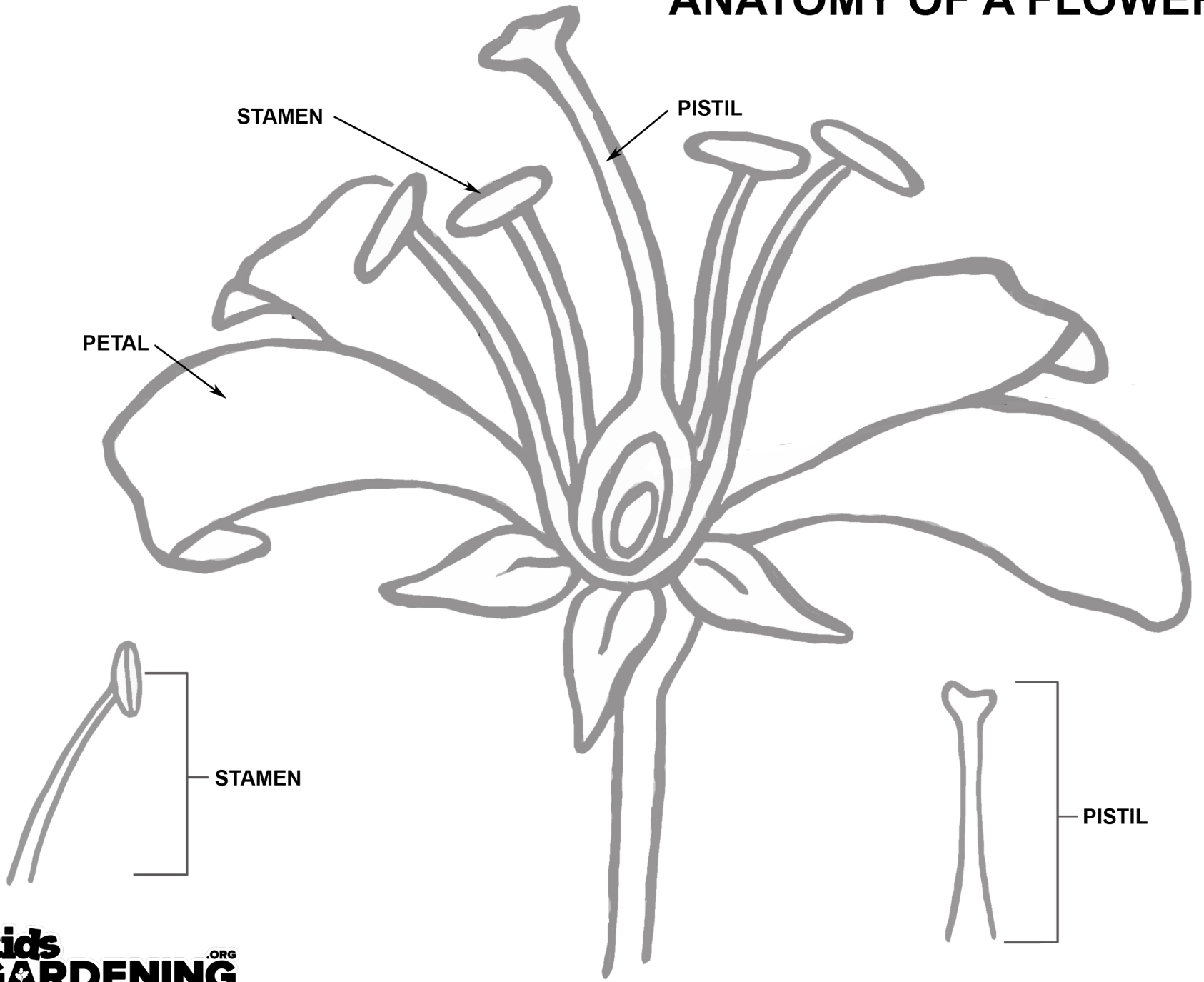


Seed-producing pine cone

Pine Cone Observation Worksheet

Sketch of pine cone	Sketch of one scale of your pine cone	How tall is your pine cone?	Is this a pollen-producing cone or a seed-making cone?	Describe your pine cone. What does it feel like? What color is it? Did you find any seeds or insects inside?	Do you know what kind of pine tree this cone came from?

ANATOMY OF A FLOWER



kids GARDENING .ORG
HELPING YOUNG MINDS GROW

Flower Comparison Worksheet

Sketch your flower or attach a sample if possible.	What do the petals look like? Are they showy? Describe below.	Can you find a pistil or pistils in your flower? How many? What size? Describe.	Can you find an anther or anthers in your flower? How many? What size? Describe below.	Does your flower have a scent? Can you find nectar? Any other traits that might attract a pollinator?	Do you think this flower is pollinated by wind or with the help of a pollinator?	Were you right?

kidsGARDENING.ORG

LESSONS TO GROW BY

Plant Parts

In this unit, we are investigating important botany basics by studying plant parts. Take a look around your yard or a nearby green space and you will most likely notice a great diversity of plants. From tall trees with woody stems to the soft, creeping grass along the ground, plants can be found in a wide variety of colors, shapes, and sizes. Despite their differences in appearance, plants share a common set of parts. Learning about how the different parts function is essential to exploring plant growth and development. This foundational knowledge also contributes to our understanding of how to care for the plants in our gardens and environment.

Module 5: Fruits

Learning Objectives:

This module focuses on an important (and often tasty) plant part: fruits. Kids will:

- Learn about the purpose of fruits and how they help with seed dispersal.
- Explore the great variations of different types of fruits.
- Discover that fruits provide many important vitamins and nutrients we need and that we should "Eat a Rainbow" every day.

Materials Needed:

Activity 1: Traveling Fruit

- Traveling Fruit Cards
- A berry, a burdock bur, a dandelion seed head, and a coconut (optional)

Activity 2: Inside a Fruit

- What is a Fruit? Reading Page
- A variety of fruits, including some that are commonly classified as vegetables. These may include, although are not limited to: apples, oranges, peaches, tomatoes, peppers, avocados, squash, cucumbers, green beans, peas (in their pods), and zucchini.
- Plate or cutting board
- Knife
- Sketching paper (or journal) and pencils, crayons, or markers

Activity 3: Eat a Rainbow

- Eat a Rainbow Coloring Page
- Crayons or markers
- Old seed catalogs or magazines (optional)
- Assorted fruits in a rainbow of colors (optional)
- Garnishes such as yogurt (optional)

Introduction: Fruit

Because plants are rooted in the ground, they encounter a dilemma when it comes to their offspring. They need to produce new plants to replace them when they die; however, if all of their seeds fall to ground at their feet, then their offspring will be competing with them — and each other — for the exact same resources. The solution? Find ways for seeds to travel away from the parent plant. Fruit is one of the ways plants help make this happen.

An estimated 80% of the world's plants are flowering plants. Flowering plants produce seeds inside of ovaries which develop into fruits. Fruits serve to protect the seeds and also to help with seed dispersal. Although an apple or orange might be the first thing to pop into your mind when you hear the word fruit, the structure itself can be very diverse. Fruits range in appearance, from a juicy watermelon to a hard pecan nut. Some fruits are considered "fleshy," and this includes many of the fruits we eat, like a peach. Others are classified as "dry;" these may not always be recognized as being fruit, like elm and maple samaras (the "helicopters" or lightweight, winged fruits that spiral through the air). Sometimes each fruit will contain lots of seeds (apple), and other times it will just contain one seed (peach). It can have a hard outer shell (pumpkin) or be soft (tomato). The range of what fruits look like and how they function is quite remarkable.

Fruits Help with Seed Dispersal

There are three primary ways that the fruit helps seeds disperse:

Wind. Many fruits are designed to help seeds be picked up in the wind and moved to another location. Often, these fruits do not have the traditional appearance that we associated with being a fruit. Commonly seen examples include a maple tree samara, a dandelion cypsela (the small brown end on the white tuft is actually a seed surrounded by a dry fruit) and a cattail follicle (similar to a dandelion cypsela). They are lightweight so the wind can scoop them up and deposit them away from the parent plant.

Water. Some fruits will float in water, allowing them to be moved in bodies of water to new locations. Coconut trees and mangrove plants produce fruits that take advantage of the ability to float to find new homes. Lotus plants live in water and produce fruit pods held upright above the water surface. When the seeds inside are mature the stems bend and release the seeds, which float away. There are many more fruits that are capable of floating even if that is not their primary means of dispersal (think of the old game of bobbing for apples).

Animal/Aided. A final major method of relocation is with the help of animals. The fruits can have an inside or outside seat for their journey. Many fruits and their seeds attract hungry animals. After the fruit is eaten, the seeds travel intact through that animal's digestive system and will eventually be deposited in their waste in a new location. In addition to the ride, the animal's poop also serves as the seeds' own little pile of compost and nutrients.

Animals can help in other ways, too. Some fruits, such as burdock burs (which inspired the creation of Velcro®) have adapted tiny hooks that latch onto the fur of animals and hitch a ride to a new location. Squirrels and other animals bury seeds, such as acorns, as a source of food for the winter. Seeds left behind are pre-planted and ready to grow. Also, many plants receive the intentional help of humans who collect and replant seeds of plants that we deem worthy for our fields and landscapes.

Fruits Nourish Seedlings — and Us!
In addition to helping with dispersal, fruits serve as a covering to protect seeds from the elements as they develop and mature. The ripe fruits of many plants contain a wealth of nutrients. If they're left to decompose on the ground around the seeds, they nourish the newly sprouted seeds.

Fortunately for us, animals also benefit from this nutrient-filled packaging. Fruits contain common vitamins such as Vitamin A, B, C, and E, along with additional health-promoting nutrients that scientist are just now exploring, such as lycopene, anthocyanins, beta-carotene, and flavonoids. These chemicals, also known as phytochemicals ("phyto" means plant) are substances the plants need to grow and protect itself from environmental factors. We can also use them in similar ways, too.

The color of a fruit is often an indicator of some of the nutrients that can be found inside. (Many phytonutrients are also pigments and are responsible for the color presented.) Rather than trying to remember lots of different chemical names, nutritionists have come up with a simple message: "Eat a Rainbow." This directive reminds us to eat fruits and vegetables in variety of colors each day to ensure we are getting the nutrients we need to be healthy.

Activity 1: Traveling Fruit

1. Use the background information above to explain to kids that one of the roles of fruits is to help the plants move their seeds. Ask and discuss, Why is it important for seeds to move away from their parent? Share that the three main methods of dispersal include wind, water, and with the help of animals. A great additional resource to check out is the book A Fruit is a Suitcase for Seeds by Jean Richards. See also this KidsGardening video about a lesson in our curriculum book Books In Bloom featuring A Fruit is Suitcase for Seeds: https://www.youtube.com/watch?v=j59AoR5EQ14&feature=youtu.be

2. Cut out the Traveling Fruit Cards and sort them by travel method (wind, water, or with the help of animals). Answers include:

Wind: Dandelion, maple samara, cattail
Water: Coconut, mangrove seed, lotus
Animal-aided: Raspberry, burdock bur, acorn

3. After sorting, talk about the characteristics of each one that helps with transport.

4. Take a nature walk and see if you can find additional examples of fruits and ask kids to predict how they might move away from the parent plant based on their characteristics. Optionally, you obtain examples to share indoors, such as a berry, a burdock bur, a dandelion seed head, and a coconut (make sure to test out its ability to float).

Activity 2: Inside a Fruit

1. Together or independently, read the "What is a Fruit?" Reading Page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Cut open a variety of common fruits, including at least one example of a fruit that is often referred to as a vegetable (such as a tomato, cucumber, or squash). If you do not have a selection available, you may also be able to find photo examples online to supplement.

3. On sketch paper or in a journal, have kids draw a picture of what the inside of each fruit looks like. You can also have them add additional observations obtained through sensory exploration such as, Is the outside hard or soft? Is the inside hard or soft? Does it have smell? Is it wet or dry? Ask them to draw a close-up picture of one of the seeds. Include as much detail as possible. Additional exploration can include counting the seeds.

4. Once they have drawn all the samples, have them compare their findings. Talk about the similarities and the differences.

5. Depending on the state of your samples after your exploration, you can end the activity by having kids taste the samples and add those observations to their notes. If you plan to eat your samples, make sure you use clean plates and knives, clean hands, and also that you wash the fruits before examining them (they will be harder to clean once they have been cut open).

Activity 3: Eat a Rainbow

1. Use the background information in the introduction to talk about all of the many important nutrients found in fruits. Older students may want to explore the health benefits of their favorite fruits on the Produce for Better Health Foundation website at: https://fruitsandveggies.org/fruits-and-veggies/.

2. Explain to kids that many of the health benefits are associated with the colors of the fruits, and that the best (and easiest!) way to make sure they're getting all the nutrients they need is to "Eat a Rainbow" every day.

3. Use the Eat a Rainbow coloring page to help kids brainstorm fruits (and veggies too if they want) that represent the different colors of the rainbow. They can either draw pictures using crayons or markers, or create a collage using pictures from old seed catalogs or magazines.

If they are having trouble getting started, here are some ideas for them:

Red: cherries, cranberries, raspberries, red apples, red peppers, strawberries, tomatoes, watermelons

Orange: apricots, cantaloupes, mangoes, oranges, peaches, pumpkins

Yellow: Bananas, pineapples, yellow pears, yellow peppers, yellow squash

Green: Green apples, green grapes, green pears, green peppers, honeydews, kiwis

Blue/Purple: blackberries, blueberries, eggplants, plums, purple grapes, raisins

4. At the end of the activity, let the kids share their favorites. Do they have a favorite color? Select a couple of examples that they have never tried and do a taste test. Plan out a few menus for the week that would allow you to incorporate each color each day.

5. As an extension, make and eat a rainbow fruit salad or a Fruit and Vegetable Art plate (check out the KidsGardening activity at: https://kidsgardening.org/resources/garden-activities-fruit-and-vegetable-art/. You can top with yogurt or other garnish.

Digging Deeper

You can use the following resources to dig deeper into this module's lessons.

Books and Additional Resources:

A Fruit is a Suitcase for Seeds by Jean Richards

The Donkey Egg by Janet Stevens

The Reason for a Flower by Ruth Heller

What's in the Garden? by Marianne Berkes

Videos:

SciShow Kids What's the Difference Between Fruits and Vegetable?
https://www.youtube.com/watch?v=DTK-uWx_VQo

Eat a Rainbow Rap from CHSAEataRainbow:
https://www.youtube.com/watch?v=CkP-sewWCeE

Life Lab's Eat a Rainbow Lesson:
https://www.youtube.com/watch?v=i9RNkIbyyz0&t=20s

Enrich LA – Eat a Rainbow:
https://www.youtube.com/watch?v=p5MMq7hH7YM

KidsGardening In The Weeds: Seeds on the Move:
https://www.youtube.com/watch?v=j59AoR5EQ14&feature=youtu.be

Additional Related KidsGardening Lessons and Activities to Try:

Fruit and Vegetable Art:
https://kidsgardening.org/resources/garden-activities-fruit-and-vegetable-art/

Kitchen Scrap Gardening:
https://kidsgardening.org/resources/garden-activities-kitchen-scrap-gardening/

Plant Parts Salad:
https://kidsgardening.org/resources/garden-activities-plant-parts-salad/

Celebrating Apples:
https://kidsgardening.org/resources/garden-activities-celebrating-apples/

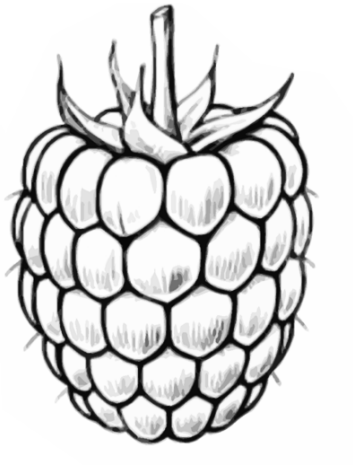
Pollinator Celebration Meal:
https://kidsgardening.org/resources/garden-activities-pollinator-celebration-meal/

Eat a Rainbow:
https://kidsgardening.org/resources/lesson-plans-eat-a-rainbow/

Fruit vs. Vegetable:
https://kidsgardening.org/resources/lesson-plan-fruit-vs-vegetable/

Rainbow Vegetable Kebabs:
https://kidsgardening.org/resources/garden-activities-rainbow-vegetable-kabobs/

Traveling Fruit Cards



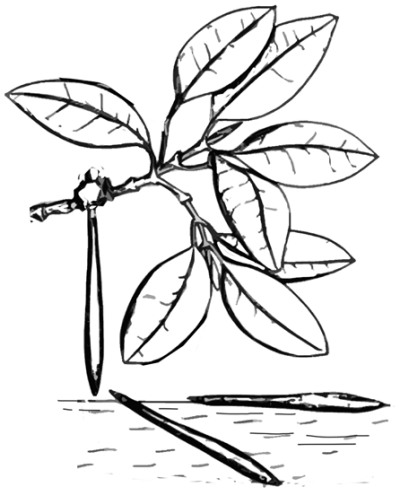
Raspberry

Burdock bur

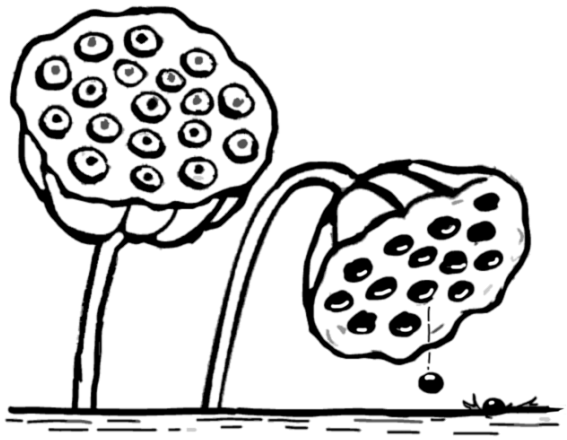
Acorn

Traveling Fruit Cards

Coconut



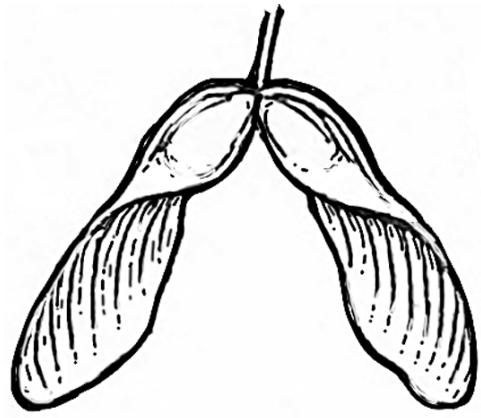
Mangrove



Lotus

Traveling Fruit Cards

Dandelion



Maple samara

Cattail

What is a Fruit?

Lessons to Grow By - Plant Parts - Reading Page

Apples, oranges, strawberries, bananas, grapes, and watermelon — yum! What do we call all these things? We call them fruit. They are sweet, tasty treats that are good for us too, because they are full of vitamins and nutrients we need to grow healthy and strong. What else do they have in common?

Inside of each piece of fruit, you will find another important plant part — seeds. From a plant's point of view, the job description of fruit is to provide protection for seeds and also to help the seeds get moved to new locations. For example, a hungry deer might eat an apple off of a tree, seeds and all. With seeds tucked safely inside its stomach, the deer then moves on to a new location. Eventually, it will drop the seeds into a new location along with their own supply of compost to help them grow (in other words, they are surrounded by the deer's poop).

Even if the apple had not been eaten, the apple would have eventually fallen off the tree, hopefully rolled some distance away from the tree, and then the fruit itself would have slowly rotted and provided nutrients for the new plants. Fruits are the plant's way of packaging its seeds to help them survive in the world.

Do all plants have fruits? Fruit is a really cool way to package seeds, but some plants make their seeds in other ways. For example, conifers like pine trees make their seeds in cones. Plants like ferns do not even make seeds, but instead make baby plants from spores in parts called sporangia. However a majority of plants in our world – an estimated 80% of all plants- do make seeds inside of fruit.

So if fruits contain the plant's seeds, you might be thinking, but I have seen seeds in vegetables too, like cucumbers, tomatoes, squash, and peppers. Guess what? Some of the things we call vegetables are actually fruits!

The use of the word vegetable to describe some plant parts that are actually fruit can be traced back to the tomato and the United States Supreme Court. Way back in 1883, the United States government wanted to make money by charging people a special tax called a tariff to bring certain vegetables into the country from other countries. A tariff is a fee you have to pay the government when you bring products into and out of the country to sell. One of these vegetables people had to pay a tariff on was tomatoes.

A very smart person who was bringing in tomatoes from other countries to sell decided that it was not fair to have to pay the tariff because he knew that since they contained seeds, tomatoes were fruits. Many people argued about this and eventually the case went to the United States Supreme Court to decide who was right.

The Supreme Court ruled that even though the tomato is scientifically a fruit, in every day life, we eat it as part of meal like other vegetables. They said that fruits are usually consumed individually or as a dessert. Therefore by ruling of the Supreme Court the tomato is a vegetable. So there are two ways to use the word fruit. In science, fruit is the part of the plant that contains the seeds. In everyday use, fruit is a sweet treat that we usually eat as a dessert or snack.

So in the future, if you're asked if a tomato (or cucumber, pepper, or squash) is a fruit or a vegetable, you can give them the answer, "Both!"

Reading Comprehension Questions:

1. True or false: All plants make fruit.

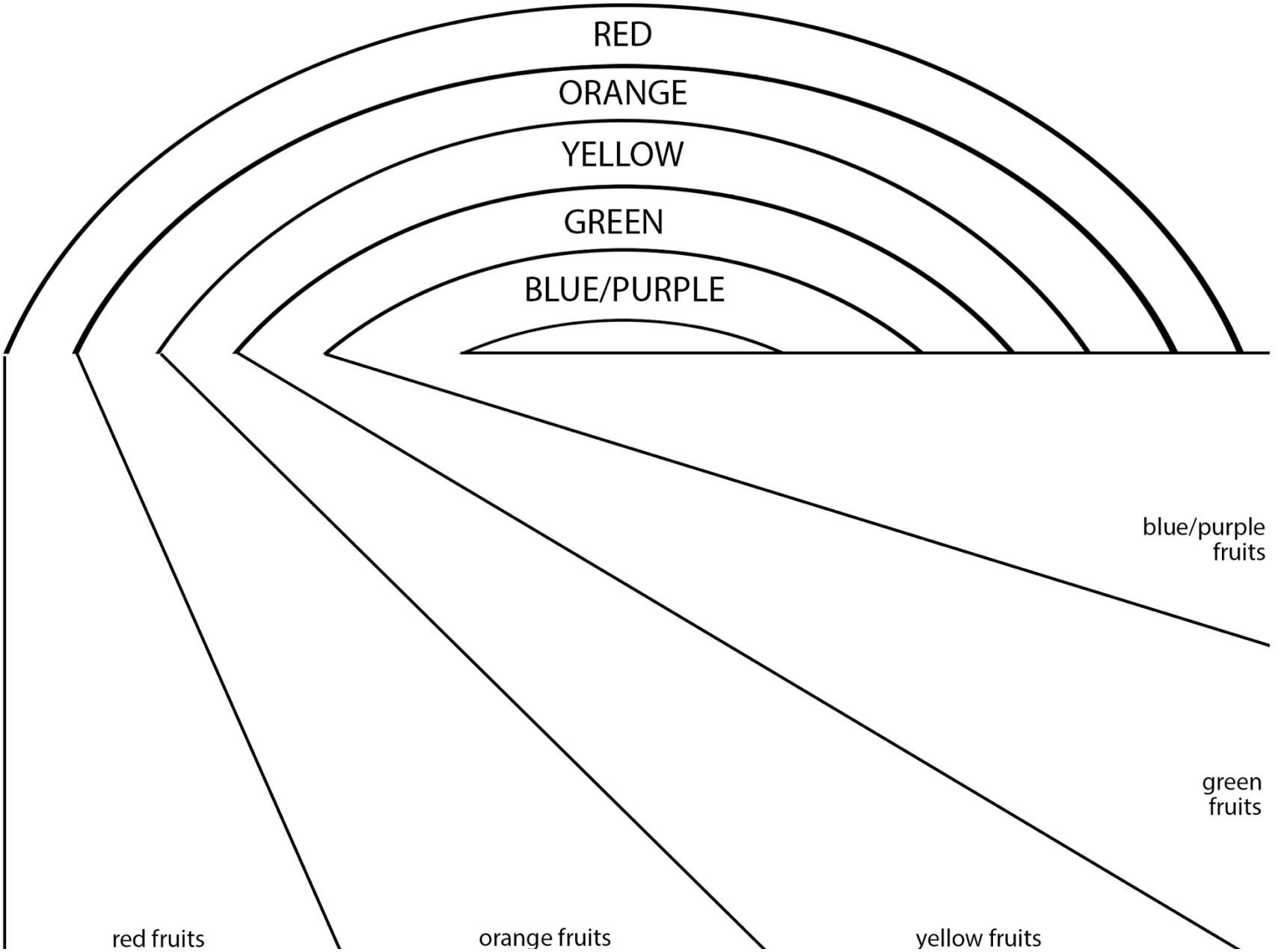
2. Why does a plant make fruit?
   A. Because it is pretty
   B. Because people like to eat them
   C. Because it helps protect and move the seeds
   D. Because it smells good

3. What is the difference between the scientific definition of a fruit and the common use definition of a fruit?

4. What are some vegetables we eat that are actually fruits?

5. What is your favorite fruit?

Eat a Rainbow Coloring Page



kidsGARDENING.ORG

LESSONS TO GROW BY

Plant Parts

In this unit, we are investigating important botany basics by studying plant parts. Take a look around your yard or a nearby green space and you will most likely notice a great diversity of plants. From tall trees with woody stems to the soft, creeping grass along the ground, plants can be found in a wide variety of colors, shapes, and sizes. Despite their differences in appearance, plants share a common set of parts. Learning about how the different parts function is essential to exploring plant growth and development. This foundational knowledge also contributes to our understanding of how to care for the plants in our gardens and environment.

Module 6: Seeds

Learning Objectives:

This module focuses on the structure of seeds. Kids will:

- Discover seeds contain baby plants inside.
- Explore the diversity of seeds in appearance and conditions needed for germination.
- Consider the importance of seeds in our world.

After a sunflower's petals drop, the center develops into a disk filled with seeds.

Materials Needed:

Activity 1: Inside a Seed

- Dried lima beans (from the soup bean aisle at the grocery store)
- Paper towels
- Hand lens (optional)
- Inside a Seed Observation Page
- Inside a Seed Worksheet
- Small, clear cups
- Construction paper (optional)

Activity 2: Sorting Seeds

- A mixture of seeds of different colors, textures, and sizes.
  A bag of mixed dried beans from the grocery store soup aisle will work, or you can save seeds from fruits and vegetables you eat. Old seeds from outdated seed packets are also

great for this exploration. Or you may also be able to find seeds through a nature walk outdoors (fluffy seeds like dandelion and cattail can be a lot of fun for comparison). Large seeds like beans, corn, peas, and squash are easiest for young kids to handle.

- Seed Sorting Worksheet

Activity 3: The Importance of Seeds

- The Importance of Seeds Reading Page
- Seeds collected from fruits and vegetables (optional)
- Soil (optional)
- Containers (optional)

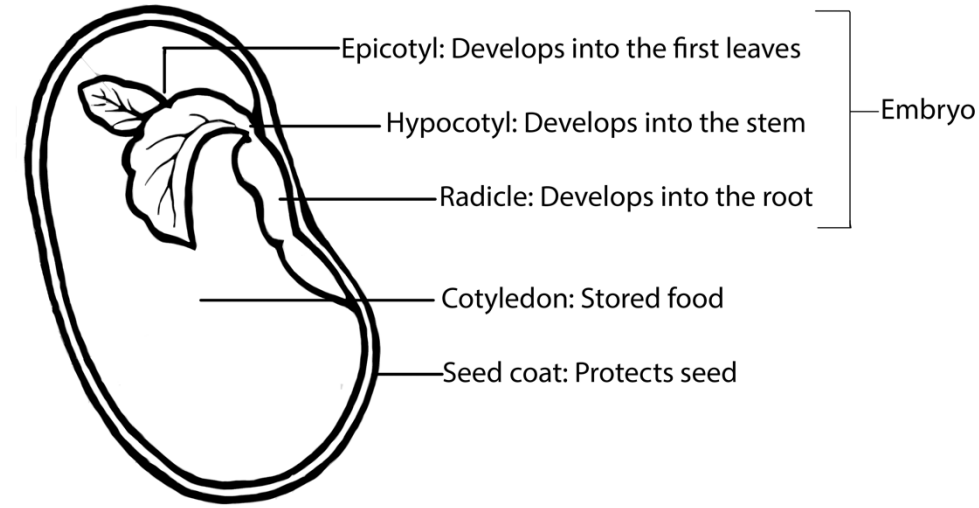
Introduction

Seeds grow the next generation of plants. Inside every seed is an embryo which is the part that actually grows into the new plant. Each embryo is made up of the epicotyl (epp-eh-COT-uhl) which develops into the first leaves, the hypocotyl (high-poe-COT-uhl) which develops into the stem, and a radicle which develops into the root.

Additionally, the seed also contains a lunchbox of sorts. The embryo is surrounded by stored food that is used by the baby plant until it can start making its own food through photosynthesis. This stored food is called the endosperm (EN-doe-sperm) or cotyledon (cot-eh-LEE-don). (Some seeds have one cotyledon and some have two). Because seeds have their own source of nutrients to sustain them through early life, they do not require additional nutrients from the soil until their roots have time to become

established. The proteins, fats, and carbohydrates stored for the benefit of the young plant are what make seeds such a rich and vital food source for humans and other animals.

Anatomy of a Bean Seed



The seed is covered by a seed coat that protects the embryo and ensures it does not germinate until environmental conditions are optimal for growth. Germination is the botanical term for sprouting. Most seeds just need moisture and warm temperatures for germination. Water is taken in through the seed coat and the embryo's cells begin to enlarge and the seed coat breaks open. The root will extend outwards first, followed by the unfurling of the stem and leaves.

Seed Germination Adaptations

However, some plants' seeds have evolved to require special treatment beyond moisture and warm temperatures for germination to begin. Two common treatments needed are exposure to cold temperatures (also called stratification) and exposure to conditions that cause chemical or mechanical damage to the seed coat (also known as scarification). These special treatments evolved as survival mechanisms.

For example, the seeds of some plants that are native to cold-winter regions need a certain amount of exposure to cold temperatures before they germinate. If a seed dropped to the ground in the fall, would it be a good idea for it to begin growing and be a young seedling right before winter arrived? Of course not, which is why this built-in need for a period of cold before sprouting is so important.

Other seeds germinate better in dark conditions (an example is a pansy seed) and others germinate better when exposed to light (an example is a lettuce seed). There are even some tree seeds, such as those of certain pines, that must be exposed to fire before they germinate. This adaptation helps repopulate forest areas after wildfires.

The circle area shows a tiny embryo with two baby leaves inside the peanut.

When you purchase seeds, you will likely find planting instructions on the seed packet. If you collect seeds from nature, you may need to research their germination requirements.

Do All Seeds Germinate?

Even with the freshest seeds you will not get 100% of them to sprout. Seeds may be damaged by environmental conditions (too dry, too wet); they may not be fully mature; or they may possess genetic defects that hamper growth. Many seed companies include the expected germination rate on their packets. Measuring germination rates and expressing the results in charts or graphs makes an excellent math lesson.

Activity 1: Inside a Seed

1. Give kids a couple of dried lima beans to observe. Have them draw a picture of one of the beans on their Inside a Seed Observation Page and make notes about its appearance. What does it look like? What does it feel like?

2. Place the lima bean seeds in a container and fill it with water until the seeds are covered. Soak for at least 2 hours or overnight. You will want to have at least two seeds per child, but more can be helpful.

2. After the seeds have finished soaking, take them out of the container and place on a paper towel. Ask kids to draw what their bean seed looks like now and add additional observations. Did anything change? What does it look and feel like now?

3. Next, let them dissect their bean seed. Have them begin by carefully peeling away the seed coat, which should be loose after being soaked in water. Then very gently, have them split the seed in half. Inside the seed, they should be able to find a tiny embryo and possibly also remove it from its cotyledons. The tiny embryo is delicate and easily broken when the seed is split open, which is why it is good to have back-up seeds available. Use the diagram on the Inside a Seed Worksheet to help kids

identify each of the parts. Have them record their observations and draw a third picture on their Observation Page. Look at the embryo with a hand lens if available.

Extension: To extend the lesson, you can make seed viewers to watch the seeds fully sprout. You can use new lima bean seeds or use the ones you have already soaked in water but did not dissect. You can also try seeing what happens if you to the embryos from the dissected beans that were separated from their cotyledons.

To make a seed viewer:

- Cut a piece of construction paper into a rectangular strip to fit inside the plastic cups. This is optional, but it helps with viewing.
- Ball up a few pieces of paper towels and place them inside the construction paper liner until the cup is full.
- Place 3 to 4 beans in the cup between the side of the cup and the paper towels or construction paper liner so the seeds are visible from the outside of the cup.
- Gently water the paper towels in the center until saturated.
- Place the cup (or cups if you would like to try multiples) on a shelf or windowsill and watch them grow. First you will notice the seed coat expanding (wrinkling) as the seed absorbs water. The root will start to grow in 2 to 3 days. Water as necessary to keep the paper towel and seeds continually moist. (Please note: seeds in the viewers will not grow well outside because they will dry out too quickly so it is best to grow them indoors). Seed germination can be impacted if the temperatures are too cold (if you are comfortable, most likely your seeds will be too).
- After the roots emerge, the stem and leaves will begin to appear. You can continue to grow your plant as long as you want for observation; however, seeds that have been sprouted this way generally do not transplant well out into the garden, and they will not be able to go grow to maturity in the cup.

In this seed viewer, the bean seeds were placed between the moist paper towel and the side of the cup.

Activity 2: Sorting Seeds

1. Seeds come in so many different sizes, shapes, colors and textures. Give each child 10 to 15 assorted seeds. Help them brainstorm ways they are alike and how they are different.

2. Ask them to brainstorm different ways we could sort them based on the way they look. Give some examples for grouping such as: rough and smooth, dark colored and light colored, large and small.

3. Use the Seed Sorting Worksheet to help them come up with properties to sort their seeds. Below is a possible example of a chart that would allow you to sort them by size, shape, color and texture. (Feel free to use your imagination and come up with other properties. Smell, weight, and ability to float are other characteristics that have been suggested. Then below each characteristic, insert different adjectives you can use to describe them.

Sample Chart:

Size	Shape	Color	Texture
huge	oval	brownish	rough
tiny	round	tan	fuzzy
big	pointed	spotted	smooth
long		red	bumpy

4. Once you have created a chart, sort your seeds by each of these characteristics. Do all the same seeds fit in the same categories in each column? Do you think the appearance of the seed is related to the final appearance of the plant?

Extension: Plant some of your seeds and compare their growth. Do they all germinate? Can you figure out the germination rate? Do you think any of your seeds had special germination needs? Alternatively, showcase the diversity in appearance of the seeds by making seed mosaic art using construction paper and craft glue.

Activity 3: The Importance of Seeds

1. Together or independently, read the Importance of Seeds Reading Page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. One of the reasons seeds are very important to people is because they make new plants and plants are an important part of our diet. With many plants we eat the fruits and vegetables that develop around the seeds. However, we also eat seeds directly, too. Go on a hunt for seeds we eat in your kitchen and pantry. Some examples of things you might find include: pumpkin seeds, tree nuts, sunflower seeds, peanut butter, peas, corn, and beans. Many of our cereal grains like wheat and oats are seeds too.

3. Explain to kids that in addition to the baby plant, seeds also contain the stored energy/food that plants need to grow until they can make their own food. Share how seeds are kind of like a lunchbox for the baby plant. The proteins, fats, and carbohydrates stored for the benefit of the young plant are what make seeds such a rich and vital food source for humans and other animals.

4. Celebrate seeds with a fun seed snack. From roasted pumpkin seeds to popcorn, seeds are an important part of our diet.

Extension: You can extend the kitchen-based seed fun by saving seeds from your fruits and vegetables and planting them in soil. Some good candidates to try include orange, avocado, pepper, and tomato seeds.

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books and Additional Resources

A Seed is Sleepy by Dianna Aston

A Fruit is a Suitcase for Seeds by Jean Richards

Pumpkin Circle by George Levenson

Because of an Acorn by Lola Schaefer and Adam Schaefer

Little Acorn by Scholastic

Sunflower House by Eve Bunting

The Donkey Egg by Janet Stevens

The Reason for a Flower by Ruth Heller

Videos

Christine's Kitchen Scrap Gardening Video:
https://www.youtube.com/watch?v=UYKiS68Vf4c

The Crop Trust, Feeding a Growing World:
https://www.youtube.com/watch?v=UGAMn4LALIs

Bean Time-Lapse from GPhase:
https://www.youtube.com/watch?v=w77zPAtVTuI

Additional Related KidsGardening Lessons and Activities to Try

Journey to the Center of a Seed:
https://kidsgardening.org/resources/lesson-plans-journey-to-the-center-of-a-seed/

Germination Exploration:
https://kidsgardening.org/resources/lesson-plans-germination-exploration/

Seed Banks:
https://kidsgardening.org/resources/lesson-plan-seed-banks/

Kitchen Scrap Gardening:
https://kidsgardening.org/resources/garden-activities-kitchen-scrap-gardening/

Seed Balls:
https://kidsgardening.org/resources/garden-activities-seed-balls/

Save Your Seeds:
https://kidsgardening.org/resources/garden-activities-save-your-seeds/

Seed Viewer:
https://kidsgardening.org/resources/garden-activities-seed-viewer/

Seed Catalog Fun:
https://kidsgardening.org/resources/garden-activities-seed-catalog-fun/

When to Plant Seeds:
https://kidsgardening.org/resources/gardening-basics-when-to-plant-seeds/

Indoor Seed Starting:
https://kidsgardening.org/resources/gardening-basics-indoor-seed-starting-qa/

Transplanting and Direct Seeding:
https://kidsgardening.org/resources/gardening-basics-transplanting-and-direct-seeding/

Saving Seed:
https://kidsgardening.org/resources/gardening-basics-saving-seeds/

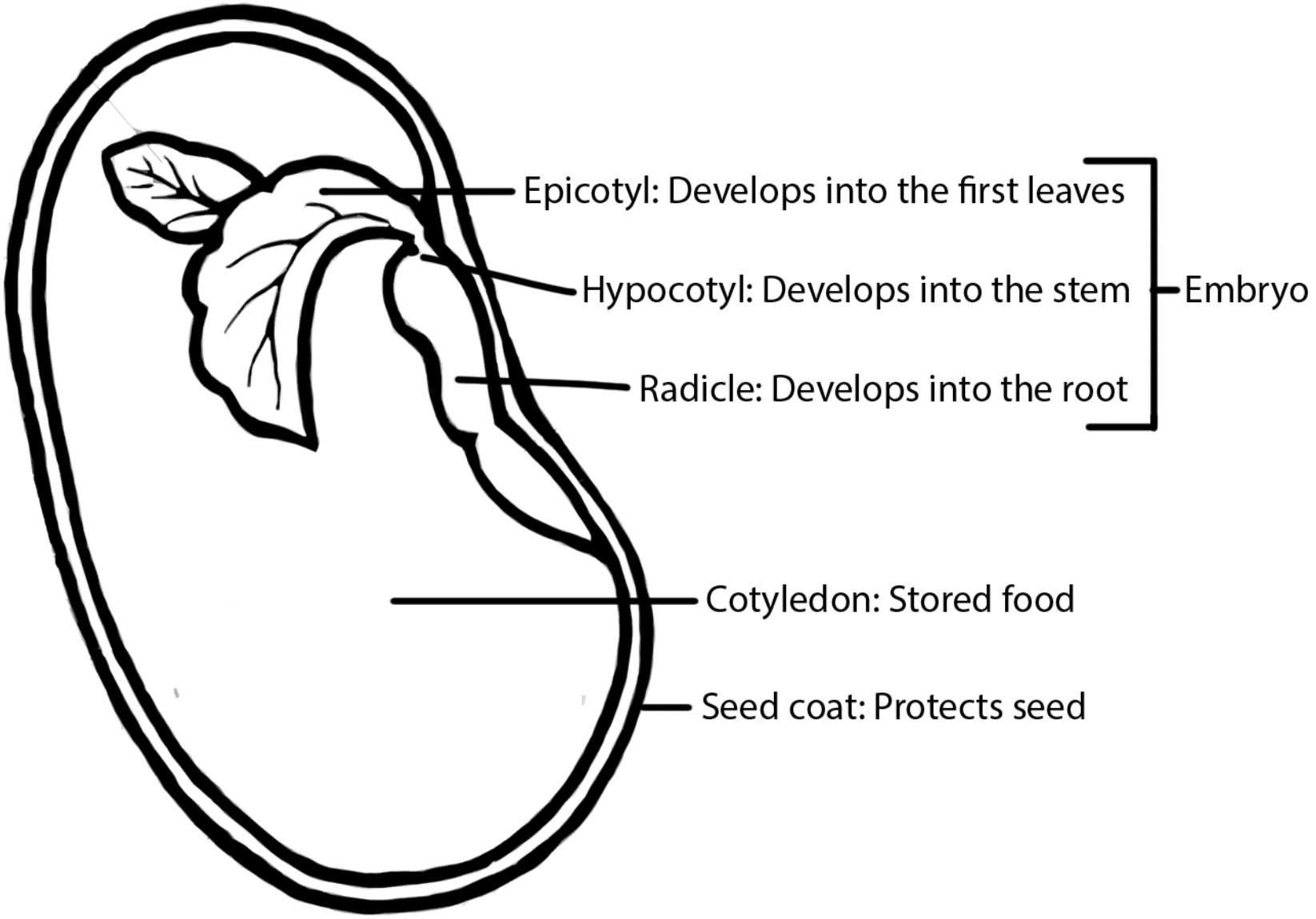
Growing and Saving Heirloom Seed:
https://kidsgardening.org/resources/digging-deeper-heirloom-seed-saving/

Starting Seeds for Hydroponics:
https://kidsgardening.org/resources/digging-deeper-starting-seeds-for-hydroponics/

Inside a Seed Observation Page

Draw your bean seed before adding water:	Draw your bean seed after it has been soaked in water:	Draw what you find on the inside of your bean seed:
Share observations about the dry bean seed:	Share observations about the wet bean seed:	Share observations about the inside of the bean seed:

Inside a Seed Worksheet



Seed Sorting Worksheet

	Characteristic 1:	Characteristic 2:	Characteristic 3:	Characteristic 4:
Description 1:				
Description 2:				
Description 3:				
Description 4:				

The Importance of Seeds

Lessons to Grow By - Plant Parts Reading Page

Look closely at the peanut in the circle and you can see the tiny plant (embryo) with two baby leaves.

Have you ever thought about a seed being a superhero? A living thing with extraordinary powers that can step in and save the day?

Inside of each seed is a baby plant just ready to grow. Plants make oxygen for our air and food for all other living creatures. They help keep our soil in place and clean our water. We use them to make medicine, shelter, and lots of other products we need to survive.

Quite simply, life would not exist on this planet without plants. Seeds are the way most plants make new plants.

In addition to plants being important in general, it is also very important that there are lots of different kinds of plants in our world. When there are lots of different kinds of living things in the ecosystem it is called biodiversity. Why is it important for our ecosystem to have many different types of members?

What if we had only one type of tree in our forests and a big insect population came in and ate all of the leaves off that particular type of tree? Or what if a disease infected the roots of plants we relied on for food. That actually happened!

White potatoes were a very important food crop in Ireland. However, in the mid-1850s a fungus started attacking the roots of the potatoes and it killed a majority of the potato plants in the country for many years in a row. People were so dependent on this one type of food that millions of people died because they did not have enough to eat. Millions more had to move to other countries that had more food available. This horrible time in history showed people how important it was to grow a variety of food crops so that if one was destroyed, there were other things that could be grown and eaten.

Seed Banks Keep Seeds Safe

To make sure this never happens again, scientists work hard to get people to grow lots of different types of plants. They also make sure to save seeds so that when natural disasters do hit (like fires, floods, and disease), we have back-ups to grow replacement plants. Scientists save these seeds in protected locations they call seed banks.

In a seed bank, seeds are kept in a cool (generally frozen), dry condition so that they do not sprout or rot. Seed banks are designed very carefully to be safe from people and the environment. However, seeds can't be stored forever. Every so often, the seeds are taken out of storage and used to grow new plants, which will in turn produce fresh seeds for storing in the seed bank. According to the United Nations, there are about 1,750 individual seed banks worldwide. Isn't it cool to think that there are millions of tiny seeds, just waiting to come save the day if needed? Seeds are superheroes!

Reading Comprehension Questions

1. True or false: Seeds contain baby plants.

2. List one of the reasons plants are important in our world:

3. What is it called when there are lots of different kinds of living things in an ecosystem?

4. What is a seed bank?

5. Draw a picture of what you think a seed superhero would look like:

kidsGARDENING.ORG

LESSONS TO GROW BY

Plant Needs

In this unit of Lessons to Grow By, we are exploring plant needs. For healthy growth and development, plants must obtain just the right amounts of light, water, air, and nutrients and they also need space to grow. These five requirements are the basic needs for all plant life. Fortunately for our world full of diverse environments, different plants need different amounts of each of these essentials so there are plants well adapted to grow in almost all environmental conditions. Through these activities, kids will investigate plant needs to better understand how to take care of their green friends while also gaining a deeper appreciation for how the living and nonliving elements in an ecosystem work together.

These houseplants are thriving under bright, full-spectrum LED grow lights.

Module 1: Light

Learning Objectives:

This module focuses on the plant need of light. Kids will:

- Learn about light and the different sources of light for plants.
- Investigate how the amount of light available to plants impacts their growth and health. Explore how plants are adapted to need different amounts of light.

Materials Needed:

Activity 1: Exploring Light

- Puzzled by Photosynthesis Worksheet
- Find the Light Worksheet
- Light meter or a light meter app (optional)
- Thermometer (optional)
- A prism or supplies to make your own prism (optional)

Activity 2: Light Experiments

- 4 to 5 potted plants of the same variety and approximately the same size (herbs in 4” pots work well) or
- Seed viewers (bean seeds, paper towels, clear plastic cups)
- Light Experiment Data Collection Worksheet

Activity 3: Sun versus Shade Plants

- Looking for Light Reading Page

Introduction

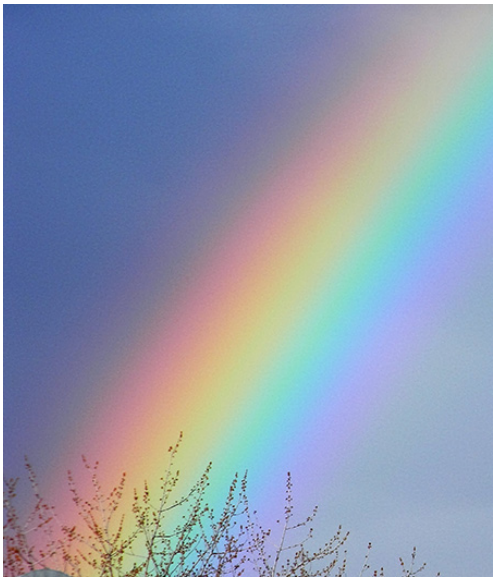
Light is among plants’ most critical needs. Plants capture light energy and use this energy during photosynthesis to help them convert carbon dioxide and water into carbohydrates — the food they use to live. Without light, plants starve and die. Beyond plant life, the food energy made by plants is the foundation of every food chain for all animal life too. All life on earth depends upon plants’ ability to photosynthesize and that process is dependent on the plant being able to capture light energy! For more background information about the process of photosynthesis, check out Photosynthesis 101 at: https://kidsgardening.org/resources/digging-deeper-photosynthesis-101/.

Plants vary in their light requirements — and these requirements can even vary depending on the plants’ stage of growth. It’s up to gardeners to evaluate whether a plant is receiving adequate light based on research as well as on observations of its growth.

Plants can get light from two sources: the sun and artificial lighting. Although outdoor plants generally rely on sunlight, plants can also be grown successfully indoors by using a variety of fluorescent and LED bulbs. Regardless of its source, light is measured in two ways: light quality, and light quantity. Although this is a bit advanced for younger gardeners, below is a bit of background information about these two measurements and what they mean for plant growth.

Light Quality

Light energy radiates from a source in electromagnetic waves of different lengths and frequencies. Some of these waves aren’t visible to humans, but those we can see are perceived as different colors. Visible light with the longest wavelength and lowest frequency is seen as red, and that with the shortest wavelength and highest frequency is seen as violet. Orange, yellow, green, and blue fall in between. When all visible wavelengths are combined, the light appears to be white or colorless, like sunlight. However, when you separate the light, as with a prism, you can see all the colors in the spectrum.



Water droplets in a rainbow act like prisms, revealing all the colors in the visible spectrum.

Light is either reflected or absorbed by objects. When you look at an object, the color you see is actually the color of light that the object reflects. If the object is white, it’s reflecting all the waves and absorbing none; if it’s black then it’s reflecting none of the waves and absorbing them all. Thus, plants appear green because they are reflecting the green light waves and absorbing all the others.

Sunlight provides the full spectrum of light; however, artificial lights may offer a more limited spectrum. Here is a brief description of the quality of light provided by common grow light bulbs:

- **Cool white bulbs** emit wavelengths primarily from the blue/violent end of the spectrum.

- **Warm white bulbs** emit wavelengths primarily from the red end of the spectrum

- **Wide-spectrum and full-spectrum bulbs** emit wavelengths from all the colors of the spectrum; these lights come the closest to mimicking sunlight.

Red and blue light are the most important for plant growth, impacting photosynthesis and flowering. A mix of 90% red light and 10% blue light provides the balance of light colors needed for most plant growth.

Fun fact: In a controlled environment where lights only radiate red and blue wavelengths, plants appear purple.

Light Quantity

Light quantity is determined by both intensity and duration.

Light intensity is the measurement of the amount of light reaching a plant (or other object). Intensity is a combination of two factors: the brightness of the light and the distance between the light and the plant (or other site of measurement). With respect to a light of a specific brightness, the closer that light is to the plant, the higher the light intensity.

Light intensity is measured in terms of foot-candles or lux. One foot-candle is the amount of light produced in a totally dark space by one candle shining on a white surface measuring 1 square foot that is 1 foot from the candle. One lux is the amount of light that shining on a surface that is 1 meter away. To convert between the two measurements: 1 foot-candle = 10.764 lux.

To provide some perspective, average office light is 300-500 lux, or 30 to 50 foot-candles and the light at noon on a sunny day may be as bright as 10,000 foot-candles or over 100,000 lux. Although the duration and intensity of sunlight far exceeds the capacity of indoor lighting, there are many flowers, vegetables, and herbs that can grow well with the 1,000 to 1,500 foot-candles of light provided by grow lights, (To achieve this, most grow lights should be suspended just a few inches above the tops of the plants.)

Light duration can help compensate for less-than-ideal light intensity. Outdoors, many common garden plants need an average of 6 to 8 hours of sunlight per day. Under grow lights, since light is less intense, plants would need exposure to 14 to 16 hours per day to achieve adequate light quantity.

So, is more light always better? Longer light duration doesn't necessarily make plants produce more abundantly. Most plants actually require a daily period of darkness in order to complete respiration – the process whereby plants convert the products of photosynthesis into usable energy. Some plants even require a certain period of uninterrupted darkness to trigger flowering. Therefore, it is not beneficial to grow plants under lights left on 24 hours a day.

Activity 1: Exploring Light

1. Plants need light to grow. Explain to kids that plants use light to make food through a process called photosynthesis. Just like people need to eat food to grow and function, plants also need to make food to grow and function, but they don't need to go to the grocery store. They can make their own food in their leaves.

2. Use the Puzzled by Photosynthesis Worksheet to explain the process of photosynthesis from a broad perspective. In very basic terms, water is absorbed from the roots and transported to the leaves. At the same time, leaves take in carbon dioxide from the air. Inside the leaf, structures called chloroplasts absorb light energy from the sun (or another light source) and use this energy to

complete a chemical reaction between the water and carbon dioxide that results in the formation of sugars and oxygen. Using the worksheet, kids can cut out the puzzle pieces and glue them into the diagram.

3. Ask kids the question, Do you think plants must have light from the sun? What other sources of light are available?

4. Go on a light hunt and search for other sources of light, such as fluorescent and LED light bulbs. Share with kids that light bulbs give off light energy similar to the sun, although it is not as bright or intense as the light we get from the sun, and may not contain the full spectrum of colors.

   Next, encourage kids to use their senses to compare sunlight and artificial light. You can use the Find the Light Worksheet to record your observations. Ask them to describe if their eyes feel different when they are in sunlight versus indoor light? (Remind them to never look directly at the sun!) Next, ask them to close their eyes. Does the sunlight make their skin feel warm? Does light from artificial light sources give off heat? Which is warmer? If you have access to a light meter, you can use it to compare the light intensity of artificial lights versus sunlight measured in lux or foot-candles. If you do not have a light meter, there are also some apps that are designed to measure light intensity that you can try, or just use observation.

5. Next, compare variations of light available outdoors. Try standing in areas that are shaded and compare with spots in the full sun. Can you find different degrees of shade or light? How is shade under a tree different than shade under a roof? If you have a thermometer, see if you can record a difference in temperature in different locations.

6. Finally, ask kids to explore how sunlight availability changes throughout the day, both indoors and outdoors. Choose a few spots to monitor (such as near a couple of windows facing in different directions, areas near trees, areas out in the open) and visit a couple of times a day to see if the amount of sunlight and/or artificial light in each location receives changes. What does this mean for the plants located there? How much light do they actually get each day?

7. Extend the Activity. All of the above observations help kids explore light quantity, including intensity and duration. For more advanced students, you can also explore light quality. Introduce kids to the different wavelengths of light which we visually see as different colors of the rainbow. Try these activities using prisms to separate out the different wavelengths of light and compare sunlight with different types of artificial lighting:

NASA's Discovering Color With a Prism:
https://www.nasa.gov/pdf/350512main_Optics_Discovering_Color.pdf

The Lawrence Hall of Science's Make a Prism:
http://static.lawrencehallofscience.org/diy_sun_science/downloads/diy_ss_make_a_prism.pdf

Activity 2: Light Experiments

1. One of the best ways for kids to understand the impact of light on plant growth is to watch the same kind of plants grow in different locations with different amounts of light available.

   Challenge your kids to brainstorm ideas for creating a light experiment. Explain to them that since the goal is test the impact of light (quality and quantity) on plants, you need to limit the number of variables that might impact your results. Here are some tips for their experiment:
   - Use the same size containers
   - Grow the same kind of plants

- Try to find plants that are approximately the same size and health at the start of your experiment
- Make sure to maintain the same soil moisture levels. (Note that plants in shady locations may take up less water, so they may need less frequent watering).
- Try to control temperature levels, or if temperature does vary, make sure to record the variation.

If you do not have any potted plants readily available, you can also start some seed viewers of bean seeds to experiment with.

To make a seed viewer:

- Cut a piece of construction paper into a rectangular strip to fit inside the plastic cups. This is optional, but it helps with viewing.
- Ball up a few pieces of paper towels and place them inside the construction paper liner until the cup is full.
- Place 3 to 4 beans in the cup between the side of the cup and the paper towels or construction paper liner so the seeds are visible from the outside of the cup.
- Gently water the paper towels in the center until saturated.
- Place the cup (or cups if you would like to try multiples) on a shelf or windowsill and watch them grow. First you will notice the seed coat expanding (wrinkling) as the seed absorbs water. The root will start to grow in 2 to 3 days. Water as necessary to keep the paper towel and seeds continually moist.

Seed viewer

*Please note: Seeds in the viewers may not grow as well outside because they will dry out too quickly, so they may be best for testing different light availability indoors.

2. Once your locations are selected and plants are placed, track plant growth using the Light Experiment Data Collection Worksheet or your garden journal. You can either describe the light intensity of each location, or use a light meter to determine the intensity of each location.

3. Depending on the kind of plants you choose to grow, it may take a while to see the impact of the different light levels. If possible, continue to track your plants for 4 to 6 weeks.

4. Compare your results. Did you find any differences in plant growth based on the amount of light available? Do you think your plants tried to adapt to the different amounts of light? Did the plants change in appearance depending on the amount of light? Did leaves get bigger? Did stems get longer?

5. Extend the Activity. As interest and time allow, expand your experiment to observe the impact of varying light on different varieties plants.

Activity 3: Sun versus Shade Plants

1. Together or independently, read the Looking for Light Reading Page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Fortunately for us, plants are adapted to need different amounts of light so they are capable of surviving in all kinds of environments. Plan a nature walk to look for plants growing well in the sun or

the shade in your area. Take pictures as you go and at the end of your trip, you can compare and contrast the characteristics of the plants you find.

3. Another great place to observe differences in sun- versus shade-loving plants is your local garden center. At the center, plants will typically be grouped by light requirements, and many times they may even labeled as sun-lovers or shade lovers, making it easy for you to compare the two groups of plants. As they walk through the aisle, have kids make a list of some of their favorite sun-loving and shade-loving plants they see.

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books and Additional Resources:

Seed School by Joan Holub

Jack's Garden by Henry Cole

Up in the Garden and Down in the Dirt by Kate Messner

Plantzilla by Jerdine Nolen

A Place to Grow by Stephanie Bloom

Videos:

Make a Plant Maze from the Potomac Valley Audubon Society:
https://www.youtube.com/watch?v=X-4vUXMMPTU

GPhase Time Lapse of Garden Cress Growing Towards Light:
https://www.youtube.com/watch?v=DhITXtENPrU

Phototropism Time Lapse of Radish Plants from Vito Pettito:
https://www.youtube.com/watch?v=G4Mo9-JAeok

Additional Related KidsGardening Lessons and Activities to Try:

Let There Be Light:
https://kidsgardening.org/resources/lesson-plan-let-there-be-light/

Photosynthesis Runs the World:
https://kidsgardening.org/resources/lesson-plan-photosynthesis/

Photosynthesis 101:
https://kidsgardening.org/resources/digging-deeper-photosynthesis-101/

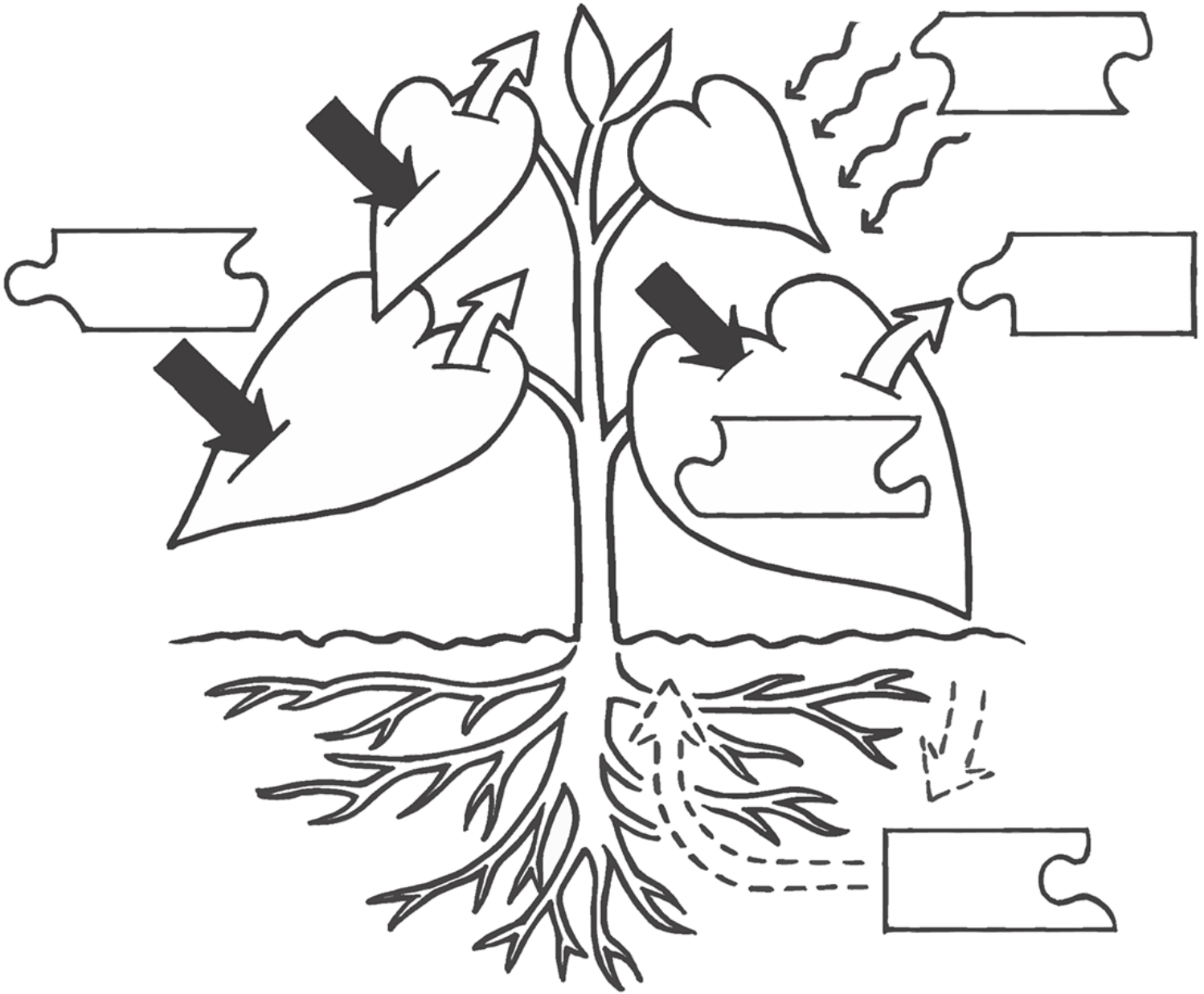
Tropical Rainforests:
https://kidsgardening.org/resources/lesson-plan-tropical-rainforests/

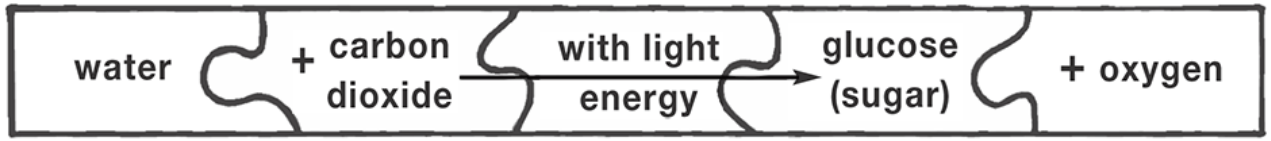
Plants in Space:
https://kidsgardening.org/resources/lesson-plans-plants-in-space/

Photoperiodism: Can Plants Tell Time
https://kidsgardening.org/resources/digging-deeper-photoperiodism-can-plants-tell-time/

Puzzled by Photosynthesis Worksheet

NOTES:





Find the Light Worksheet

Location	Source of Light	Time of Day	Describe what the light looks like. (If you have a light meter, record the intensity.)	Describe what the light feels like. (If you have a thermometer, record the temperature.)	Are there any plants growing here? Do they look healthy?

Light Experiment Data Collection Worksheet

Date	Location	Source of Light	Intensity* (brightness)	Hours of Light Per Day	Temp.	Plant Height	Appearance of Plant	Additional notes on treatment or observations:

*Rate the light intensity (how bright the light is) on a scale of 1 to 5, with 1=very bright, 5=very dark.

Looking for Light

Plant Needs - Reading Page - Light

Their name says it all! Sunflowers need lots of bright sunshine to produce their beautiful blooms.

Plants need light to live and grow. Plants have the special ability to make their own food through a process with a very long name: **photosynthesis** (foe-toe-SIN-the-sis). Through this process they catch light energy in their leaves and then use that energy to turn air and water into food. Not only do plants use this food for themselves, but all other living creatures rely on the food plants produce too.

Where does the light that plants need come from? Most plants growing outdoors gather the light they need from the sun. However, plants can also be grown indoors where they get light from different kinds of light bulbs. Some light bulbs are specifically designed to provide light for growing plants.

Do all plants need the same amount of light? Have you noticed how some plants grow out in the open in full sun, but others grow underneath other plants and spend a lot of time in the shade? Lucky for us, not all plants need the same amount of light.

Some plants need a lot of sunlight to meet their needs and we call these full-sun plants. Common examples of full-sun plants include tomato plants, roses, and fruit trees. Other plants need less light to grow and they need the protection of other plants or shade structures to be happy. Some examples of shade-loving plants include ferns, coleus, and many houseplants. Most plants are somewhere in between full sun and shade.

A tropical rainforest is a perfect example of how plants in the same ecosystem have special adaptations to survive with different amounts of light. A rainforest has 3 different layers of plants – the canopy, the understory and the forest floor.

- The **canopy** is made up of the large trees which need lots of light to be happy. This layer also includes vining plants that climb up the trees so they can get lots of sunlight too.
- The **understory** is made up of plants that are medium-sized in height. Understory plants can live in lower light levels — only 2 to 5 percent of the sunlight hitting the rainforest reaches this layer.

These houseplants are thriving indoors under "grow lights" — light bulbs specifically designed for growing plants

- Finally there is the **forest floor**. Very little light reaches the forest floor and plants like ferns grow in this layer.

A lot of our common houseplants were originally from the understory and floor of the rainforest because indoor lights are not as bright as sunlight.
What happens if plants do not get enough light? Since plants cannot get up and move if they are not getting enough light, they may make other changes in how they are growing. If plants are not getting enough light, you may notice the following:

- **Larger leaves**. Plants will start producing larger leaves to try and capture more sunlight.

- **Longer stems.** Plant stems may start to look long and skinny with fewer leaves as they try to put all their energy into stretching their stems to find more light.

- **Slower growth**. Remember that light is needed for plants to make food. So if plants are not getting enough light, they may not be making as much food and so they will not grow as fast.

- **Fewer flowers.** Plants may stop producing flowers and fruit when they do not get enough sunlight. They are using all their food to just stay alive.

Plants can also have problems if they get too much light! They can get sunburned just like people and if too much light is combined with warm temperatures and not enough rain, they dry out very quickly. It is important for gardeners to find out how much light their plants need so they can plant them in a spot where they will be happy and grow well.

Reading Comprehension Questions:

1. True or false: Plants need sunlight to grow.

2. Plants typically make food in:
   - ☐ Roots
   - ☐ Stems
   - ☐ Leaves
   - ☐ Flowers
   - ☐ Fruit

3. True or false: All plants need the same amount of light to grow well.

4. Match the layers of the rainforest with how much light the plants growing in that layer receive:

Canopy	A little bit of light
Understory	A lot of light
Forest Floor	Almost no light

5. Which of the following is <u>not</u> a sign that a plant is not getting enough light:
   - ☐ Long and skinny stems
   - ☐ Bigger leaves
   - ☐ Slower growth
   - ☐ Lots of flowers and fruit

LESSONS TO GROW BY

Lessons to Grow By – Plant Needs

In this unit of Lessons to Grow By, we are exploring plant needs. For healthy growth and development, plants must obtain just the right amounts of light, water, air, and nutrients and they also need space to grow. These five requirements are the basic needs for all plant life.

Fortunately for our world full of diverse environments, different plants need different amounts of each of these essentials so there are plants well adapted to grow in almost all environmental conditions.

Through these activities, kids will investigate plant needs to better understand how to take care of their green friends while also gaining a deeper appreciation for how the living and nonliving elements in an ecosystem work together.

Module 2: Water

Learning Objectives:

This module focuses on the plant need of water. Kids will:

- Learn about the water cycle and the role plants play in this important natural process.
- Investigate how much water plants need and what happens if they get too little or too much water.
- Compare the benefits and challenges of different kinds of watering methods.

Materials Needed:

Activity 1: Round and Round: The Water Cycle

- Round and Round Reading Page
- USGS Water Cycle Diagram, available at: https://www.usgs.gov/special-topic/water-science-school/science/water-cycle
- Indoor or outdoor plant(s)
- Plastic sandwich bag(s)

- Rubber band or twist tie or string(s)
- Terrarium supplies (optional)

Activity 2: Water Experiments

- 4 to 5 potted plants of the same variety and approximately the same size (herbs in 4” pots work well) or
- Seed viewers (bean seeds, paper towels, clear plastic cups)
- Water Experiment Data Collection Worksheet

Activity 3: Fulfilling Plants’ Water Needs

- Irrigation Comparison Worksheet

Introduction

Water is a critical component of all living things, including plants, and it plays an important role in basic functions and structure. It is also an element that is continually lost by organisms and therefore must also be constantly replaced.

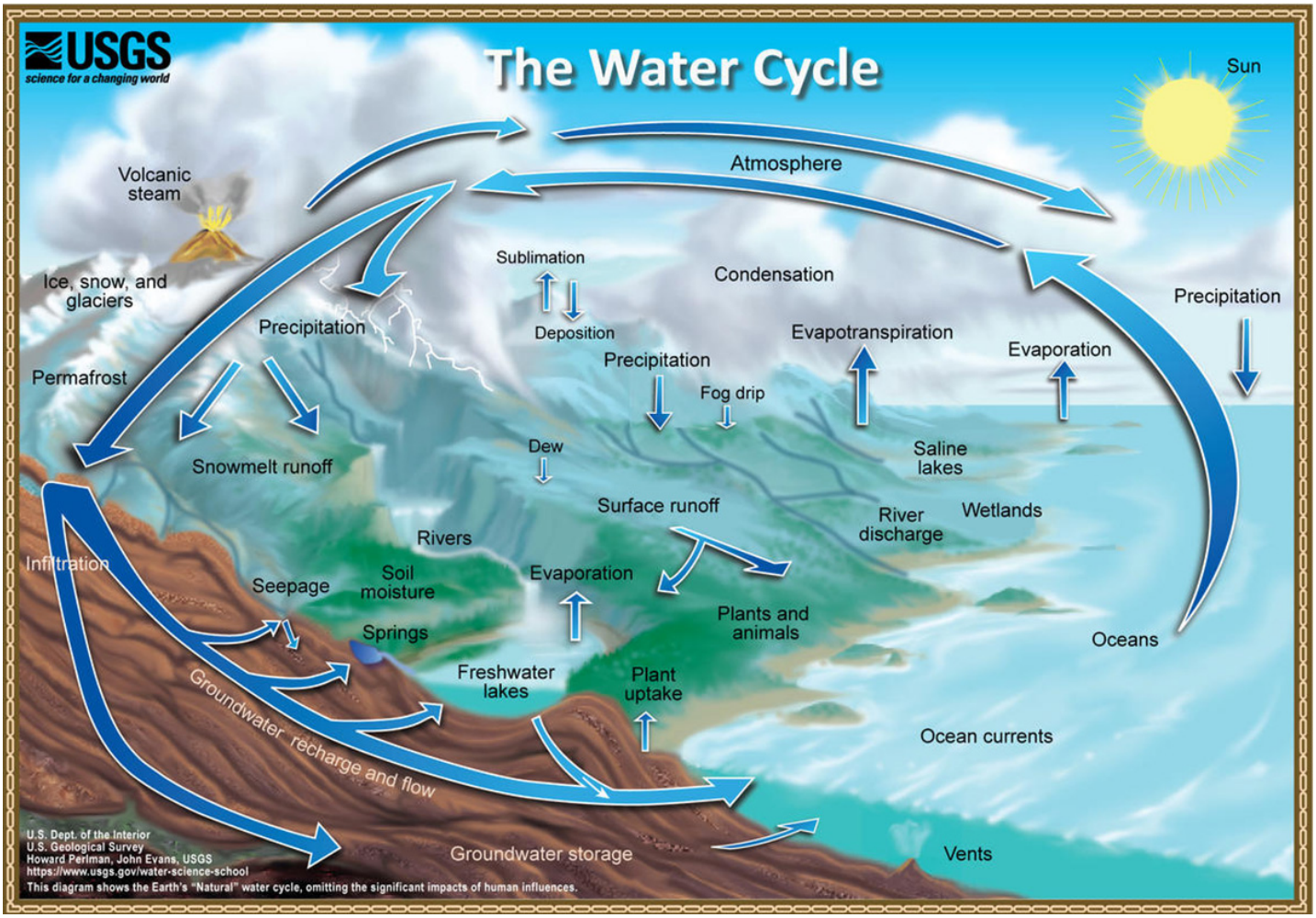
Most of the water used by plants comes from the soil. Water is absorbed by plant roots, moves up the stems and then into leaves. On this journey, it is used in plant cells as needed, and then some of it exits the leaves through small openings called stomata. This process is called transpiration, which is much like sweating in humans. The movement of water provides support for the plant and helps it adapt to varying conditions in its environment. Water is also a key component needed for photosynthesis which is how the plant makes food. There are some plants that are able to take in water through their leaves, but the vast majority of water used by plants enters through roots.

The Water Cycle

The cycling of water through the plant is also part of a bigger phenomenon known as the water cycle. In the water cycle, water vapor condenses in the air and then falls to land in the form of rain. When water hits land’s surface, it follows one of two main pathways — either it infiltrates into the soil or it runs off into local streams, lakes, and rivers.

Infiltration of water into the soil provides many environmental benefits. Healthy soil works like a sponge, soaking up water and allowing it to be processed slowly into the environment while impurities are removed. The presence of plant roots in the soil is very important for creating healthy soil and aiding in this infiltration process.

Plants then take up the water in the soil and use it to sustain their basic functions, including making the food energy for all life through photosynthesis. The plants also release water vapor into the air through transpiration — and then water cycle begins again.



The Water Cycle. Credit: Howard Perlman, USGS. https://usgs.gov/media/images/water-cycle-natural-water-cycle

Water Use and Plant Adaptations

The speed at which a plant takes in and uses water depends on a number of factors, including the size of the plant and the environmental conditions the plant is living in. Smaller plants generally use less water, while larger plants usually need larger quantities. Temperature and sun exposure — which can vary by season and location — are also critically important. Plants in hot, dry climates will lose water more quickly. Plants in cold climates will lose water more slowly. During the winter, many plants drop their leaves and enter a dormant state where they hardly use any water at all.

Because the amount of water available varies greatly in different environments, plants have developed different adaptations to help them survive the conditions they live in. Plants like cacti that live in deserts where water is scarce have modified leaves that decrease the rate of transpiration and stems that have a special ability to store extra water. Tropical plants in a rainforest where water is plentiful have pointy tips (drip tips) and waxy surfaces that help water slide off quickly. These help prevent water buildup that could lead to decay and mold.

Water: A Precious — and Endangered — Resource

Water is one of our most valuable resources. Unfortunately, it's rapidly becoming one of the most endangered. Water shortages loom as growing cities and suburbs bring increased demands in concentrated areas, and droughts threaten various regions every year. Adopting efficient watering practices that provide just the right amount of water plants need should be a priority for all gardeners because it conserves water and boosts plant health.

When we are lucky, Mother Nature provides most of the water our plants need through rain. However, for indoor plants, and for many outdoor plants too, gardeners frequently need to provide supplemental water. Here are some wise watering techniques to teach kids to make sure they know how to efficiently use water in their gardens:

When to water. Irrigate during early morning hours. Much water applied in the heat of the day is lost through evaporation. Evening watering can contribute to disease problems because plant leaves stay wet longer. Avoid watering during windy periods because wind increases water loss.

Where to apply water. Since plants absorb moisture through their roots, it makes most sense to apply water to the soil. Watering leaves is inefficient and can lead to disease problems. Soaker hoses and drip irrigation, which apply water directly to the soil, conserve water compared to overhead sprinklers (More on this below.) If your garden is in a dusty area, however, rinse plants occasionally if dust builds up on leaves.

Watch the weather. As best you can, adapt your watering schedule to weather and changing seasons. Although watering every Monday and Wednesday might be convenient for you, it may not be the right schedule for your plants.

How much to water. It is better to water thoroughly a few times a week rather than a little bit every day. For most plants, you want the soil to absorb water to a depth of 6 to 8 inches to encourage deep, strong root growth. For large plants like trees and shrubs, water until soil is moist to a depth of 8 to 12 inches. For all but new seedlings and fast-growing, shallow-rooted plants, allow soil to dry to a depth of 1 inch before watering again.

Avoid runoff. Avoid letting your irrigation water run off onto paved areas or down storm drains. If you notice runoff, apply water more slowly in cycles, taking small breaks between applications to allow the soil time to soak up moisture.

Know your soil. How fast your soil absorbs water will vary by soil type and amount of organic matter in the soil. Clay soils are slow to absorb water but tend to hold moisture longer, so they need less frequent watering. Sandy soils drain quickly and do not hold water well, so they dry out faster. Adding compost and other organic matter to your soil will improve water penetration in clay soil and water retention in sandy soil.

Keep moisture in the soil. Mulch beds and around the base of trees (but don't pile mulch up against tree trunks) to decrease water loss from evaporation. Mulch also helps regulate soil temperature and decrease weed growth.

What to plant. Choose plants adapted to your weather, climate, and soils. Native plants adapted to the conditions in your garden are often a good choice because their moisture needs have evolved within regional weather patterns. Group plants with similar water needs. It's better for the plants and makes your job easier.

Choosing an Irrigation Method

There are many different ways to deliver water to plants. Below is background information about the most common watering techniques that you can use to help kids complete Activity #3.

Hand Watering

This method is usually the cheapest in terms of equipment costs. By using proper techniques, it can also be an efficient use of water. As you use a hose or watering can to irrigate you can be selective, watering each plant or plot as it needs. You can monitor how far moisture penetrates into the soil and adjust your watering time as necessary. It's important to apply water directly to the soil beneath the plants and to avoid excessive runoff onto sidewalks and other paved surfaces.

If you choose to use watering cans, select models that are the right size for your gardeners to avoid spills and injury. Remember that a gallon of water weighs 8 pounds, so cans get heavy quickly! Fortunately, watering cans are available in many different sizes. Or you can save money by using half-gallon or gallon milk and juice jugs with handles.

If you prefer using hoses, choose adjustable spray nozzles that allow you to stop the flow without having to turn off the spigot, and that offer a range of volume and pressure options. This will ensure that you have the appropriate pressure for various kinds of plantings and reduce water waste.

The downside of hand watering is the time and energy needed. Plants need water when they need water, so you will need to work on their schedule, not yours. This can be challenging, especially during vacation breaks.

Sprinklers

Sprinklers decrease the time and effort needed for watering. You can purchase hose-end sprinklers or install a system of underground pipes with spray heads. Both types can be made even more efficient and flexible by attaching manual or automatic timers.

Hose-end sprinklers are the least expensive option and can be a good choice if you have lots of beds scattered around. Some produce a spray that moves in a circular motion, others cast a fan that can move back and forth, and still others that resemble mini-tractors “drive” through the garden guided by the hose! You can turn them off and on by hand or purchase a timer to do it for you. The first time you operate your sprinkler, observe the spray pattern to make sure it's applying water where you need it and not to paved surfaces.

Built-in sprinklers use underground pipes and spray heads. They tend to be more sophisticated to use and expensive to install, but they can be useful for permanent beds and lawns. There are many different types of spray heads available, including pop-ups, rotors, and bubblers that allow you to choose the direction and pressure of water delivery. Most built-in sprinklers are controlled by automatic timers you can program to water at the most appropriate time of day — even if you're away. A helpful feature available on some automatic timers is a moisture sensor that prevents sprinklers from activating during rain! It is important to check the system regularly to make sure broken sprinkler heads are not wasting water or delivering spray to paved areas, and that spray isn't overlapping and overwatering some plants.

The main benefit of sprinklers on automatic timers is convenience, and this is also what makes them the least efficient irrigation method. Once they're on schedule, we often forget to monitor them and end up with dried up or drowned plants and wasted water. You also have very limited control over the spray, so some plants get water whether they need it or not. Much of water sprayed into the air is lost to evaporation and wind drift, and since you don't have to be present to operate them, it might be weeks before you discover a broken sprinkler head that is wasting water or starving plants of moisture.

Drip Irrigation and Soaker Hoses

Drip irrigation and soaker hoses provide a happy medium between hand watering and sprinklers. They allow for more selective water application and can provide the convenience of automatic watering. The equipment is more costly on the front end than hand watering, but less expensive than installing

underground sprinkler systems. Water savings and convenience can give you a rapid return on your initial investment.

Soaker hose

Soaker hoses have small pores throughout their surface that leak water directly to the soil at a slow rate, allowing for increased soil absorption and less water waste. Soaker hose is a good option for rows and beds of vegetables and annual plants.

Drip irrigation features emitter hoses with components that are calibrated to deliver a precise amount of water, such as 1/2 or 1 gallon per hour. There are a variety of types. One kind features pipes with built-in emitters; others allow you to attach small-diameter flexible tubes capped with emitters to a main feeder hose, allowing you to locate emitters right under individual plants or in pots. Emitter irrigation is a great system for watering landscape beds with permanent plantings.

Both options deliver water more efficiently than sprinklers with less chance for water loss due to wind and runoff, and can be attached to timers and moisture monitors to allow for increased flexibility in scheduling. By delivering water directly to the soil, they are more selective than a sprinkler, but not quite as targeted as hand watering.

For optimal operation, you may need to add a pressure regulator to reduce and equalize water flow through the system and a filter to prevent small particles in the water from clogging pores and emitters. In some areas, insects such as ants may enter emitters in search of water and may cause clogs.

Activity 1: Round and Round: The Water Cycle

1. Together or independently, read the Round and Round Reading Page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Download one of the USGS Water Cycle diagrams to share this important process with your kids. There are two versions: one designed for younger students (shown below) and one for older students. Both are available at: https://www.usgs.gov/special-topic/water-science-school/science/water-cycle.) Talk about the role plants play in the water cycle.

3. Launch an experiment to see transpiration in action to demonstrate how plants add to the water vapor in the air. Place a plastic bag over the stem of a plant and use a twist tie, rubber band or string to close it snugly around the stem, being careful not to damage the plant. This experiment will work best with outdoor plants located in full sun and in warmer temperatures, but you can try it on any plant and use indoor plants instead during winter months. Make sure to check that the leaf (or leaves) that you place in the bag is/are dry at the start of the experiment.

4. Place the bag on your plant in the morning and return in the afternoon to see what happens. By the end of the day, you should find water vapor accumulating on the insides of the plastic bag. Explain transpiration and talk about why water is important to plants and all living creatures.


Water vapor has condensed into droplets on the inside of this plastic bag.

Extend the Lesson: You can extend this lesson by building your own terrarium. A terrarium is a miniature garden grown inside a covered glass or plastic container. It is a low-maintenance way to incorporate plants into your classroom or home and an excellent tool for teaching children about the water cycle as it demonstrates evaporation, condensation, and precipitation. Detailed instructions are available at: https://kidsgardening.org/resources/garden-activities-building-a-terrarium/.

Activity 2: Water Experiments

1. One of the best ways for kids to understand the impact of water on plant health is to watch the same kind of plants receive different water treatments and watch how they react by observing differences in their physical appearance and growth.

   Challenge your kids to brainstorm ideas for creating a water experiment. Explain to them that since the goal is test the impact of water availability on plants, you need to limit the number of variables that might impact your results and focus on only changing the amount of water you deliver. Here are some tips for their experiment:

   - Use the same size containers
   - Grow the same kind of plants
   - Try to find plants that are approximately the same size and health at the start of your experiment
   - Grow all the plants in the same environmental conditions (same light, temperature, and humidity)

   If you do not have any potted plants readily available, you can also start some seed viewers of bean seeds to experiment with.

To make a seed viewer:

- Cut a piece of construction paper into a rectangular strip to fit inside the plastic cups. This is optional, but it helps with viewing.
- Ball up a few pieces of paper towels and place them inside the construction paper liner until the cup is full.
- Place 3 to 4 beans in the cup between the side of the cup and the paper towels or construction paper liner so the seeds are visible from the outside of the cup.
- Gently water the paper towels in the center until saturated.
- Place the cup (or cups if you would like to try multiples) on a shelf or windowsill and watch them grow. First you will notice the seed coat expanding (wrinkling) as the seed absorbs water. The root will start to grow in 2 to 3 days. Water as necessary to keep the paper towel and seeds continually moist.

Seed viewer

*Please note: If using seed viewers, you can start testing the effects of varying water availability right from the start and also look at the impact on seed germination, or you can wait to begin your experiment after the first set of true leaves appears. Seeds viewers grown outside will dry out very quickly. This may help speed up your water experiments, but they may need to be watched more closely than indoor seed viewers.

2. Once your location and plants are selected, water all of your plants to the point of saturation. If you are using potted plants, add water until excess water is running out of the drainage holes. If you are using seed viewers, fill your cups with water and let the paper towels become thoroughly soaked and then drain the extra water. This is done to try to make sure all of the containers are all starting at the same point of water availability.

3. Create your water schedule. You want to water all of the plants at the same time, but just give them different amounts of water. Make sure to label each plant so you remember which treatment to give each one. For example, Plant A may get 1 cup of water every other day, Plant B may get half of cup of water every other day, Plant C may get 1 TBSP of water every day and Plant D may get 1 TSP of water every other day, etc.

4. Track your observations using the Water Experiment Data Collection Worksheet or your garden journal. If you are not seeing much variation in the appearance and growth of your plants, you may need to adjust your water schedule or the amount of water you are using.

5. Discuss your results. Did some of your plants grow better than others? What happened if your plants did not get enough water? What happened if your plants got too much water?

Extend the Activity: Different types of plants are adapted to need different amounts of water. If you want to extend this activity, try it again using a different type of plant for your observations and compare the results.

Activity 3: Fulfilling Plants' Water Needs

1. Water, especially clean water, is a very precious resource in our world. If you have older kids, you may want to research some of the water shortage crises that have occurred around the world in recent years. If you are looking for a historical perspective, check out the Dust Bowl of the 1930s in the United States. In nature, plants mostly rely on rain to fill their water needs. Ask kids, Where do our garden plants get their water from? If there is not enough rain, what do we do?

2. Introduce kids to some of the basic types of watering techniques used by gardeners listed in the Background Information. If possible, find ways to demonstrate these different methods in your schoolyard or look for examples in nearby landscapes. The Digging Deeper below has links to some watering-related video that can supplement if you do not have access to live demonstrations.

3. Use the Irrigation Comparison Worksheet to evaluate the pros and cons of each of the main types of watering techniques. After making your lists ask, Is there one best technique? Or do different techniques work better in some garden situations than others? What would be best for our school or home garden?

   Here are some possible responses for the Irrigation Comparison Worksheet:

Irrigation Method	Benefits	Challenges
Hand watering	• inexpensive • allows targeted water delivery • allows you to monitor soil conditions as you water	• time consuming • labor intensive
Sprinklers	• can be inexpensive • save time	• often waste water • built-in systems can be costly and complex to design/install
Soaker hoses & drip irrigation	• efficient water delivery • saves time	• may not be as targeted as hand watering • more expensive initially than hand watering and many sprinklers

4. Conclude by talking about how important it is for us to conserve water and protect our water resources. You can extend the lesson by having kids create ads to encourage others to use water wisely.

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books and Additional Resources:

Seed School by Joan Holub

Jack's Garden by Henry Cole

Up in the Garden and Down in the Dirt by Kate Messner

Plantzilla by Jerdine Nolen

A Place to Grow by Stephanie Bloom

The United States Geological Survey Water Science School:
https://water.usgs.gov/edu/

Videos:

National Science Foundation: The Water Cycle:
https://www.youtube.com/watch?v=al-do-HGuIk

How to Water Your Plant Right from Proven Winners:
https://www.youtube.com/watch?v=7faaR8SoYDs

10 Ways to Water Your Garden Better from Epic Gardening:
https://www.youtube.com/watch?v=ueQCiSD5AdM

5 Watering Mistakes You're Probably Making from Epic Gardening:
https://www.youtube.com/watch?v=VaTkzYv8sMo&t=118s

GrowOrganic Peaceful Valley's Drip Irrigation Series:
https://www.youtube.com/watch?v=SNZ5xOVO_SM

Fine Gardening: Drip Irrigation Basics:
https://www.youtube.com/watch?v=tmEj3MQPITY

HortTube with Jim Putnam: How to Install Drip Irrigation:
https://www.youtube.com/watch?v=PetfxgFeOkM

Additional Related KidsGardening Lessons and Activities to Try:

Building a Terrarium:
https://kidsgardening.org/resources/garden-activities-building-a-terrarium/

Catching Water:
https://kidsgardening.org/resources/garden-activities-catching-water/

Wise Watering:
https://kidsgardening.org/resources/gardening-basics-wise-watering/

Rain Gardens:
https://kidsgardening.org/resources/lesson-plans-rain-gardens/

Weather -Tracking Tools:
https://kidsgardening.org/resources/lesson-plans-weather-tracking-tools/

Digging into Soil:
https://kidsgardening.org/digging-into-soil/

Photosynthesis Runs the World:
https://kidsgardening.org/resources/lesson-plan-photosynthesis/

Photosynthesis 101:
https://kidsgardening.org/resources/digging-deeper-photosynthesis-101/

Tropical Rainforests:
https://kidsgardening.org/resources/lesson-plan-tropical-rainforests/

Round and Round: The Water Cycle

Lessons to Grow By – Reading Page - Plant Needs - Water

Have you ever heard someone tell you that we are drinking the same water that the dinosaurs drank? They can say that because of the water cycle.

What is the water cycle? On our planet, water moves round and round in a constant way. Water from the Earth's surface heats up in the sun and turns from a liquid into a gas. This water vapor then floats into the air. This part of the cycle is called evaporation.

When it gets high enough up into the sky, it gets colder and all of the water vapor gathers together to make clouds. This stage is called condensation.

When enough water gets together, it gets heavy and comes back down to earth in the form of rain or snow. This final part of the cycle is called precipitation.

Once back on land, water then follows one of two main pathways:

- It can go into the soil and get stored in the soil or in special places called aquifers (ACK-wiff-ers) below the soil.
- It can run off into local streams, lakes, and rivers.

It is in these two locations (from in or under the soil, and from bodies of water) that plants and animals can find the water they need to drink to live. Water then evaporates again (from bodies of water and also from liquid released by living creatures who have consumed it) and it all begins again.

The water cycle is a very important process in our world. Water is a basic need for all living creatures — from the little lady bugs eating aphids on your plants to the giant redwoods in California. We all need water to keep our cells alive, to grow, and to keep all of our systems working right.

Through the process of changing from liquid to gas back to liquid again (and sometimes to solid in the case of snow and ice) in the air and also through the process of soaking down into soil, another very important thing happens: Water is cleaned. Contaminants that have become mixed in the water are removed in a few different ways as water travels on this journey. Living things need clean water to be healthy.

Plants get most of the water they use from the soil. Water is absorbed by plant roots, moves up the stems and then into leaves. On this journey, it is used in plant cells as

needed. It also exits the leaves through small openings called stomata (stow MAH tah) as a result of a process called transpiration, which is much like sweating in humans.

The movement of water through the plant provides support for the plant and helps it adapt to varying conditions in its environment. Water is also a key component needed for photosynthesis, which is how the plant makes food. The movement of water through plants is also an important part of the water cycle as plants move water stored in the soil back into the atmosphere again.

How much water do plants need? This depends on many different things. Some plants need lots of water to grow and others can get by with very little. For instance, cacti (word for more than one cactus) are adapted to desert conditions and need very little water, while water lilies live fully submerged in water. Smaller plants usually do not need as much water as big ones. Young plants with short roots need small amounts of water applied frequently because the soil near the surface dries quickly. Plants in cool, humid, and shady environments will lose water to transpiration more slowly than those exposed to sunny, warm, arid (dry), and windy conditions. Learning how much water to give garden plants is one of the most important skills gardeners need to learn. A well-watered garden — not too much and not too little — is a happy garden!

Reading Comprehension Questions:

1. True or false: All living things need water.

2. Which of the following is not a stage in the water cycle?
   - ☐ Precipitation
   - ☐ Condensation
   - ☐ Pollination
   - ☐ Evaporation

3. What two things can happen to rain when it hits land?

4. What part of the plant takes in the water the plant needs to live?

5. Based on question number 4, if the plants in our garden need water, where should we put it?

Water Experiment Data Collection Worksheet

Treatment Key:

Plant A gets _____ water at each treatment.

Plant B gets _____ water at each treatment.

Plant C gets _____ water at each treatment.

Plant D gets _____ water at each treatment.

Plant E gets _____ water at each treatment.

Date	Plant A Observations	Plant B Observations	Plant C Observations	Plant D Observations	Plant E Observations

Irrigation Comparison Worksheet

Irrigation Method	Description	Potential Cost	Benefits of this Method	Challenges of this Method
Hand Watering				
Sprinklers				
Soaker Hoses & Drip Irrigation				

LESSONS TO GROW BY

Plant Needs

In this unit of Lessons to Grow By, we are exploring plant needs. For healthy growth and development, plants must obtain just the right amounts of light, water, air, and nutrients and they also need space to grow. These five requirements are the basic needs for all plant life.

Fortunately for our world full of diverse environments, different plants need different amounts of each of these essentials so there are plants well adapted to grow in almost all environmental conditions.

Through these activities, kids will investigate plant needs to better understand how to take care of their green friends while also gaining a deeper appreciation for how the living and nonliving elements in an ecosystem work together.

Module 3: Air

Learning Objectives:

This module focuses on the plant need of air. Kids will:

- Learn that people and plants work together to keep the amounts of oxygen and carbon dioxide in our air relatively consistent.
- Explore how plants need air for their leaves and stems above ground and for their roots below ground.
- Discover that plants are an important part of the Earth's carbon cycle.

Materials Needed:

Activity 1: What is Air?

- The Air Around Us Reading Page
- Plastic bags in different colors or flagging tape
- A metal clothes hanger or a plastic loop
- String

Activity 2: Air Above and Below Ground

- Microscope (optional)
- Bucket or bowl of soil (no drainage holes)
- Tape
- Watering can
- 2 potted plants of the same variety and approximately the same size (herbs in 4" pots work well). One pot needs to have no (or blocked) drainage holes. The other pot needs drainage holes.
- Seed viewers (bean seeds, paper towels, clear plastic cups)
- Air Experiment Data Collection Worksheet

Activity 3: The Carbon Cycle

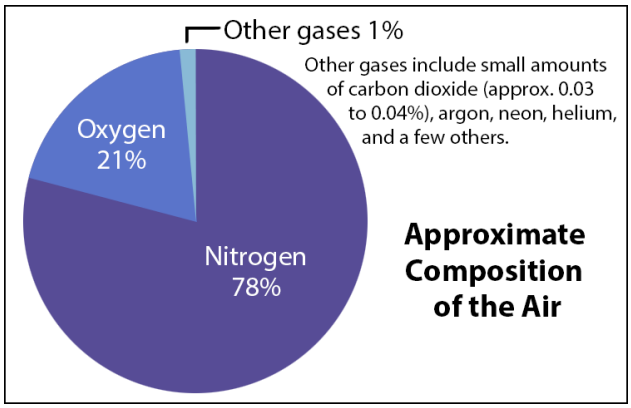
- Components of the Global Carbon Cycle Diagram from the US Department of Energy: https://public.ornl.gov/site/gallery/originals/CCycle_cover_image.jpg

- Terrestrial Photosynthetic Carbon Cycle Diagram from the US Department of Energy: https://public.ornl.gov/site/gallery/originals/Pg028_CCycle08.jpg

- Internet connection to watch the Kiss the Ground's The Soil Story

Introduction

Both animals and plants need air to live and grow. Our air is made up of many different kinds of gases including nitrogen (78%), oxygen (21%) and an assortment of others, including carbon dioxide, argon, neon, helium, and a few others (collectively 1%).



Animals need oxygen from the air for a process called respiration. Respiration is how we turn our food into energy that our body can use. Through this process oxygen is used and carbon dioxide is released. So, we breathe in air, use the oxygen, and breathe out air that has a higher concentration of carbon dioxide.

Plants also use oxygen for respiration to turn food into energy. However, unlike us, plants also need carbon dioxide from the air for photosynthesis. In the process of photosynthesis, they take the carbon dioxide out of the air and use it to make food in the form of carbohydrates. Not only do plants rely on this food — all living things rely on the food plants make! (For more details check out KidsGardening's Photosynthesis 101 at: https://kidsgardening.org/resources/digging-deeper-photosynthesis-101/.)

Plants take in air, use some of the oxygen for respiration and carbon dioxide for photosynthesis, and then release the extra oxygen back into the air.

Photosynthesis:

carbon dioxide (carbon and oxygen) + water (hydrogen and oxygen) —with light energy→ food (carbon, hydrogen, oxygen) + extra oxygen

In a very simplified way of looking at our air composition, the net impact is that people/animals are removing oxygen and adding carbon dioxide into the air, and plants are removing carbon dioxide and adding oxygen into the air. Together we work to keep a balance so that the relative amounts of oxygen and carbon dioxide stay consistent.

That being said, there are a number of other factors that come into play and impact the elements found in our air. From gases and small particles that are released through human activity and considered pollutants, to actions and activities that release these naturally occurring elements in unnatural quantities, the balance of carbon dioxide and oxygen is a present-day concern. The vast removal of plants for human use or to make way for development has decreased the amount of oxygen being released into the air in a significant way. In addition, some of our inventions and agricultural practices have increased carbon in the air. This imbalance is causing a change in our climate.

Carbon is an essential element on our planet, and the Carbon Cycle is an important part of all life. In terms of the air, atmospheric carbon combines with oxygen to become carbon dioxide, which is a greenhouse gas. Greenhouse gases absorb and then re-emit energy back to the Earth. Therefore, the more carbon dioxide in the air, the warmer the temperatures both on land and in the oceans. The warmer temperatures also increase the amount of water vapor present in the atmosphere, increasing temperatures even more.

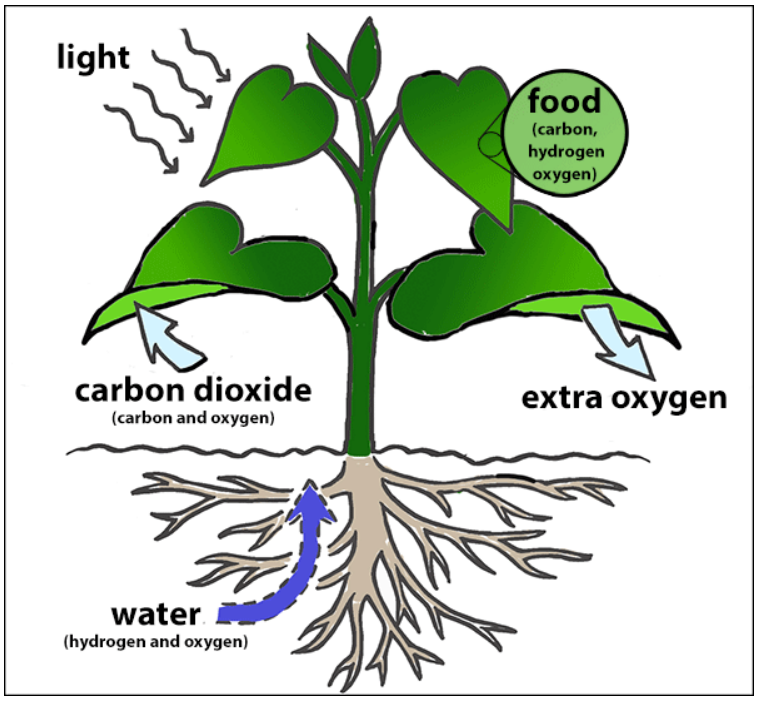
Plants' Role in the Carbon/Oxygen Balance in our Air

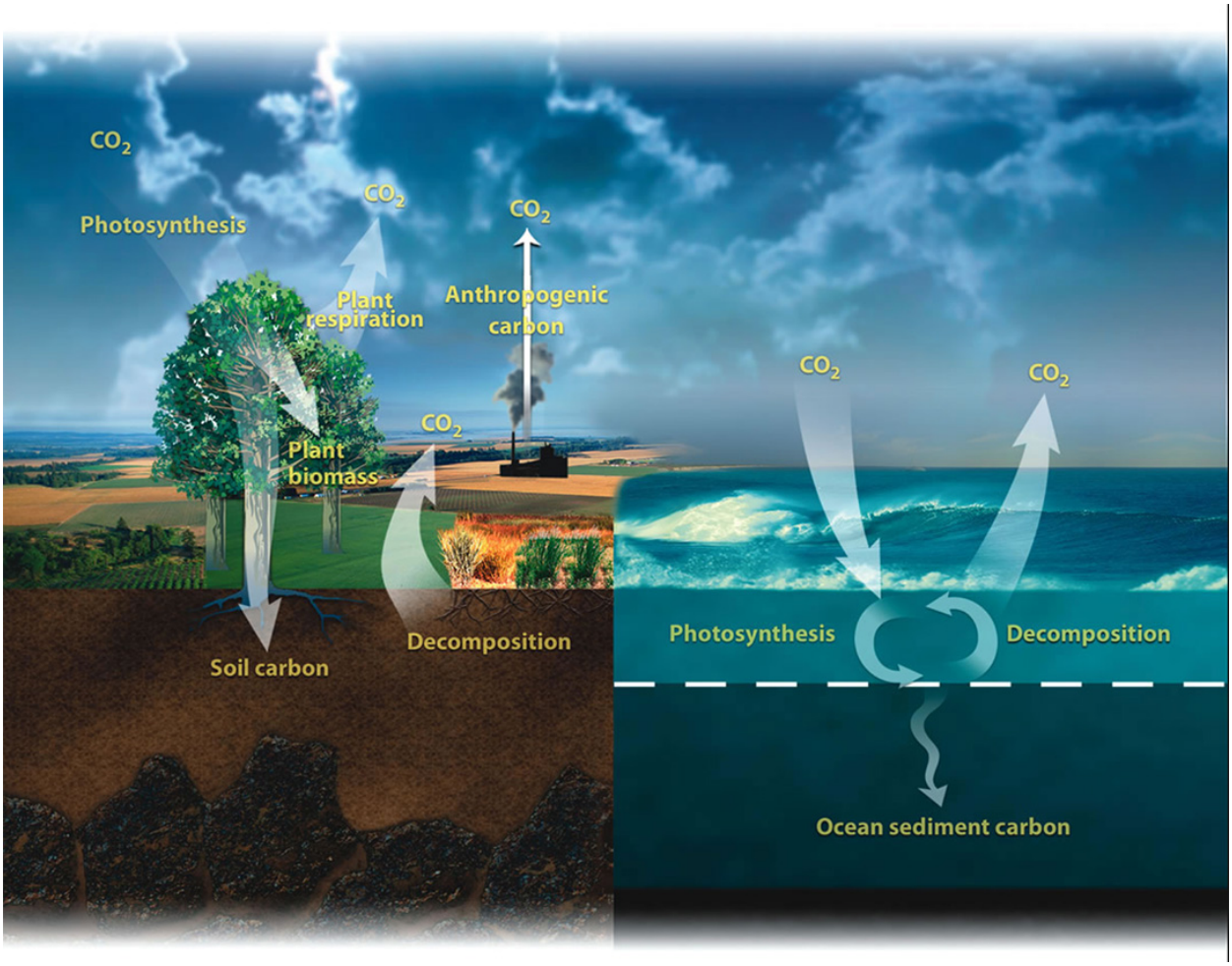
Plants are an important part of the solution for bringing balance back to our air:

- They take in carbon dioxide and use it to create food in the form of carbohydrates.
- They release oxygen back into the air.

And through this process, they not only capture carbon in their leaves, stems, and other structures, they also return carbon back to the soil and store it there in the form of living roots and decaying plant matter. Carbon that is "sequestered" in this way helps reduce the amount of carbon dioxide in the air.

Just another important job that plants do in our world! For more in-depth background information about the Carbon Cycle, check out The Carbon Cycle (shown below) from NASA's archives at: https://earthobservatory.nasa.gov/features/CarbonCycle.





Components of the Global Carbon Cycle
https://public.ornl.gov/site/gallery/originals/CCycle_cover_image.jpg
Source: Office of Biological and Environmental Research of the U.S. Department of Energy Office of Science. science.energy.gov/ber/

Activity 1: What is Air?

1. Read The Air Around Us Reading Page. This reading page may be best to read as a group with younger students (3rd through 4th grade) so you can pause for additional clarification if needed. For older students it can be an independent reading page. Together or independently, complete the reading comprehension questions and then discuss your answers as a group.

2. Understanding why people and plants need air can be especially complex for students to understand because it is not something we can see with our eyes. Take a nature walk in your schoolyard or local greenspace to "look" for air. Use all of your senses to explore air as mentioned in the reading page. What are some of the sensory signs that let us know air exists; e.g. touch (temperature and wind) and smell.

3. When air moves, we call it wind. We can feel the wind on our face and also see wind when it makes objects move.

4. Make a windsock for your garden so you can "see" air and watch as it moves through your garden:

- Cut plastic bags into strips or get a few rolls of flagging tape from a hardware store.

- Use an old metal hanger or a plastic ring to make the base for your windsock. There are many items you could repurpose to make a ring such as cutting a cross-section of a 2-liter water bottle, using an old pool toy, or if you want to go big, looking for an old hula hoop. You could also make your own hoop with a flexible piece of pipe or tubing that can be bent into a ring shape and taped.

- Securely tie the strips of plastic on your ring so that they hang down and flow easily in the wind. Make sure your ties are secure to avoid unnecessarily littering the environment with plastic.

5. Find a location to hang your new windsock that you can observe its movement regularly. You may want to experiment by tracking movement in different kinds of weather and hanging it in different places to see how plants and other objects impact wind movement.

Windsock

Activity 2: Air Above and Below Ground

Plants take in air through stomata in their leaves, and they also need air for their roots.

1. Use the background information to explain how plants take in air through the stomata on their leaves. If you have a microscope available to you, try to look for stomata on leaf samples.

   The stomata are typically found in greater numbers on the undersides of the leaves and on the outside layer of the leaf. To be able to see them under a microscope, you can fold the leaf in half and then tear it so that you can try to separate the bottom layer to get a thinner sample to look through.

   The California Academy of Sciences also offers suggestions for using clear nail polish and tape to try and separate the stomata off of your leaf for viewing. Instructions for this method can be found at: https://www.calacademy.org/educators/lesson-plans/stomata-printing-microscope-investigation.

   If you do not have a microscope, you can check out Travel Deep Inside a Leaf, also from the California Academy of Sciences: https://www.youtube.com/watch?v=Bf-RFPaZeAM.

2. Explain that plant roots need air to survive. Healthy soil is full of pore space — tiny open spaces between soil particles. These spaces contain water or air and make them available to plant roots. To demonstrate soil pore space, take a bucket or bowl with no holes in the bottom and fill it with soil. Spread the soil so it's level and place a piece of tape on the wall of the container to mark the soil line.

3. Slowly add water to the soil with a watering can. Look at the tape. Does the soil get higher? If the soil level does not rise, ask kids where the water is going? Keep adding water until your soil becomes completely saturated. Explain that the water is filling the air pockets or pores of air in your soil, displacing the air.

4. Plan an experiment to show that plant roots need these pockets of air for healthy growth. Gather two plants of the same kind that are approximately the same size. Plant them in pots that are also the same size, but one should have drainage holes and the other should either not have drainage holes or have the holes completely blocked. Add the same amount of water to each of them and place them in the same location.

5. Continue to water both plants at the same intervals and the same amount. Track the growth of each and compare. As you water, you will want to apply enough water so that your sample without holes is consistently waterlogged.

6. If you do not have any potted plants readily available (or none that you would like to sacrifice for the sake of experiment), you can also start some seed viewers of bean seeds to experiment with.

   To make a seed viewer:

   - Cut a piece of construction paper into a rectangular strip to fit inside the plastic cups. This is optional, but it helps with viewing.
   - Ball up a few pieces of paper towels and place them inside the construction paper liner until the cup is full.
   - Place 3 to 4 beans in the cup between the side of the cup and the paper towels or construction paper liner so the seeds are visible from the outside of the cup.
   - Gently water the paper towels in the center until saturated.
   - Place the cup (or cups if you would like to try multiples) on a shelf or windowsill and watch them grow. First you will notice the seed coat expanding (wrinkling) as the seed absorbs water. The root will start to grow in 2 to 3 days. Water as necessary to keep the paper towel and seeds continually moist.

Seed Viewer

   Once your seedlings have two true leaves, start your experiment. For half of your seed viewers, continue to only provide enough water to keep the paper towels moist. These samples will have air available to their roots. On the other half of the seed viewers, fill the cup completely with water so that the plants are kept in standing water which means they do not have any air available to them. Compare their growth.

   *Please note: If using seed viewers, you can start testing the effects of no air and varying water availability right from the start and also look at the impact on seed germination, or you can wait to begin your experiment after the first set of true leaves appears.

7. Track your observations using the Air Experiment Data Collection Worksheet or your garden journal. If you are not seeing much variation in the appearance and growth of your plants, you may need to adjust the amount of water you are using, which in this experiment is representing the amount of air availability.

8. Discuss your results. Did some of your plants grow better than others? What happened to the plants that did not have any air available to their roots? Does this show us that plant roots need air?

Extend the Activity: Testing the impact of air availability to leaves is very challenging. Because plants conduct both respiration (which gives off carbon dioxide) and photosynthesis (which gives off oxygen),

plants grown in an enclosed space such as a terrarium can actually continue to provide for their own air-related needs for a very, very long time. You can try growing a plant in vacuum-sealed food container that comes with a pump to remove the air; however, you may or may not notice significant differences in growth.

Activity 3: The Carbon Cycle

1. Share with your kids the Components of the Global Carbon Cycle Diagram from the US Department of Energy available at: https://public.ornl.gov/site/gallery/originals/CCycle_cover_image.jpg

   Use the background information above to help you explain how carbon moves through the atmosphere and why that it is important. There is a fixed amount of carbon on our planet. It moves between being stored in the soil, the air, the water, and in living things. Keeping a set balance of carbon is important for keeping everything in our world working right. Share that if there is too much or too little carbon in our air, it can change our climate and environment.

2. Next, share the Terrestrial Photosynthetic Carbon Cycle Diagram from the US Department of Energy available at: https://public.ornl.gov/site/gallery/originals/Pg028_CCycle08.jpg.

   Explain that plants are a really important part of the carbon cycle and how they can take extra carbon from the air and then turn it plant food that can get stored in the plant and also returned to the soil.

3. The nonprofit organization Kiss the Ground has a short video called The Soil Story that helps explain this phenomenon in simple terms. There are 3 different versions of this video available to watch (and even more translated into different languages) at: https://kisstheground.com/playmedia/

The core message of this video is that the amount of carbon on our planet does not change, but it can be stored in different locations, including the atmosphere, oceans, biosphere, soil, and fossils. As we have released more carbon into the atmosphere, we have changed the balance in the storage location of carbon, negatively impacting our environment. Kiss the Ground presents different solutions for moving carbon back into the soil as a way to solve the problem of climate change.

Ask kids to consider the role of plants in bringing and keeping carbon in balance in our atmosphere. Are plants important for people?

Digging Deeper

You can use the following resources to dig deeper into this week's lessons:

Books and Additional Resources:

Seed School by Joan Holub

Jack's Garden by Henry Cole

Up in the Garden and Down in the Dirt by Kate Messner

A Place to Grow by Stephanie Bloom

10 Interesting Things About Air from NASA Climate Kids:
https://climatekids.nasa.gov/10-things-air/

Why Does Wind Blow? From NOAA SciJinks:
https://scijinks.gov/wind/

Why is Air Invisible? From Highlight Kids:
https://www.highlightskids.com/explore/science-questions/why-is-air-invisible

For Older Kids and Parents:
Understanding Food and Climate Change from The Center for Ecoliteracy:
https://www.ecoliteracy.org/download/understanding-food-and-climate-change-interactive-guide

Understanding Food and Climate Change uses video, photography, text, and interactive experiences to show how food and climate systems interact and how personal choices can make a difference. Ideal for grades 6–12 (and adults too), the guide provides connections to Next Generation Science Standards and the National Curriculum Standards for Social Studies themes. It also offers activities for student research and resources for further investigation.

Videos:
Travel Deep Inside a Leaf from the California Academy of Sciences:
https://www.youtube.com/watch?v=Bf-RFPaZeAM

Kiss the Ground's The Soil Story:
https://kisstheground.com/playmedia/

Photosynthesis — The Dr. Binocs Show By Peekaboo Kids
https://www.youtube.com/watch?v=D1Ymc311XS8

Additional Related KidsGardening Lessons and Activities to Try:

Photosynthesis Runs the World:
https://kidsgardening.org/resources/lesson-plan-photosynthesis/

Photosynthesis 101:
https://kidsgardening.org/resources/digging-deeper-photosynthesis-101/

Tropical Rainforests:
https://kidsgardening.org/resources/lesson-plan-tropical-rainforests/

The Soil-Air Connection:
https://kidsgardening.org/resources/lesson-plan-soil-air-connection/

Garden Basic: Carbon Cycle and Carbon Sequestration:
https://kidsgardening.org/resources/digging-deeper-carbon-cycle-and-carbon-sequestration/

Building a Terrarium:
https://kidsgardening.org/resources/garden-activities-building-a-terrarium/

Weather-Tracking Tools:
https://kidsgardening.org/resources/lesson-plans-weather-tracking-tools/

Digging into Soil:
https://kidsgardening.org/digging-into-soil/

The Air Around Us

Lessons to Grow By - Plant Needs – Air

Take a deep breath in. Take a deep breath out. Of all the things animals need to survive, constant access to air is the most important.

What is air?

Air on our planet is made up of lots of different components. We usually can't see the air around us because it is made up of gases which are elements in their tiniest forms. Because they are so small, they do not reflect light that our eyes can see.

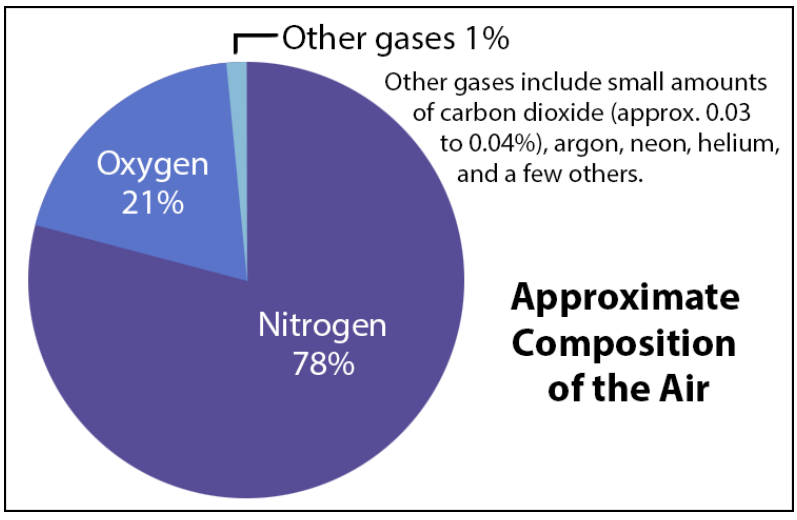
What about using our other senses? Have you ever been able to feel air? Air can change temperatures so sometimes it feels cold and other times it feels warm. Temperature changes can also cause the air particles to move and we feel wind. As the wind moves by objects it may produce a sound so that we can hear air, too!

Can you smell air?

Although normally the basic elements that make up air don't have a recognizable smell for people, sometimes, additional gases and other really small particles of matter can get into the air, and our sense of smell may notice an odor (sometimes good and sometimes yucky). Finally, can you taste air? Our sense of smell and sense of taste are connected so when things other than the normal gases are in the air around us, it can impact our sense of taste, too — but it is not exactly the same as doing a taste test.

What are these tiny components that make up air?

The elements present in the biggest amounts are nitrogen and oxygen. Under normal conditions, nitrogen makes up 78% of our air and oxygen makes up 21% of our air. Then there are components that just make up a small amount of the air, including things like carbon dioxide, argon, hydrogen, neon, and water vapor. All these other things usually make up 1% of the air.



Oxygen is the element in the air that is most important to

animals. We breathe air into our bodies and use the oxygen to transform the food we eat into the energy our bodies need to stay alive and growing. After we take the oxygen out of the air, we breathe out the stuff we do not need. If animals all over the planet kept taking all the oxygen out of the air and just putting back the other stuff, it would seem like the amount of oxygen found in the air would decrease, right?

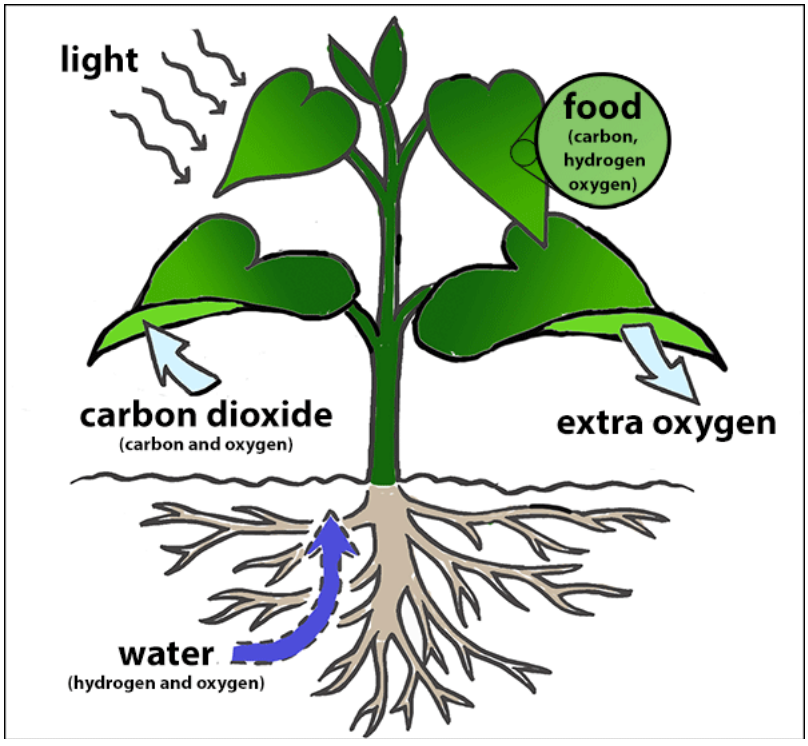
That is where our green plant friends come to the rescue! Plants also need air. Plants take in air through small openings in their leaves called stomata (stow-MAH-tuh). Like us they use the oxygen in it to transform their food into energy for them to live and grow.

However, unlike us, plants also use the carbon dioxide in the air. Carbon dioxide is made up of carbon and oxygen. Plants use the carbon dioxide they take into their leaves to make food through a process called photosynthesis (foe-toe-SIN-the-sis).

The process of photosynthesis also results in creating extra oxygen that the plants don't need. Plants release this extra oxygen back into the air.

Photosynthesis:

carbon dioxide (carbon and oxygen) + water (hydrogen and oxygen) —with light energy→ food (carbon, hydrogen, oxygen) + extra oxygen



Plants and animals are working like a team to keep the amount of oxygen and carbon dioxide in the air about the same.

So, what does all this mean for our air?

- People and animals take in air, use the oxygen in it, and then breathe out air that has more of the other elements like carbon dioxide in it.

- Plants take in air, use the carbon dioxide to make food, and then release the extra oxygen they don't need back into the air.

There are some other activities on the Earth that can also impact the types of gases in our air, but the way that people/animals and plants use air differently plays an important role in helping keep the amounts of all the elements in the air in balance. This amazing cycling of air is just another reminder of why plants are so important to us!

Reading Comprehension Questions:

1. True or false: Both plants and animals need air to live and grow.

2. What kind of particles is air usually made up of?
   A. Liquids
   B. Solids
   C. Gases
   D. None of the above

3. What element in the air is most important to animals?

4. What two elements in the air do plants need to survive?

5. Together people and plants help keep the amount of oxygen and carbon dioxide in the air about the same. What might happen to our air if we cut down too many trees and other plants on the Earth?

Air Experiment Data Collection Worksheet

Date and Treatment	Observations Plant(s) with Drainage Holes (Air Available)	Observations Plant(s) without Drainage Holes (No Air Available)
Date: Amount of Water Delivered:		
Date: Amount of Water Delivered:		
Date: Amount of Water Delivered:		
Date: Amount of Water Delivered:		
Date: Amount of Water Delivered:		
Date: Amount of Water Delivered:		

kidsGARDENING.ORG

LESSONS TO GROW BY

Plant Needs

In this unit of Lessons to Grow By, we are exploring plant needs. For healthy growth and development, plants must obtain just the right amounts of light, water, air, and nutrients and they also need space to grow. These five requirements are the basic needs for all plant life.

Fortunately for our world full of diverse environments, different plants need different amounts of each of these essentials so there are plants well adapted to grow in almost all environmental conditions.

Through these activities, kids will investigate plant needs to better understand how to take care of their green friends while also gaining a deeper appreciation for how the living and nonliving elements in an ecosystem work together.

The bright green seedlings on the left received enough nutrients. The pale seedlings on the right did not.

Module 3: Nutrients

Learning Objectives:

This module focuses on the plant need of nutrients. Kids will:

- Learn what nutrients are and how plants obtain the nutrients they need to grow.
- Investigate how nutrient availability influences plant health and growth.
- Explore decomposition and the nutrient cycle.

Materials Needed:

Activity 1: What are Nutrients?

- The Plant Nutrient Cycle Reading Page
- Nutrient Matching Game

Activity 2: Nutrient Experiments

- Tomato seeds
- Potting soil (without added nutrients), peat moss, or coir (coconut fiber)
- Containers

- Nutrient Experiment Worksheet
- A variety of fertilizers (optional)

Activity 3: The Nutrient Cycle

- Food scraps
- Plastic bags (at least 2)
- Soil from an outdoor location
- Decomposition Bag Observation Worksheet

Introduction

Just as vitamins help people grow and stay healthy, mineral nutrients help plants grow and stay healthy. The nutrients that plants require in relatively large quantities are nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. These are called macronutrients. Plants also need a number of other nutrients in much smaller quantities, including iron, copper, zinc, manganese, molybdenum, boron, nickel, and chlorine. These are called micronutrients. Though plants need just a tiny bit of these micronutrients (and many are relatively common in soils), a deficiency of any one of them can cause serious problems in plants.

Below are details about individual nutrients and how gardeners can supply some of these nutrients with fertilizers. But first, here's a closer look at the nutrient cycle in nature.

The Nutrient Cycle

In nature, plants obtain most of their needed nutrients from the soil. Nutrients occur naturally in the soil as a byproduct of the decomposition of organic matter, or in some cases they are released through the weathering process of parent rock. After being taken up by the roots, nutrients are then transported to the rest of the plant where they are needed. However, plants need help to access the nutrients.

Just like the living organisms above the ground, life underground also comprises a very intricate food web that includes both "producers" and "consumers" and results in the recycling of nutrients that plants need. In a simplified overview:

1. Plant roots give off substances called exudates that consist of carbohydrates produced by the plant through the process of photosynthesis.
2. These exudates become food for microscopic bacteria and fungi in the soil.
3. These tiny organisms are consumed by slightly larger life forms (although in most cases still too small to see with the naked eye), such as nematodes, protozoa, and some arthropods.
4. These organisms are eaten in turn by larger creatures that can be seen without a microscope, such as larger arthropods (like millipedes and sow bugs) and earthworms.
5. Finally, near the top of the web, small soil creatures become a buffet for even larger animals, such as moles.

In addition to eating each other, many of these underground dwellers also consume dead and decaying organic matter (both plant and animal) that has made its way down to the soil. As they digest the

decaying organic matter and then deposit it back into soil through their waste, these organisms return nutrients to the soil, “recycling” them so they can then be absorbed by living plants.

Additionally, there are many bacteria and fungi that also facilitate the availability of the nutrients to plants. Nutrients as they naturally exist in the soil are not always in a form that plants can use. Plants depend on soil-dwelling microorganisms to convert certain nutrients into accessible forms that are available for uptake. Some microorganisms even play an active role in helping roots with the process of absorption.

Fertilizers 101

Sometimes gardeners step in to help plants they’re growing meet their nutrient needs — especially if the existing soil is lacking any of them. Scientists spent many years conducting experiments to identify the specific nutrients needed for healthy plant growth. They used that information to create substances we call fertilizers. It is important to note that fertilizer is not the same thing as plant food. Plants make their own food (carbohydrates) through the process of photosynthesis. To put it into “people terms,” fertilizer is more accurately compared to a multivitamin.

Nutrients: The Big Three

Although plants need all of the macronutrients and micronutrients listed above for optimum growth, scientists have identified three that are needed in larger quantities. These three are often limiting factors for plant growth and are more likely to be missing from soil, especially in a garden setting. The big three plant nutrients are nitrogen, potassium, and phosphorus. Here is a brief overview of why plants need these nutrients, as well as signs that might show plants aren’t getting enough of them:

> Nitrogen is needed for the plant to make a number of essential compounds, including chlorophyll. A plant that does not have enough nitrogen will look weak and have light green to yellow older leaves.
>
> Phosphorus plays an important role in helping plants make flowers, fruits, and seeds. If a plant does not have enough phosphorus, it may have small, purple-tinged leaves, and will develop few fruits.
>
> Potassium impacts how well water can move around a plant and the opening and closing of the stomata. Common signs of potassium deficiency include stunted growth and yellowing or browning of leaf margins and weakened stems.

To help promote optimum plant growth, gardeners apply fertilizers containing missing nutrients to the soil around plants. Fertilizers are grouped into two major classifications: organic and synthetic.

Organic Fertilizers

These are derived from once-living ingredients. They include things like animal manure, composted plant matter, peat moss, and wood ash. Organic fertilizers more closely mimic the decomposition process that provides nutrients in nature.

- In addition to supplying nutrients to the plants, many organic fertilizers like compost improve the structure of the soil, thus improving the overall health of your plants.
- They are generally less concentrated and less likely to harm your plants if over-applied.
- They support the soil food web, which in turn supports plant life. There’s an old saying, “Feed the soil, and the soil will feed the plants.”
- They usually contain a multitude of other macronutrients and micronutrients, in addition to the N-P-K listed on the label, due to the variety of natural materials from which they’re made.
- Note that some “certified organic” fertilizers, such as greensand and rock phosphate, are finely ground, naturally occurring rock.

Synthetic Fertilizers

Synthetic fertilizers are made up of chemicals that are usually derived from petroleum or rock. They are generally highly concentrated, offer quick results, and may be less expensive than organic fertilizers. Concerns about synthetic fertilizers include:

- They may have a negative impact on the naturally occurring organisms in the soil.
- They may wash away in heavy rains into the water system, leading to a form of water pollution.
- Because some types are in a concentrated form designed to be readily absorbed by plants, if too much synthetic fertilizer is applied it can harm and even kill plants.
- They contain only what's listed on the label — if a nutrient isn't listed, it's not in the fertilizer. Exclusive use of synthetic fertilizers can lead to deficiencies of other nutrients.

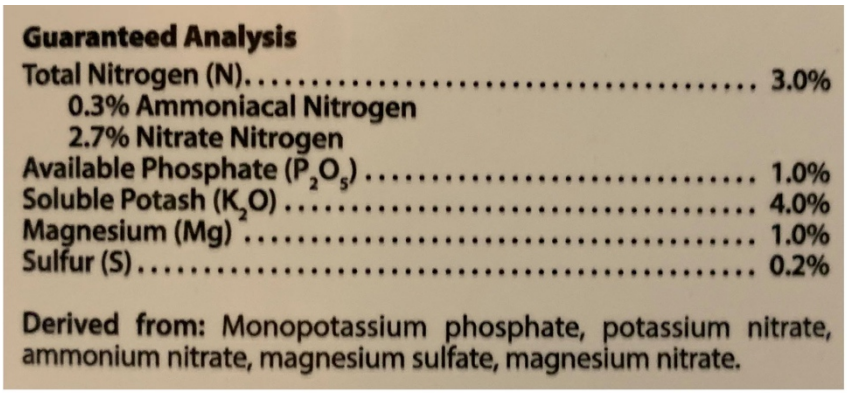
Note: To maintain plant health and reduce environmental impacts, always follow fertilizer label instructions and apply correctly.

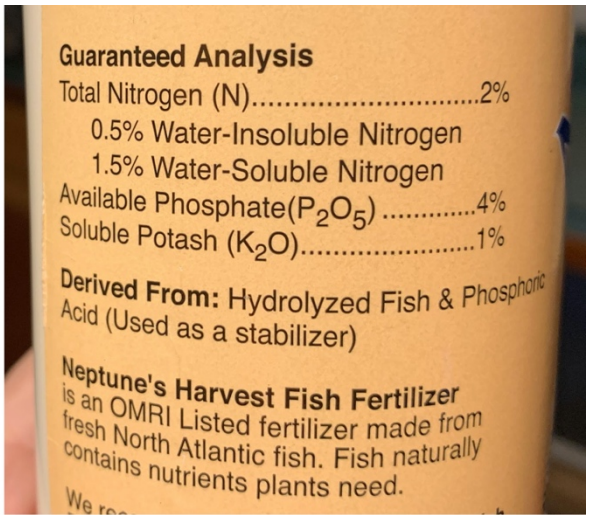
Deciphering Fertilizer Labels

No matter what kind of fertilizer you choose, most times you will notice three numbers listed on the packaging. These numbers represent the ratio of nitrogen, phosphorus, and potassium that is contained in the fertilizer.* An all-purpose fertilizer may list something like 5-5-5 which would mean that nitrogen, phosphorus, and potassium each represent 5% of the weight of the fertilizer. In a 5-5-5 synthetic fertilizer, the remaining 85% is made of some kind of filler, such as sand.

Note that organic fertilizers may have lower N-P-K numbers compared to synthetic fertilizers; at first glance it may seem that they offer less value. However, many organic fertilizers also contain a variety of important other nutrients, and the "filler" may be organic matter, humus, and other materials beneficial to soil life — as opposed to the inert material, such as sand, in synthetic options.

*Technically speaking, the three numbers represent the percentages of nitrogen (N), phosphate (P_2O_5, a source of phosphorus) and potash (K_2O, a source of potassium).





Labels from a synthetic fertilizer, above, and organic fish-based fertilizer, right.

Different Plants, Different Types and Amounts of Nutrients

Different N-P-K ratios are desirable for different types of plants. For example, flowering plants, bulbs, fruits, root crops, and vegetables require more phosphorus than potassium and nitrogen. For these crops, gardeners may choose an 8-12-4 formula.

In addition to needing different types of nutrients, different plants also need different quantities of nutrients. Some plants need a lot of nutrients for proper growth. Others are adapted to needing fewer

nutrients. Tomatoes, for example require large amounts of nitrogen. From year to year, gardeners will rotate where tomato plants are grown in the garden to allow the soil to replenish its nitrogen supply. This rotation of crops is also beneficial in preventing diseases from ravaging the same food crop year after year. Flowers such as nasturtiums, on the other hand, prefer a "leaner" (less nutrient-rich) soil. Given too much nitrogen, they'll produce loads of foliage but few blooms.

Looking Back to Nature

Although adding fertilizer is a handy trick for gardeners, imitating the nutrient cycle found in nature is much more beneficial over the long haul.

Unfortunately, a lack of understanding about the complexities and importance of the soil food web to the health of plants results in problems for many gardeners. The application of insecticides, herbicides, and synthetic fertilizers, along with horticultural practices such as repeated soil tilling, can impact underground organisms and destroy the balance of life within the soil system. For example, a fungicide applied to a lawn will not only kill the fungus that is attacking the lawn, it may also kill off the fungus that is working beneficially with the grass's roots to make nutrients and water more available to them.

Supplementing soil with organic matter such as humus and compost is the best way to not only provide nutrients but also contribute to soil health. Other organic fertilizers that are friendly to soil microorganisms include liquid seaweed, fish emulsion, composted manures, and alfalfa meal.

Soil pH (acidity/alkalinity) also affects nutrient availability. A professional soil test can help you determine your soil's pH and nutrient levels. Your state Cooperative Extension may offer soil test kits.

Activity 1: What are Nutrients?

1. Together or independently, read The Plant Nutrient Cycle Reading Page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. After getting the background information for the reading page, have kids use the Nutrient Matching Game Worksheet to further explore the Big 3 nutrients that plants need: nitrogen, phosphorus, and potassium.

3. Depending on the time of year, you can extend this lesson by going on a nature walk to look for signs of possible nutrient deficiencies in plants. Vegetable gardens are a good place to look. A lot of our common vegetable plants, especially those that bear fruit that we harvest (it takes the plant more energy to make flowers, fruit and seeds) require more nutrients than other landscape plants.

Also, because we disrupt the nutrient cycle when we harvest vegetables and remove spent plants (nutrients that in nature would be returned to the earth), the soil may become depleted in some of the essential nutrients.

If an outdoor garden is not available to explore due to season or availability, indoor plants can also be explored.

Activity 2: Nutrient Experiments

1. Tomato plants need a lot of nitrogen for healthy growth and so they make a great test subject for nutrient experiments. You can purchase tomato seeds from a seed company, or you can also collect seeds from the tomatoes you eat at the grocery store.

   If you collect seeds from tomatoes you purchased from grocery store, the plants you get may not end up looking exactly like the parent plant because a lot of tomato plants are hybrids. But for this experiment you only need to grow the plants for about a month, not necessarily to maturity.

To collect seeds from a tomato:

- Cut open and scoop out the seeds and pulp and placing them in a plastic or glass container. Add enough water to cover.

- Cover the top of the container with plastic wrap and let sit at room temperature for four days, stirring once daily. The viable seeds will sink to the bottom of the container, while the pulp and non-viable seeds will float to the top. Don't worry if you see mold forming on the floating material.

- After four days, pour off the water while retaining the viable seeds. Rinse the seeds in fresh water, and drain. You can plant these damp seeds immediately. However, if you plan to store the seeds, spread them out on a sheet of newspaper or a paper plate to dry for 7-10 days.

2. To see the impact of nutrient deficiency on plant growth most quickly, use potting soil with minimal or no nutrients already added. Another option is to sow seeds in pure peat moss or coir (coconut fiber), both of which are low in nutrients. Alternatively, depending on your budget, you can use different types of potting soil mixes and compare the growth of your plants.

3. Fill small pots or seed planting trays with moistened planting mix. Instead of purchasing pots, you can also use recycled plastic or carton food containers; be sure to clean thoroughly and put holes in the bottom for drainage. Plant your tomato seeds ¼" deep and place the containers in a warm, bright location.

4. Watch your tomato plants grow and water as needed. Track observations in your garden journal or use the Nutrient Experiment Worksheet.

Keep in mind that seeds are like a lunchbox for the new baby plant. They not only include plant food (carbohydrates), but also some nutrients to help the plant begin its new life. So, when the seeds first sprout they will have some food and nutrients available to them which will sustain them for a bit. However, tomato plants quickly use the nutrients provided in this initial store, which is why they make good subjects for a nutrient experiment.

Tomato seeds contain enough stored food and nutrients to allow the seed to begin growing. When those run out, it will need a source of nutrients.

5. About 3 to 4 weeks after sprouting (depending on the nutrients in your potting soil mix), most tomato plants will start to show signs of nitrogen deficiency, such as the yellowing of lower leaves. At this time, you can choose to end your experiment, or you can extend the learning by providing your plants with a selection of fertilizers and then watching to see what happens to the plant when additional nutrients are added.

If you decide to keep growing, there are a number of organic and synthetic fertilizers available from garden centers. All fertilizers should be applied under close supervision of an adult. Read the label and follow the directions carefully when using.

Activity 3: The Nutrient Cycle

1. Use the Background Information above and the Plant Nutrient Reading Page to help you explain the process of decomposition to your kids.

   The Natural Resources Conservation Service of the USDA has a soil food web poster that you may want to use in order to introduce some of the soil decomposers who help make this process possible available at:
   https://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_049822.jpg

2. Next, make simple decomposition observation bags to help kids visualize the decomposition process. Place pieces of plant debris, old fruit, vegetables, and moist bread in clear gallon plastic bags (make at least 2 bags). If you are only making 2 bags, place approximately the same things in about the same percentages in each bag. If you are making more than 2, you can experiment with different combinations for further exploration.

3. In half of your bags, also add a scoop of soil (do not add any soil to the other half of the bags). Close the bags and place them in a warm location where you can make daily observations. You can use your garden journal or the Decomposition Bag Observation Worksheet.

4. What to expect: You will likely see some mold and other fungal growth within a week; however, timing is dependent on the materials chosen, moisture level, and temperature. Continue the observations until the contents of some of the bags begin to resemble soil. Compile the results and discuss. Did some of the bags decompose faster than others? What factors seemed to influence the timing? What do you think was different in the bags that also contained actual soil? What does this information tell us about the formation of soil and recycling of nutrients?

5. Depending on the age and interest of your students, you can look at other variables with your test, such as sunlight availability (offering a variety of light exposures), temperature (perhaps put some in a refrigerator), and moisture levels. You can also experiment with keeping the bags/containers tightly closed versus introducing air regularly, but make sure to warn kids not to inhale or ingest contents while examining. Some types of mold can be harmful.

Extension

You can extend this activity by starting a worm bin composter to make your own fertilizer from worm compost and worm compost tea. Worms provide a free and hassle-free source of rich, organic fertilizer. What's more, they engage kids' hands and minds and teach basic environmental concepts — and they're just plain fun! To start your own worm "farm," you'll need an aerated container, bedding (such as shredded newspaper), a moist and temperate environment, a small amount of soil, and red wigglers. You can find detailed instructions for starting your own worm bin at:
https://kidsgardening.org/resources/garden-activities-worm-compost/

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books and Additional Resources:

Seed School by Joan Holub

Jack's Garden by Henry Cole

Up in the Garden and Down in the Dirt by Kate Messner

Diary of a Worm by Doreen Cronin

Compost Stew by Mary McKenna Siddals

Plantzilla by Jerdine Nolen

A Place to Grow by Stephanie Bloom

Videos:

Soil Nutrients from the Ground Up from University of Wyoming Extension:
https://www.youtube.com/watch?v=gBrhZKuG-HY

Green Our Planet's Virtual Academy – What Makes Good Garden Soil?
https://www.youtube.com/watch?v=jVXQ207D9gQ

Green Our Planet's Virtual Academy – How to Make Compost Using Worms:
https://www.youtube.com/watch?v=ZsXt1xbVwmI

Nutrient Cycling Soil Food Web School:
https://www.youtube.com/watch?v=NVhY4ssMtbI

Big Green SEK Soil Investigation Video:
https://biggreen.org/edresources/video-library/

Additional Related KidsGardening Lessons and Activities to Try:

Garden Maintenance: Weeding, Mulching and Fertilizing:
https://kidsgardening.org/resources/gardening-basics-garden-maintenance-weeding-mulching-and-fertilizing/

All the Dirt on Soil:
https://kidsgardening.org/resources/gardening-basics-all-the-dirt-on-soil/

Soil is Alive:
https://kidsgardening.org/resources/lesson-plan-soil-is-alive/

Digging into Soil:
https://kidsgardening.org/digging-into-soil/

Worm Composting:
https://kidsgardening.org/resources/gardening-basics-worm-composting/

Make a Worm Composting Bin:
https://kidsgardening.org/resources/garden-activities-worm-compost/

Gardening Basics- Composting:
https://kidsgardening.org/resources/gardening-basics-composting/

Trouble Shooting Compost Problems:
https://kidsgardening.org/resources/gardening-basics-troubleshooting-compost-problems/

Borage and Other Compost Plants:
https://kidsgardening.org/growing-guide-borage-compost-plants/

The Plant Nutrient Cycle

Plant Needs - Reading Page - Nutrients

The bright green seedling on the left received enough nutrients. The pale seedling on the right did not.

Have you ever taken a vitamin? Was it crunchy or was it a gummy? Did it look like one of your favorite cartoon characters? Do you know what was inside of it?

People take vitamins to help our bodies grow and stay healthy. Vitamins are a type of nutrient. A nutrient is something that helps our bodies work properly. Some of the nutrients people take include things like vitamin C, vitamin D, iron, and calcium. These nutrients are also found in the food we eat. So don't worry if you do not take vitamins; you are probably getting all the nutrients you need from your food.

Guess what? Plants need nutrients to grow well too! Unlike people though, plants do not eat food, so where do you think they find the nutrients they need? Plant nutrients are found in the soil. Plants absorb them through their roots and then move them to their stems, leaves, flowers, fruits, and seeds.

Do you think plants and people need the same kind of nutrients? There are some things that both of us need to grow, but people and plants are pretty different so our lists are not exactly the same.

Plants have some nutrients they need a lot of. These are called macronutrients (macro means large). Other nutrients they need in small quantities. These are called micronutrients (micro means small). There are 3 main nutrients that are really important to plants: nitrogen, phosphorus, and potassium. What do these 3 substances do for the plant?

- Nitrogen is used by the plant to make important compounds inside of the plant, including chlorophyll. Chlorophyll is the green substance that plants use to help them make their food through photosynthesis. If a plant that does not have enough nitrogen, the older leaves at the bottom of the plant will turn yellow.

- Phosphorus is used by plants to help them make flowers, fruits, and seeds. If a plant does not have enough phosphorus, it may have small, purple-tinged leaves, and will develop few flowers and fruits.

- Potassium is important for helping water move around the plant. If a plant does not have enough potassium, it will stay short and the edges of the leaves will turn yellow and brown.

So how do these important nutrients get into the soil for plants to use? In nature, the main way nutrients get added to the soil is through a process called **decomposition**.

When leaves fall on the ground or when plants and animals die, there are little creatures in the soil called decomposers that eat the dead things. These creatures include earthworms, sow bugs, ants, and even smaller things we can't see, like bacteria and fungi. When they eat the dead things, they break them into smaller pieces and deposit those pieces in the soil through their waste (their poop).

Let's think about leaves that fall off the plant and collect on the ground. Those leaves used to be part of a bigger plant, so inside they will have stores of nitrogen, phosphorus, and potassium. But all those nutrients are locked up in the leaf and can't get out, even though the leaf fell off so the plant is not using them anymore.

Decomposers to the Rescue!

Decomposers will chomp on the leaf and break it down into little pieces — the components that include nutrients. The pieces will be returned to the soil through the decomposer's waste. So through this process, which is called decomposition, the nutrients that were locked up in the leaf will get free in the soil and be ready to be picked up and used by a new plant. (And when they die, the bodies of the decomposers themselves are broken down into nutrients, too!)

Snails (above) and earthworms (below) break down organic matter, helping to recycle the nutrients it contains.

The process where plants and animals use nutrients while they are alive and then pass them along to new plants and animals when they die is called the Nutrient Cycle. Nutrients go 'round and 'round from being available in the environment to being trapped in living things to being available again.

Gardeners can add nutrients to the soil for plants, too. Just like we have vitamins that we can take, sometimes gardeners help plants get the nutrients they need by adding something called fertilizer to the soil.

Fertilizer can be a solid or a liquid and there are lots of different kinds full of lots of different nutrients. Gardeners should always read the labels on fertilizers carefully to make sure they are giving their plants what they need. Too many nutrients or the wrong kind of nutrients can be just as bad for plants as not enough.

Reading Comprehension Questions:

1. What is a nutrient?

2. Where do plants get most of the nutrients they need for healthy growth:
   A. the grocery store
   B. rain water
   C. the soil
   D. food

3. True or false, macro means large.

4. What are the 3 nutrients that plants need in big quantities to grow well:

5. Sometimes gardeners provide nutrients to help plants grow. What do we call the nutrients people give to plants?

Nutrient Matching Game

Draw lines to match the nutrient on the left side of the page to the picture of the plant on the right side of the page that needs it.

Nitrogen

Job: Helps the plant make things like chlorophyll which gives plants their green color

Phosphorus

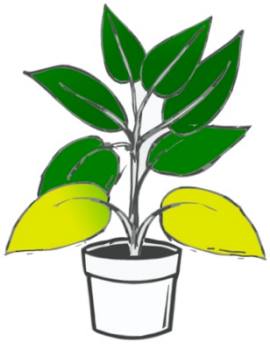
Job: Helps plants make flowers, fruits, and seeds

Potassium

Job: Helps move water around the plant and open/close stomata

Problem: This plant only has one small flower on it.

Problem: The stem is bending and the edges of the leaves are turning brown.



Problem: The bottom leaves on this plant are turning yellow.

Nutrient Experiment Observation Worksheet

Plant #	Date:		Date:		Date:		Date:	
	Height	Observations	Height	Observations	Height	Observations	Height	Observations

Potting Soil Used (note here if seeds were planted in different kinds of potting soil):

Treatment Notes (note here if fertilizer was applied to plants with date of application):

Date:

Decomposition Bag Observation Worksheet

Bag #: _____

Contents: _____

_____

Location: _____

Sunlight availability: _____

Average temperature: _____

Was soil added? _____

Moisture level rating at beginning of experiment:

☐ No moisture ☐ Low moisture ☐ High moisture

Was air added? _____

Observations: _____

_____

_____

_____

_____

_____

_____

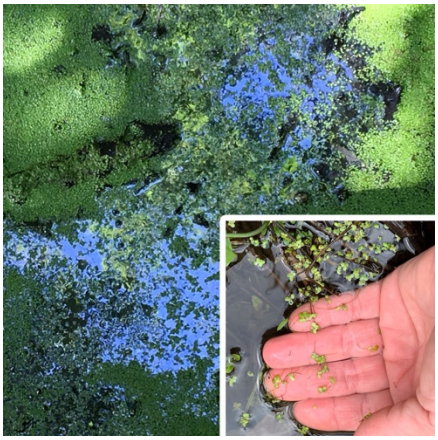
LESSONS TO GROW BY

Plant Needs

In this unit of Lessons to Grow By, we are exploring plant needs. For healthy growth and development, plants must obtain just the right amounts of light, water, air, and nutrients and they also need space to grow. These five requirements are the basic needs for all plant life.

Fortunately for our world full of diverse environments, different plants need different amounts of each of these essentials so there are plants well adapted to grow in almost all environmental conditions.

Through these activities, kids will investigate plant needs to better understand how to take care of their green friends while also gaining a deeper appreciation for how the living and nonliving elements in an ecosystem work together.



Plants come in all shapes and sizes! Tiny duckweed plants, above, are less than 1/10" long, while the giant sequoia tree, below, is 275' tall.

Module 5: Space to Grow

Learning Objectives:

This module focuses on the plant need of space to grow. Kids will:

- Learn that in addition to the needs of light, air, water, and nutrients, plants must also have adequate space to grow and thrive.
- Investigate how the space available to a plant impacts its growth.
- Explore how plants can adapt to growing in different kinds of spaces as long as their other needs are met.

Materials Needed:

Activity: 1 A Place to Call Home

- A Place to Call Home Reading Page
- Flexible measuring tape or string and a ruler
- Plant Observation Worksheet
- Clipboard or piece of cardboard
- Pencil

Activity 2: Space to Grow Experiments

- Radish or lettuce seeds
- Potting soil
- 5 pots (or repurposed plastic containers) that are all the same size — at least 4” in diameter if using radish seeds and 6” in diameter if using lettuce seeds
- Space to Grow Experiment Data Collection Worksheet

Activity 3: Straw Hydroponics

- Rockwool* or cotton ball
- Lettuce seeds
- Plastic container with lid
- Hydroponic nutrient solution (optional)*
- Drinking straw

*Rockwool is made from molten rock that is spun into fibers and then compressed into mats or cubes. Both rockwool and hydroponic nutrient solutions are available from hydroponics suppliers and on Amazon.

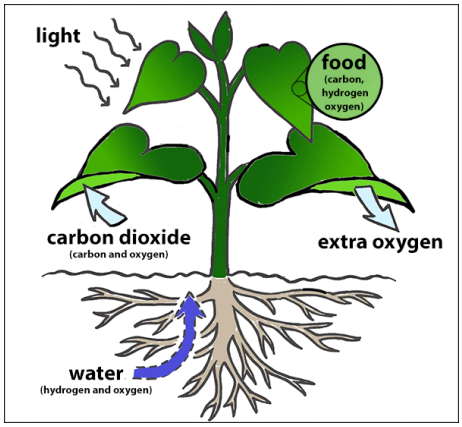
Introduction

All plants need water, air, light, nutrients, and a place to grow. Here is a brief review of the needs discussed in the previous Lessons to Grow By:

Light. Energy from light is captured to use during photosynthesis. Photosynthesis is the process by which plants make their food.

Air. Plants take in carbon dioxide to use during photosynthesis. The also take in lesser amounts of oxygen to help fuel their metabolic processes.

Water. Plants need water for a number of important processes, including photosynthesis (production of food) and transpiration (evaporation of water from the leaves into air that cools the plant and creates pressure to move water from roots to leaves). Water also aids in the absorption of some nutrients.



Nutrients. Just as people need vitamins, plants need certain nutrients to help them grow properly and for their biological processes to function. Plants obtain most of their nutrients from the soil. Nutrients occur naturally in the soil as a byproduct of decomposition of organic matter and the weathering of rocks. They can also be added through man-made fertilizer applications.

The last need plants must fulfill if they are to survive is a place to grow. Unlike most animals, plants are rooted in place. They must have a spot where they can anchor their roots, grow their stems and leaves, and obtain all of the other needs listed above. In nature, roots are usually anchored in the soil; however, there are exceptions, such as plants with aerial roots that live in rainforests and some floating water plants.

Plants come in all different shapes and sizes, so there is no set amount of space every plant needs to be thrive. Additionally, plants are extremely good at adapting. They can find ways to grow despite limited space, as long as their other needs are met.

Gardeners often push the limits regarding the space plants need to grow. Sometimes our gardens are more about our own needs and desires, rather than the plants' optimal conditions. This can have unfortunate consequences. For example, have you ever seen a sidewalk that has been cracked or buckled by tree roots because the tree wasn't given enough space to grow? Or a tree whose canopy had to be cut back because it was planted too close to power lines?

In some cases, however, limiting a plant's space to less than it needs in its native environment can have favorable results, as long as the gardener meets the plant's other needs.

For example:

- In the Japanese art of bonsai, gardeners prune the roots and stems of trees and shrubs to create healthy plants in miniature form.
- In urban areas, we grow plants in containers, in vertical gardens, and on rooftops.

These approaches allow people with limited space to be surrounded by green. Another example of this is a growing technique called hydroponics.

Bonsai artists prune the stems and roots of trees over many years to achieve miniature forms that can grow in small pots.

Hydroponics, in its simplest form, is growing plants by supplying all necessary nutrients via the plants' water supply, rather than through the soil. The word derives from the Greek root words hydro, meaning water, and ponics, meaning working.

Growing plants hydroponically helps gardeners and farmers grow more food in smaller areas, such as classrooms, greenhouses, rooftops, and living rooms. It also allows them to produce food in parts of the world where space, good soil, and/or water are limited, such as in an urban warehouse, in a desert, in Antarctica, or even on the International Space Station!

Activity 1: A Place to Call Home

1. Together or independently, read the A Place to Call Home Reading Page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Talk about how plants come in all shapes and sizes. Venture out on a nature walk and take time to observe all the different sizes of plants. You can use the Plant Observation Worksheet as a guide. Bring along a measuring tape so you can record various plants' height and width and the circumference of tree trunks.

   If you do not have a flexible measuring tape, use a long piece of string and a ruler. Wrap the string around the object and mark it to record the height or diameter of the plant. Then use the ruler to measure the length of the string.

   As you make observations, you may also want to mention to kids that the size and shape of a plant can be influenced by its age.

3. At the end of the walk, reflect on the diversity of plants you observed. Did you find many large plants on your walk? Were there more small plants? Were there some plants too big or too small to measure? Did you find any examples of plants whose size might have been influenced by the space available?

Activity 2: Space to Grow Experiments

By growing different numbers of the same plants in the same-sized containers, kids can see the impact of adequate space vs. crowding on plant growth. Lettuce and radish seeds make good test subjects.

The recommended spacing for radish and lettuce seeds planted in the garden is to sow them approximately 1" apart; then, when they're an inch or two tall, thin the radish seedlings to approximately 3" apart and lettuce seedlings to 5-6" apart. For this experiment, you'll plant one or two pots that demonstrate the recommended spacing (with just 1 or 2 plants per pot), and other pots that are overcrowded.

1. Obtain at least 5 pots of equal size. You can also repurpose plastic food containers, but be sure to punch holes in the bottom for drainage. Fill pots with moist soil.

2. Decide how many seeds to plant in each pot. Have at least one pot that has 1 plant and then choose different numbers of seeds based on the sizes of your pots. For easy comparison, you could plant in multiples of 5 for example (1, and then 5, 10, 15, 20, 25, etc.). Have kids record how many seeds were planted on the Space to Grow Experiment Data Collection Worksheet. Then have them write down a hypothesis of what they expect to see as the plants grow.

3. Provide equal amounts of water and sunshine to all the pots. Have kids record the number of seeds that germinate in each pot on their worksheets.

4. Have kids measure and record the height of the plants each week. It may be hard to measure every plant; if so, they can record the height of the tallest plant in each pot.

5. After 4 weeks, remove the plants from each container and measure the length of the longest roots. If possible, weigh the biggest plant.

6. Ask the following questions to discuss the experiment:

    - Did the measurements of the radish/lettuce plants vary based on the amount of space they had to grow?
    - Did this data match your predictions?
    - Which plants looked the healthiest?
    - Can you make any conclusions about plant needs based on this experiment?

Activity 3: Straw Hydroponics

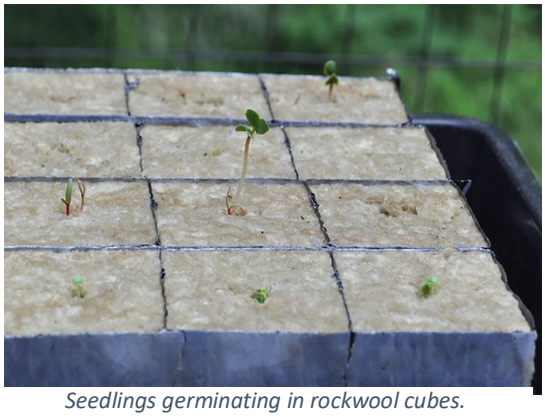
1. In nature, plants naturally adapt to the space they have to grow. In crowded conditions, many types of plants will grow taller to reach more light. When growing in nutrient-deficient soil, they will send their roots out further in search of nutrients to fill their needs. If they have lots of space available, they will spread out to their fullest.

    As gardeners, sometimes we try to grow plants in spaces that look very different than where they usually grow in nature. Share some of the examples listed in the Background Information or look for additional examples.

2. Try this simple straw hydroponic system to show kids how you can meet plant needs even in spaces that do not look like what we would find in nature. Kids are always amazed to see plants growing without soil. This kid-powered system gives them a chance to learn about hydroponic basics. Collect the materials:
    - Cotton balls or rockwool*
    - Lettuce seeds

- Plastic container with lid
- Drinking straw
- Hydroponic nutrient solution (optional)**

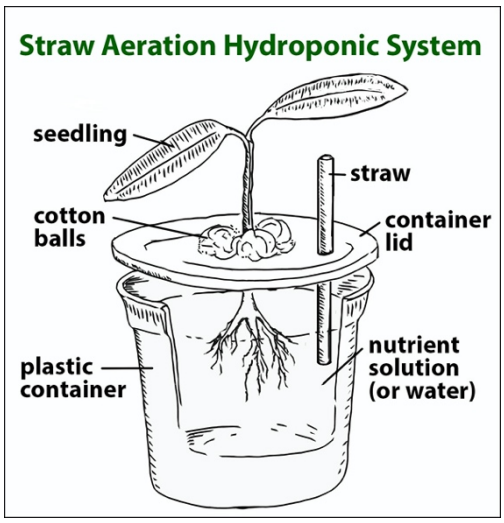
*Rockwool is made from molten rock that is spun into fibers and then compressed into mats or cubes. Both rockwool and hydroponic nutrient solutions are available from hydroponics suppliers and on Amazon.
**Though it's fairly inexpensive and recommended for optimal growth, hydroponic nutrient solution is not essential for this activity. Like all seeds, lettuce seeds contain enough food and nutrients for the plants' initial growth. The seedlings will grow for several weeks without added nutrients.



Seedlings germinating in rockwool cubes.

3. Soak small squares of rockwool or cotton balls in a dilute hydroponic nutrient solution (or plain water if you're not using the nutrient solution). Plant two or three lettuce seeds in each one, and then place them on a waterproof tray or shallow container and keep moist until seeds germinate.

4. Find a small plastic container with a lid to repurpose, such as a margarine, cottage cheese, or yogurt container. Use a utility knife to carefully cut a 1" X shape in the center of the lid. Cut a second, smaller X shape in the lid, about 1" from the edge, large enough to insert a drinking straw.



5. Gently insert the rockwool or cotton ball with the seedlings halfway through the large X so that it is held securely in place in the lid.

6. Fill the container with dilute nutrient solution (or plain water) so that the very bottom of the cotton ball or rockwool square will touch the solution, then secure the lid.

7. Insert a drinking straw through the smaller hole into the solution. Twice a day, gently aerate the solution by blowing into the straw. *Depending on the age and maturity level of your kids, this may be a job for a supervising adult. Make sure you are blowing air in and not drinking the nutrient solution.

8. Change the nutrient solution (or water) every 1 to 2 weeks.

9. As the plants grow, talk to your kids about how they are delivering the plants needs of water and air (and nutrients, if using) in a unique way. Discuss the benefits of growing plants in hydroponic systems, such as:
    - They can be used in locations where quality soil is not available.
    - They can be used in urban locations close to population centers so that food does not need to travel far from harvest to market.
    - Plants can be grown year-round.
    - The systems use less water than traditional gardening.
    - Growers can control nutrient availability
    - There are no weeds and usually fewer insect and disease problems.

Digging Deeper

You can use the following resources to dig deeper into this module's lessons:

Books and Additional Resources:

Flower Garden by Eve Bunting

Errol's Garden by Gillian Hibbs

Seed School by Joan Holub

Jack's Garden by Henry Cole

Up in the Garden and Down in the Dirt by Kate Messner

Plantzilla by Jerdine Nolen

A Place to Grow by Stephanie Bloom

Videos:

San Diego Hydroponic Farm from CaBountiful:
https://www.youtube.com/watch?v=zod-246VCkg

NASA's Doug Ming on Technologies Required for Living on Mars:
https://www.youtube.com/watch?v=QCOIHrt6eTU

Exploratorium Subzero Water Works in McMurdo Station on Ross Island, Antarctica:
https://www.exploratorium.edu/video/subzero-water-works

Exploratorium Polar Paradise:
https://www.exploratorium.edu/video/polar-paradise?autoplay=true

Can living walls reduce air pollution? BBC News and Middlesex University:
https://www.youtube.com/watch?v=CcAAeGpLN4c

Virtual Tour of the US National Bonsai Collection from Mauro Stemberger:
https://www.youtube.com/watch?v=Qy6FlhRbVcI

Additional Related KidsGardening Lessons and Activities to Try:

Room to Grow:
https://kidsgardening.org/resources/lesson-plan-room-to-grow/

Square Foot Gardening:
https://kidsgardening.org/resources/gardening-basics-square-foot-gardening/

Plants in Space:
https://kidsgardening.org/resources/lesson-plans-plants-in-space/

Exploring Hydroponics:
https://kidsgardening.org/resources/gardening-basics-exploring-hydroponics/

Container Gardening for Kids:
https://kidsgardening.org/resources/garden-activities-container-gardening-for-kids/

A Place to Call Home

Plant Needs - Reading Page - Space

Plants need five main things to stay alive. They need air and light to make their food through photosynthesis. They need to take in water and nutrients through their roots so they can be used by all parts of the plant for healthy growth. And there is one more thing on their list — they also need space to grow.

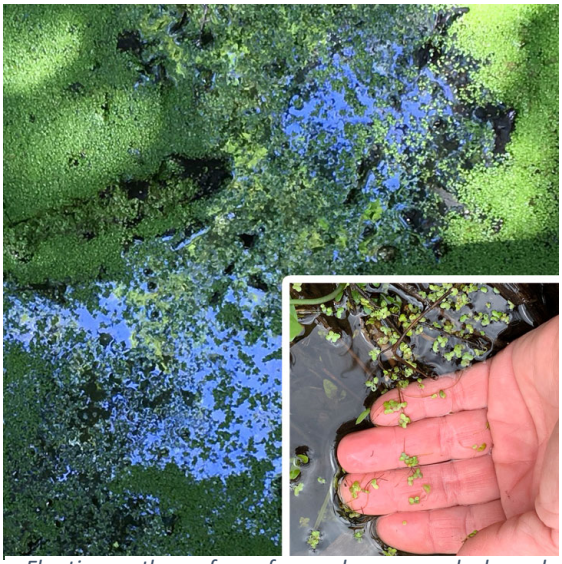
Just like animals, plants come in all shapes and sizes. For example:

- The watermeal plant is about 1/42" long and 1/85" wide, which is about the size of a candy sprinkle or the salt on a soft pretzel. (Some people think the plant, which grows in water, looks like cornmeal, which is how it got its common name.)
- The tallest tree in the world is a giant sequoia in California that is 275' tall and has a trunk that is about 32' wide. It is just a little bit shorter than the Statue of Liberty.

That is a big difference in size!

So, if a plant is given all the space in the world, along with the perfect amounts of water, nutrients, light, and air, will it keep getting bigger? Nope! Each type of plant has a specific size and shape it will reach when it's all grown up, ranging from teeny tiny to humongous.

Do plants always grow to their full size? Unlike animals that can move around to find the space they need, plants are rooted into place. So, if they are planted in a spot with limited room to grow, they will adapt to the space they have and may be thinner or shorter than normal. Also, when plants are crowded in their space they are competing with the plants around them for their other needs (light, water, air, and nutrients), and this can also keep them smaller.



Floating on the surface of a pond, common duckweed plants are less than 1/10" long. Watermeal plants are even tinier!

Can you imagine a tree so big it would take 25 kids reaching hand-to-hand to form a circle around its trunk? The General Sherman sequoia tree stands 275' tall and is more than 36' in diameter at the base. If you wrapped a tape measure around the trunk it would measure more than 100'.

Have you ever seen a garden packed with lots of plants and noticed the plants are tall and skinny? They may be stretching to try to get more sunlight. How about a tree planted in a narrow strip of land between a sidewalk and a street that never seems to get any taller? The size of its roots may be limiting how much its trunk and leaves can grow.

This ability to adapt to the space available is a cool thing about plants.

Although each type of plant has an ideal environment and amount of space where it will grow best, individual plants can adjust to less-than-ideal spots and still thrive. This is a very good thing for gardeners who like to grow plants in places and in ways that are not necessarily found in nature.

One example of this is the Japanese art of bonsai. Gardeners prune the stems and roots of plants to make them grow much smaller than they would be in nature. Towering trees can become container plants that fit on a shelf.

An example of a growing method that provides plants with a place to grow that is much different than where they grow in nature is hydroponics. In hydroponics, gardeners grow plants with their roots getting nutrients from water, instead of soil. This growing technique can be useful in environments where good soil is not available. For example, it can be used to grow plants in the desert, in Antarctica, and even on the International Space Station!

A hydroponic garden looks very different than a regular outdoor garden, but as long as all of a plant's needs can be met, it will be happy to call it home.

many years to achieve miniature forms that can grow in small pots.

With enough light, water, and nutrients to meet their needs, plants can adapt to growing in small spaces.

These plants are growing in different types of hydroponic set-ups.

Reading Comprehension Questions:

1. List the 5 basic needs of plants:

2. True or false: All plants need the same amount of space to grow.

3. What does a plant do if it does not have enough space to grow:
   - ☐ Move to a new location
   - ☐ Adapt to its space by growing differently
   - ☐ Nothing
   - ☐ File a complaint

4. Hydroponics is a way to grow plants in:
   - ☐ Soil
   - ☐ Milk
   - ☐ Water
   - ☐ Quicksand

5. List one unusual place that you have seen a plant growing:

Plant Observation Worksheet

Plant # or Name	Height	Circumference	Does this plant look like it has enough room to grow? Why or why not?

Space to Grow Experiment Data Collection Worksheet

Pot #	# of seeds planted	# of plants growing	Height of tallest plant:				Length of longest root after 4 weeks	Weight of one plant after 4 weeks	Observations
			After 1 week	After 2 weeks	After 3 weeks	After 4 weeks			