

Angiosperms

Plant Morphology, Tissues, and Reproduction

1. Pre-lab Reading

Chapter 26.3 and 26.4 “Angiosperms” and “Role of Seed Plants” [Biology2e](#), OpenStax College
Chapter 30.1 and 30.4 “The Plant Body” and “Leaves” [Biology2e](#), OpenStax College

2. Objectives

The purpose of this lab is to examine the various types of plant tissues and explore the relationship between tissue arrangement and function within different parts of the plant body.

After completing this lab exercise, you should be able to:

1. Identify the basic parts of a flowering plant and know their functions.
2. Understand ways in which monocots differ from eudicots.
3. Distinguish between the types of cells and tissues found in plants and know their functions.
4. Describe the angiosperm life cycle.
5. Distinguish between monocot and eudicot flowers.
6. Describe the male and female parts of a flower.

3. Safety Guidelines

1. Carry microscopes and stereoscopes with two hands.
2. Before and after examining any specimen under the microscope, make sure that it is set on the lowest power objective.
3. Use scalpels and razor blades with extreme care. Do not cut towards you.

4. Handle all stains with extreme care as they may contain harmful chemicals. Wear gloves and goggles.
5. Clean your lab table and wash your hands before leaving the lab.

4. Background Information – Angiosperms

This lab will focus on the angiosperms, or flowering plants. These are the most recently evolved and most numerous (more than 250,000 species) land plants. The term angiosperm literally means “enclosed seed”. In addition to the seed coat, angiosperm seeds are protected by a structure called an ovary, which is not found in the gymnosperm or “naked seed” plants. Following fertilization the ovary develops into a fruit, which contains one or more seeds.

Phylogenetic analysis indicates that there are at least six to eight distinct groups or clades of angiosperms (tolweb). Two clades, the monocots and eudicots, include the majority of species. They are distinguished by the number of cotyledons or “seed leaves” that form in the developing embryo. Some examples of monocots are grasses, palm trees, corn, and tulips. The eudicot group is larger and includes most trees, beans, cacti, roses, sunflowers, and many other flowering plants. In addition to the difference in cotyledon number monocots and eudicots also differ in stem and leaf structure and venation pattern, root structure, and the number of flower parts.

Within the angiosperm group, and especially among the eudicots, there is tremendous variation in form. Plants vary in many characteristics including height, leaf size and arrangement, stem structure, structure and size of roots, ability to store energy, and reproductive strategies. As you examine the plants provided in class and think about the characteristics of plants with which you are familiar consider how these organisms are similar and how they differ. One of the conclusion questions will ask you to speculate about how certain structural characteristics may help plants survive in certain environments.

5. Background Information – Plant Systems

A. Shoot System

The shoot system consists of a **stem** that supports **leaves**, **flowers**, and **fruits**. Leaves are the primary site of photosynthesis and are attached to the stem at sites called **nodes**. A eudicot leaf generally consists of a flattened portion, or **blade**, and a stalk that attaches the leaf to the stem and is called a **petiole**. A monocot leaf generally consists of a blade that is attached directly to the stem by a **sheath**.

Leaves have two basic types of **venation**. **Net** venation is a pattern of highly branched veins and is characteristic of eudicots whereas **parallel** venation has little or no branching and is most common in monocots.

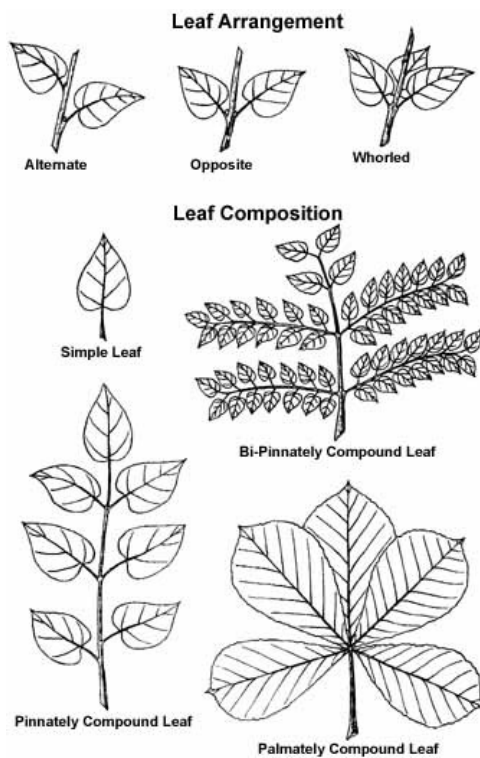


Figure 1: Leaf Arrangement and Composition in Eudicots.

Leaves are described as being **simple** (composed of a single blade) or **compound** (blade is divided into several leaflets) and are arranged on the stem in one of three patterns: **alternate** (one leaf at a node), **opposite** (two leaves at a node), or **whorled** (three or more leaves at a node). In a compound leaf, when leaflets arise from a single point on the petiole, the leaf is

palmately compound. If, however, the leaflets arise from many different points on the petiole, the leaf is **pinnately compound**.

B. Roots

Roots anchor the plant and are usually responsible for absorbing water and dissolved minerals for the plant. There are typically two kinds of root systems. A **taproot** system, found primarily in **euticots**, has a large dominant root (taproot) that produces many smaller branch or lateral roots. **Fibrous** root systems consist of numerous similar-sized roots that branch repeatedly and are commonly found in **monocots**.

C. Cells and Tissues

Cells are the basic units of structure and function for all living things. A typical plant cell consists of a **protoplast** (plasma membrane, cytoplasm and nucleus) enclosed by a **cell wall**. Some types of plant cells form a thick, rigid secondary cell wall underneath the primary cell wall after they stop growing in size. These cells help provide structural support for the plant.

In multicellular organisms, cells can be integrated into groups having a common structure and function. These groups are referred to as **tissues**. Three different tissue systems are found in plants – **dermal**, **vascular**, and **ground** – each of which are made up of various types of cells.

1. Dermal Tissue

Epidermal cells make up the **dermal tissue system** and, in young plants, usually consist of a single cell layer surrounding all parts of the plant. Basically, the epidermis is the “skin” of a plant. While the primary function of epidermal cells is to protect the plant, cells covering different organs of the plant are specialized to perform tasks specific to the needs of that organ. For example, epidermal cells of leaves secrete a waxy substance called **cutin** which forms a thin layer on the external surface of epidermal cells called the **cuticle**. This waxy coating helps prevent excess water loss from leaves.

The epidermis may contain additional specialized cells and structures such as **guard cells**, **trichomes** and **root hairs**. **Guard cells** control the exchange of gas between the surrounding air and the photosynthetic cells inside the leaf. When guard cells are closed, no gas exchange occurs. Guard cells can “pull apart”, forming a gap or space called a **stoma** (pl.

stomata). Guard cells respond to changes in light, temperature and water availability. **Trichomes** are hair-like in appearance, giving some leaves a fuzzy look and feel. They are important in helping regulate the surface temperature of a leaf and in reducing the rate of evaporation from the leaf. **Root hairs** occur in young, growing roots and are extensions of the epidermal cells. These structures increase the root surface area, allowing for enhanced uptake of water and nutrients from the soil. In fact, most of the water and mineral uptake by the roots occurs through root hairs.

2. Vascular tissue

Vascular tissue consists of the **xylem** and **phloem**. Xylem cells (**tracheids** and **vessel elements**) are actually dead at functional maturity but produce secondary walls before the protoplast dies. This creates hollow tubes through which water and minerals can be transported through the plant. **Phloem** (**sieve-tube members** and **companion cells**) consists of living cells that carry sugars, amino acids, and other organic nutrients throughout the plant.

3. Ground tissue

Ground tissue is found between dermal and vascular tissues. Several cell types may be found in ground tissue. **Parenchyma** cells are generally the least specialized of all plant cell types. Most of the metabolic functions of a plant take place in parenchyma cells. They can be used to store organic compounds such as starch and are the primary site of photosynthesis in leaves. **Collenchyma** and **sclerenchyma** cells have thickened cell walls and provide structural support for the plant.

6. Procedures: Plant Systems, Cells and Tissues

1. Obtain a monocot and a eudicot plant and gently wash the soil from their roots in the bowl of water provided if necessary. Place each plant on a separate paper towel and make a drawing of each in your lab book. Label the following on your diagram:
 - root system (note the type)
 - shoot system
 - leaf
 - blade (note the venation)
 - petiole or sheath (attaches blade to plant stem; note the arrangement)
2. Observe **two additional plants** provided by the instructor and record leaf attachment, arrangement, and venation pattern for each. State whether the plant is a monocot or eudicot.
3. Strip a small piece off of the lower epidermis of a lettuce leaf. Make a wet-mount slide and observe the epidermal cells at high power (400x). The cells may resemble puzzle pieces. Draw several of the epidermal cells, including at least one set of guard cells. Label the **guard cells**. Note whether the stomata are open or closed. Also note if chloroplasts are present in any of these cells (epidermal or guard cells).
4. Make a very thin cross section of a celery stalk (petiole). Prepare a wet-mount slide using toluidine blue O (TBO). Locate the vascular bundles. These form the “strings” that can be pulled out of the celery and are composed of **xylem** and **phloem**. A vascular bundle will resemble an acorn. The xylem cells are very large and are found in the “nut” portion of the vascular bundle. The phloem cells are between the “cap” and the “nut”. The top of the cap is made up of fibers, which help support the plant. Draw a **vascular bundle** and label the **xylem** and **phloem**.
5. Take a thin section from a potato and place on a slide. Add a drop of Lugol’s solution to the potato section and place a cover slip over the section. Examine the potato section under the microscope (100x). The cells you see are parenchyma cells. The purple granules

you should be able to see are starch granules. Draw several cells (5-6), showing their relative size, shape and arrangement. Also draw and label the starch granules in at least one of the cells.

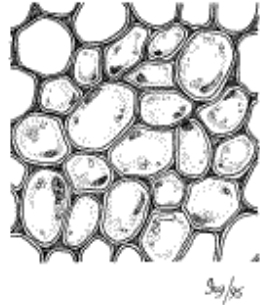


Figure 2: Parenchyma cells

7. Flowers

In this exercise, we will take a closer look at the reproductive structures of angiosperms (flowers, fruits and seeds). Flowers are actually highly modified and specialized shoots with four whorls of modified leaves separated by very short internodes. These whorls, or organs, are referred to as the **sepals**, **petals**, **stamens**, and **carpels**. Fruits are the mature ripened ovaries of angiosperms and contain the seeds. Seeds are the structures that house the plant embryo.

Many angiosperms have “perfect” flowers, that is, flowers with both male (stamens) and female (carpels) reproductive parts. Some angiosperms have “imperfect” or unisexual flowers. Plants described as being **monoecious** have both **carpellate** (female) and **staminate** (male) flowers on the same plant. An example of a monoecious plant is corn. The tassels are staminate flowers while the “ear” of corn is derived from carpellate flowers. When carpellate and staminate flowers are found on separate plants, the plant species is described as being **dioecious**. Examples of dioecious plants include hollies and date palms.

Flowers vary widely in size, color, shape, and scent. Plant biologists believe that much of this variation evolved to take advantage of different mechanisms of **pollination**. Pollination is the transfer of pollen grains from an anther (male structure) to a stigma (female structure). Cross-pollination is transfer of pollen grains from an anther of one plant to the stigma of another plant of the same species. Cross-pollination greatly increases genetic diversity in a plant population.

Pollination may occur via wind or through interactions with animals. Flowers of wind-pollinated plants tend to be small and are usually not brightly colored. Flowers of plants pollinated by animals are often large and brightly colored. Flowers pollinated by birds are often red, a color that birds see particularly well. Bees, on the other hand, do not see red but can see yellow, blue, and ultraviolet wavelengths. Bee-pollinated flowers are often yellow with markings that are visible in ultraviolet light.

Like flowers, seeds and fruits vary from one species of plant to another. One factor that has influenced the evolution of these structures is the need for plants to disperse seeds into the environment. **Seed dispersal** can occur by many mechanisms including wind, animals, and water. Seeds dispersed by wind are light weight and may have “wings”. Some seeds are dispersed by sticking to an animal passing by and then falling off at a new location. These seeds have barbs or other structures that help them stick to an animal’s fur. Seeds contained in edible fruit are often dispersed by being eaten and then shed in animal feces. Some plants produce seeds that float and can be dispersed by water.

In the exercise that follows, you will dissect flowers provided by your instructor. Please familiarize yourself with the following terms:

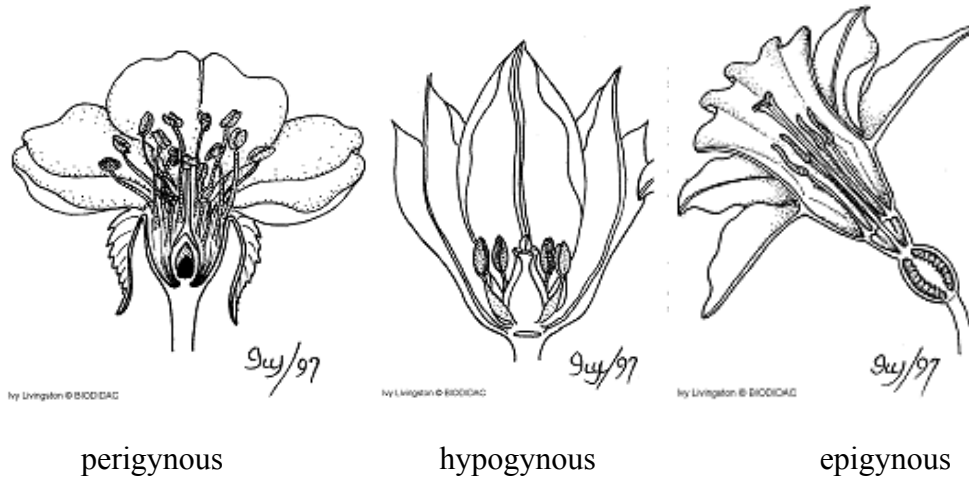
- ◆ **Inflorescence** – a flower cluster with a definite arrangement of flowers
- ◆ **Sepals** – the lowermost or outermost structures which are usually leaflike and protect the floral bud before it opens
- ◆ **Petals** – located inside and usually above the sepals; may be large and pigmented (as in insect-pollinated flowers) or absent (as in wind-pollinated flowers)
- ◆ **Tepals** – petals and sepals that look alike
- ◆ **Androecium** – the male portion of the flower which rises above and inside the petals; consists of **stamens**, each of which consists of a **filament** atop which is located an **anther**; inside the anthers are **pollen grains** which produce the male gametes

- ◆ **Gynoecium** – the female portion of the flower which rises above and inside the androecium; consists of one or more **carpels (pistils)**, each made up of an **ovary**, **stigma** (site of pollination), and **style** (structure between the ovary and stigma); inside the ovaries are **ovules** that contain the female gametophyte
- ◆ **Hypogynous** – petals and stamens are attached below the ovary
- ◆ **Epigynous** – petals and stamens attached above the ovary
- ◆ **Perigynous** – stamen and petals are fused, forming a short tube (**hypanthium**) arising from the base of the ovary

Procedure

- i. In your lab book, construct a table indicating the following: # petals; petal color; # sepals; sepal color; # stamen, # carpels, hypogynous/ epigenous/ perigenous; monocot or eudicot. Complete the table for each flower examined.
- ii. Using the flowers provided, identify as many of the parts of the flowers described in the list of terms above as possible.
- iii. Using a forceps and a stereoscope, start at the first whorl of the flower and, working inward, locate and count each of the parts. Note: you don't need to do this for the rose. Some parts may be counted as TNTC (too numerous to count).
- iv. Make a longitudinal section through each flower (if needed) and determine whether it is epigynous, perigynous or hypogynous.

Figure 3: Ovary positions in angiosperm flowers.



8. Background Information - Fruits

A fruit is a mature seed-containing ovary, a cluster of mature ovaries, or an ovary and closely associated tissues. Seeds develop from fertilized ovules and are thus inside fruits. As the ovary develops into fruit, the ovary wall thickens and becomes the **pericarp**. Fruits can be classified into three major types:

- **Simple fruits:** arise from the ovary of a single flower. Simple fruits are divided into several categories based on the consistency of the pericarp and on structure and **dehiscence** (manner of opening).
- **Aggregate fruits:** consist of a number of separate carpels of one gynoecium. The individual parts of an aggregate are known as **fruitlets**. Examples include strawberry, raspberry, blackberry and magnolia.
- **Multiple fruits:** consist of the gynoecia of more than one flower more or less coalesced into one mass. Examples include mulberry, fig, and pineapple.

In addition, fruit can be described as **accessory**, where the fruit includes carpels and other tissues. An example of an accessory fruit is the strawberry where the “fruit” is formed from the

swollen receptacle (the part of the flower stalk that bears the floral organs) and the seeds are actually a type of dry fruit (**achene**) and dot the surface of the ripened receptacle.

Simple fruits can be divided into two main groups:

- **Fleshy fruits:** The thickened pericarp sometimes becomes differentiated into three distinct layers: proceeding from the outside of the fruit, the **exocarp**, the **mesocarp**, and the **endocarp**. The development and consistency of these layers differ among types of fruit. There are three main types of fleshy fruits including **berries** (grapes, tomatoes), **drupes** (cherries, peaches), **pomes** (apples, pears). **Hesperidia** (citrus), and **pepos** (squash, melons, cucumbers) are special types of berries.
- **Dry fruits:** Dry fruits are simple fruits usually classified according to whether they are **dehiscent** (split open when ripe; peas, beans) or **indehiscent** (do not split open when ripe; sunflower seeds, wheat). Further distinctions are made according to their mechanism of dehiscence and other structural features. Examples of types of dehiscent simple fruits include **legumes** (peas and beans) and **capsules** (poppies). Indehiscent simple dry fruits include **achenes** (sunflower, buckwheat) and **samaras** which are actually winged achenes (maple, elm, ash).

Procedure

1. Observe the cut peach on demonstration. The peach is classified as a **drupe**: the single seed is enclosed by a hard, stony endocarp. In the peach, the mesocarp is fleshy and edible. The exocarp of the peach forms the skin. **Draw** the peach, labeling the exocarp, mesocarp and endocarp.
2. Cut a grape in half lengthwise. The grape is a **berry**. The endocarp, mesocarp, and exocarp are fleshy. Mesocarp and endocarp are not well differentiated. The exocarp forms the skin. **Draw** the grape, labeling the exocarp and mesocarp/endocarp. Show how the seeds are distributed within the fruit.
3. Examine the cut apple. The apple is a **pome**. The endocarp surrounding the seeds is papery or leathery. The core constitutes the extent of the ovary with the exocarp forming the outer

limit of the core line and the mesocarp being between the endocarp and exocarp. The flesh of the fruit derives from basal portions of the sepals, petals, and stamens. **Draw** the apple and label the exocarp, mesocarp and endocarp.

4. Observe four additional fruits (fleshy or dry). **Construct a table** with the following categories: fruit name, fruit type (simple, aggregate, multiple) and classification (ex. fleshy – pome or dry - achene). Using the key to simple fruits, identify each of the fruits.

9. Conclusion and Summary Questions

1. Adaptations are special characteristics that allow organisms to be successful (survive and reproduce) in a particular environment. Although a variety of plants may be found in a particular environment, some characteristics provide advantages that likely help plants survive under certain conditions.

Give two reasons why plants with large broad leaves are likely to occur in dark, moist environment such as a forest floor, whereas plants with narrow leaves with a thick waxy coating are likely to be found in a dry sunny environment such as grassland or desert.

2. What are the basic functions of each of the following: stems, roots and leaves?
3. Based on your observations, design a table that shows three ways to distinguish between monocots and eudicots.
4. Briefly describe the structure and function of the following cell types or tissues: epidermis, xylem, phloem, parenchyma.
5. What is pollination? How do flowers differ depending on the mechanism of pollination?
6. Describe three methods of seed dispersal used by plants in nature. What characteristics of seeds are best adapted for each method of dispersal?

7. Describe three ways to extend these investigations, describing what you would hope to learn as a result.

Resources

Leaf Arrangement

<http://www.horticulturist.com/mastermag5/plantform.html>

Plant Adaptations, Missouri Botanical Gardens

<http://www.mbgnet.net/bioplants/adapt.html>