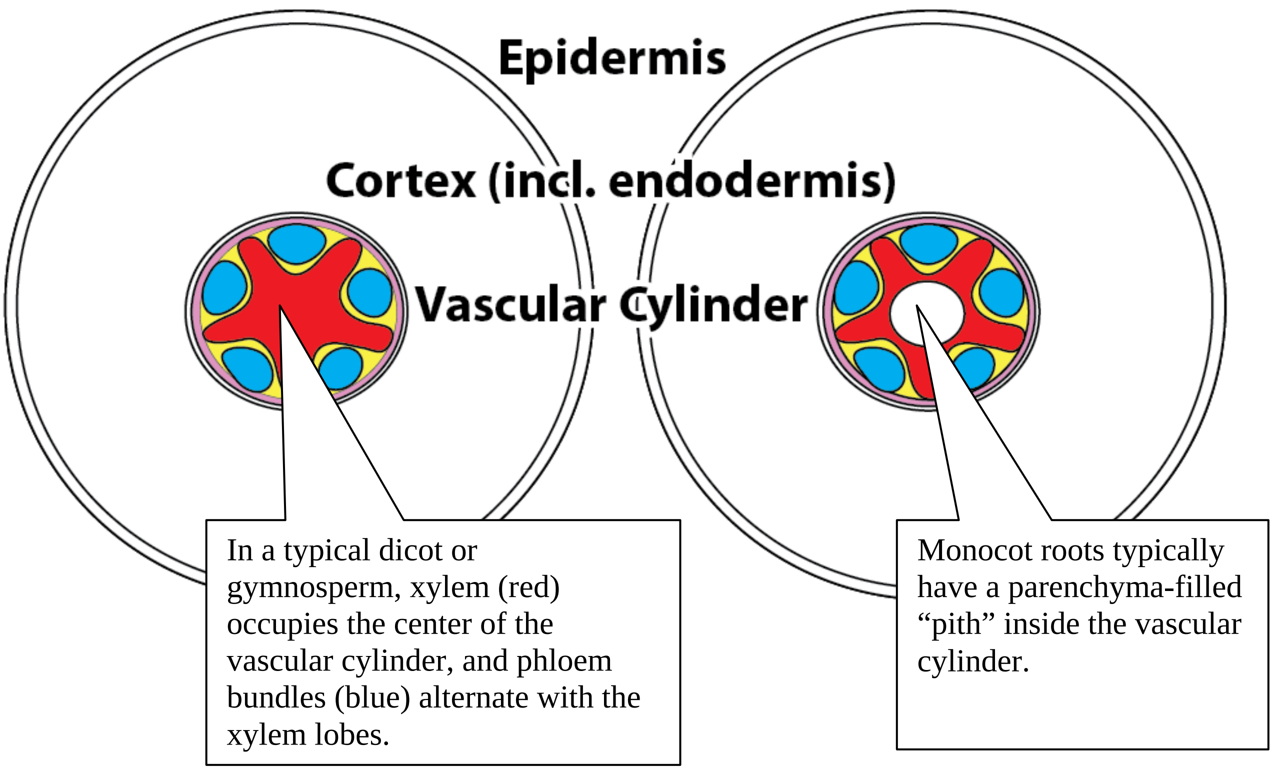
# Roots & Shoots

## A. Root

The root has the primary functions of **ABSORPTION** of water plus minerals, **ANCHORAGE** to the soil / substrate, **CONDUCTION** (via vascular tissue) of water plus minerals from area of absorption (or even of sugars from the shoot to root tissues in need), and **STORAGE** of food.

The **PRIMARY ROOT**, the plant's first root, develops from the **ROOT APICAL MERISTEM**. In gymnosperms and dicots, the primary root usually develops as a **TAPROOT**, which gives rise to thinner **LATERAL ROOTS** (i.e., branch roots). This is called a **TAPROOT SYSTEM**. In monocots, the primary root is commonly short-lived or not dominant. In fact, the root system of the adult monocot is largely **ADVENTITIOUS** (i.e., arising from the stem!). These **ADVENTITOUS ROOTS** give rise to a more or less homogeneous system called a **FIBROUS ROOT SYSTEM**.

**1. The Root in Transverse Section.** Examine the prepared slide of typical dicot and monocot roots. Compare and contrast the two and, based on the diagrams below and Figures 5.3 (monocot root) and 5.5-5.6 (dicot root) in your book (Bidlack & Jansky 2011), determine which is which. The diagrams below are abstractions and generalizations from reality. What you may see under your microscope will vary.




*a. Look in the cortex (cortical cells) of either root. Do you see evidence of a starch storing organelle? What is this organelle called?*

*b. Inspect the vascular cylinder of the dicot carefully in more detail Make a drawing. Find the following structures and label them in your drawing. Use your photoatlas or Fig. 5.5 in Bidlack & Jansky (2011) to help.*

(1) XYLEM,

(2) PHLOEM,

(3) PROCAMBIUM = undifferentiated region between the primary xylem and primary phloem that remains meristematic,

(4) ENDODERMIS = partially suberized (SUBERIN is a water-repellant substance), thick-walled cells older roots; innermost layer of the cortex. Some endodermal cells remain thin-walled & retain their <u>Casparian strips</u> for a while.

(5) PERICYCLE = thin-walled parenchyma cell layer just inside the endodermis; this is the outermost layer of the vascular cylinder. Can continue to divide to form lateral roots & part of vascular cambium upon initiation of secondary growth.

(6) PASSAGE CELLS = cells of the endodermis opposite the xylem lobes, which are not thick-walled or heavily suberized.

**<u>2. The Root in Longitudinal Section</u>.** (see Fig. 5.2 from Bidland & Jansky 2011).
Using the prepared <u>onion (*Allium*) root tip longitudinal section</u> slide, *draw and detail enough of the root apical region to include the following regions:*

(1) ROOT CAP
(2) ROOT APICAL MERISTEM
(3) PROTODERM (the primary meristem giving rise to epidermis),
(3) GROUND MERISTEM (the primary meristem giving rise to cortex),
(4) PROCAMBIUM (the primary meristem giving rise to vascular tissues).

**<u>3. Root Morphology Observations</u>.** Examine the specimens of roots in the room and answer questions.

*a. English Ivy. With what structures does this vine climb?*

*b. Philodendron or Monstera (tropical vines): What structures anchor these plants to their host trees in the rainforest canopy?*

*What do you think the diamond-shaped scars on the stem are?*

*c. Plant TBA: Is this a taproot or fibrous root system?*

*d. Plant TBA: Is this a taproot or fibrous root system?*

**4. OPTIONAL: Make your own adventitious roots.** Make your own adventitious roots using a *Setcreasea* (purple heart) plant, which is a member of the spiderwort family.

Take a stem cutting (portion of a stem) that has at least three leaves along the stem. Place the cutting in tray or small container of moist vermiculite, peat, or a beaker of water (water is inferior since it is oxygen-poor) so that the "bottom" end plus two of the three nodes are covered and moist. If in a larger group tray, label the cutting with your name and the date. Water them in weeks to come until roots form. Then take them home and start growing your own.

**For Consideration:**
*Would it make any difference which end of the cutting was inserted into the soil?*

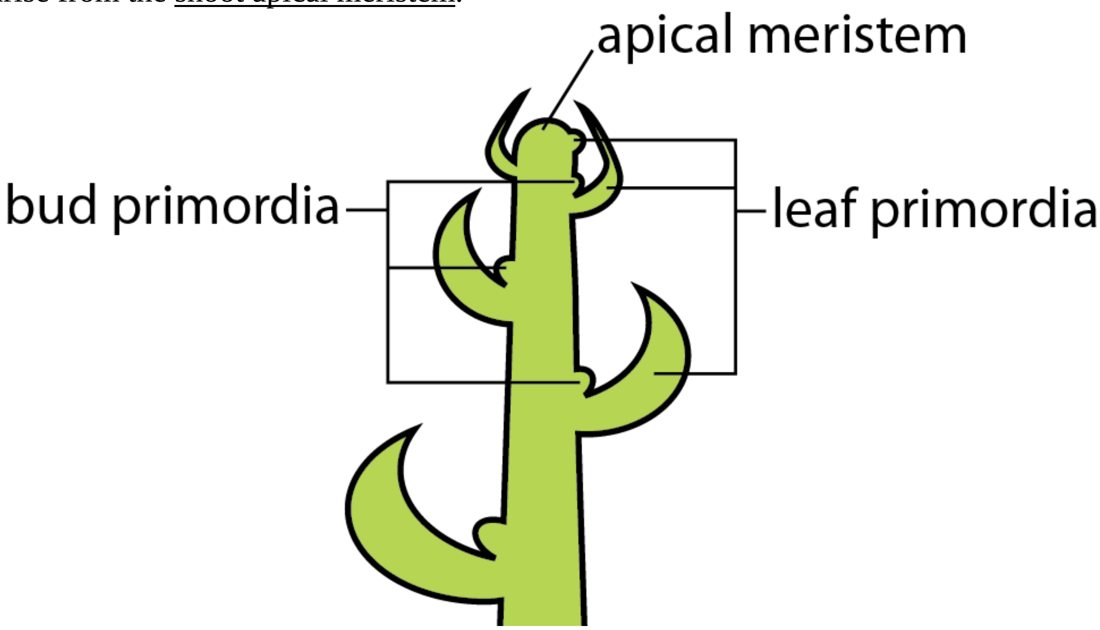
*What part of the stem will / did the adventitious roots arise from?*

*What tissue is most likely responsible for the regeneration of roots?*

*Did any new shoots develop from the cutting? If so, from where?*

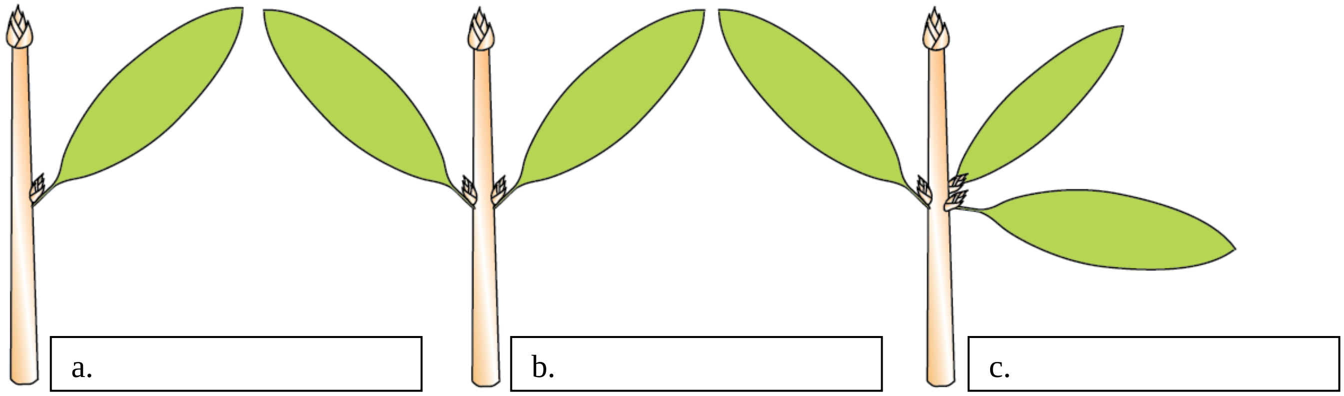
## B. Shoot

The vegetative shoot consists of the two organs, stem and leaf. Each leaf is attached to the stem at a node, an axillary bud is formed in the axil of each leaf, and the stretch of stem between two successive nodes is called an internode. All cells and organs of the primary plant body ultimately arise from the shoot apical meristem.




**1. Phyllotaxy**. Leaves can be arranged on a stem in one of three ways. Alternate phyllotaxy is where there is just one leaf per node, opposite phyllotaxy is two leaves per node, and whorled phyllotaxy is where there are 3 or more leaves per node. Sometimes it is difficult to determine the precise phyllotaxy because internodes are very short, resulting in the leaves appearing tightly clustered. Although there is always an underlying phyllotaxy, you can simply refer to these arrangements as a basal rosette (when no apparent above-ground stem) or as a terminal rosette (when the cluster is at the end of an above-ground stem).

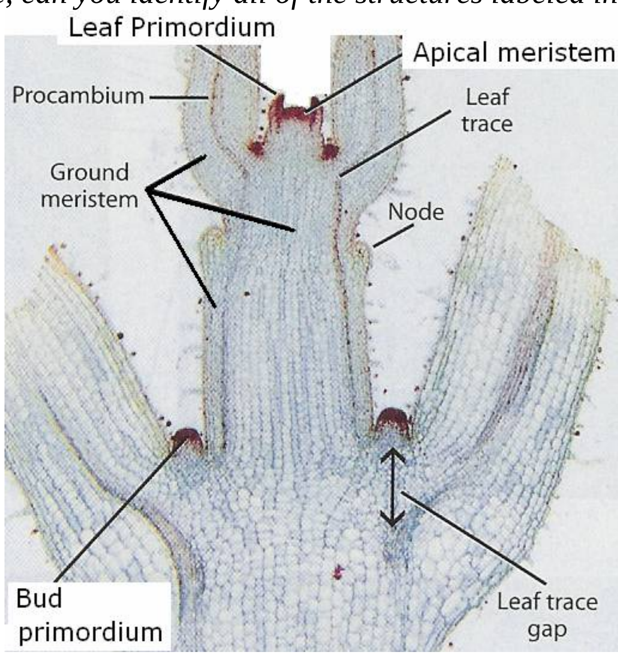
*Label the 3 drawings below as either alternate, opposite, whorled, or rosette, as appropriate.*




*d. If there are two leaves per node, how many axillary buds will you find associated with these leaves at a given node?*

**2. The Shoot Apex in Longitudinal Section.** If you have not yet done so in a previous lab or if you simply need a refresher, examine the prepared slide of a Coleus shoot tip.

*a. Under the microscope, can you identify all of the structures labeled in the figure below.*



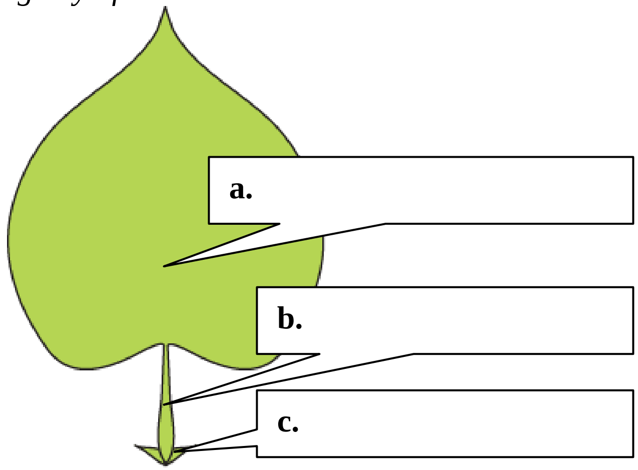

*b. What is the phyllotaxy of the Coleus plant? How can you tell?*

*c. How many nodes are portrayed in the picture above? On the stem mounted on the microscope slide?*

*d. What primary meristem is portrayed by the label "leaf trace" in the figure above? Protoderm, procambium, or ground meristem? Explain what "leaf trace"means.*

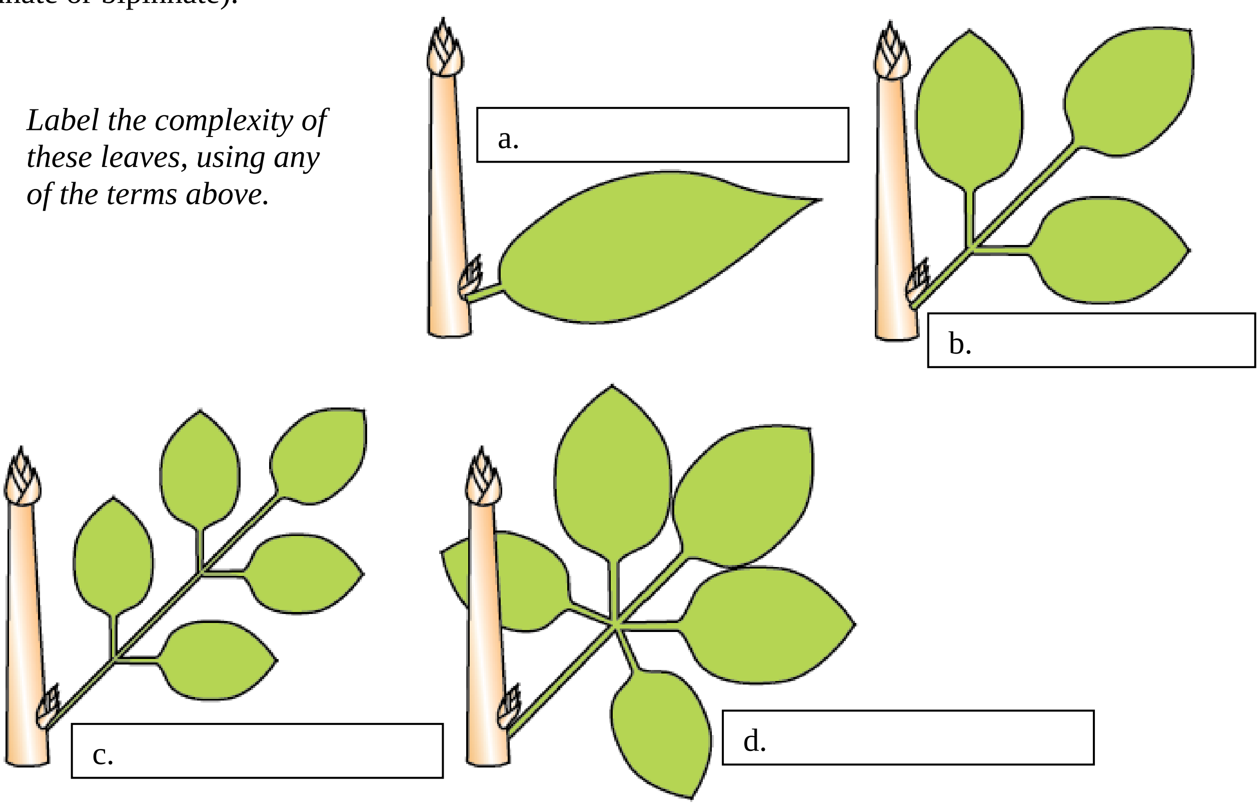
**<u>3. Parts of a Typical Leaf</u>.** Many leaves are differentiated into a <u>blade</u> (flattened, expanded portion) and <u>petiole</u> (i.e., "stalk"; a petiolate leaf has a petiole, a sessile leaf lacks one). <u>Stipules</u> (a small pair of appendages) may also be present at the base of a leaf where it joins the stem (the leaf is stipulate when present, exstipulate when lacking). The leaves of many monocots (e.g., grasses, lilies, orchids) lack a petiole and have a <u>sheathing leaf base</u> (i.e., sheathes the stem for some distance).

*Label the parts of the leaf below using any of the terms above.*

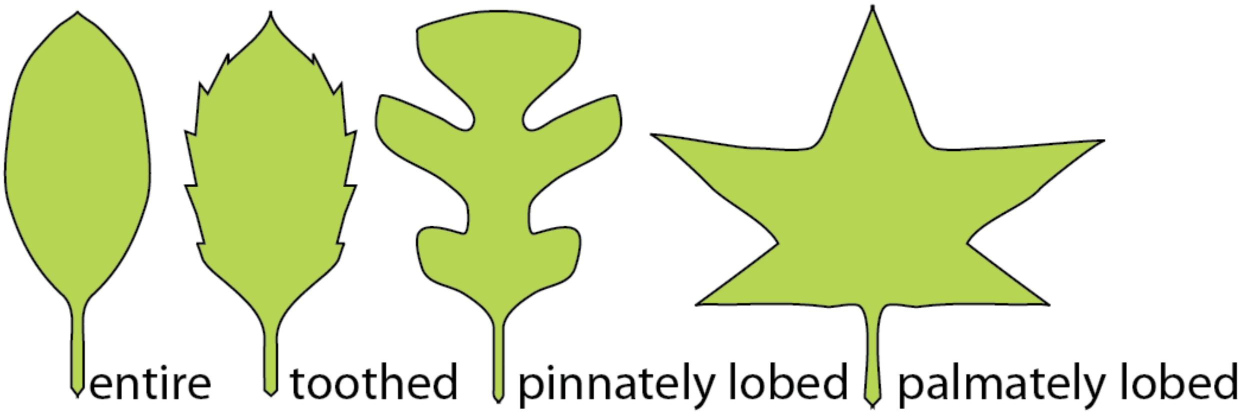



**<u>4. Leaf Complexity</u>.** Leaves may either be <u>simple</u> (one blade) or <u>compound</u> (more than one blade / <u>leaflets</u>). Compound leaves may be <u>trifoliate</u> (divided into 3 leaflets), <u>pinnate</u> (leaflets arranged laterally along one central axis called a <u>rachis</u>), or <u>palmate</u> (leaflets all radiating from a single point). Compound leaves may be <u>once</u>, <u>twice</u>, or more pinnately compound (e.g., 2-pinnate or bipinnate).

*Label the complexity of these leaves, using any of the terms above.*

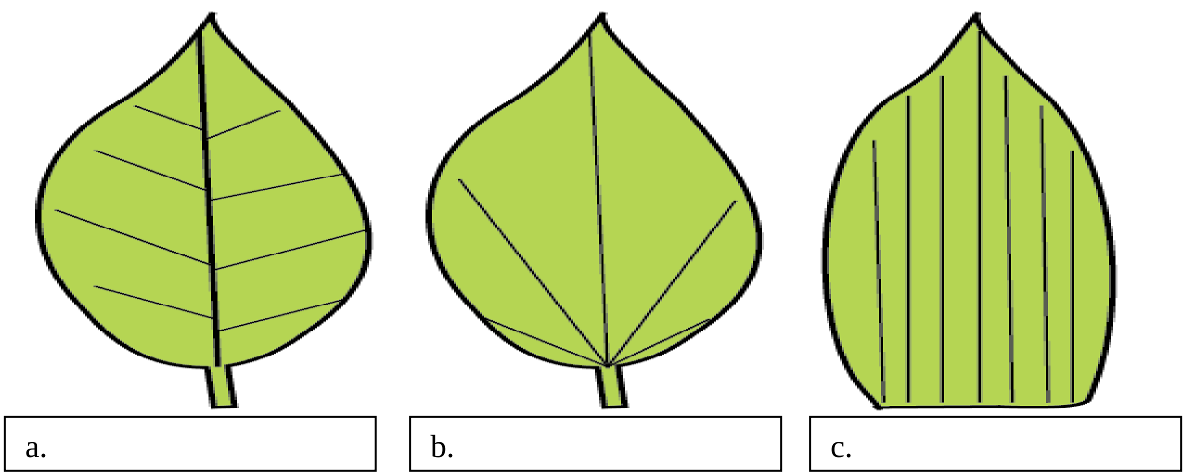


**5. Leaf/Blade Margins.** Blade margins may be entire (no teeth or lobes), toothed, or lobed. Lobed margins may be pinnately lobed (lobes arranged laterally along an imaginary central axis), or palmately lobed (lobes radiating from more or less a single point).




**6. Venation.** The main vascular bundles of leaves may be arranged in various patterns. Pinnate venation has a central midvein with lateral secondary veins, palmate venation is where there are multiple main veins radiating from a single point at or near the blade base, and parallel venation is where the main veins run more or less parallel to each other.

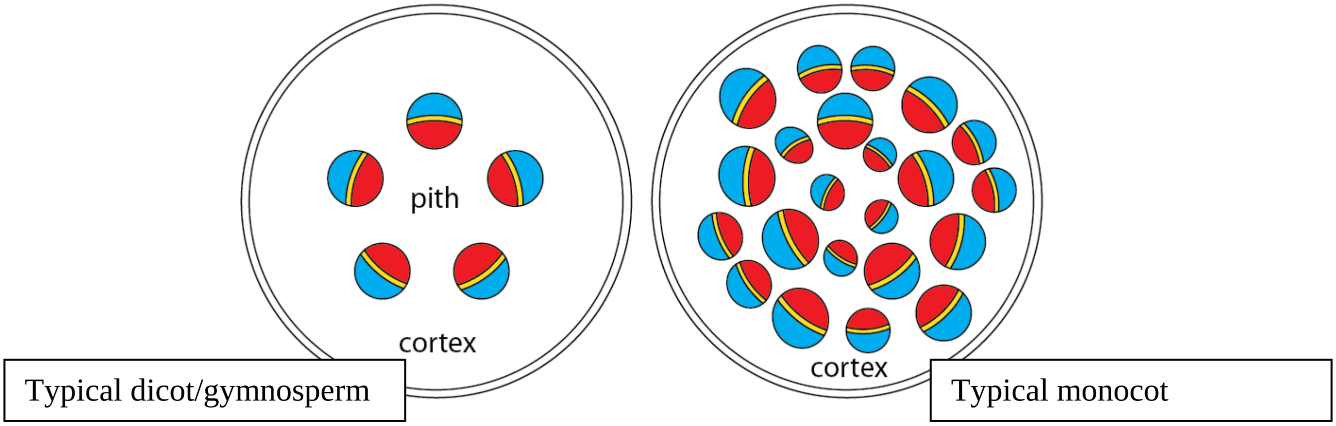
*Label the diagrams below appropriately.*



**<u>7. Live Shoot Practice Quiz</u>.** Work in groups of 3-4. Move around the room and examine the leaves of the 7 plant specimens provided and determine the venation, margin, complexity, and arrangement of each. In addition, be sure to notice the parts of the leaf and make how the shoot is organized. Record your observations of the leaf morphology below:

| **Plant Name** | **Phyllotaxy** (alternate, opposite, whorled, or rosette) | **Petiole** (petiolate or sessile) | **Stipules** (stipulate or exstipulate) | **Complexity** (simple, trifoliate, 1-pinnate, 2-pinnate, palmate) | **Margin** (entire, toothed, pinnately lobed, or palmately lobed) | **Venation** (pinnate, palmate, parallel) |
|---|---|---|---|---|---|---|
| **a.** | | | | | | |
| **b.** | | | | | | |
| **c.** | | | | | | |
| **d.** | | | | | | |
| **e.** | | | | | | |
| **f.** | | | | | | |
| **g.** | | | | | | |

**<u>8. Stem Anatomy</u>.** Examine the prepared slides of a typical dicot and monocot stem cross-sections.




*a. Note how they differ in the organization of vascular tissue.*

*b. How does the typical dicot stem differ from the anatomy of a typical dicot root in vascular organization?*

*c. How does dicot stem organization compare to monocot root organization?*

*d. Focus on a vascular bundle in either: Locate the xylem (water, mineral) and phloem (sugar solution) conducting tissues in each bundle. Note their appearance (e.g., cell types and forms) and position in the bundle.*

*Is xylem towards the inside or outside of the bundle?*

**<u>9. Leaf Anatomy</u>.** Examine a typical dicot leaf cross-section. Make a drawing, label, and answer the following questions.

*a. Locate the <u>epidermis</u> (dermal tissue), <u>mesophyll</u> (ground tissue), and <u>vascular bundles</u> (vascular tissue). How is the arrangement of these tissue systems in the leaf different than that in a typical dicot stem or root?*

*b. Identify a vascular bundle. Is the xylem on the top or bottom of the bundle? How does this relate to its position in a stem bundle?*

*c. Can you identify the thickened midrib portion of the leaf?*

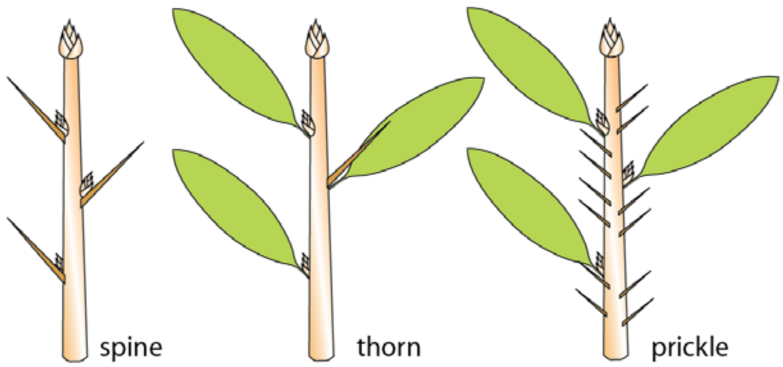
*d. Can you see stomata in the epidermis? Hint: these should be greater in frequency on the lower (abaxial) surface. Make a high-mag drawing of one plus adjacent epidermal cells. Label the guard cells.*

*e. Is the mesophyll (ground tissue) <u>more</u> or <u>less</u> densely packed immediately inside of a stoma?*

*How does this tissue density facilitate gas exchange?*

*f. The mesophyll is differentiated into <u>spongy</u> (less dense, lots of intercellular spaces) and <u>palisade</u> (densely packed, columnar cells) mesophylls. The cells of both are rich in chloroplasts, although the palisade cells may be richer. Note also that the palisade mesophyll occurs beneath the top (adaxial) surface only. How does this relate to sunlight capture and photosynthesis?*

**<u>10. Armature</u>.** "Prickly" structures can be modified leaves (<u>spines</u>), stems (<u>thorns</u>), or epidermal protrusions (<u>prickles</u>). Use your understanding of basic shoot architecture to determine which is which for the following.




a. Rose:

b. Blackberry/raspberry:

c. Barberry:

d. Cactus: The <u>spines</u> are modified bud scale leaves from an axillary bud, thus their occurrence in "clusters" at nodes.

**<u>11. Stolons & Rhizomes, Bracts & Scales</u>.** Some plants such as strawberries and grasses are able to spread vegetatively by means of specialized horizontal stems called <u>stolons</u> (above-ground) or <u>rhizomes</u> (below-ground). Since these are still stems, they will have nodes, internodes, leaves and axillary buds: however, the leaves will be reduced to mere <u>bracts</u> or <u>scales</u> (although there is no clear distinction between the two, scales are typically the smaller and less green of the two and are more likely found on rhizomes).

*a. Make observations and draw several nodes worth of the stolons and/or rhizomes on plants in the room. Draw large enough to be able to discern and label the nodes, bracts/scales, and axillary buds.*

*b. Have any of the axillary buds on the stolon/rhizome developed into an axillary shoot that resembles the parent clone (complete with expanded leaves, etc.)?*

*c. Have any small shoots resembling the parent clone developed at the end of the stolon/rhizome?*

**<u>12. Succulence</u>.** Stems and leaves of desert plants may exhibit the adaptation of succulence. This is because succulence increases the water storage capacity of the organ and plant, and decreases the surface-area-to-volume ratio of the organ which translates into increased water conservation b/c there is less surface area to lose water from.

*a. Make a study of the succulent plants in the room. For each, determine the part (stem or leaf) that is succulent.*

*b. For the aloe plant, make a thin cross section of a leaf and answer the following:*

*1) What tissue is succulent, the epidermis, ground, or vascular tissue?*

*2) Can you see vascular bundles in the tissue with your naked-eye?*

*3) What is the consistency of the succulent tissue?*

**13. Underground Storage Organs.** (see Fig. 6.14 in Bidlack & Jansky 2011)
A tuber is a underground stem swollen for food storage. Since it is a stem, it will have nodes and reduced scale-like leaves on it. A bulb consists mostly of fleshy leaves (which is where the food is stored) attached to a small stem with very short internodes. Roots grow from the bottom of the stem. Corms resemble bulbs except that most of a corm is a swollen stem (for storage) which is surrounded by dry, papery leaves. Roots grow from the bottom of the stem.

*Examine the various specimens in the room and identify each as tuber, bulb, or corm.*

**14. Cladophylls.** (see Fig. 6.15 in Bidlack & Jansky 2011)
A stem that has been modified to be green, flattened and thus superficially leaf-like is called a cladophyll.

*Examine some of the plants at the succulence station and determine which possess cladophylls.*