Plant Structure and Function

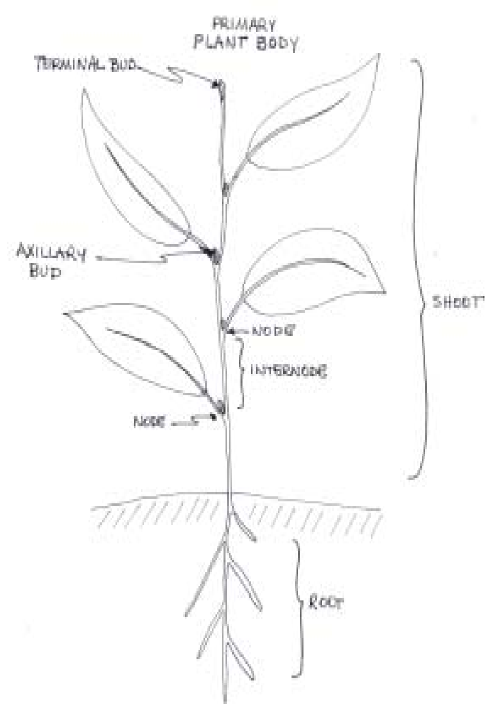
Up until this time, we have concerned ourselves with nonvascular plants; their structure and function, reproduction, and their alternation of generations. The lab after this one will concentrate on the vascular plants (those plants with specialized tissues for the conduction of food [phloem] and water [xylem]) their reproduction and alternation of generations but the complexity of vascular plants begs a little groundwork before plunging into their plant bodies and life cycles. In this lab we will concentrate on the structure and function of vascular plant stems, roots, and leaves. What we learn here will facilitate our study of all vascular plants.

Primary Growth *vs* Secondary Growth in Vascular Plants

All vascular plants exhibit primary growth. Some vascular plants exhibit additional growth after primary growth (secondary growth). Primary growth may be defined as the growth which occurs immediately after the germination of seeds which leads to the formation and growth of the fundamental tissues of the plant. Secondary growth may occur in some plants and gives plants the ability to grow as large as they do and obtain the characteristics you associate with the giant redwoods of the west coast of the United States. Many plants never produce secondary growth and these plants are often referred to as **herbaceous**. Those that do undergo secondary growth are often referred to as **woody**. Nevertheless, all start with primary growth.

The Primary Plant Body

Figure 1. Primary plant body.



The primary plant body may be divided into an above ground portion of the plant - the **shoot**, and a below ground portion of the plant - the **root**. You'll later learn that some portions of the shoot may reach underground and some roots may actually rise above ground, but in general, shoots are above ground and roots below.

All the growth of the shoot occurs at the terminal bud. As growth takes place and the shoot elongates, additional **axillary buds** may form in the axils of leaves or branches. Buds may form flowers, branches or stems, twinings, and thorns. Leaves, the primary site of photosynthesis, are attached at specific points on the shoot called **nodes**. The distance from one node to the next is referred to as the **internode.**

The Primary Plant Shoot or Stem

All growth of the shoot begins in the terminal bud. At the apex of the terminal bud is a region of tissue which actively undergoes cell division (mitosis). This region is called the **apical meristem**. A word of caution - an apical meristem is also found in the root. Apical simply means the tip; either shoot or root.

As more cells are produced by the apical meristem, the shoot elongates and the cells behind the apical meristem begin to differentiate into special cells that give rise to the fundamental plant tissues. There are three fundamental tissues in plants: **protoderm**, **provascular tissue**, and **ground tissue**.

Protoderm, as the name implies, forms tissue which becomes the epidermis of the plant (and, in some cases, bark). Provascular tissue forms the vascular tissue of vascular plants: primary xylem, primary phloem, and cambium. Cambium is another meristematic tissue that continues to produce xylem and phloem in plants and cambium can lead to secondary growth in plants. Ground tissue gives rise to two tissues: **pith** and **cortex**. Pith is found in the center of the plant and it is primarily storage tissue. Amylose and amylopectin are often stored in the pith. Pith does have some ability to provide support, but its primary function is storage. Cortex, like pith, serves as a storage tissue. However, in the primary plant body, it may also contain chloroplasts and aid in photosynthesis. There may also be special cells that are designed to provide support to the stem.

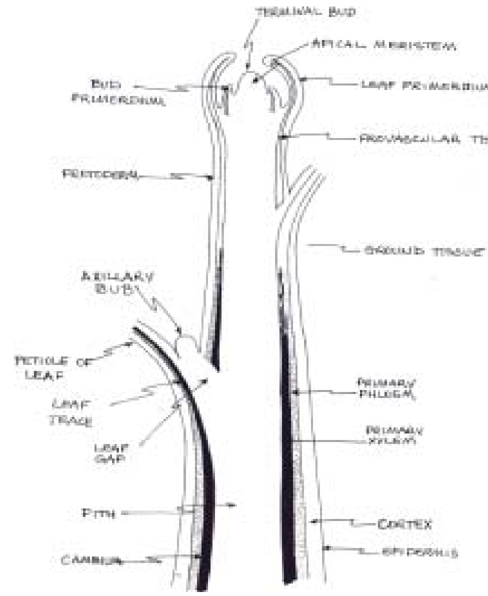


Figure 2. Primary plant body stem, l.s. From Bold HC. 1973. Page 326 *in* Morphology of plants, 3rd ed. New York: Harper & Row.

The apical meristem also is responsible for the generation of **bud** and **leaf primordia**. Bud primordia give rise to axillary buds and leaf primordia, of course, give rise to the leaves. Vascular tissue may be established through out the leaf. However, where vascular tissue enters a leaf, it often forms a **leaf gap** where it has broken away from the primary xylem and phloem. That part of the vascular tissue which enters the leaf is called the **leaf trace**.

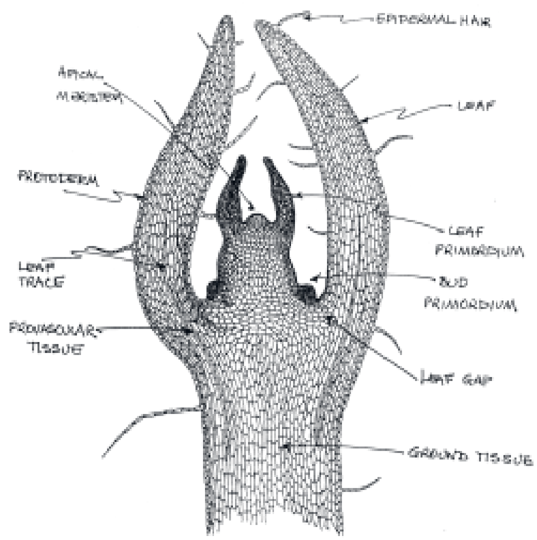


Figure 3. Coleus *stem, l.s. From Bold HC. 1973. Page 327* in *Morphology of plants, 3rd ed. New York: Harper & Row.*

Meristems arise in one of two ways. Meristematic tissue (whether in the shoot or root) may form from a single cell or from a multiple layer of cells. When the meristem forms from a multiple layer of cells, that type of meristem is referred to as a **tunica corpus** meristem. The tunica portion is the outside layer and the corpus is the body of the meristem.

☐ Observe the prepared slide of longitudinal section of *Coleus* stem tip. *Coleus* is a common ornamental plant found throughout the southeastern US and it exhibits primary growth. The tip of the stem will have only primary growth and should show you the fundamental plant tissues along with other primary growth structures. Try to locate the following: **apical meristem, leaf primordium, bud primordium, protoderm, provascular tissue, primary xylem, primary phloem, ground tissue, pith, cortex, leaf trace, and leaf gap.** What type of meristem does *Coleus* have? Single apical cell or tunica corpus?

As these tissues continue to mature, epidermis, cortex, pith, xylem and phloem continue to differentiate and a lateral meristem begins to produce more xylem and phloem. The lateral meristem is called the cambium and it allows the plant body to grow in girth as well as height.

Just as animal cells have different types of cells, *e.g.* nerve cells, muscle cells, blood cells, plants have specialized cells. At least seven cell types can be found in the plant with primary growth: parenchyma, collenchyma, sclerenchyma, chlorenchyma, xylem, phloem, and cambium.

Parenchyma

Parenchyma cells are the fundamental cells of the primary plant body. The cells are somewhat round in shape and represent the basic plant cell you studied in lecture. They may store starch, provide limited support (by tightly packing cells together), and allow for some lateral transport of water and food.

☐ Make a wet mount of a very thin slice of potato and place on a slide with a drop of water. Add a coverslip and place under a microscope. Focus first on scanning, then go to low and focus. Eventually make your observations on high power. Look for the parenchyma cells. Note the starch grains found within each parenchyma cell. Also pay attention to the relative thinness of the cell walls.

Collenchyma

Collenchyma are modified parenchyma cells where the primary cell wall becomes thickened in the angles of the cell. When you eat celery, you are generally eating collenchyma cells.

☐ Make a wet mount of a thin slice of celery. The celery slice needs to be paper thin, so make sure you use a sharp razor blade. Place the slice in a drop of distilled water and cover with a coverslip. Place on the microscope and focus first on scanning, then low, and finally high power. Look along the edges of the slice for cells with very thick cell walls. Make sure you light is adjusted to allow contrast between the cells. If you note primary walls thickened in the angles of the cells, these are collenchyma cells. These cells provide tremendous support to the growing plant stem. They're also what gives celery that "chewy" sensation.

Sclerenchyma

Sclerenchyma cells produce secondary cell walls which are impregnated with lignin - the material which makes wood hard. Sclerenchyma cells are often found in plants with secondary growth, however, some special sclerenchyma cells called **sclereids** can be found in primary plant tissues. Sclereids are sometimes referred to as **stone cells** and they are abundant in pears. When you eat a pear and detect that gritty sensation, those are sclereids grinding against your teeth.

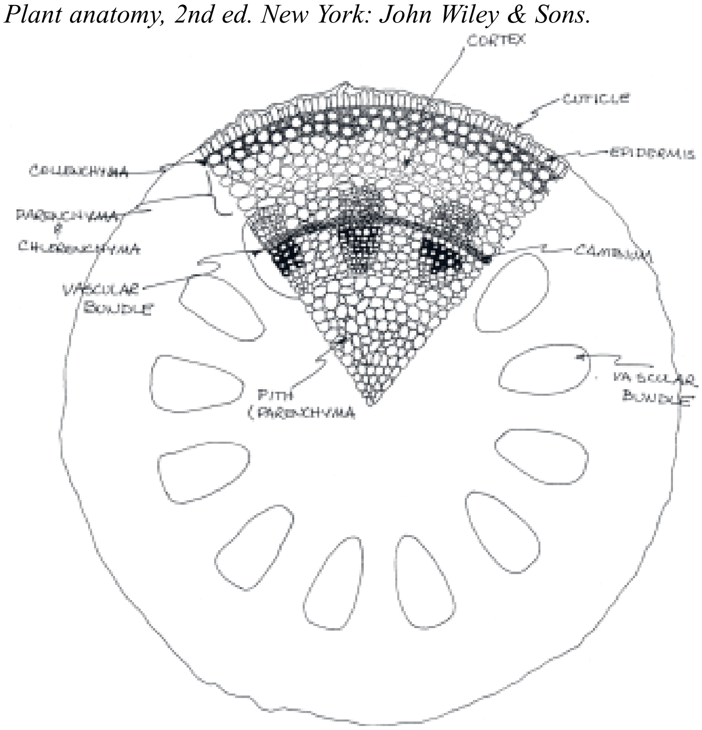
☐ Make a wet mount of the "meat" of a pear fruit by scraping some cells from underneath the peel onto a clean, dry slide. Add a drop or two of distilled water and cover with a coverslip. Focus first on scanning, the low and finally high. Sclereids are irregularly shaped cells with very thick cell walls. They should stand out from the other parenchyma cells found in the pear fruit.

Chlorenchyma

Chlorenchyma cells are simply modified parenchyma cells. They contain chloroplasts and are active in photosynthesis. Technically, you could consider the photosynthetic cells in leaves as chlorenchyma. However, in herbaceous plants, you often find chlorenchyma in the stems.

☐ Make a wet mount of a cross section of *Coleus* stem. You will need to use a very sharp razor blade to make the cross section and you need to make the section as thin as possible. Try to obtain a section thinner than a piece of paper. Place

Figure 4. Coleus *stem x.s. From Esau K. 1967. Page 396* in *Plant anatomy, 2nd ed. New York: John Wiley & Sons.*



this on a clean, dry slide and add a drop or two of water and a coverslip. Focus first on scanning, then low power and finally high power. Look along the edge of the cross section just under the epidermis. You may find collenchyma cells there also but look for the more abundant parenchyma cells with chloroplasts. These are chlorenchyma cells. Note the depth to which they extend into the cortex. Keep this slide to look for the next cell types.

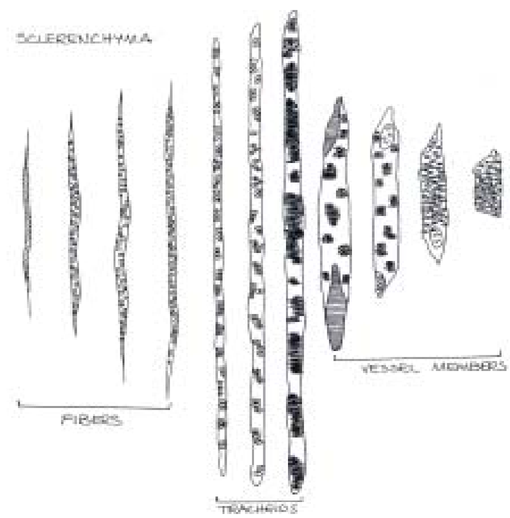


Figure 5. Fibers, tracheids, and vessels. From Easu K. 1967. Page 228 in *Plant anatomy, 2nd ed. New York: John Wiley & Sons.*

Xylem

As previously mentioned, xylem is specialized tissue for the conduction of water. Xylem is technically a tissue composed of several types of cells: fibers, vessels, tracheids, and parenchyma cells. Fibers are long, thin, tapered sclerenchyma cells with secondary walls. They may or may not have pits in their walls and their major function is support and lateral conduction of water. Tracheids, on the other hand are much larger and longer and less tapered. Pits are abundant in their walls and they serve as skeletal support and lateral transport of water. Vessel members are short, fat, and only slightly tapered. The end walls of vessel members are often missing and when one vessel member fits to another vessel member to form a tube, then it referred to as a vessel. Vessel members often have pits and their main function is vertical transport of water and to a less degree, lateral water transport and support of the plant.

☐ Using the previous slide, look for a vascular bundle. The vascular bundle is composed of xylem, phloem and cambium. Xylem cells which are thin and large in diameter are called protoxylem. These are differentiated from the metaxylem cells which are thick with obvious secondary cell walls with smaller diameter openings. The metaxylem is often found to the interior of the protoxylem. The cell type is usually a vessel in this type of stem. The parenchyma cells form xylem rays, brick-like cells radiating out from the center of the vascular bundle. Again, keep this slide for the next type of cells.

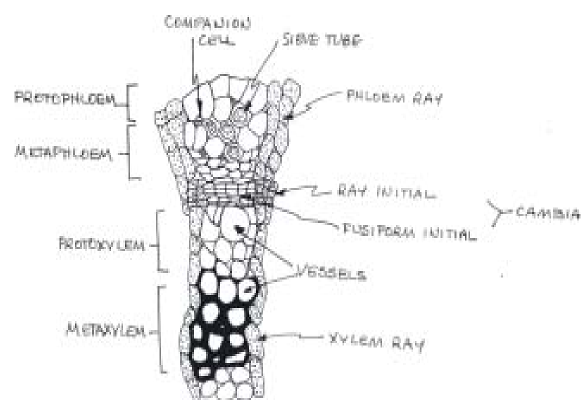


Figure 6. x.s. through a vascular bundle. From Esau K. 1967. Page 399 in *Plant anatomy, 2nd ed. New York: John Wiley & Sons.*

Phloem

Phloem is specialized tissue for the conduction of food, typically from the leaf downward through the rest of the plant. Phloem may have five types of cells: **sieve cells, albuminous cells, sieve tube member, companion cells, fibers** and **parenchyma**. Gymnosperms have sieve cells and albuminous cells. The angiosperms instead have sieve tube members and companion cells, but both serve similar functions. Sieve cells are found in gymnosperms and serve for vertical conduction of food products. Associated with sieve cells in gymnosperms are nucleated albuminous cells. Angiosperm sieve tube members are highly porus and their end plates are often significantly porus. These may connect together to form sieve tubes. Companion cells in angiosperms are nucleated and seem to regulate the activities of sieve tube members. Fibers are like those in xylem but they are not involved in conduction of food - simply for support of phloem. The parenchyma cells in phloem form phloem rays - the continuation of xylem rays.

☐ Look again at the vascular bundle and try to find the phloem (to the outside of the xylem). You may be able to distinguish between companion cells and sieve tubes. Companion cells are small and the only real way to determine their presence is to look for a nucleus associated with the cell. Sieve tube members are larger and if you cut through the sieve plate, they are easily identified by that. Fibers are associated with the sieve tube members and companion cells and have obviously thickened secondary walls.

Again, save the slide for the next cell type.

Cambium

Cambium is a lateral meristematic tissue composed of two types of cells: fusiform initials and ray initials. As cambium divides, it produces phloem to the outside and xylem to the inside within the vascular bundle. Xylem and phloem are produced by the fusiform initials. Ray initials produce xylem rays to the inside and phloem rays to the outside. Rays may be a form of lateral transport within the stem.

☐ Look for the vascular bundle and look between the xylem and phloem. You will find a thin layer of cells between the two. This is the cambial layer. Again, keep this slide.

Patterns of Xylem Distribution

The arrangement of protoxylem and metaxylem within the vascular bundle is significant. If protoxylem is found closer to the stem surface (and cortex) and metaxylem closer to the pith, differentiation is said to be **exarch.** If the condition is reversed, differentiation is said to be **endarch.** If metaxylem is found inside the protoxylem, differentiation is said to be **mesarch**. **Centrarch** differentiation is where the size of the cells is reversed - protoxylem is smaller and metaxylem is larger. Lastly, if there is no protoxylem, only metaxylem, differentiation is said to be synchronous. Previously we looked at the number of points of xylem. If the xylem is a central core of tissue, it is said to be **monarch**. If there are two lobes of xylem, it is said to be **diarch.** Three lobes is **triarch,** etc.

Types of Vascular Cylinders

The arrangement of the vascular bundles within a stem is significant. If there is a solid core of vascular

Figure 7. Patterns of xylem differentiation. From Bold HC. 1973 Page 330 in *Morphology of plants, 3rd ed. New York: Harper & Row.*

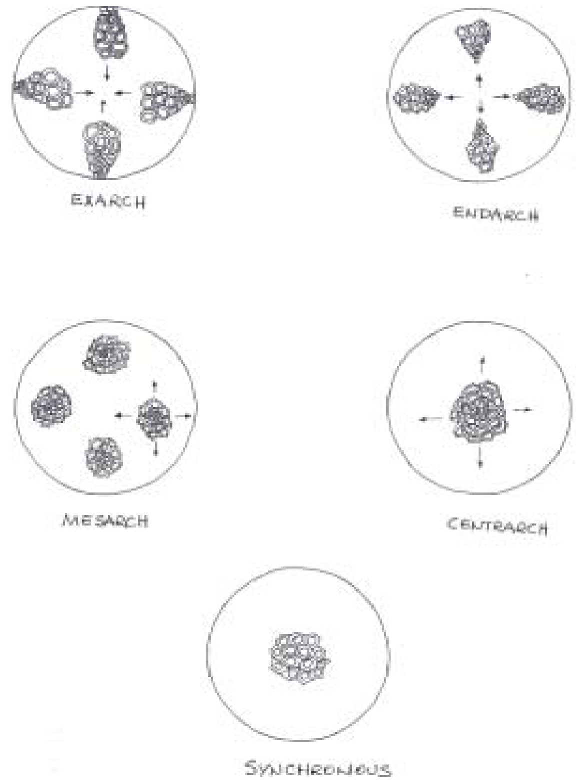
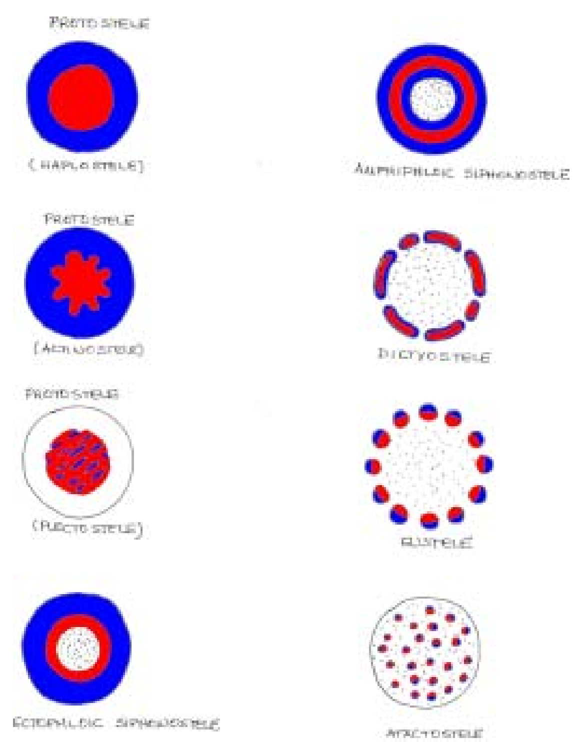


Figure 8. Types of steles. From Bold HC. 1973. Pages 333 in *Morphology of plants, 3rd ed. New York: Harper & Row.*



tissue (only one bundle), it is called a **protostele**. In a protostele, there is a solid core of xylem surrounded by phloem. This is considered the most primitive of arrangements. There are three subtypes of protosteles: **haplostele**, **actinostele**, and **plectostele**. The haplostele is the basic protostele concept. The actinostele is where the solid core of xylem is lobed with phloem found in between the lobes of xylem. A plectostele is where the phloem is interlaced within the xylem.

A **siphonostele** a ring of xylem surrounded by a ring of phloem but there is a core of pith inside the xylem and cortex outside the phloem. If phloem is found only on the outside of the xylem of a siphonostele, it is said to be **ectophloic**. If phloem is found both outside and inside the ring of xylem, it is said to be **amphiphloic.** A dissected siphonostele is called a **dictyostele.** If the dissections are in discrete units, it is called a **eustele.** If vascular bundles are scattered in no apparent order, the arrangement is called an **atactostele.**

☐ What type of stele system is found in your cross section of *Coleus*? ______________________

☐ Now observe a prepared slide of a cross section of corn stem. What type of stele is present?

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Monocot *vs* Dicot Stems

Coleus represents a dicotyledonous stem. In a dicot stem, the vascular bundles are in a regular ring pattern between the cortex and the pith. In a monocot, the vascular bundles are scattered within the stem with little or no pattern. Corn (*Zea mays*) is an example of a monocot stem.

☐ Obtain a prepared slide of a cross section of a monocot and dicot stem. The monocot section on the slide is corn. Note how the vascular bundles are scattered within the stem. Observe the vascular bundle on low and high power. Note the rather large metaxylem elements and the large air space. Some biologists like to point out it has the look of a clown face. Compare the anatomy of both the monocot and dicot stems. Does the monocot stem have both pith and cortex?

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Secondary Plant Growth

Obtain a prepared slide of an angiosperm stem cross section showing secondary growth. Note the growth rings present. Compare this to the slide of *Coleus* and note the similarities and differences. List the things found in *Coleus not* found in the slide with secondary growth and any other unusual features of difference.

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Figure 9. Zea mays *cross section and vascular bundle. From Raven PH, Evert RF, Eichhorn SE. 1986. Page 421* in *Biology of plants, 4th*

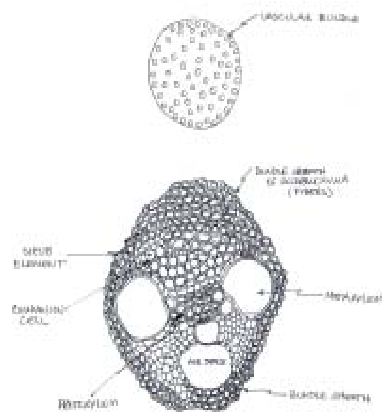


Figure 10. Leaf trace and leaf gap. From Bold HC. 1973. Page 332 in *Morphology of plants, 3rd*

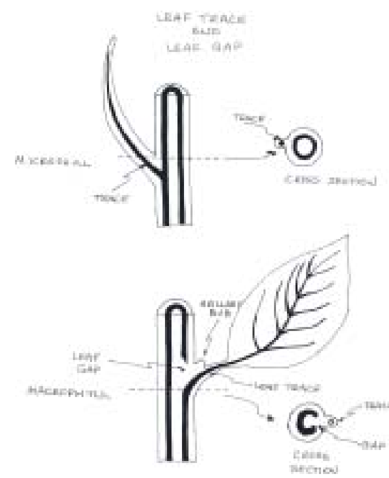
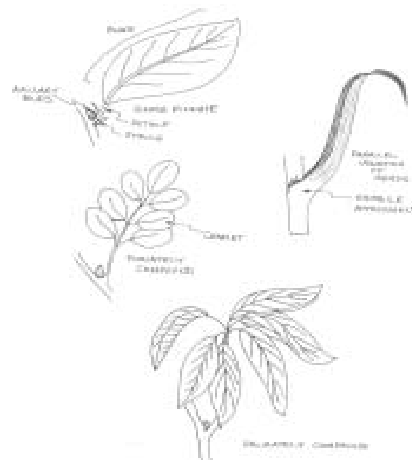
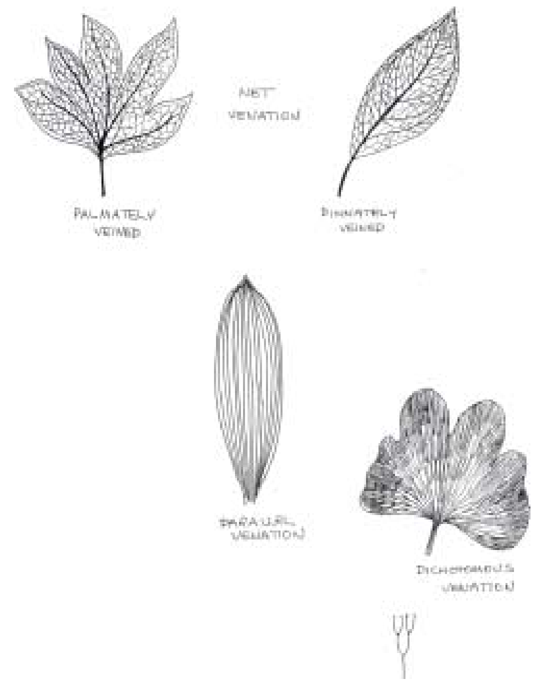


Figure 11. Leaf types. From Bold HC. 1973. Page 337 in *Morphology*



The Leaf

Figure 12. *Venation in leaves. From Bold HC. 1973. Page 338* in *Morphology of plants, 3rd ed. New York: Harper & Row.*



Leaves are often the most conspicuous part of the plant with the exception of flowers (which are modified leaves anyway). Not all plants have leaves but the vast majority do. The most important function of leaves is photosynthesis. When asked what constitutes a leaf, a **true leaf** is an outgrowth that contains vascular tissue and a l**eaf gap** in the vascular cylinder of the stem. This type of leaf is referred to as a **macrophyll. Microphylls**, found in members of the fern allies, do not have the leaf gap in the vascular cylinder and they are much smaller. Macrophylls are found in ferns, gymnosperms and angiosperms.

True leaves typically have three basic structures (1) the broad, expanded **blade** (or **lamina**), (2) the **petiole** or portion that attaches the blade to the stem, and (3) the **stipules** (small leaf-like structures at the base of the petiole). If a leaf has all three parts, it is called a **complete leaf**. If it is missing any one or more of the three parts, the leaf is said to be **incomplete.** Some leaves don't have stipules, others may not have petioles (they are said to be **sessile** in their attachment to the stem), and some leaves don't have blades (the spines of a cactus are actually leaves without the blade).

Simple or Compound Leaves

Leaves may be either simple or compound. To determine whether or not the leaf is simple or compound, look for the **axillary bud** present in the axil of each *leaf*. The axillary bud tells you where the leaf begins. If the leaf has a single blade or lamina arising from the axillary bud, it is a simple leaf. If more than one blade or **leaflet** arises from the axillary bud, it is a compound leaf. Note the individual blades are called leaflets.

Compound leaves may be **pinnately compound** or **palmately** compound depending upon the arrangement of the leaflets on the petiole. If the leaflets radiate out from the petiole at one point like the fingers from the palm of your hand, the leaf is palmately compound. If instead, the leaflets are arranged like the veins of a feather, the leaf is said to be pinnately compound.

Venation in Leaves

Venation in leaves refers to the arrangement of the veins (vascular tissue) in a leaf. There are two major types of venation: **parallel** and **net** (but there are variations on this theme). In parallel venation, the veins of a leaf don't appear to meet; instead they run parallel down the blade. If the veins to meet and appear net-like or reticulate, the venation is said to be net.

Net venation is further subdivided into two parts. Leaves may be pinnately net veined or palmately net veined, depending upon the arrangement of major veins of the net. Palmately net veined leaves have the major veins arising from a single point.

A special case of venation is **dichotomous**. It's a throwback to more ancient plants. Ferns and *Ginkgo* exhibit dichotomous venation - where the veins fork off one another.

☐ Observe the sample of leaves provided and try to indicate the characteristics in the table provided on page 8.

Phyllotaxy

The arrangement of leaves on the stem is also significant. Leaves are placed so as to most efficiently gather sunlight for photosynthesis. It would not do to haphazardly arrange leaves upon a stem. Instead, leaves may be found at right angles to one another. This allows each leaf to better be exposed to light. The arrangement of leaves on a stem is called **phyllotaxy.** There are three major arrangements: **alternate, opposite,** and **whorled.**

In alternate phyllotaxy, there is one leaf per node. Remember, the node is the location of axillary buds. Opposite phyllotaxy is where there are two leaves per node and whorled phyllotaxy is where more than two leaves are found per node.

☐ Examine the stems provided and determine the phyllotaxy of each.

Table 1: Leaf type

NAME OF PLANT	SIMPLE/ COMPOUND	PETIOLATE OR SESSILE	STIPULATE OR EXSTIPULATE	DICHOTOMOUS/ PARALLEL /NETTED: PINNATELY/ PALMATELY

Figure 13. Phyllotaxy of leaves.

Leaf Anatomy

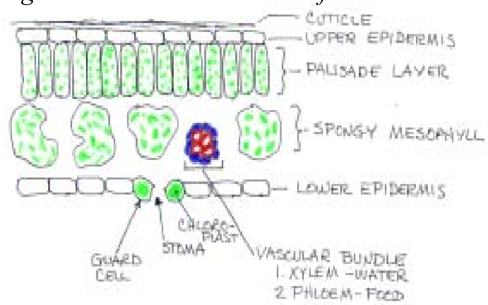
The typical leaf is made up of several layers. First, there is the **upper and lower epidermis**. The upper epidermis often has a cuticle on it's surface, often wax. The waxy layer protects the leaf from damage by insects, fungi, and bacteria - and also helps to prevent water loss. There are no chloroplasts in the upper or lower epidermis except in the **guard cells** of **stomata**. Stomata are the openings (typically on the lower surface) used in gas exchange. Often, there are **substomatal chambers** found just inside the leaf of each stomata. The chamber allows for gas to collect and also provides a place for condensation of water vapor to occur to help retard water loss. What are the three main gases exchanged by a plant?

____

Immediately beneath the epidermis is the **palisade layer**, loaded with chloroplasts. This is the region where a large part of photosynthesis occurs. Beneath the palisade layer is the **mesophyll**, also with chloroplasts but fewer in number but larger in size. Photosynthesis occurs here but not as much as in the palisade layer. The mesophyll is characterized by large **intracellular spaces**. **Vascular bundles** are also found scattered in the leaves. In most leaves, these are composed of xylem surrounded by phloem.

☐ Observe the cross section of the leaf and try to identify the structures indicated above.

Figure 14. Calvin-Benson leaf.



Leaf Modifications

There is no *typical* leaf. All leaves have one or more modifications to the plan outlined above. One modification that may occur within leaves on the same plant is an environmental modification called **sun** and **shade** leaves. Leaves found at the top of the plant are often exposed to intense sunlight. This requires a modification of the leaf anatomy. First the palisade layer may be several cells thick. The epidermal cells are also thicker. Sun leaves also have more vascular tissue present (perhaps to offset greater loss of water by transpiration). The surface area of the mesophyll is greater in sun leaves to the overall area of the blade, meaning the mesophyll cells are smaller in size then in shade leaves.

☐ Observe the prepared slide of sun and shade leaves and compare the two. Be able to identify which is sun and which is shade.

Xeric Leaves

Plants that grow in dry climates or in dry conditions require modification of the leaf to prevent excess water loss. These type of leaves are called **xeric**. One obvious modification is that stomata are sunken into **stomatal crypts** to allow a surface for water condensation and thus retention. The cuticle is much thicker and the palisade layer is often multilayered. The vascular bundle may have a bundle sheath around it, and even if it does not, the xylem is totally surrounded by phloem. There are often many crystals found within this leaf, depositions of calcium carbonate or calcium oxylate.

Mesic Leaves

This type of leaf more readily follows the basic structure of a leaf. The epidermis is a single cell thick, the palisade a single layer, no bundle sheath and the phloem is found only on one side of the xylem.

Hydric Leaves

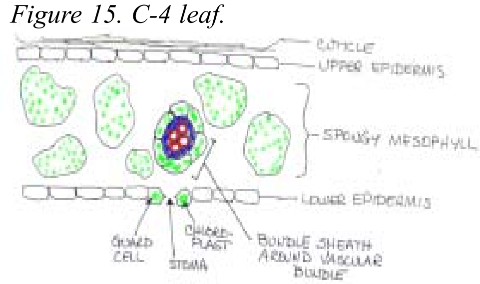
These are the floating leaves of plants such as water lilies. The stomata are found only along the upper epidermis since the lower epidermis is in contact with the water. The cuticle is thin since there is no special need to retard water loss. The vascular tissue is much reduced, especially the xylem since there is plenty of water. Often there are large numbers of sclereids present to give support to the leaf. Also, there are abundant air spaces or intercellular spaces to cause the leaf to float. The palisade layer may be several cells thick.

☐ Observe the prepared slide of xeric, mesic, and hydric leaves. Try to identify which type is which. You may wish to make sketches of the three.

Grass Leaves, Corn Leaves

Grasses, especially corn, have highly modified leaves. Corn is a plant that undergoes C-4 metabolism. These leave exhibit what is referred to as **Krantz anatomy**. In this leaf, the vascular bundle is surrounded by a bundle sheath. It's in the bundle sheath that the Calvin-Benson cycle occurs. There is no palisade layer - only mesophyll. It's in the mesophyll that C-4 metabolism occurs. The bundle sheath may also be supported by extensions of sclerenchyma tissue that reach to both the upper and lower epidermis. There are numerous vascular bundles due to the parallel venation of the leaf. The epidermis of corn is modified by the presence of **bulliform cells**. These seem to serve as a device to allow the leaves to curl up to retard water loss. Additionally, stomata have associated with them **accessory cells**. Accessory cells are often misinterpreted as stomata.

Figure 15. C-4 leaf.



☐ Observe the prepared slide of corn leaf cross section. Identify the structures indicated above and compare this leaf to the typical leaf at the beginning of the leaf exercises.

Roots

Roots, for the most part, remain below the ground. However, some roots arise in unusual places, for example, the prop roots of Banyan trees or the prop roots of corn plants. Any root which arises in an unusual place is said to be **adventitious.** Roots have several functions. They, of course, **anchor** the plant to the substrate.

The primary root is the first root produced by a plant. As a seed germinates, the radicle of the embryo often exits the seed through the micropyle and extends into the ground. A protective root cap protects the tender **apical meristem** of the growing root. (Remember, apical refers to either shoot or root apex.) As the root continues to push into the soil, the root cap wears away and is replenished by the apical meristem.

As growth continues, tiny **root** hairs grow from the epidermis of the root. Root hairs are simple outgrowths from an epidermal cell and are thus composed of a single cell. They increase the surface area of the root for **absorption**, a second function of roots.

☐ Observe the radish seedlings provided in the Petri dish of blue agar (to enable you to see them better). You may wish to use a dissection scope. Try to find the root cap and observe the fuzzy aspect of root hairs.

If you observe a longitudinal section of a root under a microscope, you will find the same three fundamental tissues present in the stem: **protoderm, procambial tissue,** and **ground meristem.** These tissue function the same here as they did in the stem. In addition, there are three zones found in the root. They are (the **quiescent zone**, (2) the **zone of elongation,** and (3) the **zone of maturation.**

The quiescent zone is where the root apical meristem is located. This is the region of all growth of the root. The zone of elongation is a region of active cell division. Here is where you find cells undergoing mitosis: interphase, prophase, metaphase, anaphase, telophase, and cytokinesis. The zone of maturation is self descriptive. Here the cell continues to grow and differentiate into the cell it is genetically predetermined to be.

Figure 16. Allium ***root tip, l.s.***

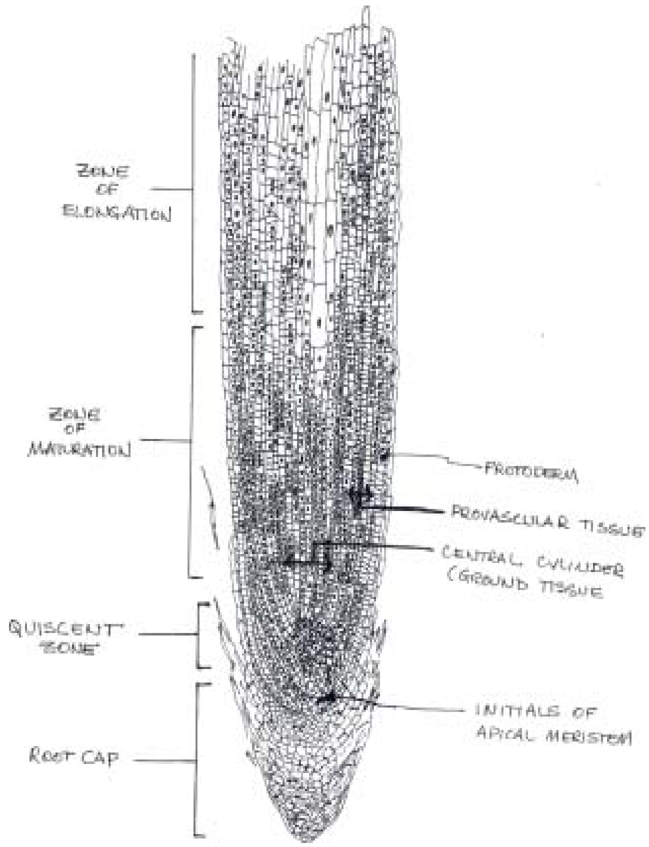
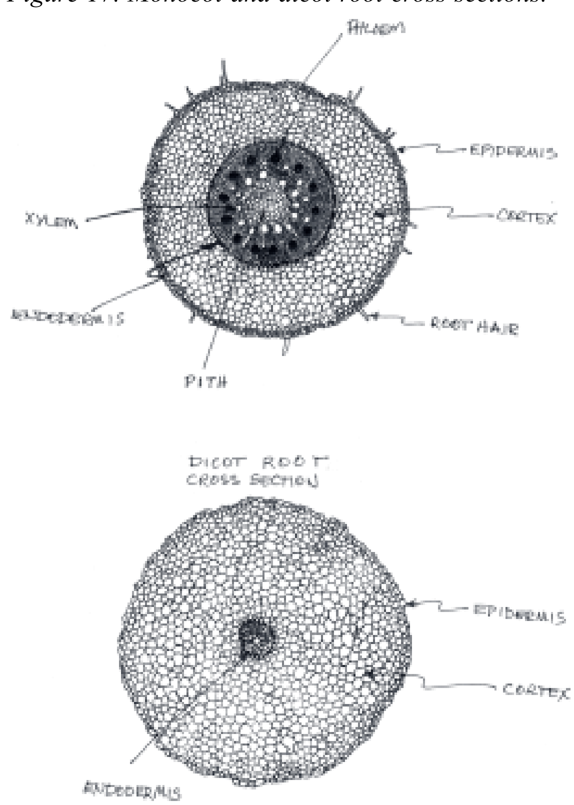


Figure 17. Monocot and dicot root cross sections.

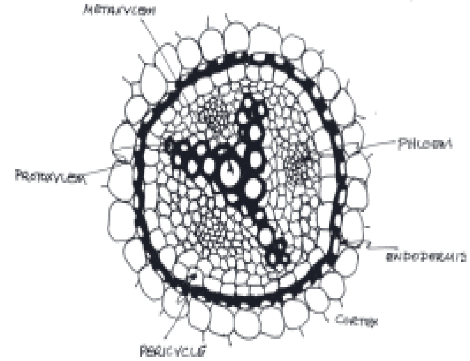


☐ Observe the prepared slide of a longitudinal section of *Allium* root tip. Try to identify each zone and region.

Flowering plants are divided into two major categories: monocotyledons and dicotyledons. Monocot roots differ from dicots.

☐ Observe the two root systems provided and notice that in one root there is a central axis with smaller roots branching off from the central root. The central root is called the **tap** root and the branches are called **lateral** or **branch** roots. Dicots typically have tap roots.

Figure 18. Dicot root vascular bundle.



The second root has no main axis. Instead, it appears to be composed entirely of lateral roots. This is misleading. It at one time had a central root but later branch or lateral roots developed as quickly as the central root. We say this type of root system is **diffuse.** Diffuse roots are generally found in monocots. A word of caution - some monocots have tap roots and some dicots have diffuse root systems.

Lateral or branch roots have an interesting origin. If you look at a root in cross section, you should be able to see a vascular bundle of xylem and phloem. Around the vascular bundle is a layer of cells (sometimes several cell thick) that have an unusual appearance. The cells are collectively called the **endodermis**. The endodermis represents cells which have a waterproofing material embedded in four of the six sides of the cell. The waterproofing material is called **subrin** and the subrinized walls (called **Casparian strips**) force water up the vascular bundle and prevents water loss to the cortex.

Just underneath the endodermis is a layer of cells called the **pericycle**. It is in the pericycle from which lateral roots arise.

☐ Observe the prepared slide of a cross section of a dicot root. Identify the following structures: **epidermis, cortex, endodermis, pericycle, phloem, xylem,** and **lateral root**.

Some roots, such as those of *Smilax*, commonly called cat briar, may contain pith.

☐ Observe the cross section of *Smilax* root. *Smilax* is a monocot root. Compare this root to the one showing lateral root origin, a dicot root. How does the monocot root differ from the dicot root? ____

____

____

Secondary growth may also occur in roots. Secondary growth is that growth that occurs after primary growth and is due to a lateral meristem called the cambium. These types of roots should show growth rings and instead of epidermis (**periderm**) they should have bark produced by the **phellogen (**or **cork cambium)** just as in stems.

Some types of adventitious roots form **prop roots**. Prop roots, as found in corn, provide additional support to the plant shoot. If a corn stem is available, note the prop roots and diffuse roots.

Prop roots can take several forms. The Florida red mangrove forms extensive prop roots to hold it up in the soft, muddy bottom of estuaries. It is said that in some places of the world, you can walk for miles through mangrove swamps without getting your feet wet because you can walk on the prop roots.

Perhaps you have noticed the roots that appear on the branches of ficus trees here is south Florida. These may form extensive prop roots. The old world banyan tree is famous in India because of the extensive prop roots produced. It is estimated a single banyan tree in India may take up as much as an acre of ground with its canopy due to the extensive nature of prop roots holding up the branches.

Prop roots thus demonstrate a third function of roots: **support.** A fourth function of roots is

storage. Storage in roots occurs mostly in the cortex of a root. Sweet potatoes are an example of a storage root. (Caution! Irish potatoes, Idaho potatoes, etc. are not roots but specialized stems called **tubers**.)

☐ Observe the growing sweet potato and notice the secondary or branch roots from the major axis. What you eat of the sweet potato is actually the root of a plant. Next observe the Irish potato provided and note there are "eyes" found on the surface. These eyes are axillary buds with their reduced leaves. From these grow branches. Since you find axillary buds on the Irish potato, it is not a root but a stem.

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