



Plant Science Kit

Understanding PlantScience Basics Curriculum



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Plant Science Basics

Curriculum



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The accompanying curriculum helps students learn about basic plant science concepts, including plant cells, roots, leaves, stems, flowers, identification features, photosynthesis and careers.

Curriculum Structure

The Plant Science Basics curriculum is composed of the following lessons. Approximate lesson times are included.

Lesson	Title	Approximate Time
1	Introduction to Plant Science	35-45 minutes
2	Plant Cell Structure	85-130 minutes
3	Leaves, Roots and Stems	115-195 minutes
4	Flowering Plants	65 minutes
5	Plant Identification Features	105-130 minutes
6	Photosynthesis, Respiration and Transpiration	100-115 minutes
7	Exploring Botany and Plant Science Careers	85-160 minutes
	Pre/Post Assessment	20 minutes
	Total	10-14 hours

Lesson Structure

Each lesson begins with an overview, lesson objectives and a Lesson at a Glance table which lists the lesson activities, materials required, suggested preparation steps and approximate class time.

Lesson Sections

The actual lesson follows the overview, which will contain some of the sections described below. Approximate class times are included for each lesson.

FOCUS

Every lesson begins with a FOCUS activity intended to capture participants' attention. This may be in the form of a small or large class discussion, a game, a review of previous lesson information or a demonstration. During this activity, participants are introduced to the topic of the lesson.

LEARN

The LEARN activity in each lesson varies in its presentation mode. It may be a slide presentation, group activity and/or demonstration.

REVIEW

The majority of lessons end with a REVIEW activity intended to briefly review the lesson's key messages or main points.

Lesson 1 – Introduction to Plant Science

Lesson Overview

Plant science, also known as botany or plant biology, is one of the world's oldest natural sciences. This lesson will introduce participants to the definition of plant science and the many things in our lives that relate to it. Participants will be introduced to different classifications of plants, key terms and how plants are used to meet human needs.

Lesson Objectives

After completing this lesson, participants will be able to:

- Define plant science
- Classify different types of plants
- Identify the uses of plants

Lesson at a Glance

Activity	Materials	Preparation	Approximate class time
FOCUS	• <i>Lesson 1 presentation slides</i> • <i>Plant Science Mind Map</i>	1. Print/photocopy <i>Plant Science Mind Map</i> (one per participant)	10-15 minutes
LEARN	• <i>Lesson 1 presentation slides</i> • <i>Lesson 1 Note Sheet</i> • <i>Lesson 1 Note Sheet Answer Key</i>	1. Print/photocopy <i>Lesson 1 Note Sheet</i> for each participant 2. Prepare <i>Lesson 1 presentation slides</i> for viewing	20-25 minutes
REVIEW	• <i>Lesson 1 presentation slides</i> • <i>Lesson 1 Note Sheet</i>	1. Prepare <i>Lesson 1 presentation slides</i> for viewing	5 minutes

Lesson 1 – Introduction to Plant Science

FOCUS: Plant Science Mind Map

10-15 minutes

Purpose:

Participants will work individually to complete a mind map, identifying connections relating to plant science. Participants will learn the definition for plant science.

Materials:

- *Plant Science Mind Map*
- *Lesson 1 presentation slides*

Facilitation Steps:

Slide 3: What are plants used for? How do they meet human needs? Ask students to brainstorm all of the ways they can identify how plants meet human needs.

Slide 4: Here are a few of the ways we use plants. Give one example for each use listed.

- a. Clothing – cotton
- b. Shelter – wood for houses
- c. Food – vegetables
- d. Medicines – aloe vera
- e. Aesthetic value – bouquet of roses
- f. Other

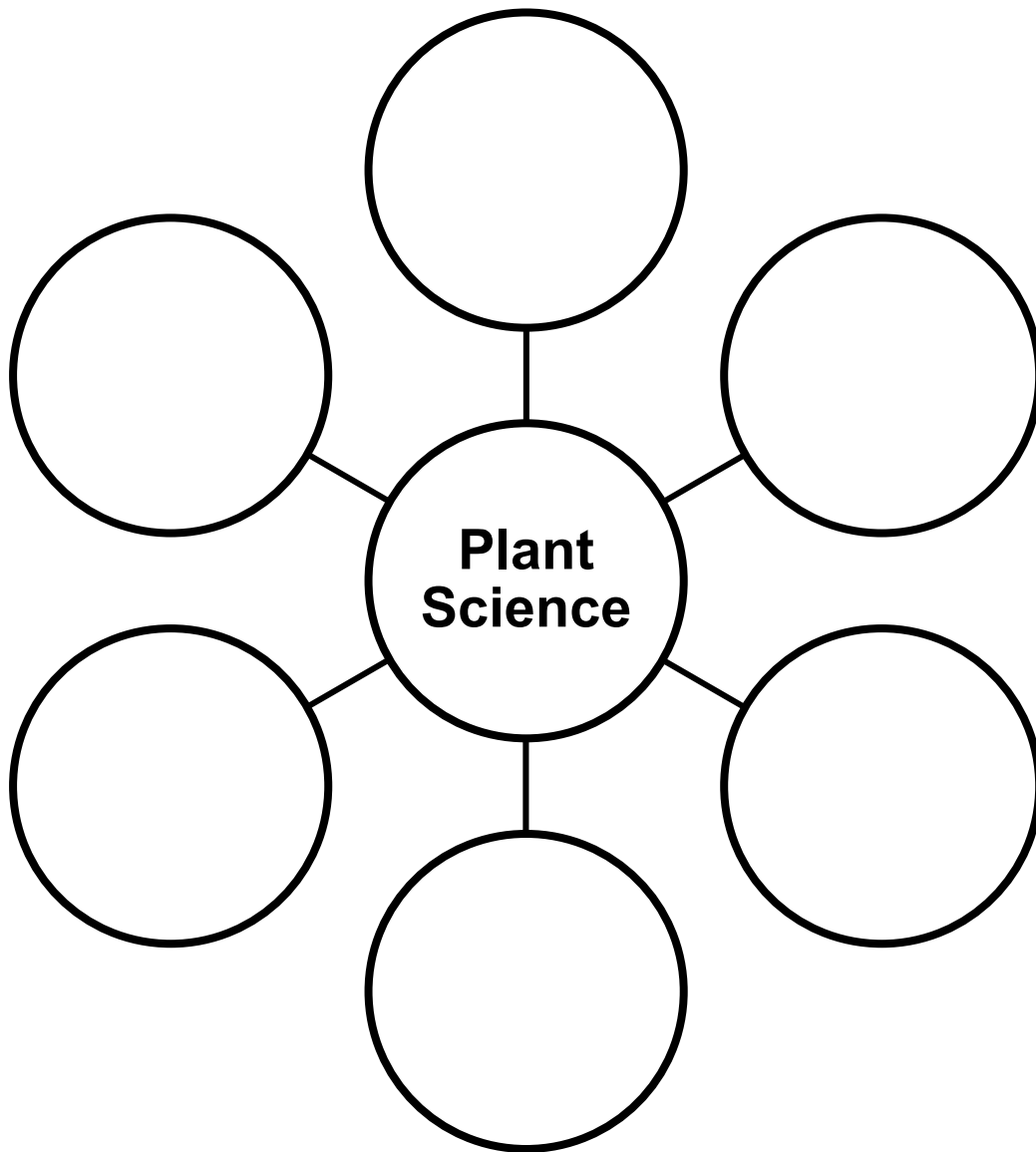
1. To help participants understand what plant science is, give each of them the *Plant Science Mind Map* handout. Explain how a mind map works: start with a topic in the center, draw a line, and connect it to another circle off of it that contains an idea related to the first topic. The goal is to continually divide into more ideas until the entire paper is filled, making connections to as many circles as possible.
2. Allow participants five minutes to complete the mind map.

3. Have each participant share five connections, discussing how varied and broad their answers were and how many different items could be connected off of just one word. All of the connections relate to the overall definition of what plant science is. Today our goal is to define plant sciences.

Name: _____ Class: _____

Plant Science Mind Map

A mind map starts with a topic in the center. Fill in each surrounding circle with a topic relating to plant science. Draw another line and circle that relates to the Plant Science. Try to completely fill the page with connections to plant science.



Lesson 1 – Introduction to Plant Science

LEARN: What is Plant Science?

20-25 minutes

Purpose:

Participants will learn the definition of plant science or botany, key vocabulary and how plants are classified.

Materials:

- *Lesson 1 presentation slides*
- *Lesson 1 Note Sheet*
- *Lesson 1 Note Sheet Answer Key*

Facilitation Steps:

1. Show the *Lesson 1 presentation slides*. Give each student the *Lesson 1 Note Sheet* to complete as you discuss the presentation slides. Share the following notes:

Slide 5: Plant science, also called botany or plant biology, is the science of plant life and a branch of biology.¹ In plant science we study the structure, function, growth and protection of plants. Note that many of the connections that you identified in your mind map are included in this definition.

Slide 6: Botanists (the scientists who study plants) categorize plants into different species. While all plants are made up of similar parts that are essential in maintaining their survival, like leaves, roots and stems, these parts do not look alike. These differences in characteristics are used to group plants into species, which further divides into classifying and organizing plants. Some plants, such as algae, do not have cells and tissues that are highly organized. For our chart, we will focus on those plants that have cells and tissues organized into functional structures. An example of how to classify plants is vascular and non-vascular, seed-bearing and spore-bearing, and angiosperms and gymnosperms.

Slide 7: Nonvascular vs Vascular - Nonvascular plants are small, simple plants without a vascular system. They do not have a phloem or xylem. Examples of nonvascular plants are mosses or liverworts. Vascular plants, such as trees and flowering plants, have specialized conducting vessels to transport water and food throughout the plant. Within vascular plants is the phloem, the vessel that transports food, and the xylem, which transports water.²

Slide 8: There are two types of vascular plants: plants with seeds (or dispersed by seeds) and those that are seedless (or dispersed by spores). Examples of plants with/dispersed by seeds are gymnosperms and angiosperms. Examples of plants that are seedless/dispersed by spores are ferns and horsetails.

Slide 9: Gymnosperms versus angiosperms – An angiosperm is a flowering, fruit-bearing plant or tree known for having ovules, and therefore seeds, that are developed within an enclosed ovary.³ The difference between gymnosperms and angiosperms is that the seeds of the gymnosperms are naked, meaning the seeds are not enclosed within the ripened ovary, i.e., a fruit. The seeds of the gymnosperms develop on the surface of scales or leaves.⁴

Slide 10: Dicot vs monocot – A dicot is a group of flowering plants that have two photosynthetic cotyledons in the seed, which may emerge from the ground when the seed germinates. Examples are beans, oaks, or sunflowers.⁶ A cotyledon is the primary leaf in the embryo of the higher plants or the seed-leaf. Upon germination, the cotyledon may become the first embryonic leaves of a seedling.⁷ A monocot is a group of flowering plants that have only one cotyledon in the seed and an internal manner of growth. Examples are palms, grasses, or orchids.⁵

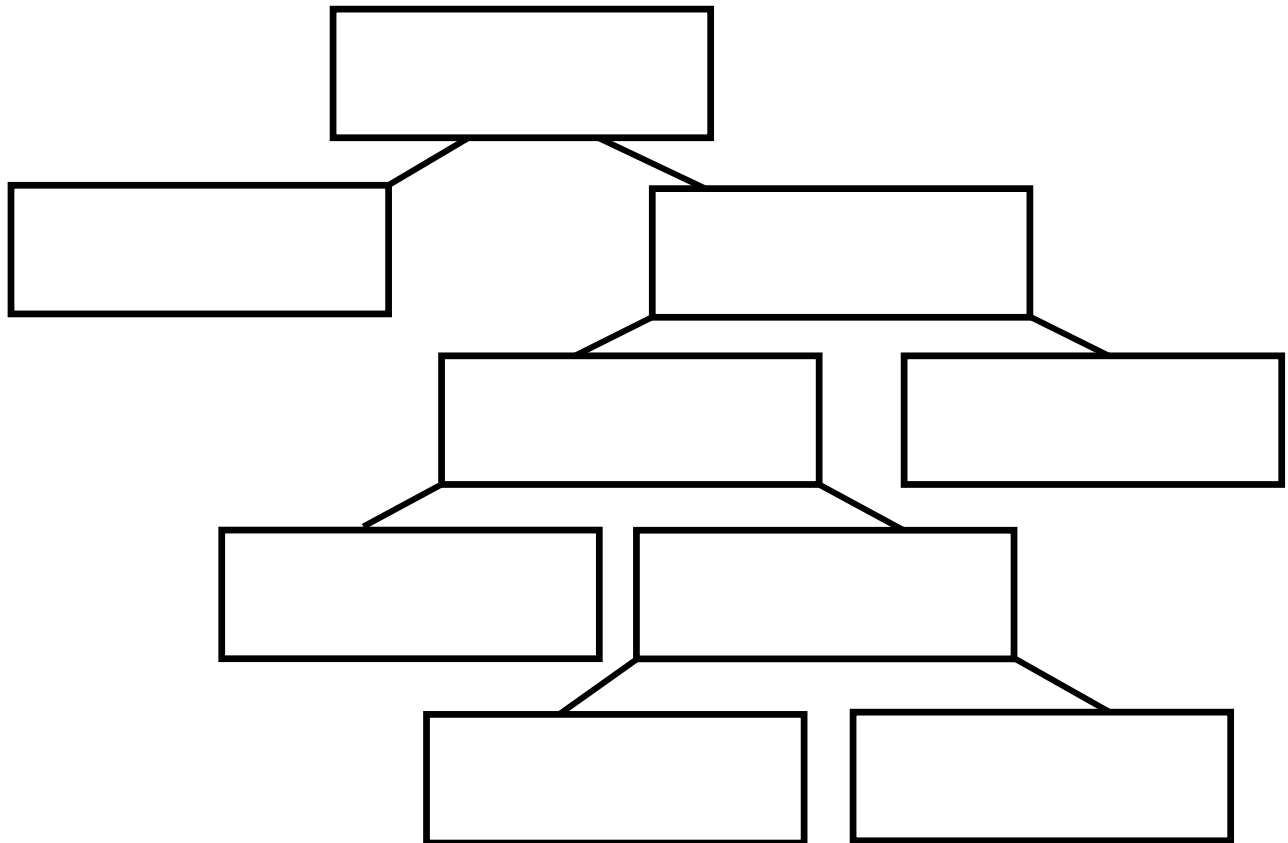
Name: _____ Class: _____

Lesson 1 Note Sheet

Complete the following note sheet as you view the Lesson 1 presentation slides.

1. Define plant science.

2. Complete the plant classification chart.



3. Define the following key vocabulary words:

a. Nonvascular

b. Vascular

Plant Science Basics

- c. Phloem
- d. Xylem
- e. Gymnosperm
- f. Angiosperm
- g. Dicot
- h. Monocot
- i. Cotyledon

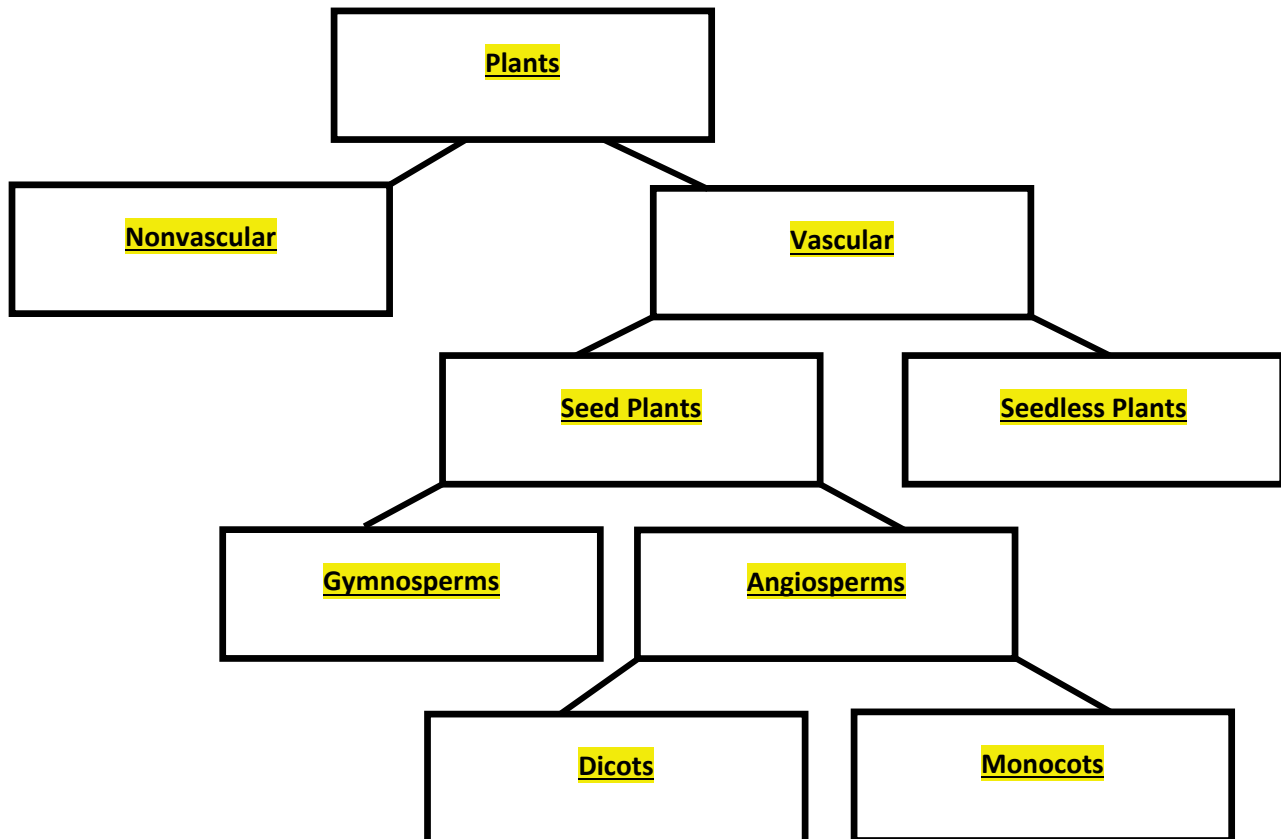
Lesson 1 Note Sheet Answer Key

Complete the following note sheet as you view the Lesson 1 presentation slides.

1. Define plant science.

Plant science, also called botany or plant biology, is the science of plant life and a branch of biology. In plant science we study the structure, function, growth and protection of plants.

2. Complete the plant classification chart.



3. Define the following key vocabulary words:

a. **Nonvascular** - Small, simple plants without a vascular system. They do not have a phloem or xylem.

b. **Vascular** - Vascular plants, such as trees and flowering plants have specialized conducting vessels to transport water and food throughout the plant.

c. **Phloem** - The vessel that transports food in a vascular plant.

- d. Xylem – The vessel which transports water in a vascular plant.
- e. Gymnosperm –A flowering, fruit-bearing plant or tree known for having ovules, and therefore seeds, which are naked, meaning the seeds are not enclosed within the ripened ovary, i.e., fruit. The seeds of the gymnosperms develop on the surface of scales or leaves.
- f. Angiosperm - A flowering, fruit-bearing plant or tree known for having ovules, and therefore seeds, that are developed within an enclosed ovary.
- g. Dicot - A group of flowering plants that have two photosynthetic cotyledons in the seed, which may emerge from the ground when the seed germinates. Examples are beans, oaks, or sunflowers.
- h. Monocot - A group of flowering plants that have only one cotyledon in the seed and an internal manner of growth. Examples are palms, grasses or orchids.
- i. Cotyledon - The primary leaf in the embryo of the higher plants or the seed-leaf. Upon germination, the cotyledon may become the first embryonic leaves of a seedling.

Lesson 1 – Introduction to Plant Science

REVIEW: The Purpose and Use of Plants

5 minutes

Purpose:

Participants will learn how plants are used to meet human needs.

Materials:

- *Lesson 1 presentation slides*
- *Lesson 1 Note Sheet* (use the back side)

Facilitation Steps:

1. Show the *Lesson 1 presentation slide 11*.

Slide 11: Review

- What is plant science?
- What are plants used for and how do they meet human needs?
- How do plants impact our daily lives?
- How are plants categorized?

Lesson 2 – Plant Cell Structure

Lesson Overview

The parts in a plant cell work together to carry out a variety of functions. Cells have the ability to metabolize food for energy, respond to the environment, grow and reproduce. Learning the parts of a cell and the function of each will help participants understand how all of the parts work together as a system.

Lesson Objectives

After completing this lesson, participants will be able to:

- Define key vocabulary terms relating to plant cell structure
- Accurately draw and label the parts of a plant cell
- Identify the function of plant cell parts

Lesson at a Glance

Activity	Materials	Preparation	Approximate class time
FOCUS	• Access to books, websites and other resources on plant cells • <i>Plant Cell Key Vocabulary</i> handout • <i>Plant Cell Key Vocabulary Answer Key</i>	1. Print/photocopy <i>Plant Cell Key Vocabulary</i> handout for each participant 2. Gather books, websites and other resources on plant cells	15-25 minutes
LEARN	• <i>Plant Cell Model</i> • Internet for access to plant cell videos • <i>Drawing a Plant Cell</i> handout • <i>Drawing a Plant Cell Answer Key</i> • <i>Plant Cell Model Instructions</i> • <i>Plant Cell Model Grading Rubric</i> • <i>Lesson 2 presentation slides</i>	1. Print/photocopy <i>Drawing a Plant Cell</i> for each participant 2. Print/photocopy <i>Plant Cell Model Instructions</i> for each participant 3. Print/photocopy <i>Plant Cell Model Grading Rubric</i> for each participant 4. Prepare <i>Lesson 2 presentation slides</i> for viewing 5. Have the <i>Plant Cell Model</i> available 6. Gather websites for plant cell videos	60-90 minutes
REVIEW	• <i>Plant Cell Structure Quiz</i> • <i>Plant Cell Structure Answer Key</i>	1. Print/photocopy <i>Plant Cell Structure Quiz</i> for each participant	10-15 minutes

Lesson 2 - Plant Cell Structure

FOCUS: Plant Cell Key Vocabulary

15-25 minutes

Purpose:

Participants will research key vocabulary terms associated with the structure and function of plant cells.

Materials:

- *Plant Cell Key Vocabulary* handout
- *Plant Cell Key Vocabulary Answer Key*
- Access to books, websites and other resources on plant cells

Facilitation Steps:

1. In order to learn the parts of a plant cell, there are many definitions that participants need to understand. Give each participant the *Plant Cell Key Vocabulary* handout.
2. Assign each participant one vocabulary term or more, depending on the number of participants, which they will research and define. Give participants five to ten minutes to do their research.
3. Call the class back together and discuss the vocabulary list, allowing participants to share the definition(s) they found. Answers will vary. Use the *Plant Cell Key Vocabulary Answer Key* provided to assist with any terms that need clarification. Definitions can be found at:
<https://www.vocabulary.com/dictionary/>

Name: _____ Class: _____

Plant Cell Key Vocabulary

Write the definition of each vocabulary word in the space provided.

Term	Definition
Cell membrane	
Cell wall	
Centrosome	
Chlorophyll	
Chloroplast	
Chromoplast	
Chromosomes	

Cytoplasm	
Endoplasmic Reticulum	
Golgi apparatus	
Leucoplast	
Lysosome	
Mitochondrion	
Nuclear membrane	
Nucleolus	
Nucleus	

Organ	
Organelle	
Plasmodesma	
Primary Pit Field	
Ribosomes	
Rough endoplasmic reticulum (rough ER)	
Smooth endoplasmic reticulum (smooth ER)	
Tissue	
Vacuole	

Plant Cell Key Vocabulary Answer Key

Write the definition of each vocabulary word in the space provided.

Term	Definition
Cell membrane	A cell membrane is a barrier that surrounds and protects the contents of a cell. It controls which substances can enter and exit the cell. The membrane also gives a cell its shape and enables it to attach to other cells, forming tissues.
Cell wall	The cell wall is the protective, semi-permeable outer layer of a plant cell. A major function of the cell wall is to give the cell strength and structure and to filter molecules that pass in and out of the cell.
Centrosome	A centrosome is the small region of cytoplasm adjacent to the nucleus that contains the centrioles and serves to organize the microtubules.
Chlorophyll	Chlorophyll is a group of green pigments used by organisms that convert sunlight into energy via photosynthesis. It gives plants their green color. Plants use chlorophyll to trap energy from the sun. Without this energy, plants would be unable to initiate the process of photosynthesis, which converts water and carbon dioxide into starches that plants can use for food.
Chloroplast	The chloroplast is the place in a plant cell where photosynthesis happens. It is a plastid containing chlorophyll and other pigments in plants that carry out photosynthesis.
Chromoplast	Chromoplasts are colored plastids found in roots, leaves, flowers and ripe fruits. They contain lipid-soluble pigments, referred to as carotenoids, that provide color to many different types of plants and flower.
Chromosomes	A chromosome is one of the tiny, threadlike, DNA-containing bodies found in the cell nuclei of all plants, responsible for transmitting hereditary characteristics.
Cytoplasm	Cytoplasm is the material in a cell, such as mitochondria, that aren't the cell's nucleus and control the cell's metabolism.

Endoplasmic Reticulum	ER is a continuous membrane system that forms a series of flattened sacs within the cytoplasm of eukaryotic cells and serves multiple functions, being important particularly in the synthesis, folding, modification and transport of proteins.
Golgi body	A flattened, layered, sac-like organelle that looks like a stack of pancakes and is located near the nucleus. It produces the membranes that surround the lysosomes. It packages proteins and carbohydrates into membrane-bound vesicles for export from the cell.
Leucoplast	A leucoplast is a colorless organelle found in plant cells, used for the storage of starch or oil.
Lysosome	It is an organelle found in the cytoplasm of most cells. This is where the digestion of cell nutrients takes place.
Mitochondrion	It is an organelle containing enzymes responsible for producing energy.
Nuclear Membrane	It is a membrane that surrounds the nucleus.
Nucleolus	This is a small, round body of protein in a cell nucleus, such organelles, that contains RNA and is involved in protein synthesis.
Nucleus	A nucleus is often called the brain, or control center, of a eukaryotic cell. It is the part of the cell containing DNA and RNA and is responsible for growth and reproduction.
Organ	In a plant or animal, it is a specialized structure that performs a particular function, such as the heart.
Organelle	An organelle is one small part of a cell that has a very specific function or job. The nucleus itself is an organelle. The different parts of a cell, especially the ones that are separated from the rest of the cell by a membrane, are known as organelles. An organelle supports the individual cell.
Plasmodesma	Plasmodesmata (singular, plasmodesma) are small channels that directly connect the cytoplasm of neighboring plant cells to each other, establishing living bridges between cells.

Primary pit field	In the primary cell wall, there is a cluster of holes. These holes are called plasmodesmata and they go through the primary cell wall. A cluster of plasmodesmata is called a primary pit field.
Ribosomes	Ribosomes are small organelles composed of RNA-rich cytoplasmic granules that are sites of protein synthesis.
Rough endoplasmic reticulum (rough ER)	Rough ER is a vast system of interconnected membranous, infolded and convoluted sacs that are located in the cell's cytoplasm. Rough ER is converted with ribosomes that give it a rough appearance. Rough ER transports materials through the cell and produces proteins in sacks called cisternae, which are sent to the Golgi body.
Smooth endoplasmic reticulum (smooth ER)	Smooth ER is a vast system of interconnected membranous, infolded and convoluted tubes that are located in the cell's cytoplasm. The space within the ER is called the ER lumen. Smooth ER transports materials through the cells. It contains enzymes and produces and digest lipids, i.e., fats, and membrane proteins. Smooth ER buds off from rough ER, moving the newly-made proteins and lipids into the Golgi body, lysosomes and membranes.
Tissue	Tissue is a mass of cells in a plant body as they form a specific organ.
Vacuole	Vacuole is a large, membrane-found space within a plant cell that is filled with fluid. Most plant cells have a single vacuole that takes up much of the cell. It helps maintain the shape of the cell.

Lesson 2 – Plant Cell Structure

LEARN: Parts of a Plant Cell

60-90 minutes

Purpose:

Participants will be able to identify the parts of a plant cell and understand the function of each part. Participants will use this knowledge to create their own plant cell model from materials of their choice.

Materials:

- *Plant Cell Model*
- Internet access for plant cell videos
- *Drawing a Plant Cell* handout
- *Drawing a Plant Cell Answer Key*
- *Plant Cell Model Instructions*
- *Plant Cell Model Grading Rubric*
- *Lesson 2 presentation slides*

Facilitation Steps:

1. Now that participants have some knowledge of key vocabulary words and definitions, these will be put into the context of the actual plant cell. Kick off this part of the lesson by showing a short video introducing the parts of a plant cell and their function. SchoolTube™ and YouTube™ host a variety of short, well-produced videos on this topic to choose from.
2. Access the *Plant Cell Model*. Display it in front of the class and point out each part of the cell. Pass it around so participants can take a closer look at it.
3. Give each participant the *Drawing a Plant Cell* handout. Show the *Lesson 2 presentation slides*. Have students draw a plant cell in the space provided as they view the presentation slides. Use the *Drawing a Plant Cell Answer Key* to assess their work.
4. Give each participant the *Plant Cell Model Instructions* and *Plant Cell Model Grading Rubric*. Review the instructions. Tell participants that the project is to create a three-dimensional plant cell model. Materials may be edible or nonedible. You can use materials like Styrofoam, buttons, yarn, pasta, chenille stems, etc. Be creative! Choose items that accurately represent each organelle in size, shape and location. You should include the 12 plant parts in the model listed on the instructions. Prepare a separate key that lists each cell component and its function in the cell. Remember to use the grading rubric as a guide.
5. Allow participants to use the remaining class time to plan their model. The model should be constructed during the next class period or may be assigned as homework. If you allow participants to do it during class, they should bring all of the needed materials for constructing their model.
6. Grade each project according to the established rubric.

Name: _____ Class: _____

Drawing a Plant Cell

Draw a plant cell in the space provided below. Make sure to draw and label all of the parts listed below.

Cell wall

Chloroplast

Chromoplast

Endoplasmic reticulum

Golgi Apparatus

Leucoplast

Mitochondrion

Nuclear membrane

Nucleolus

Nucleus

Plasmodesma

Primary pit field

Vacuole

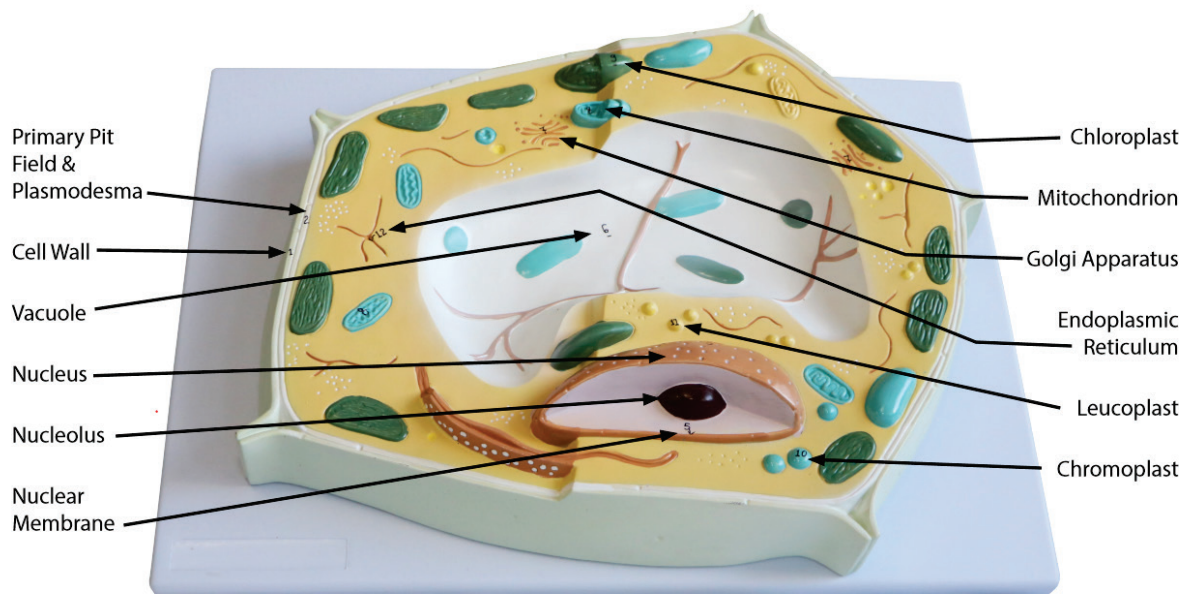
Plant Cell

Drawing a Plant Cell Answer Key

Draw a plant cell in the space provided below. Make sure to draw and label all of the parts listed below.

Cell wall
Chloroplast
Chromoplast
Endoplasmic reticulum
Golgi Apparatus
Leucoplast
Mitochondrion
Nuclear membrane
Nucleolus
Nucleus
Plasmodesma
Primary pit field
Vacuole

Plant Cell



Plant Cell Model Instructions

Your project is to create a three-dimensional plant cell model. Materials may be edible or nonedible. You can use materials like Styrofoam, buttons, yarn, pasta, chenille stems, etc. Be creative!

Step 1: Choose items that accurately represent each organelle in size, shape and location. You should include the following plant parts in your model:

Cell wall	Nuclear membrane
Chloroplast	Nucleolus
Chromoplast	Nucleus
Endoplasmic reticulum	Plasmodesma
Golgi Apparatus	Primary pit field
Leucoplast	Vacuole
Mitochondrion	

Step 2: Secure each plant cell part to the model and label each of the components.

Step 3: Prepare a separate key that lists each cell component and its function in the cell.

Step 3: Use the grading rubric to ensure you receive the maximum points available.

Name: _____ Class: _____

Plant Cell Model Grading Rubric

Fill out the top portion of this sheet and turn it in with your project. Use this as a guide to ensure you have fully completed the project. The total project is worth **59 points**.

1. Model construction **(5 points for each)**

- ____ The plant cell model is the appropriate shape.
- ____ Four or more different materials or media were used in construction.
- ____ The model is 3-D.
- ____ Materials chosen accurately represent each cellular component in shape, size and location.

____ Total

2. Model plant cell parts are clearly labeled and accurately placed within the cell. **(2 points for each part)**

- | | |
|----------------------------|------------------------|
| ____ Cell wall | ____ Nuclear membrane |
| ____ Chloroplast | ____ Nucleolus |
| ____ Chromoplast | ____ Nucleus |
| ____ Endoplasmic reticulum | ____ Plasmodesma |
| ____ Golgi Apparatus | ____ Primary pit field |
| ____ Leucoplast | ____ Vacuole |
| ____ Mitochondrion | |

____ Total

3. The key lists cellular components and their functions accurately. **(13 points – 1 for each part)**

____ Total

_____ **Total for the project**

Lesson 2 – Plant Cell Structure

REVIEW: Plant Cell Structure Quiz

10-15 minutes

Purpose:

Participants will review key vocabulary and plant cell structure knowledge learned in the lesson.

Materials:

- *Plant Cell Structure Quiz*
- *Plant Cell Structure Answer Key*

Facilitation Steps:

1. Give each participant the *Plant Cell Structure Quiz*. Allow 5 to 10 minutes to complete the quiz.
2. Share answers to the quiz as participants exchange papers and peer grade each other.

Name: _____ Class: _____

Plant Cell Structure Quiz

Complete the following quiz using what you have learned about plant cells.

1. Which substance makes plants green? _____
2. Where does photosynthesis happen in a cell? _____
3. What is the function of a cell wall?
4. The tiny, threadlike, DNA-containing bodies found in cell nuclei are called _____
5. Which organelle is responsible for producing energy? _____
6. Match the following term with the correct description.
 - a. Nucleus
 - b. Nucleolus
 - c. Nuclear membrane
 - d. Organ
 - e. Organelle

___ One small part of a cell that has a very specific job.

___ A membrane that surrounds the nucleus.

___ A specialized structure that performs a particular function.

___ A small, round body of protein in a cell that contains RNA.

___ The brain or control center of a cell responsible for growth and reproduction.

7. What is the difference between rough ER and smooth ER?

Rough ER	Smooth ER

Plant Cell Structure Quiz Answer Key

Complete the following quiz using what you have learned about plant cells.

1. What substance makes plants green? **chlorophyll**
2. Where does photosynthesis happen in a cell? **chloroplast**
3. What is the function of a cell wall?

The function is to give the cell strength and structure, and to filter molecules that pass in and out of the cell.

4. The tiny, threadlike, DNA-containing bodies found in cell nuclei are called **chromosomes.**
5. Which organelle is responsible for producing energy? **mitochondrion**
6. Match the following term with the correct description.
 - a. Nucleus
 - b. Nucleolus
 - c. Nuclear membrane
 - d. Organ
 - e. Organelle

e One small part of a cell that has a very specific job.

c A membrane that surrounds the nucleus.

d A specialized structure that performs a particular function.

b A small, round body of protein in a cell that contains RNA.

a The brain or control center of a cell responsible for growth and reproduction.

7. What is the difference between rough ER and smooth ER?

Rough ER	Smooth ER
Sac-like structure	Tube shape
Transports materials through the cell	Transports materials that contains enzymes
Produces proteins	Produces lipids and membrane proteins
Sends proteins to the Golgi body	Digests lipids and membrane proteins

Lesson 3 – Leaves, Roots and Stems

Lesson Overview

Everywhere we go, inside or outside, plants surround us. Plants have many parts that work together to help it grow healthy. These parts are leaves, roots and stems. This lesson will help participants understand the important and unique functions that each of these parts serve.

Lesson Objectives

After completing this lesson, participants will be able to:

- Identify the function of leaves, roots and stems
- Identify the internal parts of a leaf, root or stem from a cross-section diagram
- Accurately label the external parts of a leaf, root or stem and the function of each part

Lesson at a Glance

Activity	Materials	Preparation	Approximate class time
FOCUS	• Lesson 3 presentation slides	1. Prepare Lesson 3 presentation slides for viewing	10-15 minutes
LEARN	• Leaf, Root, Stem poster • Dicot Plant Leaf model • Leaves, Roots and Stems Research Project Instructions • Leaves, Roots and Stems Research Project Grading Checklist • Internet access	1. Print/photocopy Leaves, Roots and Stems Research Project Instructions for each participant 2. Print/photocopy Leaves, Roots and Stems Research Project Grading Checklist for each participant 3. Access the poster and model for reference	60-120 minutes
REVIEW	• Leaves, Roots and Stems Project Grading Checklist • Copies of note sheets from presentations for participants to complete • Dicot Plant Leaf model	1. Print/photocopy Leaves, Roots and Stems Project Grading Checklist for each participant 2. Copies of note sheets for participants to complete	45-60 minutes

Lesson 3 – Leaves, Roots and Stems

FOCUS: What am I? Game

10-15 minutes

Purpose:

Participants are shown various food plant parts that they are familiar with and must determine if what they eat is the leaf, root, stem or flower of the plant. This is a fun activity for getting familiar with leaves, roots and stems.

Materials:

- *Lesson 3 presentation slides 1-17*

Facilitation Steps:

1. Tell participants that you are going to show a short series of slides. As you show each slide, have them write down the food item name and whether they think we eat the root, stem, leaf or flower.
2. Show the *Lesson 3 presentation slides 1-17*.
3. Go through each food item and identify the correct answer. Share the following notes.

Slide 4: Sweet potato –root

Unlike a regular potato, it is really a modified root that we eat.

Slide 5: Onion – leaf

There are arguments to be made for leaf, stem and roots. If we eat the bulb it is considered a modified stem. Others say it is leaves because the layers are what we eat and they are considered leaves. Still, other sources say that when you pass the onions, roots are on the menu. Roots, incidentally, are the portions of plants that serve as storage areas for plant foods manufactured by leaves.

Slide 6: Ginger – stem

Many times in the store, you will see this labeled as ginger root. This is tricky, however, because it is a modified storage stem that we eat. Ginger root is actually not

a root, but a rhizome or underground stem. The rhizome is the part that can be eaten, used in food or teas, dried and ground to create powdered ginger and used to create ginger oils and extracts.

Slide 7: Carrot – root

More specifically it is known as a tap root.

Slide 8: Potato – stem

Potatoes have an underground storage stem called a tuber.

Slide 9: Celery – stem

The part we eat is an enlarged petiole (a plant part you'll be learning about soon)

Slide 10: Artichoke – flower

The green layers that we eat are part of a flower bud, therefore making it a flower.

Slide 11: Broccoli (tops) – flower

We eat the tops of broccoli plants, which are called florets, which means flowers.

Slide 12: Rhubarb – stem

We eat the fresh raw stalks (petioles) that are crisp (similar to celery), which makes it a stem.

Slide 13: Cauliflower – flower

This is easy because you hear the word in the name. It is a flower.

Slide 14: Yam – root

We eat the edible, starchy, tuberous root of this vegetable.

Slide 15: Kale – leaf

This is also known as leaf cabbage, making it a leafy vegetable.

Slide 16: Lettuce – leaf

This vegetable is most often consumed as a leafy green.

Slide 17: Wild rice – stem

While it is now a delicacy in North America, the grain part is eaten even less in China, where the plant's stem is used as a vegetable. We are considering this a stem.

4. Ask for a show of hands to find out which participants had the most correct answers.

Lesson 3 – Leaves, Roots and Stems

LEARN: Leaves, Roots and Stems Research Project

60-120 minutes

Purpose:

Participants work in groups or individually to complete an in-depth research project on roots, leaves and stems.

Materials:

- *Leaf, Root, Stem* poster
- *Dicot Plant Leaf* model
- *Leaves, Roots and Stems Research Project Instructions*
- *Leaves, Roots and Stems Project Grading Checklist*
- Internet access
- *Lesson 3 presentation slides 18-22*

Facilitation Steps:

1. Hang the *Leaf, Root, Stem* poster on the wall for reference during this lesson.
2. Explain that participants will be completing a research project on one of three important seed-bearing plant structure (gymnosperms and angiosperms) main parts; the root, stem and leaves.
3. Show *Lesson 3 presentation slides 18-22* while you discuss the information below and pass the *Dicot Plant Leaf* model around for participants to have a closer look.

The leaves are the primary photosynthesizing material. They contain subsystems that control water loss in the leaves.

The root absorbs water and nutrients and sends them throughout the whole plant.

The stem is tube-like and is a vital structural support. It transports water from the roots to the leaves and takes the products of photosynthesis down to the roots.⁹

4. Give each participant the *Leaves, Roots and Stems Research Project Instructions* and *Leaves, Roots and Stems Project Grading Checklist*. Make the decision to do this as an individual or group project.

As an individual project: participants are to choose one of the three parts: leaf, root or stem.

As a group project: assign one of the three parts to each group. The size of the groups will be dependent on what you are comfortable with and how many presentations you want to see on each part – leaf, root or stem.

5. Review the research project instructions. Make sure participants understand each required component. Groups can decide how they wish to divide the workload among the members so that all components get completed.
6. Allow time during class to begin research. You may assign additional research outside of class time or set aside a number of class periods so participants can complete it then.

Leaves, Roots and Stems Research

Project Instructions

You have been assigned a research project that will help you learn more about leaves, roots and stems. The following is a list of what must be included in your final project, regardless of which of the three parts you are researching.

Project Component	Description
Note Sheet	This is a handout that will be completed by participants as you give your presentation.
Diagram - Cross Section	Create an original diagram or model of the cross section of the leaf, root or stem system. Label each part on the diagram. Provide a hard copy in your report and include it in your slide presentation and note sheet.
Diagram - External	Create an original diagram or model of the exterior of the root, stem or leaf. Label each part on the diagram. Provide a hard copy in your report and include it in your slide presentation and note sheet.
Key Vocabulary List	Create a key vocabulary list with definitions of words relating to your topic. Include all parts found on your cross section and external diagrams. Include any terms that you found as you completed your research. Include a minimum of 20 words on this list.
Sources	Create a list properly documenting all sources used in your research, including web sites, books, articles, etc. Use the APA format.
Slide Presentation	Prepare a five-minute slide presentation that you will share with other participants. Include both diagrams in this slide presentation as well as the function of the leaf, root or stem, and some of the key vocabulary words with examples.

Name: _____ Class: _____

Leaves, Roots and Stems Research Project Grading Checklist

The following checklist will be used to grade the research project.

Project Component	1	2	3	4	Points
Note Sheet	Content doesn't follow the presentation and has many gaps.	Content follows half of the presentation with some gaps.	Content follows most of the presentation with a few minor gaps.	Content completely follows the presentation.	
Diagram - Cross Section	The diagram is a copy, or an original that is difficult to read.	The diagram is original, but slightly illegible with a few missing parts.	The diagram is original and neatly labeled but is missing a few parts.	The diagram is original, neatly labeled and includes all parts.	
Diagram - External	The diagram is a copy, or an original that is difficult to read.	The diagram is original, but slightly illegible with a few missing parts.	The diagram is original and neatly labeled but missing a few parts.	The diagram is original, neatly labeled and includes all parts.	
Key Vocabulary List	The vocabulary list is missing more than half of the parts from diagrams and has fewer than 10 words with complete definitions.	The vocabulary list includes half of the parts from diagrams and has at least 15 words with complete definitions.	The vocabulary list includes most parts from diagrams and has at least 18 words with complete definitions.	The vocabulary list includes all parts from diagrams and has at least 20 words with complete definitions.	
Sources	No sources are documented.	Few sources are documented.	Most sources are documented using the APA format.	All sources are documented using the APA format.	
Slide Presentation	The presentation did not include information about the subject.	The presentation includes rudimentary information with several gaps.	The presentation was good but could include a bit more essential information.	The presentation was complete giving all of the essential information to understand leaves, roots or stems.	

Total Points for the project: _____

Lesson 3 – Leaves, Roots and Stems

REVIEW: Presentation Day

45-60 minutes

Purpose:

Participants will present their research project on leaves, roots or stems.

Materials:

- *Leaves, Roots and Stems Project Grading Checklist*
- Copies of note sheets from presentations for participants to complete
- *Dicot Plant Leaf* model
- *Leaf, Root, Stem* poster

Facilitation Steps:

1. Have each group/participant deliver their research presentation to the class.
2. Use the checklist to assess each project as it is completed.
3. Share the checklist with each group/participant when all presentations are completed.
4. Review the essential parts of leaves, roots and stems using the model and poster if needed.

Lesson 4 – Flowering Plants

Lesson Overview

Flowering plants are plants which produce flowers as their reproductive structures. They come in a great variety of shapes and sizes and are found in every kind of habitat, from deserts to rivers. There are about 250,000 known species. This lesson will introduce participants to flowering plants, their parts and their functions.

Lesson Objectives

After completing this lesson, participants will be able to:

- Define what a flowering plant is
- Accurately identify the parts of a flower
- Dissect a real flower and identify the parts
- Understand key vocabulary terms relating to flowering plants and their definitions

Lesson at a Glance

Activity	Materials	Preparation	Approximate class time
FOCUS	• <i>Lesson 4 presentation slides</i>	1. Prepare <i>Lesson 4 presentation slides</i> for viewing	10 minutes
LEARN	• Real flowers, i.e., lilies, irises etc. • Scalpel or sharp knife • Magnifying glass or microscope • <i>Flower Parts poster</i> • <i>Flower Dissection Note Sheet</i> • <i>Lesson 4 presentation slides</i>	1. Get real flowers to dissect 2. Have scalpels/knives and magnifying glasses/microscopes available 3. Have the poster available as a resource 4. Print/photocopy <i>Flower Dissection Note Sheet</i> for each participant 5. Prepare <i>Lesson 4 presentation slides</i> for viewing	45 minutes
REVIEW	• <i>Flower Vocabulary Quiz</i> handout • <i>Flower Vocabulary Quiz Answer Key</i>	1. Print/photocopy <i>Flower Vocabulary Quiz</i> for each participant	10 minutes

Lesson 4 – Flowering Plants

FOCUS: What is Your Flower Power?

10 minutes

Purpose:

Participants are shown common flowers and will see how sharp their recognition skills are. This activity will expose participants to a variety of flowers in a fun and engaging activity.

Materials:

- *Lesson 4 presentation slides 1-12*

Facilitation Steps:

1. Tell participants that you are going to show a short series of slides. As you show each slide have them write down the name of the flower.
2. Show the *Lesson 4 presentation slides 1-12*.
3. Go through each item and identify the correct answer. Share the following notes.

Slide 3: Carnation

Slide 4: Daffodil

Slide 5: Iris

Slide 6: Orchid

Slide 7: Peony

Slide 8: Sunflower

Slide 9: Rose

Slide 10: Gladiola

Slide 11: Begonia

Slide 12: Lily

4. Ask for a show of hands to find out which participants had the most correct answers.
5. The proper definition of a flower found in the Merriam-Webster dictionary is: *the part of a seed plant that normally bears reproductive organs, a shoot of the sporophyte of a higher plant that is modified for reproduction and consists of a shortened axis bearing modified*

leaves, and a plant cultivated for its blossoms.

We already learned in a prior lesson that some vegetables are considered flowers like artichokes and broccoli. There are still other flowers that are considered edible like dandelions. There are fruit flowers such as apple blossoms. There are herb flowers such as ginger, fennel and cilantro. Our definition of flowers is greater than the flowers we just saw in the presentation slides.

Lesson 4 – Flowering Plants

LEARN: Flower Dissection Activity

45 minutes

Purpose:

Using a real flower, participants will dissect it, taking a closer look at each part under a magnifying glass or microscope. This activity will help participants identify parts of a flower.

Materials:

- Real flowers, i.e., lilies, irises etc.
- Scalpel or sharp knife
- Magnifying glass or microscope
- *Flower Parts* poster
- *Flower Dissection Note Sheet*
- *Lesson 4 presentation slides 13-20*

Facilitation Steps:

1. Hang the *Flower Parts* poster up for reference during this lesson.
2. Give each participant the *Flower Dissection Note Sheet*. They will use this to take notes before completing the dissection activity.
3. Show *Lesson 4 presentation slides 13-20*.

Slide 14: Here are the parts of a flower. Label these on your handout. Point out the parts of a flower using your Flower Parts poster.

Slide 15: The female reproductive part of a flower is called the pistil. The pistil, centrally located, typically consists of a swollen base (the ovary) that contains the potential seeds (ovules); a stalk (or style) arising from the ovary; and a pollen-receptive tip (the stigma) which is variously shaped and often sticky.¹⁰

Slide 16: The male reproductive part of a flower is called the stamen. Stamens

produce pollen in terminal saclike structures called anthers. The number of stamens is usually the same as the number of petals. Stamens usually consist of a long slender stalk and the filament with the anthers at the tip.¹¹

Slide 17-18: A few other parts of the flower that need to be defined are the following:

Sepal is a part of the flower of angiosperms, flowering plants. Usually green, sepals typically function as protection for the flower in the bud and often as support for the petals when in bloom. Collectively, sepals are called the calyx, the outermost whorl of parts that form a flower.¹²

Petals are modified leaves that surround the reproductive parts of flowers. They are often brightly colored or unusually shaped to attract pollinators. Together, all of the petals of a flower are called a corolla.¹³

The ovule is the structure that contains female reproductive cells. It has three parts: the integument forming the outer layer, the nucellus and the female gametophyte in the center. The female gametophyte, called a megagametophyte, is also called the embryo sac in angiosperms. The megagametophyte produces an egg cell for the purpose of fertilization. After fertilization, the ovule develops into a seed.¹⁴

A stalk is a long, vertical stem or connecting part of a plant.¹⁵

The receptacle is the thickened part of a stem from which the flower organs grow. In some accessory fruits, the receptacle gives rise to the edible part of the fruit.¹⁶

Slide 19: Pollination is the process by which pollen is transferred to the female reproductive organs of a plant, thereby enabling fertilization to take place. There are two types of pollination, cross-pollination and self-pollination. Cross-pollination is fertilization by transfer of pollen from the anthers of one flower to the stigma of another. Self-pollination is fertilization by transfer of pollen from the anthers to the stigma of the same flower.¹⁷

Slide 20: The Reproductive Cycle of Plants – The sex cells of the flowering plant are called gametes. There are both male and female gametes thus the flower undergoes sexual reproduction.

The parts on the slide are as follows:

1) Sporophyte; 2) Anther; 3) Ovule; 4) Ovary; 5) Microspore Mother Cell; 6) Megaspore Mother Cell; 7) Microspore; 8) Megaspore; 9) Pollen Grain (Male Gametophyte); 10) Embryo Sac (Mature Female Gametophyte); 11) Seed; 12) Endosperm (3n); 13) Mature Seed; I) diploid (2n); II) haploid (n); III) Meiosis; IV) Mitosis; V) Pollination; VI) Double Fertilization

Share the following regarding the reproductive cycle of flower plants:

The reproductive cycle in flowering plants begins with the development of both the male and female gametophytes. The male gametophytes are produced when the microspore mother cell in the pollen sacs of the anther goes through meiosis and produces four microspores, i.e., pollen.

The female gametophyte is produced when a megaspore mother cell in the ovule goes through meiosis and produces four megaspores. In many flowering plants, three of the four megaspores will disintegrate.

The male gametophytes develop into pollen grains and the female megaspore develops into a megagametophyte. When a pollen grain germinates on the stigma, it produces a pollen tube that extends in the style until it reaches an ovule of the ovary. Double fertilization occurs when the pollen tube releases two sperm. One sperm fertilizes the egg to produce a zygote and the other fertilizes the central cell, which has two polar nuclei, producing a triploid endosperm cell.

The zygote is a new sporophyte generation that divides to produce an embryo. The endosperm divides to produce endosperm food for the embryo. The ovule develops into a seed and contains both the embryo and the endosperm. When conditions are appropriate, the seed germinates and the embryo develops to produce the plant. The plant becomes a mature sporophyte.¹⁸

Dissection Activity

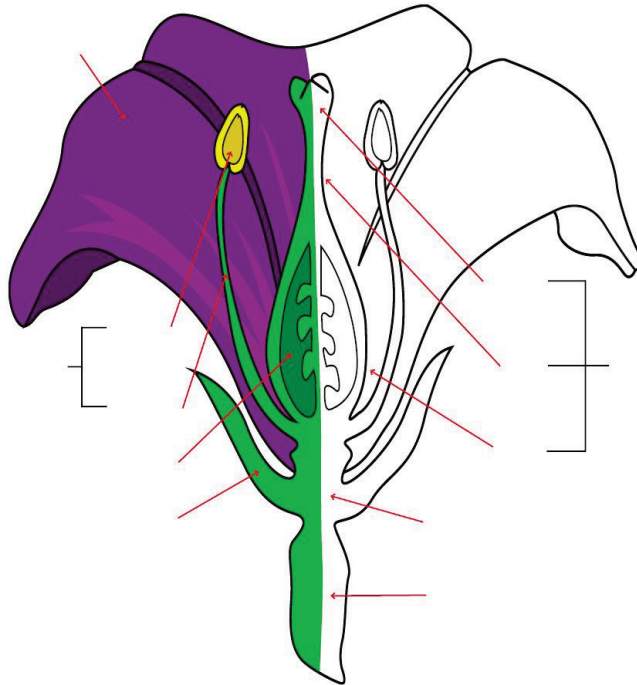
1. Give each student (or pair of students) a real flower to dissect. Flowers with large parts like lilies or irises work well. It is recommended to check with a local florist for free discarded flowers. A scalpel or sharp knife will be needed to cut through the flower parts. A magnifying glass to view pollen and other small flower parts is also necessary.
2. Begin by examining the flower. Answer the questions on the note sheet as you complete your dissection.

Name: _____ Class: _____

Flower Dissection Note Sheet

Complete the questions on this handout as you view the presentation slides for this lesson. Answer the remaining questions during the flower dissection activity.

1. Label the parts of a flower.



2. Define the following terms:

Anther -

Calyx -

Corolla -

Cross-pollination -

Filament -

Gametes -

Integument -

Megagameteophyte -

Nucellus -

Ovary -

Ovule -

Petal -

Pistil -

Pollination -

Receptacle -

Self-pollination -

Sepal -

Stalk -

Stamen -

Stigma -

Style -

3. Flower Dissection Activity

Exterior examination

- a. Describe the color of the petals.
- b. How many petals does it have? _____
- c. Describe the color of the sepals.
- d. How many sepals does it have? _____

Reproductive parts

- a. How many pistils does it have? _____
- b. Describe the stigma. (hint: look at the shape, color, etc)
- c. Find the ovary at the base of the pistil. Is it located above or below the sepals? _____

- d. Remove the pistil with the ovary. Draw an illustration of the pistil and label the stigma, style and ovary.

- e. How many eggs (ovules) are inside the ovary? _____

- f. Is the pistil a male or female reproductive organ? _____

- g. Locate the stamens. Describe their color and appearance. Draw an illustration of one stamen, then label the anther and filament.

- h. Is the anther above or below the stigma? _____

- i. Use a microscope or magnifying glass to look at the anther. Do you see small round pollen grains? _____

- j. Is the stamen the male or female reproductive organ? _____

Lesson 4 – Flowering Plants

REVIEW: Flower Vocabulary Quiz

10 minutes

Purpose:

This activity will provide a review for participants of key vocabulary terms learned relating to flowering plants, their parts and their functions.

Materials:

- *Flower Vocabulary Quiz*
- *Flower Vocabulary Quiz Answer Key*

Facilitation Steps:

1. Give each participant the *Flower Vocabulary Quiz*.
2. Allow 5 to 10 minutes for completion.
3. Have participants turn them in or peer grade as you share answers from the *Flower Vocabulary Answer Key*.

Name: _____ Class: _____

Flower Vocabulary Quiz

Match the vocabulary term with the correct definition.

- a. Anther
- b. Calyx
- c. Integument
- d. Megagametophyte
- e. Ovary
- f. Ovule
- g. Pistil
- h. Receptacle
- i. Sepal
- j. Stamen
- k. Stigma

- ___ The thickened part of a stem from which the flower organs grow
- ___ Also called the embryo sac in angiosperms that produces an egg cells for the purpose of fertilization
- ___ Terminal saclike structures in stamens that produce pollen
- ___ Collectively what the sepals are called forming the outermost whorl that forms a flower
- ___ Swollen base of the pistil containing the potential seeds
- ___ The male reproductive part of a flower
- ___ The female reproductive part of a flower
- ___ Typically functions as protection for the flower in bud
- ___ Various shaped and often sticky
- ___ Outer layer of the ovule
- ___ Structure that contains the female reproductive cells

Flower Vocabulary Quiz Answer Key

Match the vocabulary term with the correct definition.

- a. Anther
- b. Calyx
- c. Integument
- d. Megagameteophyte
- e. Ovary
- f. Ovule
- g. Pistil
- h. Receptacle
- i. Sepal
- j. Stamen
- k. Stigma

h The thickened part of a stem from which the flower organs grow

d Also called the embryo sac in angiosperms that produces an egg cells for the purpose of fertilization

a Terminal saclike structures in stamens that produce pollen

b Collectively what the sepals are called forming the outermost whorl that forms a flower

e Swollen base of the pistil containing the potential seeds

j The male reproductive part of a flower

g The female reproductive part of a flower

i Typically functions as protection for the flower in bud

k Various shaped and often sticky

f Outer layer of the ovule

f Structure that contains the female reproductive cells

Lesson 5 – Plant Identification Features

Lesson Overview

Plant identification can be challenging. Being able to identify a plant is important, especially in the case of noxious weeds or toxic plants. However, looking at just a few morphological features of a plant can help you narrow down the options or even identify the plant's genus and species. The purpose of this lesson is to introduce shape, margin and venation to help identify plants with speed and accuracy.

Lesson Objectives

After completing this lesson, participants will be able to:

- Accurately identify nine different leaf venations
- Describe and recognize 40 common leaf shapes
- Accurately identify 12 different leaf margins
- Understand how plant identification features can be used together to identify plants

Lesson at a Glance

Activity	Materials	Preparation	Approximate class time
FOCUS	• Samples of real leaves • <i>Lesson 5 presentation slides</i> • <i>Leaf Venation</i> handout • <i>Leaf Venation Answer Key</i> • <i>Plant Identifiers – Margin & Venation</i> poster	1. Gather enough leaves for each pair of participants to have four to five samples 2. Print/photocopy <i>Leaf Venation</i> handout (one per participant) 3. Prepare <i>Lesson 5 presentation slides</i> for viewing 4. Have <i>Leaf Venation Answer Key</i> available for reference	20-25 minutes
LEARN Part 1	• <i>Lesson 5 presentation slides</i> • <i>Leaf Shape</i> handout • <i>Leaf Shape Answer Key</i> • <i>Plant Identifiers - Shape</i> poster	1. Print/photocopy <i>Leaf Shape</i> handout for each participant 2. Prepare <i>Lesson 5 presentation slides</i> for viewing 3. Have <i>Leaf Shape Answer Key</i> available for reference	45-60 minutes
LEARN Part 2	• Samples of real leaves • <i>Lesson 5 presentation slides</i> • <i>Leaf Margin</i> handout • <i>Leaf Margin Answer Key</i> • <i>Plant Identifiers – Margin & Venation</i> poster	1. Gather enough leaves for each small group of participants to have four to five samples 2. Print/photocopy <i>Leaf Margin</i> handout (one per participant) 3. Prepare <i>Lesson 5 presentation slides</i> for viewing 4. Have <i>Leaf Margin Answer Key</i> available for reference	30 minutes
REVIEW	• <i>Plant Science Trivia Cards</i>	N/A	10-15 minutes

Lesson 5 – Plant Identification Features

FOCUS: Leaf Venation

20-25 minutes

Purpose:

The way a leaf looks in terms of leaf shape, leaf margin, leaf arrangement and leaf venation is important for identifying plants. The design and function of leaf venation specifically are important to plant performance, with key implications for the distribution and productivity of ecosystems, and applications in biology, agriculture and technology.

Materials:

- Samples of real leaves
- *Lesson 5 presentation slides 1-12*
- *Leaf Venation* handout
- *Leaf Venation Answer Key*
- *Plant Identifiers – Margin & Venation* poster

Facilitation Steps:

1. Display the *Plant Identifiers – Margin & Venation* poster as a reference during this lesson.
2. Pair participants up. Give each pair several leaves to compare and contrast. Have them make a list of how the leaves are the same and different. Give five minutes for this activity. Tell participants to save the leaves as they will be using them again.
3. Call the class back together and have each pair share a few of the ways that they compared/contrasted the leaves.
4. Explain that the way a leaf looks in terms of leaf shape, leaf margin, leaf arrangement and leaf venation is important for identifying plants.
5. This part of lesson will focus on venation. Give each participant the *Leaf Venation* handout. Have them complete it during the slide presentation.
6. Show the *Lesson 5 presentation slides*
 - Slide 3:** What is venation? Venation is the arrangement of the veins in a leaf.¹⁹ Most of these vein patterns can be categorized into two groups, monocots or dicots. Monocots have parallel veins. Dicots have veins which connect and branch from each other. Here are some examples of different kinds of venation.
 - Slide 4:** Palmate – several primary veins diverging from a point
 - Slide 5:** Parallel – veins arranged axially, not intersecting
 - Slide 6:** Dichotomous – veins branching symmetrically in pairs
 - Slide 7:** Pinnate – secondary veins paired oppositely
 - Slide 8:** Reticulate – smaller veins forming a network
 - Slide 9:** Rotate – veins radiating
 - Slide 10:** Arcuate – secondary veins, bending toward apex
 - Slide 11:** Cross-venulate – small veins connecting secondary veins
 - Slide 12:** Longitudinal – veins aligned mostly along long axis of leaf
7. Have participants pair back up. Using the real leaves they used to compare and contrast earlier, have participants identify the type of venation found in each leaf.

Name: _____ Class: _____

Leaf Venation

Identify each type of leaf venation in the chart below.

Leaf Venation Answer Key

Identify each type of leaf venation in the chart below.

		
<u>Palmate</u>	<u>Parallel</u>	<u>Dichotomous</u>
		
<u>Pinnate</u>	<u>Reticulate</u>	<u>Rotate</u>
		
<u>Arcuate</u>	<u>Cross-Venulate</u>	<u>Longitudinal</u>

Lesson 5 – Plant Identification Features

LEARN: Leaf Shape (part 1)

45-60 minutes

Purpose:

The way a leaf looks in terms of leaf shape, leaf margin, leaf arrangement and leaf venation is important for identifying plants. The shape is one of the primary tools in plant identification. This lesson will introduce participants to 40 common leaf shapes.

Materials:

- *Lesson 5 presentation slides 13-33*
- *Leaf Shape* handout
- *Leaf Shape Answer Key*
- *Plant Identifiers - Shape* poster

Facilitation Steps:

1. Display the *Plant Identifiers - Shape* poster as a reference during this lesson.
2. Explain that the way a leaf looks in terms of leaf shape, leaf margin, leaf arrangement and leaf venation is important for identifying plants. This part of the lesson will focus on common leaf shapes. Give each participant the *Leaf Shape* handout. Have them complete it during the slide presentation.
3. Show the *Lesson 5 presentation slides 13-33*.

Slide 14: Acicular – needle

shaped/acuminate – tapering to a long point

Slide 15: Alternate – leaflets arranged

alternately/Aristate - with a spine-like tip

Slide 16: Bipinnate – leaflets also

pinnate/Cordate – heart-shaped stem in cleft

Slide 17: Cuneate – wedge shaped acute

base/Deltoid - triangular

Slide 18: Digitate – with finger-like

lobes/Eliptic – oval-shaped, small or no point

Slide 19: Even pinnate – leaflets in rows, two at a tip/Falcate – hooked or sickle shaped

Slide 20: Flabellate – fan shaped/Hastate – triangular with basal lobes

Slide 21: Lanceolate – pointed at both ends/Linear – parallel margins, elongate

Slide 22: Lobed – deeply indented margins/Obcordate – heart-shaped stem at point

Slide 23: Obovate– egg-shaped narrow at base/Obtuse – bluntly tipped

Slide 24: Odd pinnate – leaflets in rows one at tip/Opposite – leaflets in adjacent pairs

Slide 25: Orbicular – circular/Ovate – egg shaped wide at base Ovate

Slide 26: Palmate – like a hand with fingers/Pedate –palmate, divided lateral lobes

Slide 27: Peltate – stem attached

centrally/Perfoliate – stem seeming to pierce leaf

Slide 28: Pinnatisect – deep opposite

lobing/Reniform – kidney-shaped

Slide 29: Rhomboid – diamond-shaped/Rosette – leaflets in tight circular rings

Slide 30: Spatulate – spoon-shaped/Spear-shaped – pointed barbed base

Slide 31: Subulate – tapering point, awl-shaped/Trifoliate/Ternate – leaflets in threes

Slide 32: Tripinnate – leaflets also bipinnate/Truncate – squared-off apex

Slide 33: Unifoliate – having a single leaf/Whorled – rings of three or more leaflets

Name: _____ Class: _____

Leaf Shape

Complete a short description and illustration for each of the following common leaf shapes.

Shape	Description	Illustration
Acicular		
Acuminate		
Alternate		
Aristate		
Bipinnate		
Cordate		
Cuneate		
Deltoid		

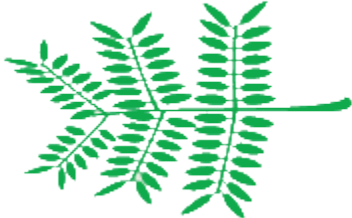
Digitate		
Elipctic		
Even Pinnate		
Falcate		
Flabellate		
Hastate		
Lanceolate		
Linear		
Lobed		
Obcordate		
Obovate		

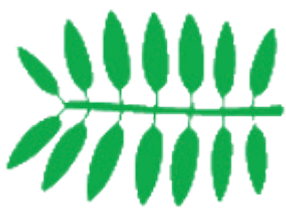
Obtuse		
Odd Pinnate		
Opposite		
Orbicular		
Ovate		
Palmate		
Pedate		
Peltate		
Perfoliate		
Pinnatisect		
Reniform		

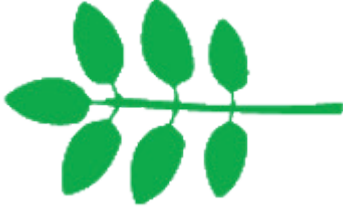
Rhomboid		
Rosette		
Spatulate		
Spear-shaped		
Subulate		
Trifoliate/Ternate		
Tripinnate		
Truncate		
Unifoliate		
Whorled		

Leaf Shape Answer Key

Complete a short description and illustration for each of the following common leaf shapes.

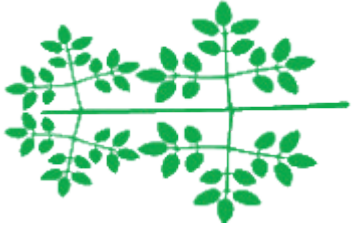
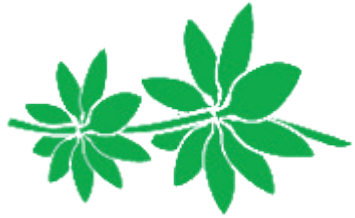
Shape	Description	Illustration
Acicular	<u>Needle-shaped</u>	
Acuminate	<u>Tapering to a long point</u>	
Alternate	<u>Leaflets arranged alternately</u>	
Aristate	<u>With a spine-like tip</u>	
Bipinnate	<u>Leaflets also pinnate</u>	
Cordate	<u>Heart-shaped stem in cleft</u>	
Cuneate	<u>Wedge-shaped, acute base</u>	

Deltoid	<u>Triangular</u>	
Digitate	<u>With finger-like lobes</u>	
Elliptic	<u>Oval-shaped, small or no point</u>	
Even Pinnate	<u>Leaflets in rows, two at tip</u>	
Falcate	<u>Hooked or sickle-shaped</u>	
Flabellate	<u>Fan-shaped</u>	
Hastate	<u>Triangular with basal lobes</u>	

Lanceolate	<u>Pointed at both ends</u>	
Linear	<u>Parallel margins, elongate</u>	
Lobed	<u>Deeply indented margins</u>	
Obcordate	<u>Heart-shaped stem at point</u>	
Obovate	<u>Egg-shaped narrow at base</u>	
Obtuse	<u>Bluntly tipped</u>	
Odd Pinnate	<u>Leaflets in rows one at tip</u>	

Opposite	<u>Leaflets in adjacent pairs</u>	
Orbicular	<u>Circular</u>	
Ovate	<u>Egg-shaped wide at base</u>	
Palmate	<u>Like a hand with fingers</u>	
Pedate	<u>Palmate, divided lateral lobes</u>	
Peltate	<u>Stem attached centrally</u>	

Perfoliate	<u>Stem seeming to pierce leaf</u>	
Pinnatisect	<u>Deep opposite lobing</u>	
Reniform	<u>Kidney-shaped</u>	
Rhomboid	<u>Diamond-shaped</u>	
Rosette	<u>Leaflets in tight circular rings</u>	
Spatulate	<u>Spoon-shaped</u>	
Spear-shaped	<u>Pointed, barbed base</u>	
Subulate	<u>Tapering point awl-shaped</u>	

Trifoliate/Ternate	<u>Leaflets in threes</u>	
Tripinnate	<u>Leaflets also bipinnate</u>	
Truncate	<u>Squared-off apex</u>	
Unifoliate	<u>Having a single leaf</u>	
Whorled	<u>Rings of three or more leaflets</u>	

Lesson 5 – Plant Identification Features

LEARN: Leaf Margin (part 2)

30 minutes

Purpose:

The way a leaf looks in terms of leaf shape, leaf margin, leaf arrangement and leaf venation is important for identifying plants. The margin of a leaf refers to the edge of the leaf. While leaves on a single tree may differ in size, they will all have the same general shape and margin. Thus, the leaf margin can be an indicator of the species of the tree in question.²⁰

Materials:

- Samples of real leaves
- *Lesson 5 presentation slides 34-46*
- *Leaf Margin* handout
- *Leaf Margin Answer Key*
- *Plant Identifiers – Margin & Venation* poster

Facilitation Steps:

1. Display the *Plant Identifiers – Margin & Venation* poster as a reference during this lesson.
2. Create small groups of participants. Give each small group several leaves to study. Have them study the shape of each leaf. Using the *Plant Identifiers – Margin & Venation* poster as a reference, give five minutes for participants to decide which margin each leaf has.
3. Call the class back together and have each pair show one of their leaves, identifying the type of margin they believe it to have.
4. Explain that the way a leaf looks in terms of leaf shape, leaf margin, leaf arrangement and leaf venation is important for identifying plants. This part of lesson will focus on margin. Give each participant the *Leaf Margin* handout to complete during the presentation slides.

5. Show *Lesson 5 presentation slides 34-46*.

Slide 34: What is margin? The margin of a leaf refers to the edge of the leaf. While leaves on a single tree may differ in size, they will all have the same general shape and margin. Thus, the leaf margin can be an indicator of the species of the tree in question

Slide 35: Undulate – widely wavy

Slide 36: Serrulate – with fine serration

Slide 37: Entire – even and smooth throughout

Slide 38: Dentate – with symmetrical teeth

Slide 39: Spiny – with sharp stiff points

Slide 40: Serrate – teeth forward-pointing

Slide 41: Doubly Serrate – serrate with sub teeth

Slide 42: Crenate – with rounded teeth

Slide 43: Sinuate – with wave-like indentations

Slide 44: Lobate – indented, but not to midline

Slide 45: Denticulate – with fine dentition

Slide 46: Ciliate – with fine hairs

6. Have students regroup and use their *Leaf Margin* handout to discuss if their original guesses were correct.

Name: _____ Class: _____

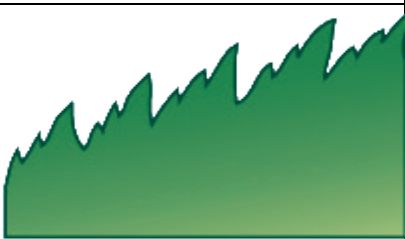
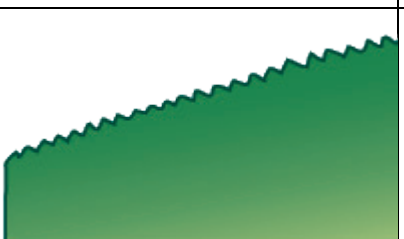
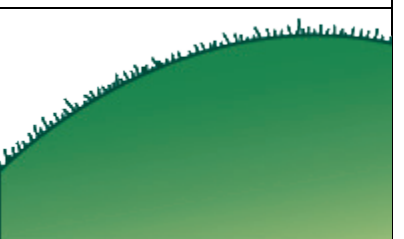
Leaf Margin

Identify each type of leaf margin in the chart below.

Leaf Margin Answer Key

Identify each type of leaf margin in the chart below.

		
<u>Undulate</u>	<u>Serrulate</u>	<u>Entire</u>
		
<u>Dentate</u>	<u>Spiny</u>	<u>Serrate</u>
		
<u>Doubly Serrate</u>	<u>Crenate</u>	<u>Sinuate</u>
		
<u>Lobate</u>	<u>Denticulate</u>	<u>Ciliate</u>

Lesson 5 – Plant Identification Features

REVIEW: Trivia Card Game

10-15 minutes

Purpose:

Participants will review their knowledge of shape, venation and margin through this interactive game.

Materials:

- *Plant Science Trivia Cards*

Facilitation Steps:

1. To provide additional practice on plant identification features, use the *Plant Science Trivia Cards*.

Whole group method: One side of each card has the feature and the other side has the illustration. The instructor can show the trivia card and then take volunteers for answers, or go around the class asking each participant to give an answer to a card.

Large group: "Around the World." Students sit in a circle. Choose a starting person. This student stands behind the next student in the circle. The teacher holds up a trivia card. The first student to say the answer stands behind the next person in the circle. If a sitting student says the answer first, the standing student sits down in the winner's chair. This process continues until at least one student makes it completely around the circle.

Small group method: Divide the class into small groups. Give each group an equal number of the *Plant Science Trivia Cards*. One person in the group picks a card, showing the illustration to the group members. The first person in the group to get the answer correct picks a card and asks the next question. Every few minutes, groups should exchange cards so they get through all of the trivia cards in the deck.

Face-off method: Divide the class into two equal groups. Line up each group and give each group a bell. Show the first person in each line the trivia card (illustration-side) at the same time. The first person to ring the bell and correctly identify the feature keeps the card. Have the next people step forward and follow the same procedure until you run out of cards. The group with the most cards at the end of the round wins.

Lesson 6 – Photosynthesis, Respiration and Transpiration

Lesson Overview

Photosynthesis is the most important reaction on Earth. All life forms depend on it! Without plants the entire food chain would lose its foundation. All animals, including humans, ultimately depend on plant material, either directly or indirectly, for survival. Participants will experience, see and learn about this essential

Lesson Objectives

After completing this lesson, participants will be able to:

- Explain the process of photosynthesis
- Define photosynthesis, respiration and transpiration
- Articulate how photosynthesis, respiration and transpiration functions in plant growth and development
- Describe the reactants and products of photosynthesis and the source of reactions from the environment

Lesson at a Glance

Activity	Materials	Preparation	Approximate class time
FOCUS	• Fruit with natural sugar, i.e., strawberries • Lesson 6 presentation slides	1. Prepare Lesson 6 presentation slides for viewing 2. Purchase, wash and prepare fruit for eating	10 minutes
LEARN Part 1	• Lesson 6 presentation slides • Photosynthesis Note Sheet • Photosynthesis Note Sheet Answer Key	1. Print/photocopy Photosynthesis Note Sheet for each participant 2. Prepare Lesson 6 presentation slides for viewing	20-30 minutes
LEARN Part 2	• Photosynthesis Leaf Disk Lab Instructions • Photosynthesis Lab Data Table • Photosynthesis Lab Data Graph • Photosynthesis lab materials available for each group • Liquid dish soap • Eyedropper • 1.5 g sodium bicarbonate, i.e., baking soda • Plastic syringe (20-65 mL) • Plastic spoon • Leaf material, i.e., spinach, ivy, etc. • Hole punch • One large beaker or plastic cup • Two small beakers or plastic cups • Timer • Light source – 60-watt bulb or higher • Paper towels	1. Print/photocopy Photosynthesis Leaf Disk Lab Instructions for each participant 2. Print/photocopy Photosynthesis Lab Data Table for each participant 3. Print/photocopy Photosynthesis Lab Data Graph for each participant 4. Gather all of the needed lab materials for each group	60 minutes

Plant Science Basics

	• Safety goggles		
REVIEW	• <i>Photosynthesis Lab Questions</i> • <i>Photosynthesis Lab Questions Answer Key</i>	1. Print/photocopy <i>Photosynthesis Lab Questions</i> for each participant	10-15 minutes

Lesson 6 – Photosynthesis, Respiration and Transpiration

FOCUS: Introduction to Photosynthesis

10 minutes

Purpose:

Participants will practice respiration and explain their role and the plants' role in creating homeostasis with this physical activity.

Materials:

- Fruit with noticeable amounts of natural sugar, i.e., strawberries, enough for all participants to have one or two pieces.
- *Lesson 6 presentation slides 3 and 4*

Facilitation Steps:

1. Give each participant a few strawberries (or similar piece of fruit) with a fair amount of natural sugar.
2. Have each participant eat the piece(s) of fruit.
3. Have participants exercise for three minutes in place. They could do things like jumping jacks, squat thrusts, or similar exercises. Time them for three minutes.
4. Now stop at the three-minute mark. Have participants take a seat and ask them, "How do you think this activity was a benefit to plants?"
5. Take a few answers from participants. Explain that what everyone just did was to eat sugar and exercise. This process is known as respiration. By eating the sugar in the fruit and breathing in oxygen, everyone was producing something that is necessary for plant life. Ask participants if they know what that is? Write a few answers on a white board.

6. Explain that what they just produced was carbon dioxide (breathing out) and water (sweat). We do that for plants, but they also do that for us. Ask participants what the process is called when plants produce sugar and oxygen for us. Write suggested answers on a white board.
7. Explain that the process of plants converting carbon dioxide and water into sugar or carbohydrates and oxygen is photosynthesis.
8. Show *Lesson 6 presentation slides* –

Slide 3: Share the following background information: Photosynthesis (photo=light and synthesis=to make) is the process plants use to change carbon dioxide and water into sugar using sunlight. This sugar/glucose is their food, and the process gives off oxygen. ²¹

Slide 4: Photosynthesis is the conversion of light energy into chemical energy by living organisms. The raw materials are carbon dioxide and water. The energy source is sunlight and the end-products include glucose and oxygen. It is the most important biochemical process, since nearly all life depends on it.

Photosynthesis is the process by which plants and some bacteria use the energy from sunlight to produce sugar, which cellular respiration converts into ATP (adenosine triphosphate), the fuel used by all living things. ATP is simply the energy created from glucose. The conversion of unusable sunlight energy into usable chemical energy is associated with the actions of the green pigment called chlorophyll. Most of the time, the photosynthetic process uses water and releases the oxygen that we must have to stay alive. ²¹

Lesson 6 – Photosynthesis, Respiration and Transpiration

LEARN: Photosynthesis, Respiration and Transpiration Lecture (Part 1)

20-30 minutes

Purpose:

Participants will learn the definition of key concepts relating to photosynthesis. They will be able to explain the process of photosynthesis. Participants will also perform a lab activity that will demonstrate photosynthesis.

Materials:

- *Lesson 6 presentation slides 3-9*
- *Photosynthesis Note Sheet*
- *Photosynthesis Note Sheet Answer Key*

Facilitation Steps:

1. Give each participant the *Photosynthesis Note Sheet*. They should complete this as you go through the *Lesson 6 presentation slides*.
2. As you show the *Lesson 6 presentation slides*, share the following information:

Slide 3: Photosynthesis is the manufacture of food by plant cells. In order for photosynthesis to occur, four things must be present: chlorophyll, light, carbon dioxide and water.

Slide 4: There are two major phases to this process. Plant leaves soak up sunlight gathering energy, and then convert it from sunlight into stored chemical energy, forming glucose/sugar.²² In other words, plants have chlorophyll in their leaves. Leaves absorb necessary energy from the sun's rays (or artificial light). Carbon dioxide enters the plant through the stomata in the leaves. Carbon dioxide is split during this process. Water is also split during photosynthesis.

Slide 5: The Photosynthesis Equation

- a) Occurs in the chloroplasts.
- b) The equation is water plus carbon dioxide is converted by sunlight into sugar/glucose and oxygen²³.
- c) The chemical equation written in words is: Six molecules of carbon dioxide plus twelve molecules of water in combination with a healthy plant and light energy will create one molecule of sugar plus six molecules of water and six molecules of oxygen.

Slide 6: What is respiration? It is the process of metabolizing/burning sugars to yield energy for growth, reproduction and other life processes. Plants convert the sugars through photosynthates back into energy for growth and other life processes like metabolic processes.²⁴

Slide 7: The chemical equation for respiration shows that the photosynthates are combined with oxygen releasing energy, carbon dioxide and water. Here is the chemical reaction. It is the opposite of photosynthesis.

Slide 8: What is transpiration? It is the loss of water vapor through the stomata of leaves. Water in the roots of the plant is pulled through the plant in this process. Transpiration uses about 90-97% of the water that enters the plant. The remaining 10% or less is an ingredient found in cell growth and photosynthesis.²⁵

Slide 9-11: Further describe the transpiration process.

1. Water molecules enter the roots passively, passing through the cortex, and are guided to

xylem tissue by the Casparian strip. A concentration gradient of solutes within the xylem leads to further passive transport of water into the vessel elements.

2. Once the water has entered the xylem, the forces of adhesion and cohesion take effect. Adhesion causes the molecules to adhere to sides of the vessels, and cohesion causes the molecules to adhere to each other, forming a column of water that extends from the roots to the top of the plant.

3. Water from the xylem is let into the spongy mesophyll, where it can come into contact with stomata. When the stomata are open, the cells in this layer are exposed to the outside air and evaporation occurs. When water molecules evaporate out of the stomata, they create tension in the water column, as the forces of cohesion pull nearby molecules up with them, creating pulling force down the length of the xylem.

Name: _____ Class: _____

Photosynthesis Note Sheet

Complete this as you view the Photosynthesis presentation slides.

1. What is photosynthesis?
2. What four things need to be present for photosynthesis to occur?
3. What is the chemical equation for photosynthesis?
4. What is the word equation for photosynthesis?
5. What is respiration?
6. What is the chemical equation for respiration?
7. What is the chemical equation for respiration?
8. What is the opposite of photosynthesis?
9. What is transpiration?
10. What is pulled through the plant in the transpiration process?

Photosynthesis Note Sheet Answer Key

Complete this as you view the Photosynthesis presentation slides.

1. What is photosynthesis? **The manufacture of food by plant cells**

2. What four things need to be present for photosynthesis to occur?
Chlorophyll, light, carbon dioxide and water

3. What is the chemical equation for photosynthesis?



4. What is the word equation for photosynthesis?



5. What is respiration? **The process of metabolizing sugars to yield energy for growth, reproduction and other life processes**

6. What is the chemical equation for respiration?



7. What is the word equation for respiration?



8. What is the opposite of photosynthesis? **Respiration**

9. What is transpiration? **The loss of water vapor through the stomata of leaves**

10. What is pulled through the plant in the transpiration process? **Water in the roots of the plant**

Lesson 6 – Photosynthesis, Respiration and Transpiration

LEARN: Photosynthesis Lab (Part 2)

60 minutes

Purpose:

Participants will describe the reaction and products of photosynthesis as well as the source of reactants from the environment. During the lab, they will explain the relationship of this process to the observations made during the experiment.

Materials:

- *Photosynthesis Leaf Disk Lab Instructions*
- *Photosynthesis Lab Data Table*
- *Photosynthesis Lab Data Graph*
- Photosynthesis lab materials available for each group:
 - Liquid dish soap
 - Eyedropper
 - 1.5 g sodium bicarbonate, i.e., baking soda
 - Plastic syringe (20-65 ml)
 - Plastic spoon
 - Leaf material, i.e., spinach, ivy, etc.
 - Hole punch
 - One large beaker or plastic cup
 - Two small beakers or plastic cups
 - Timer
 - Light source – 60-watt bulb or higher
 - Paper towels
 - Safety goggles

2. It is recommended to test the amount of sodium bicarbonate needed prior to the experiment. This sodium bicarbonate solution adds carbon dioxide to the solution to stimulate photosynthesis.
3. As the solution enters the leaf spaces and the air is forced out. The additional mass causes the disks to sink in the solution. The solution should be vacuumed through the leaf disks several times, shaking the syringe after each attempt.
4. Remind the students to grasp the syringe firmly and keep one finger over the tip to prevent water from escaping. If the disks do not sink, add a bit more detergent to the solution.
5. The leaf disks are divided equally into two cups, and the remaining solution is added equally to each. One cup is exposed to light while the other is labeled the control and is covered. As photosynthesis occurs, oxygen is produced which fills the intercellular spaces. The decrease in density causes the leaf disks to rise and float. Observations are made as the disk cells undergo photosynthesis and participants will observe, recording the time it takes for the leaf disks to rise to the surface.

Facilitation Steps:

1. Give each participant the *Photosynthesis Leaf Disk Lab Instructions, Data Table and Graph*. In this lab activity, participants will use a syringe to vacuum air from the spongy mesophyll of leaf disks. The spaces will then be infiltrated with a sodium bicarbonate, i.e., baking soda, solution which includes a small amount of detergent to break down the waxy leaf coating.

Name: _____ Class: _____

Photosynthesis Leaf Disk Lab

Instructions

Follow the procedures and answer the questions as you record your observations during the lab.

In this experiment, the spaces in the spongy mesophyll of leaf disks are filled with sodium bicarbonate solution, which causes them to sink in the solution. The leaf disks are then exposed to light and observations are made as the cells undergo photosynthesis.

Materials:

- Liquid dish soap
- Eyedropper
- 1.5 g sodium bicarbonate (1/3 teaspoon baking soda)
- Plastic syringe (20-65 ml)
- Plastic spoon
- Leaf material, i.e., spinach, ivy, etc.
- Hole punch
- One large beaker or plastic cup
- Two small beakers or plastic cups
- Timer
- Light source – 60-watt bulb or higher
- Paper towels
- Safety goggles

Procedure:

1. Using a hole punch, cut out 20 leaf disks from your group's leaf material.
2. Prepare a 0.2% solution of sodium bicarbonate and water in the large beaker by adding approximately 1.5 g sodium bicarbonate to 300 ml of water. Stir until dissolved, then add about two drops of dish detergent to the solution using the eye dropper. Stir again. There should be no bubbles when you are finished stirring.
3. Remove the plunger from a large, clean syringe. Place 20 leaf disks into the body of the syringe. Be sure the disks are near the tip of the syringe so that when you re-insert the plunger, you do not damage the disks.
4. Insert the tip of the syringe into a beaker of 0.2% sodium bicarbonate solution and draw 15 to 20 mL into the syringe. The leaf disks should be floating at this time.
5. Hold the syringe tip upward and expel the air by depressing the plunger carefully. Stop before solution comes out of the tip.

6. Seal the tip of the syringe using the index finger of your hand and hold it tightly. Pull back the plunger, creating a partial vacuum with the syringe. If you have a good seal, it will be hard to pull on the plunger and you should see bubbles coming from the edge of the leaf disks.
7. Hold for a count of ten.
8. Simultaneously release your index finger and the plunger. Some of the leaf disks should start to sink. Tap the side of the tube or shake gently to break any bubbles on the edges of the disks.
9. Repeat steps 6 to 8 until all disks sink. **Do not overdo these steps!** You have been successful if the disks sink to the bottom. Don't repeat, as it could damage the leaf cells.
10. Remove the plunger from the syringe and pour the solution containing the disks into two cups or beakers. Add the remainder of the solution equally to both containers. There should be 10 disks per cup. Make sure they sink to the bottom.
11. Cover one of the beakers to block light from the leaf disks. Place the second beaker/container under a light source, approximately six to eight inches below the light. The lights are best held in a clamp on a ring stand if possible. Begin timing the experiment as soon as the light is turned on. Record your observations on the Data Table.
12. Observe what is happening to the leaf disks as photosynthesis proceeds. Continue to record your observations on the Data Table. After each time check, tap the side of the beaker or container to make sure disks are not sticking to the walls. When checking the covered beaker, do so quickly so as to limit light exposure.
13. Clean the lab equipment and dispose of solutions in the sink.

Name: _____ Class: _____

Photosynthesis Lab Data Table

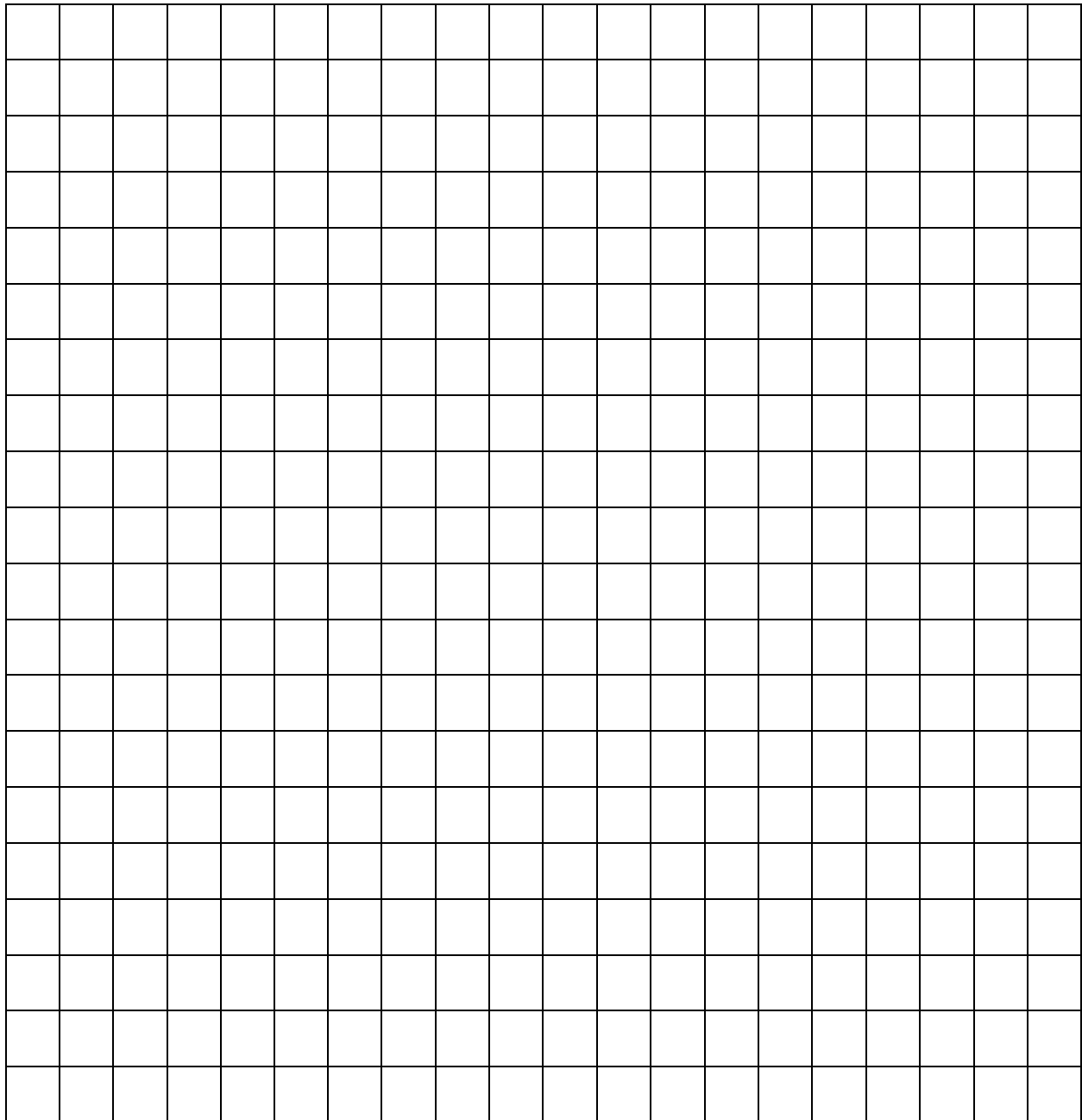
Record the number of leaf disks floating at each time in both environments, light and dark.

Time (minutes)	Number of Leaf Disks Floating (Light)	Number of Leaf Disks Floating (Dark)
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Photosynthesis Lab Data Graph

Using the data from your Data Table, complete a double line graph showing the results of the lab activity. Include a title, label the x and y axis and label each line appropriately or use color coding.

Title _____



Lesson 6 – Photosynthesis, Respiration and Transpiration

REVIEW: Photosynthesis Lab Debrief

10-15 minutes

Purpose:

Participants will reflect on the lab activity and answer some key questions regarding their observations and knowledge of photosynthesis.

Materials:

- *Photosynthesis Lab Questions*
- *Photosynthesis Lab Questions Answer Key*

Facilitation Steps:

1. Give participants the *Photosynthesis Lab Questions* handout. Give them 10 minutes to complete it.
2. Collect the *Photosynthesis Lab Questions* for assessment or share the answers from the *Photosynthesis Lab Questions Answer Key* with participants if you choose to self-check.

Name: _____ Class: _____

Photosynthesis Lab Questions

Complete the following questions at the conclusion of your lab.

1. What question are you trying to answer in this experiment?
2. What is the function of sodium bicarbonate?
3. Why was it important to keep one beaker covered and one uncovered?
4. What is the relationship between the number of disks floating and time as shown on the graph?
5. Did any leaf disks float in the dark environment? Why or why not?
6. What changes occurred to the leaf tissue that allowed the leaf disks to rise to the surface?

Photosynthesis Lab Questions Answer Key

Complete the following questions at the conclusion of your lab.

1. What question are you trying to answer in this experiment?

What is the effect of light on photosynthesis?

2. What is the function of sodium bicarbonate?

To provide the leaves with a source of CO₂ after all gasses were removed from the leaves.

3. Why was it important to keep one beaker covered and one uncovered?

The uncovered beaker is exposed to light and the covered beaker is the control. This will allow us to see how photosynthesis (including light) impact the leaf disks.

4. What is the relationship between the number of disks floating and time as shown on the graph?

As photosynthesis occurs, oxygen is produced filling the intercellular spaces. Density decreases, causing leaf disks to rise and float. More disks will float over time exposed to light.

5. Did any leaf disks float in the dark environment? Why or why not?

Darkness slows the rate of photosynthesis. Even in darkness, there is typically some light. However without a lot of light, photosynthesis cannot occur at a high rate.

6. What changes occurred to the leaf tissue that allowed the leaf disks to rise to the surface?

As photosynthesis proceeds, CO₂ is converted to oxygen gas, which accumulates and fills the interior (mesophyll layer) of the leaf, changing the buoyancy of the leaf, causing it to rise.

Lesson 7 – Exploring Botany and Plant Science Careers

Lesson Overview

There are a wide variety of career choices relating to botany and plant science. Participants will explore a variety of related occupations to see if this may be a good fit for their interests and abilities.

Lesson Objectives

After completing this lesson, participants will be able to:

- Identify several professions in the botany and plant science fields
- Consider if any of the occupations covered in class are appropriate for them

Lesson at a Glance

Activity	Materials	Preparation	Approximate class time
FOCUS	• <i>Career Exploration Brainstorming Web</i> handout	1. Print/photocopy <i>Career Exploration Brainstorming Web</i> handout (one per participant)	10 minutes
LEARN	• <i>Career Exploration Brainstorming Web</i> handout • <i>List of Botany and Plant Science Careers</i> • Library and Internet resources • <i>Career Exploration Research Summary</i> handout	1. Print/photocopy <i>List of Botany and Plant Science Careers</i> for each participant 2. Print/photocopy <i>Career Exploration Research Summary</i> for each participant	30-90 minutes
REVIEW	• Panel of three to five local professionals who work in a variety of related careers	1. Contact panel participants	45-60 minutes

Lesson 7 – Exploring Botany and Plant Science Careers

FOCUS: Brainstorming Activity

10 minutes

Purpose:

There are many occupations that involve working with plants in some capacity. Participants may be unaware of the many career opportunities that exist. This activity will get participants to begin thinking about careers surrounding horticulture, agronomy, greenhouse, nursing management and plant research.

Materials:

- *Career Exploration Brainstorming Web* handout

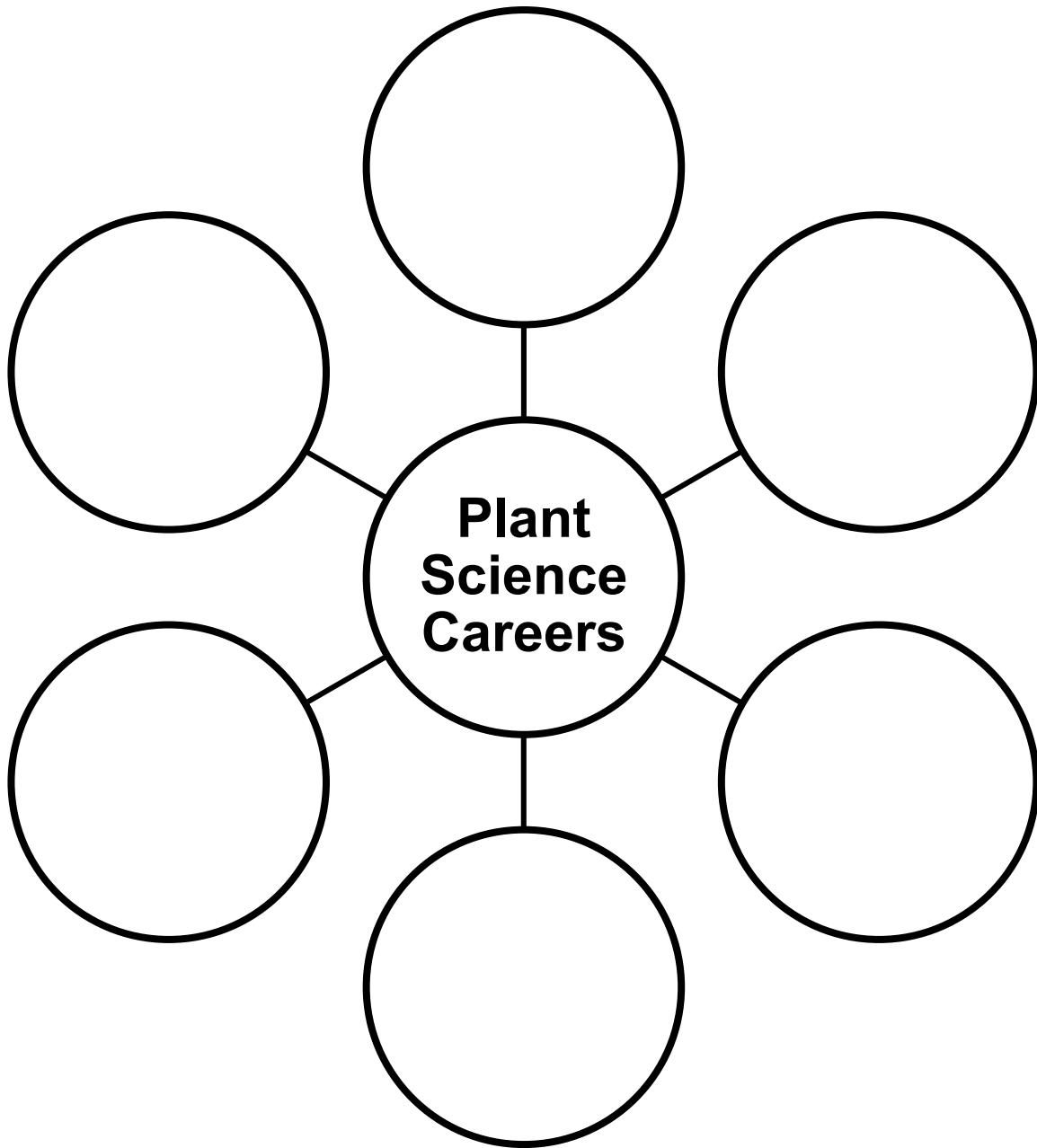
Facilitation Steps:

1. Divide the class into five groups. Make a photocopy for each participant of the Career Exploration Brainstorming Web handout. After welcoming participants to the class, explain the purpose of the activity, distribute it and give participants five minutes to complete.
2. After five minutes, call the groups back together. Ask each group to share one of the careers they identified as relating botany and plant science in their brainstorming session. Write these on a master list on a white-board or similar item. Continue calling upon each group until all careers that were brainstormed are written down on the master list.
3. Extension Activity – If your students are interested in learning whether they are a good match for working in the plant science field, find a career skills inventory or survey on the internet. Here is an example of a general career interest inventory:
<http://www.iseek.org/careers/clusterSurvey>

Name: _____ Class: _____

Career Exploration Brainstorming Web

With your group, brainstorm as many careers relating to botany and plant-related occupations as you can in five minutes. Write each career identified in a circle. Draw additional circles as needed.



Lesson 7 – Exploring Botany and Plant Science Careers

LEARN: Research Project

30-90 minutes

Purpose:

The purpose of this activity is to have participants take a closer look at botany and plant science-related career options. Participants will research one career of interest identified from the original brainstorming session. Information learned from the research will be shared with the group via a brief presentation.

Materials:

- Career Exploration Brainstorming handout
- List of botany and plant science careers from the brainstorming session
- Library and Internet resources
- Career Exploration Research Summary handout

Facilitation Steps:

1. Give participants the Career Exploration Research Summary handout. Tell them that they can use the internet or other sources in the library for their research. Here are a few helpful websites:
www.bls.gov
<http://www.bls.gov/ooh/>
www.careerinfonet.org
www.careervoyages.gov
http://careerplanning.about.com/od/occupations/a/career_briefs.htm
<http://www.myplan.com/careers/index.php>
2. Give participants one or two class periods to complete their research. You can also assign this as homework. Participants should prepare a five-minute presentation about this career including the information on the summary sheet.

3. Have each participant present their chosen botany or plant science-related career to the group.
4. Here is a suggested grading rubric for the class presentation:

30 points – Completed all information on the Career Exploration Research Summary handout

20 points – Prepared for the presentation

20 points – The presentation content was clear, concise and gave a good understanding of the chosen career

20 points – Demonstrated the ability to think critically, taking information from other sources to create something new

10 points – Demonstrated time management skills by delivering a well-planned five-minute presentation

Name: _____ Class: _____

Career Exploration Research Summary

Identify and research one career relating to botany or plant science. Complete this worksheet for your career choice. Possible sources for information include your school library, public library, the Bureau of Labor Statistics website, the Occupational Outlook Handbook website and other career-related websites on the internet.

Career name: _____

Degree or licenses required: _____

Length of time to complete training or earn degrees: _____

Average tuition and fees for training: _____

Average starting salary: _____

Job outlook: _____

Short job description:

Technical and soft skills a person needs to be successful in this career:

Sources used for this project:

List of Botany and Plant Science Careers

This is a list of potential careers relating to botany or plant science related occupations. Add any additional careers that participants may have brainstormed that are not on the list.

- Agronomy business
- Plant researcher
- Business owner or manager of orchard, vegetable farm, greenhouse, flower or plant shop, nursery, landscaping service, garden center, or food processing firm
- Public garden manager
- Conservatory manager
- Marketing retail or wholesale of fresh or processed fruits and vegetables, seeds, cut flowers, house plants, floral arrangements, nursery stock
- Buyer for chain store, government institution, private institution or wholesale distributor of plants
- Horticulture teacher
- County extension agent
- Horticulture specialist
- Agriculture instructor
- Consultant for research development, technical services or sales
- Inspector of produce
- Landscape contractor
- Landscape designer
- Media specialist in horticulture
- Pest management
- Taxonomist
- Agronomist
- Ecologist
- Mycologist
- Plant Breeder
- Horticulturist
- Biophysicist
- Forester
- Naturalist

Lesson 7 – Exploring Botany and Plant Science Careers

REVIEW: Career Panel Discussion

45-60 minutes

Purpose:

To hear from real professionals who work in botany or plant science-related careers.

Materials:

- Panel of three to five local professionals who work in a variety of related careers

Facilitation Steps:

1. Contact local plant science professionals from a variety of occupations such as a botanist, gardener, extension agent, ag teacher, florist, etc. and invite them to attend a panel discussion in your class.
2. The day of the panel discussion, set up your space so that there is a table with seating for all panel members at the front of the room. If sound is an issue, have a microphone available.
3. Invite participants in the audience to ask questions to panel members. Have a few questions of your own ready in case you need to get the ball rolling. Remind participants ahead of time to keep questions relevant to the panel members' work. You may ask participants to submit questions in advance if desired.

Name: _____ Class: _____

Assessment/Quiz

The following questions will ask you about your knowledge of plant science. Answer the questions by circling the best answer or writing your response in the space provided.

1. What is another word for plant science?

2. Match the correct definition to each of the terms below:

- | | | |
|----------------|-----|---|
| a. Vascular | ___ | A flowering, fruit-bearing plant or tree known for having ovules; developing within an enclosed ovary |
| b. Nonvascular | ___ | A group of flowering plants with only one cotyledon in the seed |
| c. Xylem | ___ | Plants that have vascular vessels to transport food and water throughout the plant |
| d. Phloem | ___ | The vessel that transports food |
| e. Gymnosperm | ___ | The vessel that transports water |
| f. Angiosperm | ___ | Simple plants without a vascular system |
| g. Dicot | ___ | Seeds of this are not enclosed within the ripened ovary |
| h. Monocot | ___ | A group of flowering plants that has two photosynthetic cotyledons in the seed |

Label the parts of a plant cell using the following list:

Cell wall
Chloroplast
Chromoplast
Endoplasmic reticulum
Golgi Apparatus
Leucoplast
Mitochondrion

Nuclear membrane
Nucleolus
Nucleus
Plasmodesma
Primary pit field
Vacuole



4. Seed-bearing plants are made up of what three parts?

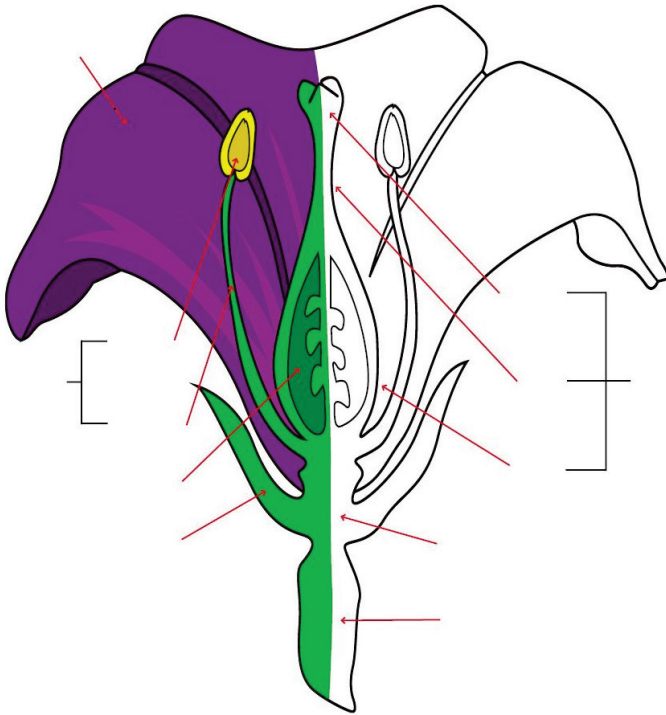
5. Choose the correct plant part which matches each description.

a. Root b. Leaf c. Stem

- ___ Is tube-like
- ___ Absorbs water and nutrients
- ___ They contain subsystems that control water loss in the leaves
- ___ Transports water from roots to leaves
- ___ Provides vital structural support
- ___ Sends water and nutrients throughout the whole plant
- ___ Takes the products of photosynthesis down to the roots
- ___ These are the primary photosynthesizing material

6. Label the parts of a flower using the following list:

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



7. What is venation?

8. Choose the correct Plant Identification Feature for each of the following:

a. Venation

b. Shape

c. Margin

- ☐ Palmate
- ☐ Spiny
- ☐ Serrate
- ☐ Pinnate
- ☐ Lobate
- ☐ Longitudinal
- ☐ Rotate
- ☐ Rhomboid
- ☐ Dichotomous
- ☐ Parallel
- ☐ Pedate

- ☐ Spatulate
- ☐ Truncate
- ☐ Serrulate
- ☐ Lobed
- ☐ Entire
- ☐ Linear
- ☐ Ciliate
- ☐ Cordate
- ☐ Digitate

9. What is photosynthesis?

10. During photosynthesis, light energy is converted into _____ energy by living organisms.
11. Few living organisms depend on photosynthesis. True or False
12. What four things must be present for photosynthesis to occur?
 - 1.
 - 2.
 - 3.
 - 4.
13. Where does carbon dioxide enter the plant in photosynthesis?
14. What is the chemical equation for photosynthesis?
15. What is the word equation for photosynthesis?
16. What is the chemical equation for respiration?
17. What is the word equation for respiration?
18. What happens during respiration?
19. What is transpiration?

Name: _____ Class: _____

Assessment Answer Key

The following questions will ask you about your knowledge of plant science. Please answer the questions by circling the best answer or writing your response in the space provided.

1. What is another word for plant science?

botany

2. Match the correct definition to each of the terms below:

- | | | |
|----------------|----------|--|
| a. Vascular | f | A flowering, fruit-bearing plant or tree known for having ovules; develop within an enclosed ovary |
| b. Nonvascular | h | A group of flowering plants with only one cotyledon in the seed |
| c. Xylem | a | Plants that have vascular vessels to transport food and water throughout the plant |
| d. Phloem | d | The vessel that transports food |
| e. Gymnosperm | c | The vessel that transports water |
| f. Angiosperm | b | Simple plants without a vascular system |
| g. Dicot | e | Seeds of this are not enclosed within the ripened ovary |
| h. Monocot | g | A group of flowering plants that has two photosynthetic cotyledons in the seed |

3. Label the parts of a plant cell using the following list:

Cell wall
Chloroplast
Chromoplast
Endoplasmic reticulum
Golgi Apparatus
Leucoplast
Mitochondrion

Nuclear membrane
Nucleolus
Nucleus
Plasmodesma
Primary pit field
Vacuole



4. Seed-bearing plants are made up of what three parts?

Leaves, roots, and stems

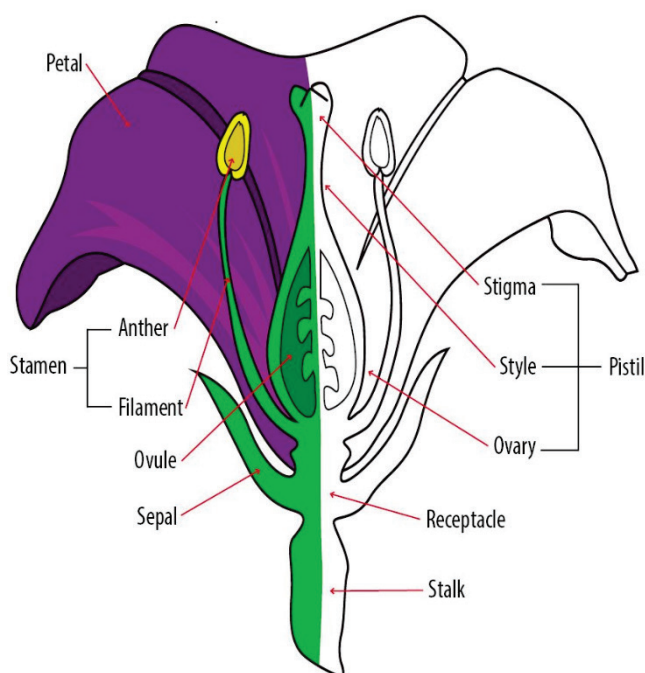
5. Choose the correct plant part which matches each description.

a. Root b. Leaf c. Stem

- c** Is tube-like
- a** Absorbs water and nutrients
- b** They contain subsystems that control water loss in the leaves
- c** Transports water from roots to leaves
- c** Provides vital structural support
- a** Sends water and nutrients throughout the whole plant
- c** Takes the products of photosynthesis down to the roots
- b** These are the primary photosynthesizing material

6. Label the parts of a flower using the following list:

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



7. What is venation? **The arrangement of veins on a leaf**

8. Choose the correct Plant Identification Feature for each of the following:

a. Venation b. Shape c. Margin

a/b	Palmate	b	Pedate
c	Spiny	b	Spatulate
c	Serrate	b	Truncate
a	Pinnate	c	Serrulate
c	Lobate	b	Lobed
a	Longitudinal	c	Entire
a	Rotate	b	Linear
b	Rhomboid	c	Ciliate
a	Dichotomous	b	Cordate
a	Parallel	b	Digitate

9. What is photosynthesis?

Answers may vary. It is the process plants use to change carbon dioxide into sugar using sunlight. Or it is the conversion of light energy into chemical energy by living organisms.

10. During photosynthesis, light energy is converted into **chemical** energy by living organisms.

11. Few living organisms depend on photosynthesis. True or **False**

12. What four things must be present for photosynthesis to occur?

1. **Chlorophyll**

2. **Light**

3. **Carbon Dioxide**

4. **Water**

13. Where does carbon dioxide enter the plant in photosynthesis?

Through the stomata in the leaves

14. What is the chemical equation for photosynthesis?



15. What is the word equation for photosynthesis?

Carbon dioxide + water $\xrightarrow{\text{light}}$ sugar + oxygen

16. What is the chemical equation for respiration?



17. What is the word equation for respiration?

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

18. What happens during respiration?

It is the process of metabolizing or burning sugars to yield energy for growth, reproduction and other life processes. It is the opposite of photosynthesis.

19. What is transpiration?

It is the loss of water vapor through the stomata of leaves.

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