CLASSROOM LEARNING ACTIVITES FOR SECONDARY STUDENTS

NUTRITION FROM TREES

ENVIRONMENTAL BENEFITS OF TREES

SOIL BIOLOGY FOR GROWING HEALTHY TREES

TREE BIOLOGY FOR MAINTAINING HEALTHY TREES

Curriculum provided by Kansas City Community Gardens
and sponsored by EPA Region 7

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SECONDARY TABLE OF CONTENTS

SECTION TWO: TREE BIOLOGY

PARTS OF A TREE

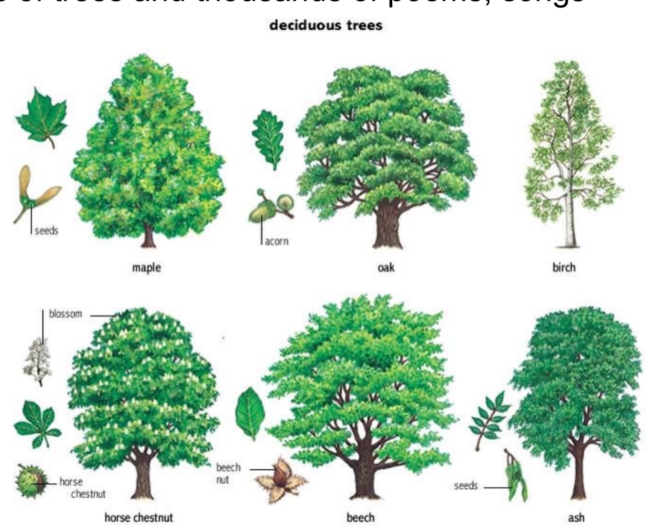
Lesson Objective: The Learner will identify the parts of a tree and tree trunk and describe the function of each part. The Learner will analyze cross-sections of the tree trunk to determine factors that affect tree growth.

Key Questions: How do trees help people, animals, and the environment? What are factors that affect the tree's growth? What can we determine about a tree's growth by analyzing a cross-section of the tree's trunk?

Background Information:

Trees are an important part of our world. They provide wood for building and pulp for making paper. They provide habitats (homes) for all sorts of insects, birds and other animals. Many types of fruits and nuts come from trees -- including apples, oranges, walnuts, pears and peaches. Even the sap of trees is useful as food for insects and for making syrup -- yum!

Trees also help to keep our air clean and our ecosystems healthy. We breathe in oxygen and breathe out carbon dioxide. Trees breathe in carbon dioxide and breathe out oxygen. We're perfect partners! Trees do lots for us, our environment and other plants and animals in nature but we don't just love trees for practical reasons. Trees can also be very beautiful -- tall enough they seem to touch the sky and so big around you can't even hug them. Thousands of artists, professional and amateur alike have painted pictures of trees and thousands of poems, songs and stories have been written about them. I would guess that just about everyone on earth has at some point in their life stopped to enjoy the beauty of a tree.



There are two main types of trees: deciduous and evergreen. Deciduous trees lose all of their leaves for part of the year. In cold climates, this happens during the autumn so that the trees are bare throughout the winter. In hot and dry climates, deciduous trees usually lose their leaves during the dry season.

Evergreen trees don't lose all of their leaves at the same time -- they always have some foliage. They do lose their leaves a little at a time with new ones growing in to replace the old but a healthy evergreen tree is never completely without leaves.

Parts of a Tree

- **Roots**

Roots are usually found underground, but in some cases this is not so. Some rainforest plants, known as epiphytes, grow right on trees. Their roots hang down in the air (called aerial roots) and are used to receive water and nutrient intake directly from the humid air. Most tree roots grow 2-3 feet deep, but under ideal soil and moisture conditions, roots have been observed to grow to more than 20 feet (6 meters) deep. There are two sorts of root systems:

⇒ taproot system: there is one very big root that goes down into the ground, and many smaller roots that come out of it

⇒ diffuse root system: there are many roots that go in all directions

Roots generally spread out wider than the tree canopy. It is a common misperception that the tree roots are as deep as the height of the tree. Besides keeping the tree from tipping over, the main job of the roots is to collect water and nutrients from the soil and to store them for times when there isn't as much available.

- **Crown (Canopy)**

The crown is made up of the leaves and branches at the top of a tree. The crown shades the roots, collects energy from the sun (photosynthesis) and allows the tree to remove extra water to keep it cool (transpiration -- similar to sweating in animals). The crowns of trees come in many shapes and sizes!

- **Leaves (Foliage)**

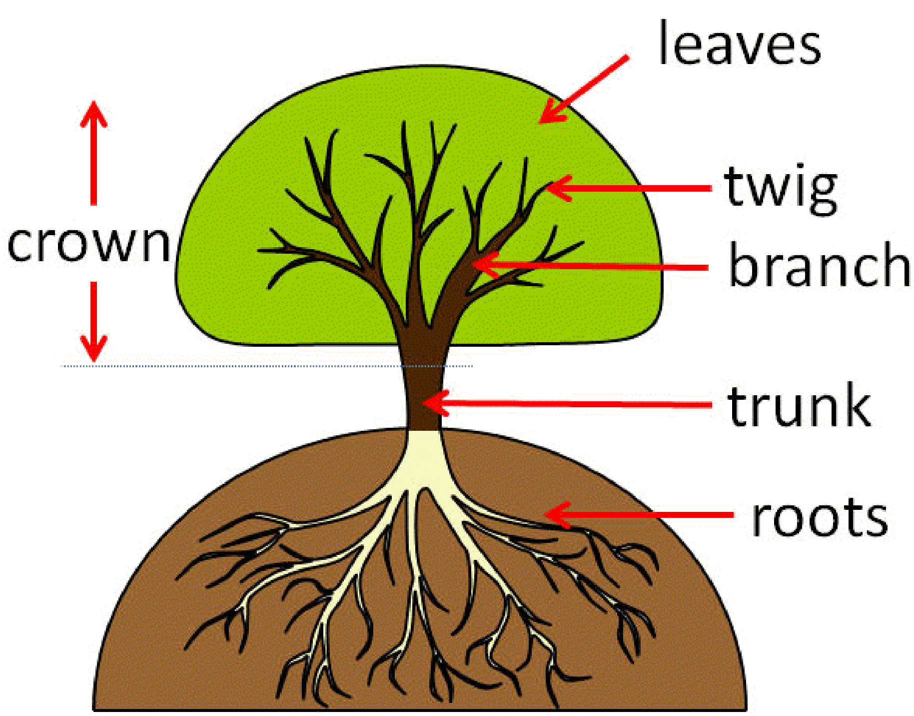
Leaves are the part of the crown of a tree. They are the part of the tree that converts energy into food (sugar). Leaves are the food factories of a tree. They contain a very special substance called chlorophyll -- it is chlorophyll that gives leaves their green color. Chlorophyll is an extremely important biomolecule, used in photosynthesis -- leaves use the sun's energy to convert carbon dioxide from the atmosphere and water from the soil into sugar and oxygen. The sugar, which is the tree's food, is either used or stored in the branches, trunk and roots. The oxygen is released back into the atmosphere.

- **Branches (Limbs)**

The branches provide the support to distribute the leaves efficiently for the type of tree and the environment. They also serve as conduits for water and nutrients and as storage for extra sugar.

- **Trunk**

The trunk of the tree provides its shape and support and holds up the crown. The trunk transports water and nutrients from the soil and sugar from the leaves.



Parts of the Trunk

Inside the trunk of a tree are a number of rings. Each year of the tree's life a new ring is added so many people refer to them as the annual rings. The rings are actually made up of different parts:

- **Bark**

The outside layer of the trunk, branches and twigs of trees. The bark serves as a protective layer for the more delicate inside wood of the tree. Trees actually have inner bark and outer bark -- the inner layer of bark is made up of living cells and the outer layer is made of dead cells, sort of like our fingernails. The scientific name for the inner layer of bark is Phloem. The main job of this inner layer is to carry sap full of sugar from the leaves to the rest of the tree.

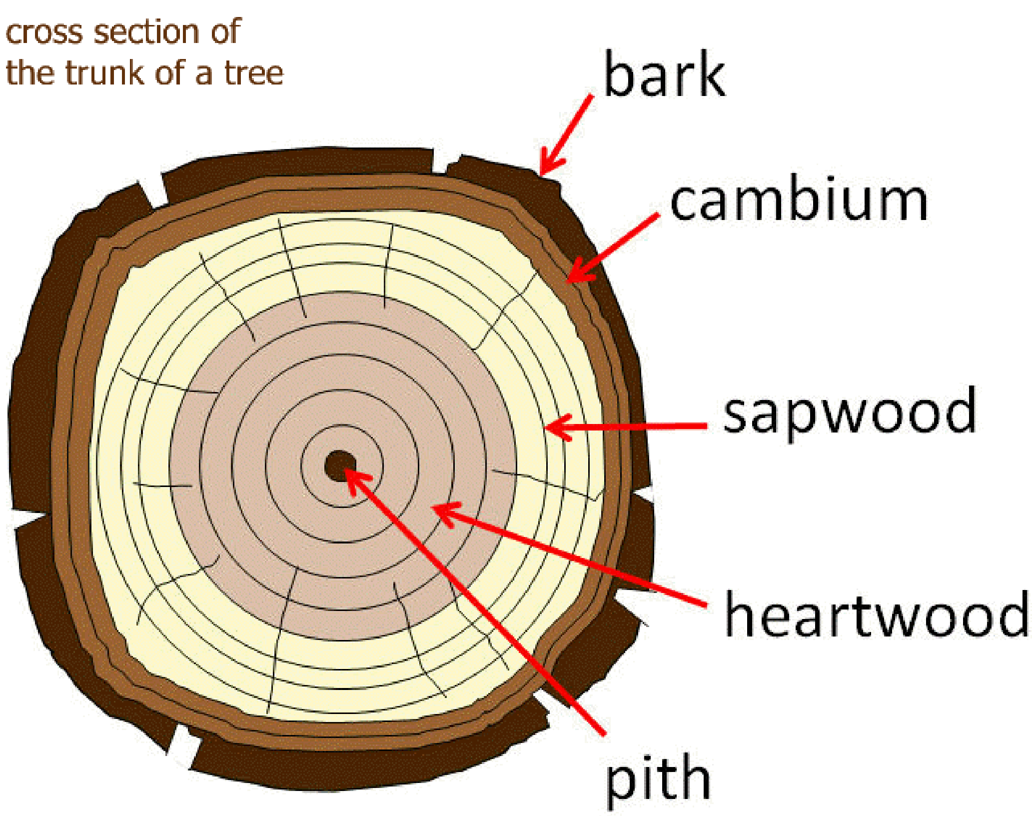
A number of handy things are made from bark including latex, cinnamon and some kinds of poisons. Because bark is a protective layer for the tree, keeping it safe from insects and animals, it isn't surprising the strong flavors, scents and toxins can often be found in the bark of different types of trees.

- **Cambium**

The thin layer of living cells just inside the bark is called cambium. It is the part of the tree that makes new cells allowing the tree to grow wider each year.

- **Sapwood (Xylem)**

The scientific name for sapwood is xylem. It is made up of a network of living cells that bring water and nutrients up from the roots to the branches, twigs and leaves. It is the youngest wood of the tree -- over the years, the inner layers of sapwood die and become heartwood.



- **Heartwood**

The heartwood is dead sapwood in the center of the trunk. It is the hardest wood of the tree giving it support and strength. It is usually darker in color than the sapwood.

- **Pith**

Pith is the tiny dark spot of spongy living cells right in the center of the tree trunk. Essential nutrients are carried up through the pith. It's placement right in the center means it is the most protected from damage by insects, the wind or animals. The pith becomes non-functional as the tree ages.

Materials:

Cross section from various tree trunks (ask a local tree trimming company)

Activity Sheet “Reading Between the Rings”   Science journal

Learning Activity:

- Provide students with several different cross sections of various types of tree trunks in conjunction with the Activity Sheet “Reading Between the Rings”.
- By “Reading between the Rings”, students will gain knowledge of the factors that affect tree growth.
- A cross section of a tree shows much more than its age! Diameter growth is particularly sensitive to fluctuations in the environment: moisture in the soil and air, temperature, and sunlight. Very broad rings generally indicate a good growing year. The tree apparently received everything it needed.
- The growth rate of a tree can be compared to the growth of a child. A young sapling grows much faster than an adult tree. A cross section of an older tree shows rings that are quite broad at the beginning of its life (in the center) but that become progressively smaller. An old tree produces very narrow rings and its diameter and height growth are considerably slower.

Look carefully at the pictures and read the explanations to understand what may have caused the cross section. What story is told about the life of the tree?

1. Narrow rings do not only signify a lack of sun or water. A forest fire may have damaged the tree's crown and slowed its growth. Defoliation by insects or fungi can have the same effect. After several years, the tree gained strength and returned to normal growth.

2. This tree had a rough time during its first ten years! Maybe someone helped it by cutting the large trees around it to give it more light.

3. Trees don't all have their heart in the right place! This tree shows off-center growth. If the tree was in a location exposed to high winds, its wood would grow faster (wider rings) on the side away from the wind than on the side facing the wind.

This cross section may also come from a tree that was leaning. The tree formed reaction wood (compression wood) that enabled it to straighten up. The wider rings are on the underside of the leaning trunk because growth was faster there.

4. Do you see waves? Look at the outer bark. Wasn't there a branch here?

Lesson Extension:

- Distribute tree rounds to groups with measuring tapes. Identify various parts of the tree trunk.
- Measure the diameter. Multiply by (3.14) to find the circumference. (C = Xd)
- Check the location of the **PITH**. Is it in the center? Have students hypothesize why the pith may not be in the center of the trunk (i.e. too much shade from surrounding foliage blocked sunlight).
- Count the trunk rings, marking off each decade.
- Figure the percent of growth for each ten year period. Do this by dividing the measured section by the total radius.

  Example: total radius = 40 cm

  1st decade = 15 cm

  15 ÷ 40 = .375 = 38%

  (in the first ten year period, the tree received 38% of its growth)

- Additional questions for class discussion/research:
  - ⇒ Life can be pretty tough on a tree! What factors affect the growth of trees? (i.e. drought, excessive rain, fire, insect plagues and disease epidemics, injuries, thinning, air pollution, all leave their mark on a tree's annual growth rings.)
  - ⇒ How can we identify the heartwood from the sapwood? The inner bark from the outer bark?
  - ⇒ What are the functions of each part of a tree/tree trunk? What benefits do trees provide for people, animals and the environment?
  - ⇒ What factors do you think might affect the position of the pith?
  - ⇒ When does a tree have its greatest percent of growth
  - ⇒ Are the rings of a tree all the same size? What might account for the different widths in the rings?
  - ⇒ Is there a relationship between trees within a certain area?
  - ⇒ Can we determine what year a tree germinated?
  - ⇒ Are trees with the same diameter the same age? Why?

Additional Resources

https://www.kidzone.ws/plants/trees.htm

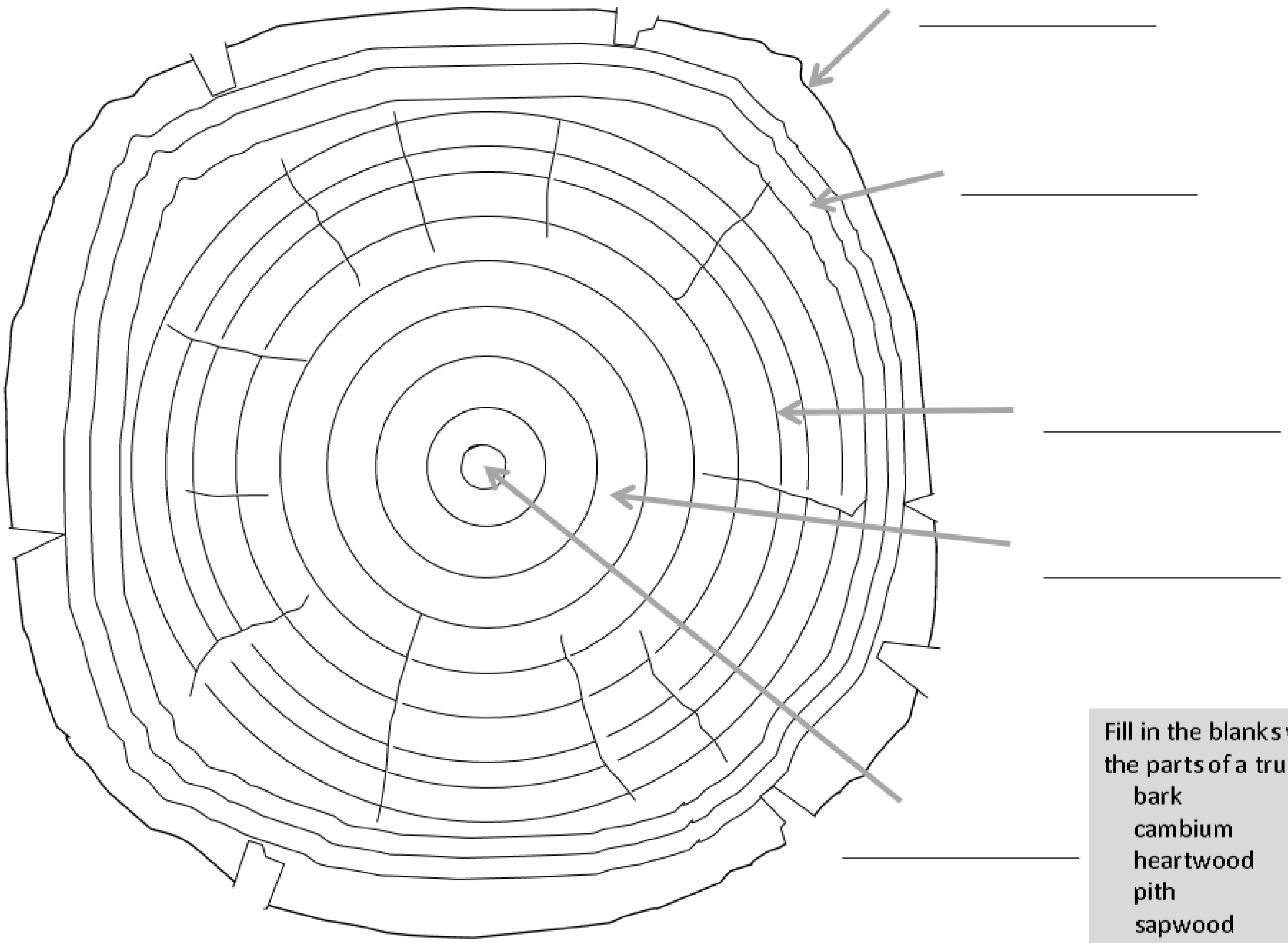
https://www.theforestacademy.com/tree-knowledge/annual-growth-rings/#.XGHKDlVKjcs

Extension activity adapted from AIMS Education Foundation “Our Wonderful World”

NAME: ___________________

PARTS OF A TREE TRUNK

Use the Word Bank to fill in the parts of a tree trunk.



Fill in the blanks with the parts of a trunk:
- bark
- cambium
- heartwood
- pith
- sapwood

1. What is the main job of the tree's outer bark and inner bark?:________________________
____
2. What part of the trunk makes new cells and allows the tree to grow wider each year?
____
3. What part of the trunk brings water and nutrients up from the roots to the leaves?
____
4. What part of the trunk gives the tree strength and support?
____
5. The _______________ is the tiny dark spot of living cells right in the center of the trunk.
6. What would cause some trunk rings to be wider than others? ________________________
____

NAME: ___________________

READING BETWEEN THE RINGS

Look carefully at these tree trunk cross-sections. Describe the story that is told about the life of the tree.

Where is the location of the PITH? ____________________________

What does that tell you about the growth of the tree?

____

What observations can you make about the rings? __________________

____

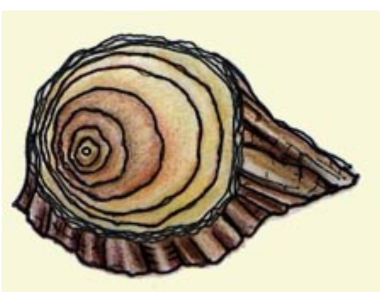
What observations can you make about the rings? __________________

____

What might have caused the tree to have such small rings in the first 10 years of its life? ____

____

____



Where is the location of the PITH? ______________________________

What might have caused the pith to be in this location?

____

____

____

What observations can you make about the rings? _________________

____

Look at the wave in the outer bark. What do you think caused this?

____

____

IDENTIFYING LEAVES

Lesson Objective: The Learner will identify various characteristics of tree leaves and classify trees based on their leaf structure.

Key Questions: What are some differences between conifer and broadleaf (deciduous) trees? How can leaf characteristics help us identify trees?

Background Information:

There is a scientific process scientists use to classify plants and animals. This process is called TAXONOMY. Taxonomy provides an organized system for grouping things based on certain "like" characteristics.

When scientists classify trees they start by dividing trees into two main groups.

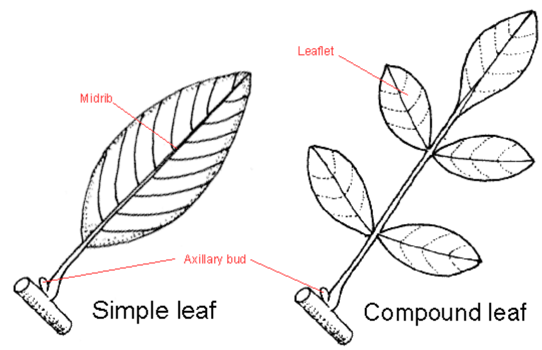
1. **CONIFERS** – Conifers are cone bearing trees and most are evergreen. Conifers have needle-like or scale-like leaves.

   A. **Conifers with needle-like leaves** –Closely examine a conifer sample with needle-like leaves. Look to see if each needle attaches singly to the twig or if the needles are attached to the twig in bundles of needles grouped together. This is one clue you may need to look for when identifying a mystery tree.

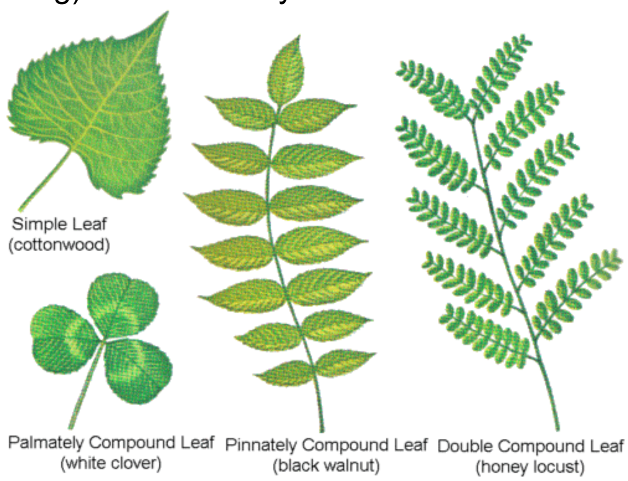
   B. **Conifers with scale-like leaves** – Look closely at a sample of a conifer that has scale-like leaves. Point out how the tiny, scale-like leaves overlap each other. Some of these conifers may have cones that look more like small berries. Make sure you can distinguish between conifers with needle-like and scale-like leaves before proceeding to a discussion of broadleaf trees.

2. **BROADLEAF TREES** – Broadleaf trees have thin, flat leaves that are usually shed annually (deciduous). Broadleaf trees bear a variety of fruit and flowers. In the classification process of broadleaf trees, scientists look at two important clues to further separate these trees into groupings. Where the leaf stalk attaches to the twig there is usually a BUD. That bud is next year's leaf, already on the tree. The leaf will fall off, but the bud will remain on the twig through the winter, opening into a leaf the following spring. Point out that if a bud is not exposed or visible, look for a swelling at the base of the leaf to determine attachment. The bud (or swelling) is an important clue...it tells them THE LEAF STARTS HERE!

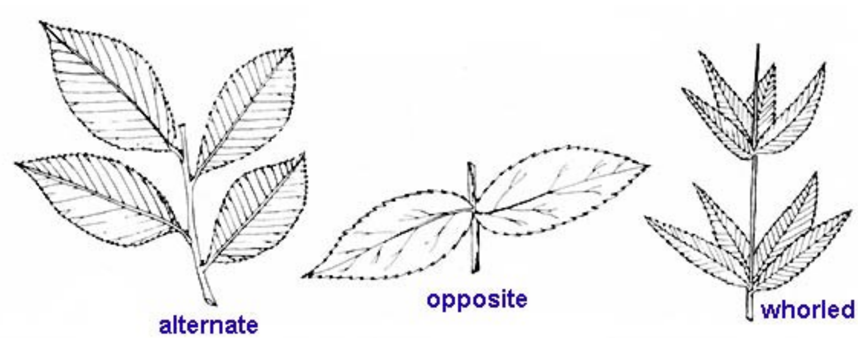
A. **<u>Simple leaves OR Compound leaves</u>** - One important reason to look for the bud is to determine if the tree has simple leaves or compound leaves. Find the bud and then look at the leaf stalk (petiole). If there is just one blade on the leaf stalk, it is a SIMPLE LEAF. If there are many blades on the leaf stalk, it is a COMPOUND LEAF. The multiple blades of the compound leaf are called LEAFLETS.



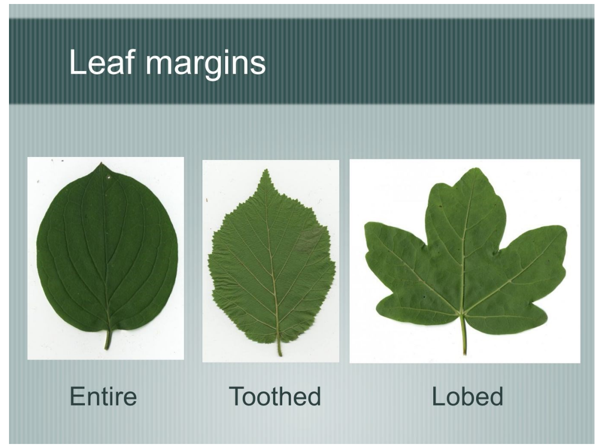
Also important to know is that the LEAFLETS of the compound leaves are attached to the leaf stalk (not the twig) in several ways. When leaflets are attached across from each other on the leaf stalk in a pattern that resembles a feather, that leaf is referred to as a PINNATELY COMPOUND LEAF. If the leaf stalk comes up and branches out again giving the appearance of a number of feathers attached to the leaf stalk, that leaf is referred to as a BIPINNATELY or DOUBLE COMPOUND LEAF. If the leaflets are arranged on the leaf stalk in a pattern that looks like the fingers on the palm of a hand, that leaf is referred to as a PALMATELY COMPOUND LEAF.



B. **<u>Opposite Arrangement OR Alternate Arrangement</u>** – Another very important reason to look for the bud or swelling where the leaf stalk attaches to the twig is that it will also help determine the ARRANGEMENT of the leaves on the twig. When two or three leaves are arranged directly across from each other on the twig it is called an OPPOSITE ARRANGEMENT. When leaves stagger up the twig and are not located directly across from each other on the twig that is called an ALTERNATE ARRANGEMENT. It is very important to stress that opposite and alternate arrangement refers to the way the LEAVES are arranged on the TWIG, not the way the leaflets are arranged on the leaf stalk. Sometimes many buds will be clustered close together near the end of the twig giving the impression of being opposite (often common with oaks) but if you look down a little further on the twig you will see that these buds or leaves actually have an alternate arrangement. A plant has whorled leaves when there are three or more equally spaced leaves at a node.



C. **Margin** – The MARGIN of a leaf is the leaf edge. Some broadleaf trees have leaves with smooth edges or ENTIRE MARGINS. Some broadleaf trees have LOBED LEAVES, leaves with projections that shape the edge of the leaf. Some broadleaf trees have TOOTHED MARGINS characterized by a saw-like edge on the leaf. Many other factors are important in tree identification. Other things scientists look at are the bark, the seeds/fruits, the shape of the tree, and the shape of the leaf.



Materials:

Leaf samples from the Conifer and Broadleaf trees outlined below

"Mystery Tree" Activity Sheet Clue Sheets

Learning Activity:

- Divide students into pairs. Give each pair of students a mystery tree sample and a worksheet. All students will start at clue sheet #1 with their mystery tree sample in hand. Instruct students to read the two questions on clue sheet #1.
- Students must decide which question best describes their mystery sample, and follow the "GO TO" directions for that question, proceeding to whatever clue sheet number is indicated by the best question.
- By repeating this process and physically moving to each new clue sheet indicated by the GO TO number, the GO TO directions will eventually lead the students to the identification of their mystery tree.
- Have students identify as many samples as time permits.
- This activity uses the following trees. These trees are common to many areas in the United States. If you would like to select different trees you may create your own clues specific to your tree samples.
- **CONIFER EXAMPLES USED**

  1. Arborvitae
  2. Eastern redcedar (juniper)
  3. Colorado blue spruce (square needle)
  4. Norway spruce (square needle)
  5. Hemlock
  6. Fir (Concolor/white Fir) (cone grows up)
  7. Larch (deciduous needles)
  8. Eastern white pine
  9. Scotch pine

BROADLEAF EXAMPLES USED

1. Ash
2. Boxelder (ashleaf maple)
3. Ohio buckeye
4. Catalpa
5. Dogwood
6. Chestnut
7. Linden (Basswood)
8. Redbud
9. Magnolia (flowers are large & showy)
10. Bur oak
11. Tuliptree (tulip-poplar or yellow-poplar)
12. Bitternut hickory
13. Honeylocust
14. Maple

- NOTE: This hands-on activity is not designed to replace direct observation and identification of living trees. It merely offers a great introduction to the classification process. When time and weather permit, get your students outside exploring the world of trees on their school grounds or in their community. Once your students have the basic skill and the enthusiasm for tree identification this can lead to the use of a more detailed dichotomous tree key or field guide like ***What Tree is That?***—available online identification guide **https://www.arborday.org/trees/whatTree/whatTree.cfm?ItemID=E6A**
- TO REPLACE AN EXAMPLE WITH A DIFFERENT SAMPLE OF YOUR OWN: If you wish to collect different tree samples from those listed above and, using this framework, create your own clues, you will need to replace a tree on the list with a tree from the same "clue grouping" or family of trees. Some possibilities are listed for you. You will also need to replace the marked text on the clue sheets with new clues specific to your sample. (Example: If you replace Colorado blue spruce with a white spruce sample you will need to insert a descriptive clue for white spruce on clue sheet #11 and an identification of white spruce on clue sheet #14.) Clue ideas can be found at **www.arborday.org/trees/treeid.html**.
- Clue sheet #5 – There are a number of conifers with scale-like or awl-shaped leaves. This activity uses arborvitae and eastern redcedar as examples. Other samples you might collect could include southern whitecedar, western redcedar, cypress, Port Orford-cedar, and incense-cedar. You would need to create appropriate clues on clue sheet #5 and identify your mystery samples on sheet(s) #6 and/or #7.
- Clue Sheet #10 - This activity uses hemlock and white fir as examples of conifers that have flat needles that attach singly to the twig. Other trees could include balsam fir, noble fir, red fir, subalpine fir, baldcypress, and douglasfir. You would need to create appropriate clues on clue sheet #10 and identify your mystery samples on sheet(s) #12 and/or #13.
- Clue Sheet #11 - There are many kinds of spruce. In addition to the Colorado blue spruce and Norway spruce listed in the activity, other common spruces include Sitka spruce, black spruce, white spruce, and red spruce, just to name a few. You would need to create appropriate clues on this sheet and identify your mystery samples on sheet(s) #14 and/or #15.
- Clue Sheet #17 – There are many species of pine. Eastern white pine and Scotch pine are the samples listed in the activity. Other common pines include pinyon pine, ponderosa pine, digger pine, Coulter pine, knobcone pine, Austrian pine, pitch pine, lodgepole pine, western white pine, sugar pine, longleaf pine, loblolly pine, slash pine, shortleaf pine, red pine, and Jack pine ...to name just a few! You would need to create appropriate clues on sheet #17 and identify your mystery samples on sheet(s) #18 and/or #19.
- Clue Sheet #26 - Ash and boxelder are listed in the activity. The other common tree with pinnately compound, opposite leaves is the elderberry. If you wish to switch elderberry for the ash or boxelder clue you would need to create appropriate clues on sheet #26 and identify your mystery sample on sheet #28 or #29.
- Clue Sheet #27 – The example listed in this activity is an Ohio Buckeye. Other samples could include yellow buckeye, California buckeye, and horsechestnut. If you have a sample for any of these other trees, just insert a new identification and description of that tree on this clue sheet.
- Clue Sheet #31 - Trees that have simple, opposite non-lobed leaves include dogwoods and catalpa, which are listed in the activity. The desert-willow also has simple, opposite, unlobed leaves and could be substituted for either the dogwood or catalpa as an example. You would need to create appropriate clues on clue sheet #31 and identify the mystery sample on either sheet #32 or #33.

- Clue Sheet #36 – The chestnut and linden are just two examples of a wide variety of trees that have simple, alternate, non-lobed leaves with toothed (jagged edge) margins. Some other common trees that fit this description include holly, beech, certain oaks, aspen, poplar, mulberry, hackberry, alder, many elm species, birch, willow, many fruit trees, crabapple, hornbeam and hophornbeam ...to name just a few. You would need to create appropriate clues on sheet #36 and identify your mystery samples on sheet(s) #38 and/or #39.
- Clue Sheet # 37 – The redbud and magnolia used in this activity are just two examples of a wide variety of trees that have simple, alternate, non-lobed leaves with entire (smooth edged) margins. Some of these other common trees include Russian-olive, western redbud, Osage-orange, pawpaw, live oak, madrone, black tupelo, and persimmon ...to name just a few. You would need to create appropriate clues on sheet #37 and identify your mystery samples on sheet(s) #40 and/or #41.
- Clue Sheet # 42 – To arrive at this clue sheet you need to have a sample of an oak that has lobed leaves. The example used in this activity is bur oak, but a number of other oak species could be substituted on this sheet. Some other oaks that would follow this identification pattern would include black oak, white oak, Gambel oak, swamp white oak, northern red oak, post oak, overcup oak, English oak, scarlet oak, and pin oak ...to name just a few. To substitute a different oak sample (must have lobed leaves) simply change the last two sentences (printed in blue) of the identification description to best fit your new tree sample.
- Clue Sheet #43 – The tuliptree used in this activity is just one example of a wide variety of broadleaf trees that have simple, alternate, lobed leaves but do not bear acorns (not in the oak family). Some other trees include ginkgo, tuliptree, sassafras, sweetgum, white poplar, sycamore, some hawthorns, and mulberry ...to name just a few. If you have a sample of any of these other trees, just insert a new identification and description of that tree on this clue sheet.
- Clue Sheet #44 - The hickory is just one example of a wide variety of broadleaf trees that have pinnately compound, alternate leaves. Some of these trees include Japanese pagodatree, goldenraintree, black locust, tree-of-heaven, mountainash, walnut, pecan, hickory, tesota ...to name just a few. If you have a sample of any of these other trees, just insert a new identification and description of that tree on this clue sheet.
- Clue Sheet #45 - The honeylocust sample is just one example of a wide variety of broadleaf trees that have bipinnately (two or three times) compound, alternate leaves. Some of these other trees include goldenraintree, mesquite, paloverde, Kentucky coffeetree, mimosa, and Jerusalem thorn ...to name just a few. If you have a sample of any of these other trees, just insert a new identification and description of that tree on this clue sheet.

Additional Resources:

Lesson activity adapted from https://www.arborday.org/kids/treemazefinal.pdf

NAME: ________________________

MYSTERY TREE CHALLENGE

Directions: It is your challenge to identify as many different mystery leaf samples as possible. Each mystery leaf sample is marked with a different letter. Use the clue sheets to help you identify the mystery leaf sample. Start with Clue #1. Read the two clue questions. Which one best describes your mystery leaf sample? Follow the "GO TO" directions of the question most correctly answered yes, moving to the next clue sheet indicated. By repeating this process, you will eventually identify your mystery sample. Record your results on the chart below.

Mystery Leaf Sample	These are the clue sheets I followed in order (always begin at #1)	This is my Mystery Tree
A	#1 → #3 → #4 → #9 → #17 → #18	White Pine

Mystery Leaf Sample	These are the clue sheets I followed in order (always begin at #1)	This is my Mystery Tree

Can you find a picture of the mystery trees you identified?

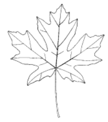
What are some of the unique qualities of these trees?

What unique benefits do these particular trees provide for people, animals, or the environment?

1

START HERE:
Do you have a ….

BROADLEAF (tree with leaves that are thin, flat & usually shed annually)?
If so, GO TO #2.



OR

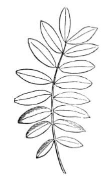
CONIFER (tree that bears cones and has needle-like or scale-like leaves)?
If so, GO TO #3.

2

Are the leaves SIMPLE (one blade attached to the leaf stalk or petiole)?
If so, GO TO #20.

OR

Are the leaves COMPOUND (more than one blade attached to the leaf stalk or petiole)?
If so, GO TO #21,



3

Does the conifer have…

NEEDLE-LIKE LEAVES?
If so, GO TO #4.

OR

SCALE-LIKE or AWL-SHAPED LEAVES? If so, GO TO #5.

scale-like

awl-like

4

Are the needles attached…

SINGLY, each needle attached directly to the twig? If so, GO TO #8.

OR

In BUNDLES or CLUSTERS of needles?
If so, GO TO #9.

5

Does your mystery sample have blue, berry-like cones with both scale-like & awl-shaped leaves?
If so, GO TO #6.

OR

Does your mystery sample have scale-like leaves in a flattened fern-like spray?
If so, GO TO #7.

6

You have a **JUNIPER** or **EASTERN REDCEDAR**. The wood of this tree is especially noted for its ability to resist the effects of moisture. The wood is also notable for its fragrance and it is often used in cedar chests. The berries are eaten by many kinds of birds. These trees are often called cedars, however they are not true cedars.
(The **JUNIPER** is just one of a number of conifers with scale-like or awl-like leaves.)
Check with your teacher to see if you have correctly identified your mystery tree.

7

You have an **EASTERN ARBORVITAE** or **NORTHERN WHITECEDAR**. This is one of the most easily recognized of the evergreens because of its flattened, fern-like branches.

(The **ARBORVITAE** is just one of a number of conifers with scale-like or awl-like leaves.)

Check with your teacher to see if you have correctly identified your mystery tree.

8

Are the needles FLAT? If so, GO TO #10.

OR

Are the needles SQUARE or 4-SIDED? If so, GO TO #11.

9

Does your tree have…

Soft, DECIDUOUS needles growing in clusters of many needles? (These needles are shed in the fall) If so, GO TO #16.

OR

EVERGREEN needles that grow in bundles of 2-5? (These needles stay on the twig through the winter) If so, GO TO #17.

10

Does your sample have short needles, less than 1” long, and a small cone that hangs down?
If so, GO TO #12.

OR

Does your sample have needles over an inch long with cones that grow upward?
If so, GO TO #13.

11

(These are spruce trees. Most spruce have 4-sided, stiff, sharp-pointed needles.)

Does your spruce sample have blue-green or silvery-blue needles with a cone that is 2”-4” long?
If so, GO TO #14.

OR

Does your spruce sample have dark green needles and a cone that is 4”-8” long? If so, GO TO #15.

12

You have a **HEMLOCK**. Its needles are arranged in flattened sprays along the twig. Native Americans and early settlers valued the hemlock for the tannin in its bark which was used to tan leather.
(The **HEMLOCK** is just one of several kinds of conifers that have flat needles. Others include fir, douglasfir, and baldcypress.)

Check with your teacher to see if you have correctly identified your mystery tree.

13

You have a **FIR**. Your mystery sample is a **WHITE FIR** or **CONCOLOR FIR**. White fir do not begin producing cones or seeds until the tree is about 40 years old. The white fir makes a beautiful Christmas tree and it is important to many species of wildlife.
(The **FIR** is just one of several kinds of conifers that have flat needles. Others include hemlock, douglasfir, and baldcypress.)

Check with your teacher to see if you have correctly identified your mystery tree.

14

You have a **COLORADO BLUE SPRUCE**. Because of its beautiful blue-green needles and adaptability to different soils and climates, the Colorado blue spruce is one of the most popular evergreens for ornamental planting.

(This is just one of a number of spruce species in the United States.)

Check with your teacher to see if you have correctly identified your mystery tree.

15

You have a **NORWAY SPRUCE**. These trees are easily recognized by their drooping branches. They have rapid, symmetrical growth and keep foliage on the lower as well as upper branches, making it a popular conifer for planting.

(This is just one of a number of spruce species in the United States.)

Check with your teacher to see if you have correctly identified your mystery tree.

16

You have an **LARCH**. Larches have their needles in clusters of many needles. These soft, needle-like leaves are shed each year in the fall so the tree appears bare, except for the cones, through the winter. There are many larch species including the Tamarack (eastern larch), western larch, European larch, and subalpine larch.

Check with your teacher to see if you have correctly identified your mystery tree.

17

(These are **PINE** trees. Pines are evergreen conifers that grow their needle-like leaves in bundles.)

Does your tree have needles held in BUNDLES OF 5?
If so, GO TO #18.

OR

Does your tree have needles held in BUNDLES OF 2?
If so, GO TO #19.

18

You have an **EASTERN WHITE PINE**. White pine have needles that grow in bundles of 5’s and their cones are long with thin scales. Towering white pines were used as masts for ships in Colonial America. It is believed that J. Sterling Morton was the first person to plant eastern white pine in Nebraska.

Check with your teacher to see if you have correctly identified your mystery tree.

19

You have a **SCOTCH (or SCOTS) PINE**. This species of pine is widely planted for Christmas trees. While it is an adaptable tree, it is vulnerable to disease.

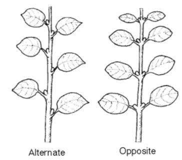
(There are many species of pine. The **SCOTCH PINE** is just one of the many kinds of pines found in the United States.)

Check with your teacher to see if you have correctly identified your mystery tree.

20

Do the SIMPLE leaves have an OPPOSITE arrangement? (Leaves located directly across from each other on the same twig.) If so, GO TO #22.

OR



Do the SIMPLE leaves have an ALTERNATE arrangement? (Leaves that are staggered, not located directly across from each other on the same twig.) If so, GO TO #23.

21

Do the COMPOUND leaves have an OPPOSITE arrangement? (Leaves located directly across from each other on the same twig.) If so, GO TO #24.

OR

Do the COMPOUND leaves have an ALTERNATE arrangement? (Leaves that are staggered, not located directly across from each other on the same twig.) If so, GO TO #25.

22

Are the simple, opposite leaves LOBED? (Lobes are projections that shape a leaf) If so, GO TO #30.

OR

Are the simple, opposite leaves NOT LOBED? If so, GO TO #31.

23

Are the simple, alternate leaves LOBED? (Lobes are projections that shape a leaf) If so, GO TO #34.

OR

Are the simple, alternate leaves NOT LOBED? If so, GO TO #35.

24

Are the leaves PINNATELY COMPOUND? (with blades or leaflets arranged like vanes of a feather)? If so, GO TO #26.

OR

Are the leaves PALMATELY COMPOUND (with blades or leaf-lets arranged like fingers on the palm of a hand)? If so, GO TO #27.

25

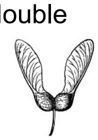
Are the leaves only ONCE PINNATELY COMPOUND? (with blades or leaflets arranged like vanes of a feather)? If so, GO TO #44.

OR

Are the leaves 2 or 3 TIMES PINNATELY COMPOUND? If so, GO TO #45.

26

Are there generally 3-5 BLADES that are LOBED or very coarsely toothed, and is the fruit a double SAMARA (winged seed)? If so, GO TO #29.



OR

Are there generally 5-13 BLADES that are NOT LOBED, and is the fruit a single SAMARA (winged seed)? If so, GO TO #28.

27

Your sample is an **OHIO BUCKEYE.** These trees have nut-like seeds that are shiny and dark brown with a light colored spot that gives them the appearance of a deer's eye, which gave rise to the buckeye name. While these seeds are poisonous if eaten, they were popularly believed to bring good luck when carried in a pocket. Other common trees with PALMATELY COMPOUND leaves include other buckeye species and the horsechestnut.
Check with your teacher to see if you have correctly identified your mystery tree.

28

You have an **ASH**. There are a number of species of ash in the United States including green ash, white ash, and blue ash. Ash wood is hard and durable; it is often used for tool handles and for baseball bats.

(Boxelder and elderberry are other common trees that have PINNATELY COMPOUND, opposite leaves.)

Check with your teacher to see if you have correctly identified your mystery tree.

29

You have an **BOXELDER**, also called **ASHLEAF MAPLE.** This tree is really a maple, but it resembles an ash because of its opposite, compound leaves. The weak wood of the boxelder makes it of little use to the lumber industry, but its seeds that appear in the spring are eaten by a variety of wildlife.
(Ash and elderberry are other common trees that have PINNATELY COMPOUND, opposite leaves.)

Check with your teacher to see if you have correctly identified your mystery tree.

30

These are **MAPLE** trees Maples have winged seeds, called SAMARAS, that flutter to the ground like little helicopters. Maples usually have lovely fall color. The wood of the maple is prized for its strength and beauty. A number of different maple species can be found in the United States.

Check with your teacher to see if you have correctly identified your mystery tree.

31

Does your tree have LARGE, HEART-SHAPED LEAVES and a long BEAN-LIKE SEED POD? If so, GO TO #32.

OR

Does your tree have leaves with veins that follow the leaf edge and a BERRY-LIKE FRUIT? If so, GO TO #33.

32

You have a **CATALPA.** Catalpa trees have showy blossoms in early summer that are succeeded by long, slender pods, which make the trees easy to identify in the fall.

Check with your teacher to see if you have correctly identified your mystery tree.

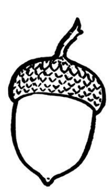
33

You have a **DOGWOOD**. Many species of dogwood are planted as ornamental trees because of their lovely spring flowers. In the fall, these trees have berries that are food for woodland birds. In the winter, dogwood trees can be identified by the little button-like buds on the twig.

Check with your teacher to see if you have correctly identified your mystery tree.

34

Is the seed or fruit an ACORN in a cap? If so, GO TO #42.

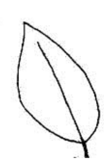


OR

Is the seed or fruit NOT an ACORN? If so, GO TO #43.

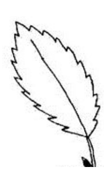
35

Are the LEAF MARGINS ENTIRE (SMOOTH EDGED)? If so, GO TO #37.



OR

Are the LEAF MARGINS TOOTHED (JAGGED EDGED)? If so, GO TO #36.

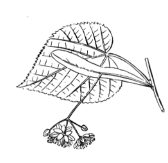


36

Are the LEAVES LONG with SHARP TEETH and is the fruit a NUT in a SPINY CAP? If so, GO TO #38.

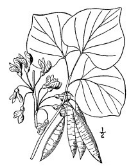
OR

Are the LEAVES HEART-SHAPED and is the fruit a few BERRY-LIKE SEEDS attached to a leaf-like bract? If so, GO TO #39.



37

Are the leaves HEART-SHAPED, is the fruit a SMALL POD, and are the spring blooms purple? If so, GO TO #40.



OR

Are the leaves OVAL-SHAPED, are the flowers large and showy, and do the flowers grow at the branch tips? If so, GO TO #41.

38

You have a **CHESTNUT**. The American Chestnut was once widely planted, but American chestnuts have been damaged by blight. The Chinese chestnut is more blight resistant and more commonly found. (Your sample is just one of a variety of trees that have simple, alternate, non-lobed leaves with toothed margins. Some of these trees include many fruit trees.)

Check with your teacher to see if you have correctly identified your mystery tree.

39

You have a **LINDEN** or **BASSWOOD**. These tall, stately trees make attractive street trees. The lightweight, soft wood is often used for carving.
(Your sample is just one of a variety of trees that have simple, alternate, non-lobed leaves with toothed margins. Some of these trees include many fruit trees.)

Check with your teacher to see if you have correctly identified your mystery tree.

40

You have an **EASTERN REDBUD**. These small trees welcome spring with a burst of vivid purple color. These trees grow well in a shaded location.
(Your sample is just one of a variety of trees that have simple, alternate, non-lobed leaves with smooth-edged margins. Some of these trees include pawpaw, magnolia, persimmon, and Russian-olive.)

Check with your teacher to see if you have correctly identified your mystery tree.

41

You have a **MAGNOLIA**. Throughout American history, the beauty of the magnolia has made it a popular tree for planting.
(Your sample is just one of a variety of trees that have simple, alternate, non-lobed leaves with smooth-edged margins. Some of these trees include pawpaw, redbud, persimmon, and Russian-olive.)

Check with your teacher to see if you have correctly identified your mystery tree.

42

Your sample is a **BUR OAK**. There are 58 species of oak native to North America. These broad spreading trees have fuzzy capped acorns that help identify this hardy tree. Some oaks do not have lobed leaves, but all oaks bear acorns. Its amazing strength, beauty and long life have made the oak a central part of American history. (Other examples of broadleaf trees with simple, alternate, lobed leaves include sycamore, tuliptree, and hawthorns.)

Check with your teacher to see if you have correctly identified your mystery tree.

43

Your sample is a **TULIPTREE**. Not only an important timber tree, the tuliptree is prized for its beautiful, yellow-orange, tulip-like blossoms that appear in early summer. Its leaves have a T-shirt shape and its winged seeds grow in an upright cone-like container. (Other examples of broadleaf trees with simple, alternate, lobed leaves include sycamore, oaks, and hawthorns.)

Check with your teacher to see if you have correctly identified your mystery tree.

44

Your sample is a **BITTERNUT HICKORY**. The nut of this tree is so bitter even a half-starved squirrel often passes it up.
(Hickory trees are just one example of broadleaf trees that have pinnately compound, alternate leaves including Japanese pagodatree, locust, walnut, and pecan.)

Check with your teacher to see if you have correctly identified your mystery tree.

45

Your sample is a **HONEYLOCUST**. These trees have a long, brown, leathery pod with seeds inside about the size of watermelon seeds. In the wild these trees have hard, sharp thorns. Thornless honeylocusts are available that make a beautiful, hardy city tree.
(Your sample is just one example of broadleaf trees that have bi-pinnately compound, alternate leaves including Jerusalem thorn, mesquite, and mimosa.)

Check with your teacher to see if you have correctly identified your mystery tree.

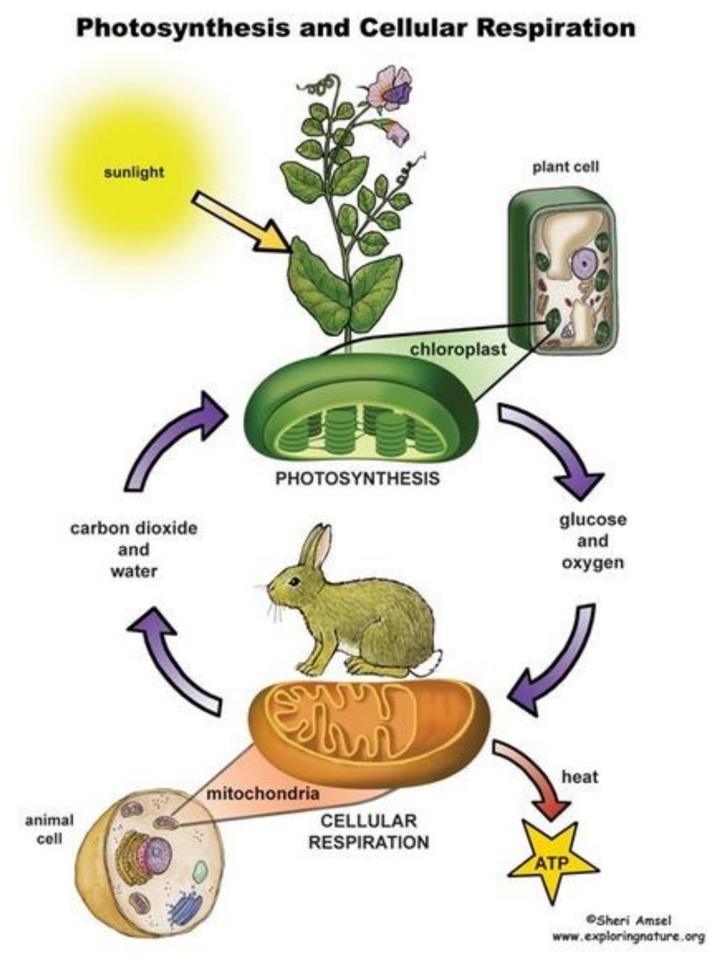
PHOTOSYNTHESIS AND CELLULAR RESPIRATION

Lesson Objective: The Learner will construct a conceptual understanding of the process of photosynthesis/cellular respiration, explain their role in the relationship between plants and animals, and construct the chemical formula for photosynthesis/cellular respiration.

Key Questions: Can you describe the process of photosynthesis and cellular respiration? How are these processes connected? How do these processes enable life as we know it?

Background Information:

Photosynthesis and cellular respiration are complementary processes by which living things obtain needed substances. They both consume and create the same substances (water, glucose, oxygen, and carbon dioxide) but in different ways. Through these processes, plants obtain the carbon dioxide they need and living organisms obtain the oxygen they need. They are also necessary to the energy exchange that living things need to survive.



Photosynthesis is the process by which green plants create their own food by turning light energy into chemical energy. Chlorophyll in the leaves transform carbon dioxide, water, and minerals into oxygen and glucose. Photosynthesis takes place in the chloroplasts of cells. This process is what gives energy to all living organisms either directly or indirectly. Without it, life on Earth would cease to exist.

Cellular respiration, on the other hand, is the process by which living things convert oxygen and glucose to carbon dioxide and water, thereby yielding energy. It does not require the presence of sunlight and is always occurring in living organisms. Cellular respiration takes place in the mitochondria of cells.

While photosynthesis requires energy and produces food, cellular respiration breaks down food and releases energy. Plants perform both photosynthesis and respiration, while animals can only perform respiration.

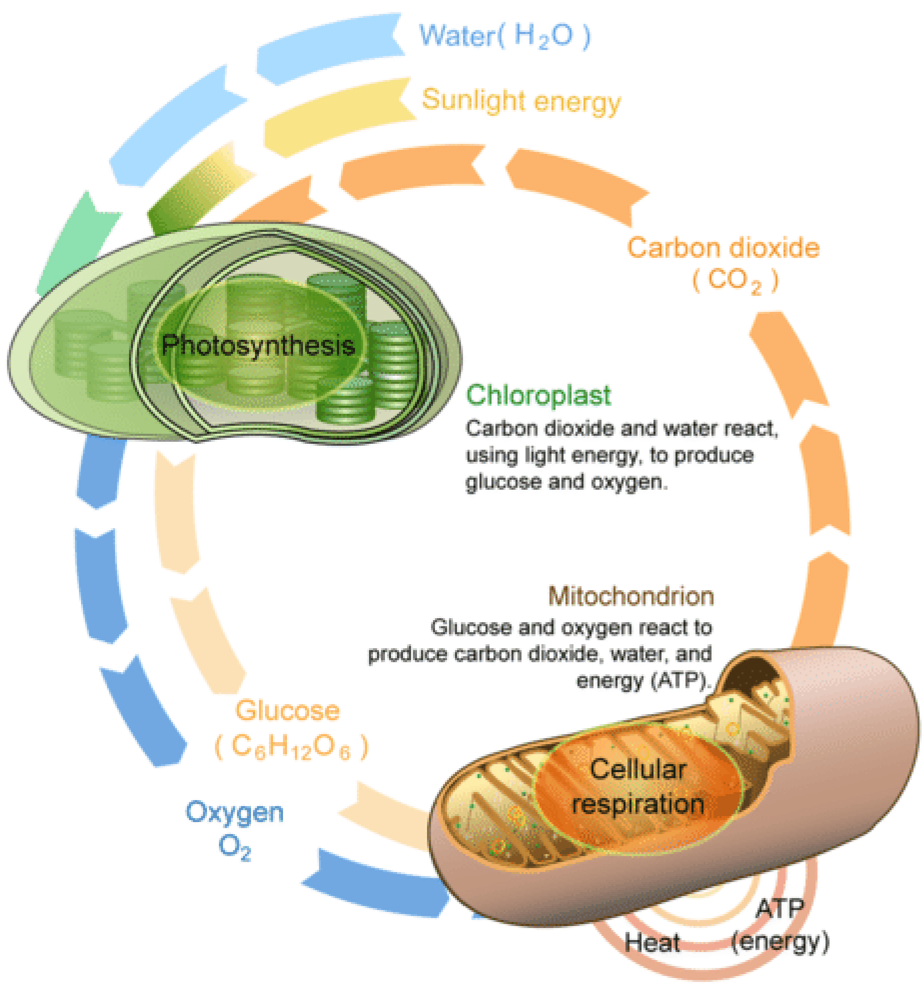
Photosynthesis and cellular respiration are connected through an important relationship. This relationship enables life to survive as we know it. The **products** of one process are the **reactants** of the other. Notice that the equation for **cellular respiration** is the direct opposite of **photosynthesis**:

- Cellular Respiration: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
- Photosynthesis: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Photosynthesis makes the glucose that is used in cellular respiration to make ATP. The glucose is then turned back into carbon dioxide, which is used in photosynthesis. While water is broken down to form oxygen during photosynthesis, in cellular respiration oxygen is combined with hydrogen to form water. While photosynthesis requires carbon dioxide and releases oxygen, cellular respiration requires oxygen and releases carbon dioxide. It is the released oxygen that is used by us and most other organisms for cellular respiration. We breathe in that oxygen, which is carried through our blood to all our cells. In our cells, oxygen allows cellular respiration to proceed. Cellular respiration works best in the presence of oxygen. Without oxygen, much less ATP would be produced.

Cellular respiration and photosynthesis are important parts of the **carbon cycle**. The **carbon cycle** is the pathways through which carbon is recycled in the biosphere. While cellular respiration releases carbon dioxide into the environment, photosynthesis pulls carbon dioxide out of the atmosphere. The exchange of carbon dioxide and oxygen during photosynthesis and cellular respiration worldwide helps to keep atmospheric oxygen and carbon dioxide at stable levels.

Cellular respiration and photosynthesis are direct opposite reactions. Energy from the sun enters a plant and is converted into glucose during photosynthesis. Some of the energy is used to make ATP in the mitochondria during cellular respiration, and some is lost to the environment as heat.



Common Misperceptions:

- Plants get their food from the environment rather than manufacturing it internally.
- Food for plants is taken in from the outside.
- Soil supplies most of the “raw materials” for photosynthesis. (Students have difficulty accepting that plants make food from water and air and that this is their only source of food)
- Water and minerals are food for plants.
- Soil is the plant’s food. People put food (fertilizer) in the soil for plants to eat.
- Respiration and photosynthesis are not seen as energy transfer processes.
- Plants take their food in through the roots and then store it in their leaves. Plants convert energy from the sun directly into matter.
- Plants change water and carbon dioxide into sugar (instead of plants convert carbon dioxide from air and hydrogen atoms from water into sugar.
- Plants only give off oxygen.
- Photosynthesis is a plant process and respiration is an animal process.

Materials:

Unifix cubes or legos (6 red, 12 blue, 18 green)

Stickers that say “The Sun’s Energy”

Learning Activity:

- You may remember the movie, "Billy Madison", where the main character says "Chlorophyll? Sounds more like bore-aphyll." This is what many of the students are thinking as soon as the concept of photosynthesis makes an appearance in the curriculum. This negative attitude is usually a response when students get lost among the details of the chemical reaction and lose site of the big picture of the process of photosynthesis. To simplify the process for your students, explain photosynthesis as a chemical reaction that simply absorbs light energy using the green pigment of chlorophyll to create glucose sugar, or stored chemical energy. The chemical reaction of photosynthesis is far more complex and detailed, but it is up to you to differentiate the instruction based on the academic abilities of your students.

- This video is a short introduction to present the chemical reaction of photosynthesis to your students https://youtu.be/aupr9qT2qgc
- This song parody covers the basic chemical reaction involved in Photo-synthesis. It is based on the song "Teenage Dream": (Composers: Benjamin Levin; Bonnie Leigh Mc Kee; Max Martin; Lukasz Gottwald; Katy Perry. Recorded by Katy Perry and Darren Criss with the Warblers on GLEE.)

$$\text{water} + \text{carbon dioxide} \xrightarrow{\text{light}} \text{glucose} + \text{oxygen}$$

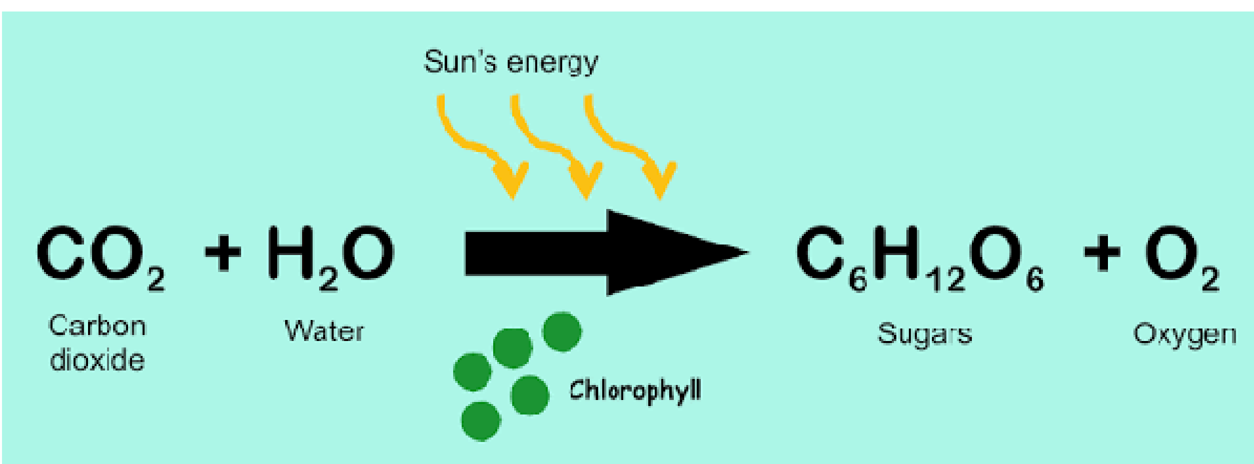
$$6H_2O + 6CO_2 \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$$

- Hopefully you will know the chemical equation for Photosynthesis after listening to this song a few times. Here are the words:

  Plants and some protists and some bacteria
  Will use the energy from sunlight in a process
  Called PHOTOSYNTHESIS, a chemical reaction - to make food.
  Six molecules of water will start to react
  With six molecules of carbon dio-xide
  And chlorophyll in the leaves absorb the sun's ... energy.
  The water's drawn from the roots, by the xy-lem cells.
  Carbon dio-xide comes from the air Into the leaves, through the sto-ma-ta.
  THESE RE-ACT-ANTS COME TO PRODUCE GLU-COSE (SUGAR) AND OXYGEN
  C6H12O6 plus 6O2, - Yeah, 6O2.
  THESE RE-ACT-ANTS COME TO PRODUCE GLU-COSE (SUGAR) AND OXYGEN
  C6H12O6 plus 6O2, - Yeah, 6O2.

- Use unifix cubes, legos, pattern blocks (or similar manipulatives) to lead students in a discussion about the chemical formula for photosynthesis.
- You will need 6 red cubes (Carbon), 12 blue cubes (Hydrogen), and 18 green cubes (Oxygen)
- Ask students, "*What is water made of? What elements? Do you know other names for water?*" This question should lead to the idea that water is made of H_2O.
- Write H_2O on the board next to the key. Ask, "*What does H_2O mean? Can you make H_2O out of the blocks that are provided?*" Water is made out of two hydrogen atoms and one oxygen atom (two green blocks and one blue blue).
- Tell students; "*Plants take in six molecules of water at a time. Please make six molecules of water.*" Write on the board "6 H_20 +"
- Ask students, *"Plants need water to survive. What else to they need?"* Allow students to answer carbon dioxide.
- Ask students, *"What do you think carbon dioxide looks like?"* Allow them time to build their idea and then invite students up to explain their thinking. Carbon dioxide is made up of one carbon atom and two oxygen atoms (one red and two blue blocks), have them use the remaining blocks to make carbon dioxide.
- Ask students, *"How many molecules of carbon dioxide did you make?"* When students answer six, add this to your equation on the board: "6 H_2O + 6 CO_2"
- Ask students, *"What else does a plant needs to survive?"* Most likely they will answer sunlight. Ask, *"What is the sunlight made out of? Are there any more blocks to make more molecules? What can you tell about sunlight?"* With guidance, students should conclude that sunlight is an energy source.
- Ask students, *"What is the energy source in this model? What is moving the blocks?"* They will answer that they are the energy source in the model, and they should realize that in this model they are playing the role of the sun.
- Give each student a sticker that say's "The Sun's Energy," so they can remember that they are the energy in the model.

- On the equation on the board of "6 H_2O + 6 CO_2" write the "Sun's Energy" and draw an arrow toward the equation to show that it helps the reaction take place but is not part of the molecular equation itself.
- Ask students, *"What does a plant release during photosynthesis?"* Students should answer with oxygen. Tell students that, *"a plant does give off oxygen. In fact, it gives off six molecules of oxygen in the form of O_2. Can you* ***REARRANGE*** *your blocks to make six molecules of O_2?"*
- Add oxygen to your equation, "6 H_2O + 6 CO_2 $\longrightarrow$ 6 O_2"
- Say to students, "*Now look at all the blocks you have left. What else can the plant make? Use the blocks to make only one molecule of the last remaining chemical a plant makes during this chemical reaction. Figure out the molecular equation and write it down yourself from the blocks you have left."*
- Have students share the chemical equation of the molecule that they have left. They should come up with $C_6H_{12}O_6$. Add that to the equation "6 H_2O + 6 CO_2 $\longrightarrow$ 6 O_2 + $C_6H_{12}O_6$".
- Ask students what they think this is. Tell them that, *"this molecule is called glucose. It is really a type of sugar. Plants go through a process called photosynthesis to make this sugar. When you eat plants, you consume the sugar."*
- If you want students to show the entire chemical formula with their blocks, you will need double the amount (12 red, 24 blue, 36 green). This will demonstrate that a BALANCED FORMULA shows the same amount of each element is used on both sides of the formula.



Lesson Extension

Materials Needed: Activity Sheet “Mission: Photosynthesis, Science journal, graph paper

1. Lead students through a performance task using the Activity Sheet “Mission: Photosynthesis”. Students will be asked to solve a problem, design a solution, analyze information, develop and use data to communicate information, and use research to communicate their understanding.

Materials Needed: Activity Sheet “Photosynthesis Research Project”

Access to research materials on Global Warming and Deforestation

2. Lead students through a research activity using the Activity Sheet “Photosynthesis Research Project”. The topics of Deforestation and Global Warming can be discussed during this unit to provide a context for photosynthesis. It is important to address the question most students ask (“why do I need to know this?”) in a way that provides an application of photosynthesis that is relevant to their everyday lives. These topics relate very closely to photosynthesis and are social topics that are often discussed in the media. By exposing the students to the scientific background of these issues the students will gain a better understanding of the issues, therefore enabling them to give a rationale for their stance on these political issues. These skills prepare them to be thoughtful and critical members of society.

Additional Resources

https://youtu.be/aupr9qT2qgc

http://www.softschools.com/difference/photosynthesis_vs_cellular_respiration/146/

https://www.ck12.org/biology/cellular-respiration-and-photosynthesis/lesson/Connecting-Cellular-Respiration-and-Photosynthesis-MS-LS/

https://betterlesson.com/lesson/634381/putting-the-energy-into-photosynthesis

Activity worksheets adapted from Newark Public Schools Next Generation Science Unit

NAME: ___________________

MISSION: PHOTOSYNTHESIS

Imagine that you are with a group of scientists on a rescue mission to find your colleague, Jordan, who has been living successfully in a greenhouse on Mars. However, when you arrive, you find the plants dying and Jordan is having a difficult time breathing. You have 26 hours to figure out what is going wrong before the plants, Jordan AND all of you die. The key is the plants…your task is to figure out why the plants are dying.

Hypothesis: What could cause the plants to die that also makes it difficult for Jordan to breathe? The answer can include anything, but the explanation must make sense.

While you have been hypothesizing about what could go wrong, your colleague has been doing research and has found the environmental data that Jordan has been collecting over the past two weeks. Examine the data provided. Then follow the directions to complete your task and save the plants and your lives!

Table 52: Week 52 in Mars Greenhouse

Environmental data at 12:00 p.m. (noon)…all seems normal.

Temp. (°C)	Light (nm)	CO2 (%of air)	Water intake rate	Stomatal opening factor	Photosynthesis rate
25	1500	0.03	1.0	1.0	100
25	1500	0.03	1.0	1.0	100
25	1500	0.03	1.0	1.0	100
25	1500	0.03	0.9	1.0	90
25	1500	0.03	0.9	0.9	100
25	1500	0.03	0.8	0.9	90
25	1500	0.03	0.8	0.8	80

Table 53: Week 53 in Mars Greenhouse

Environmental data at 12:00 p.m. (noon)…Something is wrong.
Note from Jordan: I don't think the urine/water recycler is working properly…need to check that out.

Temp. (°C)	Light (nm)	CO2 (%of air)	Water intake rate	Stomatal opening factor	Photosynthesis rate
25	1500	0.03	0.8	0.9	70
25	1500	0.03	0.6	0.8	50
25	1500	0.03	0.5	0.6	30
25	1500	0.04	0.5	0.4	20
25	1500	0.06	0.4	0.2	10
25	1500	0.08	0.3	0.1	0
25	1500	0.1	0.1	0.1	0

<u>Data Analysis:</u> For each of the columns in Tables 52 and 53, write a sentence which describes the trend of the data.

- **Temperature:** (Example: "The temperature in the greenhouse remained constant at 25°C for weeks 52 and 53.")
- **Light:**
- **CO2:**
- **Water intake:**
- **Stomatal opening factor:**
- **Photosynthesis rate:**

<u>Graphing:</u> On the graph paper provided, graph the data of the photosynthetic rate and one other factor which YOU think is affecting the photosynthetic rate. Each graph should have a title, labeled axis and a key.

<u>Explanation of the Problem:</u> Having examined the data, reassess your hypothesis and determine whether or not it was accurate or if it should be revised. Make a statement of your inferences as to what is killing the plants. Fully describe the factor(s), primary and secondary, causing the plant death and Jordan's breathing problem. Be sure to support this with data; reference the data tables provided and the graphs you created. Write a detailed explanation of how the factor(s) affects the photosynthetic rate. Include as much detail as you can on the process of photosynthesis. 8

<u>Proposed Solution to the Problem :</u> In detail, recommend how to fix the problem in the greenhouse, explain why you came to those conclusions and develop a model of your solution.

NAME: ____________________

PHOTOSYNTHESIS RESEARCH PROJECT

Design a brochure about one of the two current "Hot Topics" related to photosynthesis:

Deforestation or Global Warming

Content: Be sure to include the following items in your brochure

⇒ Complete introduction of the topic including definition

⇒ Connection to photosynthesis (how this topic is related to photosynthesis)

⇒ Description of how topic affects society

⇒ Personal Recommendations/Solutions to the problem

⇒ Inclusion of one scientist and a description of their contribution to the topic.

Methods: You are allowed to use the following resources

Scientific Journal Articles   Newspaper Articles   Books   Internet

Notes: You must compare at least two points of view within your brochure. You also must include citations from at least one newspaper article and one scientific journal. The final product should be constructed using Microsoft Word or Publisher. Make sure that all pictures obtained from the Internet are cited. Original artwork can also be used!

NOTES:

TRANSPIRATION: THIRSTY GREENS

Lesson Objective: The Learner will define transpiration, explain why it occurs in plants, and describe how environmental conditions alter rates of transpiration.

Key Questions: Why do plants require so much water to survive? What factors affect transpiration rates?

Background Information:

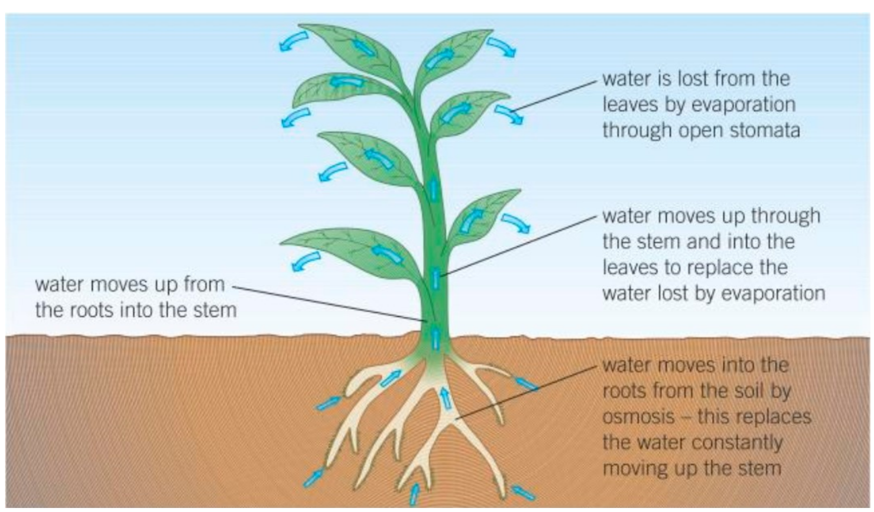
Plants lose gallons of water every day, mainly through the pores in their leaves, through a process called **TRANSPIRATION**. Up to 99% of the water absorbed by roots is lost via transpiration through plant leaves.

In actively growing plants, water is continuously evaporating from the surface of leaf cells exposed to air. This water is replaced by additional absorption of water from the soil. Liquid water extends through the plant from the soil water to the leaf surface where it is converted from a liquid into a gas through the process of evaporation. Plants have a "cooling effect" on our environment due to the "air conditioning" created by the evaporation of water through the surfaces of plants.

The state of evaporation will depend on several variables. Transpiration increases in dry air and decreases in moist air. Factors that affect air moisture levels also affect transpiration rates. Consequently, plants lose more water on hot, dry days than on cool, moist nights. Windy conditions also increase transpiration rates because the evaporated moisture around a plant is more quickly carried away to be replaced by drier air.

Plant wilting is related to transpiration. The plant's stiffness depends on the pressure of protoplasm against the plant cell walls. Protoplasm consists mostly of water. When the loss of water through transpiration is greater than the ability of the plant to replace the water, wilting occurs because the protoplasm no longer exerts the same pressure on the cell walls. When the pressure of the protoplasm decreases, the cell walls lose some of their rigidity, and the plant wilts.

Plant transpiration is pretty much an invisible process, since the water is evaporating from the leaf surfaces, you don't just go out and see the leaves "sweating". Just because you can't see the water doesn't mean it is not being put into the air, though. During a growing season, a leaf will transpire many times more water than its own weight. An acre of corn gives off about 3,000-4,000 gallons (11,400-15,100 liters) of water each day, and a large oak tree can transpire 40,000 gallons (151,000 liters) per year.



The amount of water that plants transpire varies greatly geographically and over time. There are a number of factors that determine transpiration rates:

- **Temperature:** Transpiration rates go up as the temperature goes up, especially during the growing season, when the air is warmer due to stronger sunlight and warmer air masses. Higher temperatures cause the plant cells which control the openings (stoma) where water is released to the atmosphere to open, whereas colder temperatures cause the openings to close.
- **Relative humidity:** As the relative humidity of the air surrounding the plant rises the transpiration rate falls. It is easier for water to evaporate into dryer air than into more saturated air.
- **Wind and air movement:** Increased movement of the air around a plant will result in a higher transpiration rate. This is somewhat related to the relative humidity of the air, in that as water transpires from a leaf, the water saturates the air surrounding the leaf. If there is no wind, the air around the leaf may not move very much, raising the humidity of the air around the leaf. Wind will move the air around, with the result that the more saturated air close to the leaf is replaced by drier air.
- **Soil-moisture availability:** When moisture is lacking, plants can begin to senesce (premature ageing, which can result in leaf loss) and transpire less water.
- **Type of plant:** Plants transpire water at different rates. Some plants which grow in arid regions, such as cacti and succulents, conserve precious water by transpiring less water than other plants.

Other interesting facts about Transpiration:

- ♦ A leaf transpires about 90% of the water evaporated from a water surface of the same area—even though the combined area of stomatal pores is only 1-2% of the total leaf area.
- ♦ Transpiration rates are highest in leaves that are stiff with turgor (water pressure). When leaves wilt, they offer less surface area to sun exposure, and thus will transpire less, saving water. Watch a tough, drought-tolerant plant like lilac when temperatures are high for a demonstration of this water-saving strategy.
- ♦ Succulents save water by opening the stomata pores at night to reduce transpiration and to take in carbon dioxide which is stored in their leaves until the next day when they can photosynthesize. Cacti, since they don't have leaves, only have a few stomata in their green stems and so transpire very little.
- ♦ In the summer, a large maple tree can transpire 50-60 gallons of water per hour into the atmosphere. This adds to the humidity which helps us to feel more comfortable, is less drying for our skin and reduces bronchial problems in our lungs. It also helps to cool our environment. Where there are large areas of trees, the combined effect of their transpiration can create a super-saturated condition in the clouds, which can result in rain or snow. The Snows of Kilimanjaro have disappeared primarily because deforestation has reduced local transpiration, resulting in less (or no) snowfall.

Try this experiment!

This experiment is exciting. Look at Celery stalk that has been divided into two parts. Each part is put in different colours. after about 1 day, you'll notice that the water carrying tubes in each half will be different in colour – according to the colour of water they were put in.

Each celery is put into different coloured water. after a day, take out the celery stalks and cut across the stem. You will notice that the water-carrying tubes in each will have the colour of water that the stem was put in.

Materials:

Graduated cylinders | Plastic bags | Pebbles | Rubber bands | Science journal

Centimeter grid paper | Science journal | Access to a variety of trees/plants

Activity sheet "Transpiration: Thirsty Greens"

Learning Activity:

- In this activity, the learner will investigate how much water is given off by trees and plants.
- If available, take students to a heavily foliaged area that contains different trees and plants. If not, bring a variety of potted trees/plants into the classroom.
- Select a small branch with several leaves and cover them with the plastic bag. Record the time at which the leaves were covered.
- Place a pebble in the bag to force the bag to droop so moisture can be collected in the low area reservoir.

- Secure with a rubber band.
- When results are visible, record time, uncover and measure the amount of water in a graduated cylinder.
- Record results and compare the amount of water obtained from the different experimental plants.
- The amount of water you collect will depend on weather conditions. Measurements may be taken several times a day, or if the amount of water is too small to measure, the experiment may be continued over several days.

- Journal questions: Does the leaf size seem to have an effect on the amount of water given off by a plant? Does the size of the plant contribute to the amount of water given off through the leaves? Where does the water come from?
- Count the number of leaves on a single branch. Multiply by the number of branches on the plant and estimate the approximate amount of water released by that plant during a single day.

Additional Resources

https://www.sciencemag.org/site/feature/misc/webfeat/vis2005/show/transpiration.pdf

https://water.usgs.gov/edu/watercycletranspiration.html

http://www.harlequinsgardens.com/mikls-articles/what-is-transpiration-and-why-should-we-know-about-it/

Lesson activity adapted from AIMS Education Foundation "Our Wonderful World"

NAME: ___________________

TRANSPIRATION: THIRSTY GREENS

Select a small branch with several leaves and cover each leaf with a plastic bag. Record the time covered. Find the surface area of the leaf by measuring the length and width. Place a pebble in the bag to force the bag to droop so moisture can be collected. Secure with a rubber band. When results are visible, record the time, uncover and measure the amount of water in a graduated cylinder. Record your results.

NAME/LEAF DRAWING	WIDTH	LENGTH	AREA	START TIME	FINISH TIME	TOTAL TIME	AMOUNT OF WATER	AMOUNT OF WATER PER DAY	AMOUNT OF WATER PER YEAR

- Does the leaf size seem to have an effect on the amount of water given off by a plant?
- Does the size of the plant contribute to the amount of water given off through the leaves?
- Where does the water come from?
- Count the number of leaves on a single branch. Multiply by the number of branches on the plant and estimate the approximate amount of water released by that plant during a single day.

# of leaves on branch:	# of branches on plant:	Approximate # of leaves per plant (A x B = C):	Amount of water from 1 leaf in 1 day x C will equal the amount of water from whole plant in 1 day:
A. ____________	B. _____________	C. _____________	________________________

POLLINATION: FLOWER TO FRUIT

Lesson Objective: The Learner will identify the different parts of a flower, describe their functions, and understand the importance of pollen for plant reproduction and diversity.

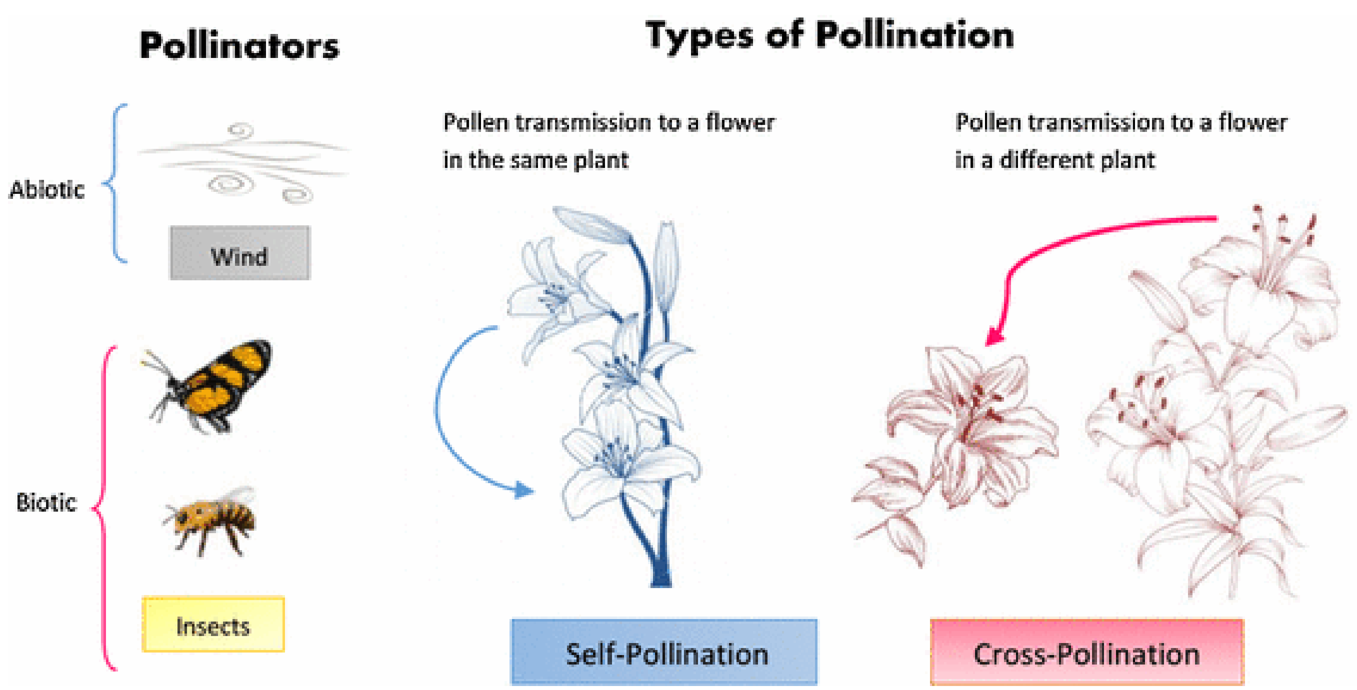
Key Questions: How do plants reproduce? What is pollination? How does fruit form?

Background Information:

For angiosperms, or flowering plants, to reproduce, they go through pollination, create fruits, and disperse seeds. For the students, it is useful to describe the process in four steps: flower, pollination, fruit, and seed dispersal. In some cases, plants do not need animals for pollination or seed dispersal. In other cases, plants rely on animals for both processes and must attract each animal in a different way.

1. Pollination: Pollination is the transfer of pollen from the stamens to the stigma of flowers. Pollen can be carried by insects, other animals, wind, or water. Self-pollination refers to the process in which pollen lands on the stigma of its own flower or another flower on the same plant. Cross-pollination refers to the process where pollen is transferred to the stigma of a flower on another plant of the same species. Since ovules within the same plant can differ genetically from one another, self-pollination can result in some variation in the offspring. Cross-pollination, in which genetic material comes from two parents, results in greater variation and is therefore considered advantageous.

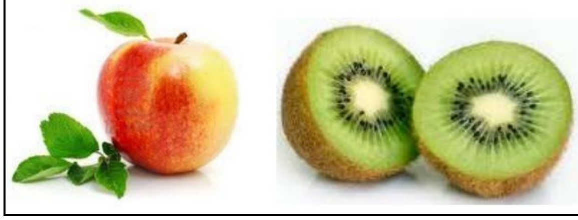
2. Fertilization: Once the pollen grain reaches a compatible stigma, it receives a chemical signal from the stigma. The pollen then produces a tube, which grows down through the style, into the ovary, and into one of the ovules. This allows the male pollen cell to fuse with the female cell inside the ovule. This process if called fertilization. Afterwards, the ovule develops into a seed.



3. Formation of the fruit: After fertilization has occurred, the ovule develops into a seed. The seed(s), surrounded by the ovary wall, develop into the fruit. In some plants, other parts of the flower may also help to form the fruit. Many of the seeds formed inside the fruit do not land in a suitable place for germination or do not survive the early stages of growth. Plants produce large numbers of seeds in order to make sure that at least some of the new plants survive.

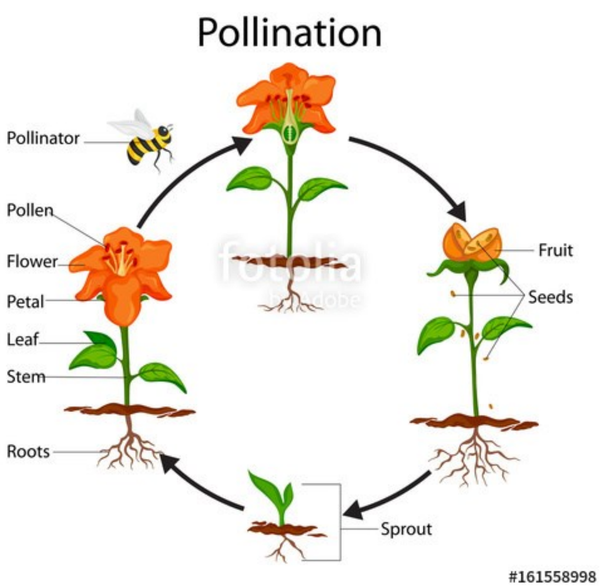
How does fruit form?

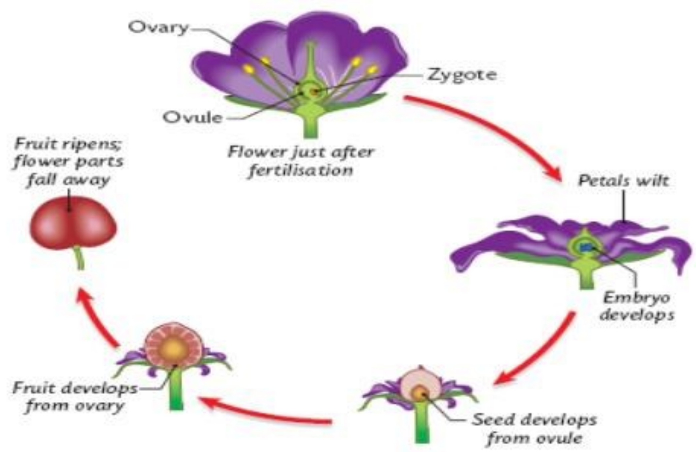
1) A flower is pollinated.
2) Fertilization occurs, and a zygote forms.
3) The ovary where the zygote is swells up and becomes a fruit. Meanwhile, the petals and other parts of the flower fall off so only the fruit is left.



4. Seed dispersal: To avoid overcrowding and reduce competition for light, water and mineral salts, the seeds must spread away from the parent plant and from each other. Seed-containing fruits disperse in four ways:

- *Animal dispersal*. Animals may eat the fruits and drop seeds in other places. The seeds may also pass through the animal's digestive system and be deposited in the animal's feces. Some fruits are covered in hooked bristles that cling to an animal's fur (or your socks) and ensure that the seeds get carried elsewhere.
- *Wind dispersal*. Some seeds are small enough to float in the air. Others have special structures, comparable to wings or parachutes, which keep them airborne for a longer period.
- *Water dispersal*. The seeds of these plants (found in or near water) are buoyant.
- *Self dispersal*. As some fruit ripens, the fruit wall dries and twists until the two halves of the fruit wall are pulled violently apart and the seeds shoot out. Other plants, such as the poppies, produce capsules full of small seeds. When the seeds are ripe, small holes develop around the top of the capsule and the seeds get knocked out by wind and passing animals. This process is nicknamed "pepperpot."





Materials:

Magnifying glasses (microscope) Science Journals

Real flowers (lilies, irises, daffodils, tulips, gladiolas, poppies, or other large flowers with distinguishable parts)

Learning Activity:

- Discuss with students the structure of flowers. Begin by making a list of all the flower parts they know. Then show students a diagram of a flower and discuss the locations of the parts of the plants and their functions.
- Once students are familiar with the different flower parts, have each student select a flower to study. Ask students to observe the flower with their eyes and with a magnifying glass. Record observations in science journal. First, have them answer the following questions:

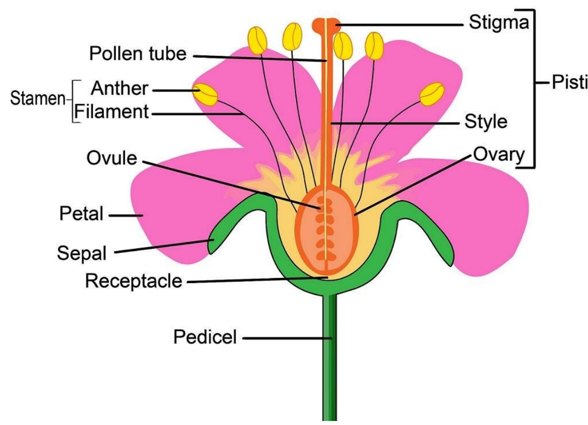
  How big is the flower?

  What is the shape of the flower?

  Does the flower have a color?

  Does the flower have an odor?

  What flower parts can you see?



- As a class, brainstorm ways that plants are pollinated. Discuss how the structure of plants contributes to pollination. Ask students to consider whether they think insects, other animals, or the wind are involved in pollination. Then, on the basis of their observations and the class discussion, ask students to develop their own hypothesis about the mechanism of flower pollination. Have them write their hypothesis on their science journal.
- Have students dissect the flower they chose. Although each student has his or her own flower, students can dissect their flowers in small groups so that they can share ideas and problem solve together. Each student should dissect his or her flower by carefully removing each part, starting from outside the flower and working inward, counting how many of each part is present on the flower. If a dissecting microscope is available, have students look at each part under the microscope.
- Students should record their data in their science journal. Students could include a sample of the flower part by taping or gluing it in place. After students have identified all the flower parts, discuss the similarities they found among all the flowers. How were the female parts of each flower similar? How were the male parts similar? Based on this information, challenge students to conclude how each flower is pollinated.
- After doing the necessary research, have students address their hypotheses. Were they correct, or did the experimentation and research prove otherwise? Have students write a conclusion in their science journal.

Lesson Extension:

- Have students prepare thin tissue samples to study under a dissecting or compound micro-scope. Students should be able to identify the ovules in an ovary and the pollen sacs in an anther. Estimate how many seeds the flower could produce by counting the number of ovules in the ovary.
- Compare and contrast the structure and function of the flower parts studied. What is similar in each flower? What varied? What functions do they have in common?
- Explain how each flower studied would be pollinated. Which flowers would be best pollinated by a bee? Which would be best pollinated by the wind? How did the stigma of each flower adapt to trap pollen? Is one method of flower pollination more common among the flowers studied than another? Why?
- The angiosperm (flowering) group is the largest, most successful plant group on Earth. Angiosperm species are also the youngest, evolving 125 million years ago. Debate possible reasons for their success. Provide a number of examples to support your hypothesis.
- Compare the number of each flower part among the flowers studied. Was a pattern evident? Classify each flower as a monocot or a dicot. (Monocots have floral parts in multiples of three, and dicots have floral parts in multiples of four or five.)
- Consider how the flowers you studied ensure that pollen grains reach the stigma, which is a necessary process for fertilization. Compare each flower's method of pollination. How successful is each method?
- Discuss the benefits of animal pollination for both flowers and their animal pollinators. Explain how this codependence influences diversification. What disadvantages can be attributed to the mutual dependence of plants and animals?
- Dissect a Fruit: After studying a number of different flowers, have students study fruits. What part of the fruit was the ovary? What part of the fruit were the ovules? Compare the fruit structure of apples, berries, and olives (or other one-seeded fruits).
- Design a Flower: Have students work in groups to design models of flowers that are pollinated various ways. One flower could mimic an insect to attract other insects for pollination. Another flower could rely on humans for pollination. Still another flower could be pollinated by the wind. Display the designs in the classroom with small captions describing the flower's unique characteristics.

Additional Resources

Lesson adapted from http://www.discoveryeducation.com/teachers/free-lesson-plans/plant-pollination.cfm

https://www.hunker.com/13429275/how-does-a-fruit-tree-grow-fruit

https://www.calacademy.org/educators/lesson-plans/flowers-seeking-pollinators