Primary Structure of the Stem and Shoot

The shoot system includes the stem and its appendages, leaves; both derived from shoot meristem. The shoot meristem, which originates in the embryonic epicotyl, contains the apical initials and derivative meristems for primary shoot growth along the plant axis, along with leaf and bud primordia. , the embryonic lateral shoot systems. Flowers, the reproductive organs of angiosperms, are modified shoots. Shoot meristems are located at the growing tips of stems, and in buds.

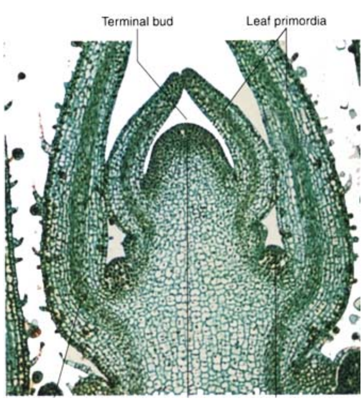
The stem has two principal functions: **support**, and **conduction** of nutrients and water. Substances manufactured in the leaves are transported through the phloem tissue of stems to regions of the plant that are growing, to developing flowers, seeds, and fruits, or to storage regions of the plant. Much of the nutrient material is stored in parenchyma cells of roots, seeds, and fruits, but stems are also important storage organs. Water and dissolved minerals are transported from the roots to the leaves in the xylem of the stem. Leaves, the principal photosynthetic organs of the plant, are supported by the stems, which place them in positions favorable for absorption of light. Most dicots and all conifers have secondary growth, an expansion in girth as well as in length. Most monocots lack true secondary growth, although some obtain large dimensions. While increase in length is accomplished by the meristems at growing tips of plants (which is primary growth), secondary growth is accomplished by a special meristem, called cambium. You will observe features primary growth in stems in this lab, along with the transition to secondary growth in dicots.

A. Shoot Meristem

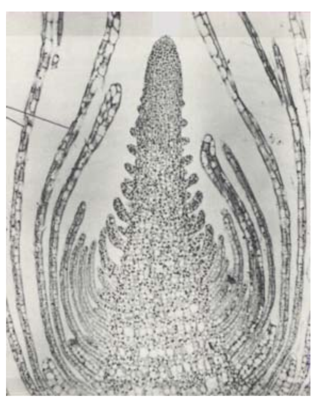
Observe the prepared slide of *Elodea* or *Coleus* shoot meristem available. Note that the apical meristem is located with a set of leaf and bud primordia, with the youngest close to the apical initials. Bud primordia are located in the axils of leaf primordia.

Identify the derivative meristems in the shoot tip. Stem tissues are produced from the same three derivative meristems as root tissues are:

- Protoderm is responsible for Epidermis
- Ground Meristem differentiates into ground tissues
- Procambium produces the vascular tissues



Coleus stem tip, l.s.


Elodea shoot tip, l.s.


SEM of shoot tip

How is the arrangement of procambium in the shoot tip different from the location of procambium in root meristem?

Locate the central strands of procambium that extend out into the leaf primordia from the shoot meristem. These are called leaf traces.

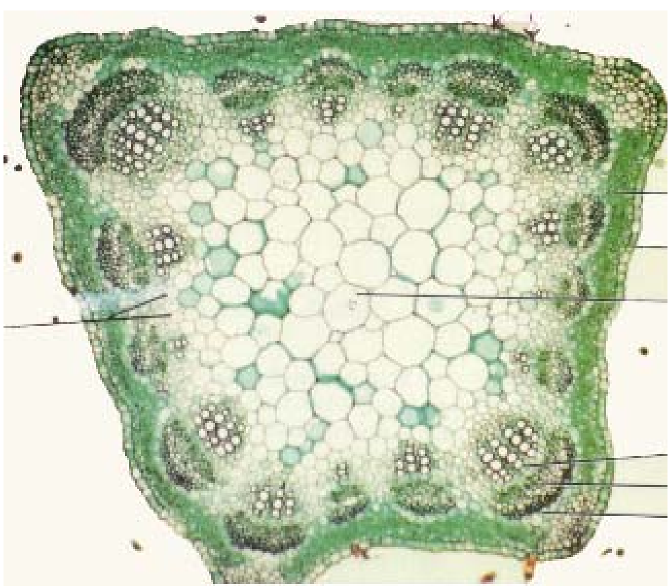
The positioning of new leaf primordia, and hence branches, is regulated by the inhibition effect of existing primordia so that leaf and branching patterns generally spiral along the stem. This pattern is obvious in young shoots and in cross sections of shoot meristem.

B **Herbaceous Dicot Stem Structure**

Observe the stem cross section of alfalfa (*Medicago*), young Geranium (*Pelargonium*) or sunflower (*Helianthus*). On this slide you will be able to examine the primary plant structure, although a little secondary growth may have occurred in some of the stem sections. Both alfalfa and sunflower are good examples of herbaceous dicotyledons with little secondary growth. You will want to compare stem structure in younger and in older stems.

Identify the following tissues in your stem section moving from the exterior of the stem toward the interior:

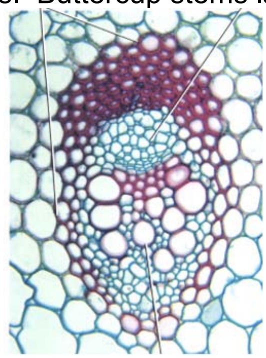
- **Epidermis**
- **Cortex** region composed of collenchyma (the outer 3 – 5 cell layers) and parenchyma
- Primary **vascular bundles** with conspicuous primary **phloem** fibers and phloem sieve tubes and companion cells to the outside of a cambium layer of cells, and **xylem**, with larger vessels and fibers to the inside of the cambium layer. The cambium layer cells are very small in diameter. Vascular bundles that have a cambium layer are said to be **open** vascular bundles because additional growth can and does originate from the cambium layer within the bundle. Although most dicots have discreet vascular bundles in a ring separating the cortex from pith, some woody dicots have a complete cylinder of vascular tissue even in primary growth.
- **Pith**. Note the pith rays between the vascular bundles. Look for **cambium** cells moving into the pith rays in the alfalfa stem sections. This is the start of secondary growth, which results in the familiar growth rings of wood. Another term for a bundle is 'fascicle". The cambium that extends through the pith rays is called interfascicular cambium and that within the primary growth vascular bundles, fascicular cambium.



Dicot Stem Cross Section

Dicot Stem Open Vascular Bundle

Now examine a *Ranunculus* (buttercup) stem, xs slide. *Ranuculus* has closed vascular bundles. Note the absence of a cambium layer between the xylem and phloem, and there will be no meristem activity in the pith rays. Buttercup stems lack secondary growth.



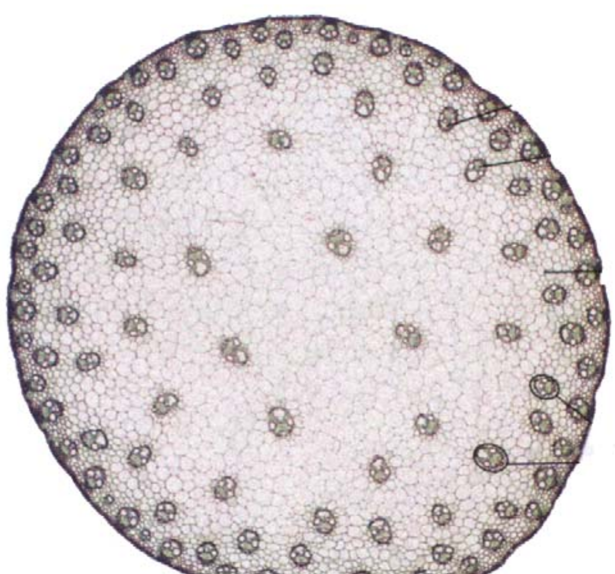
Closed Vascular Bundle of *Ranunculus* stem

C. Monocot Stem Structure

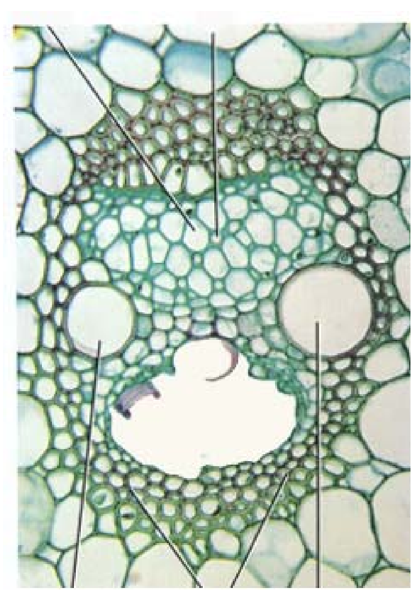
The corn (*Zea mays*) stem is an example of a stem whose vascular bundles are distributed throughout the ground tissue. The vascular bundles in corn are **closed**, that is, no cambium is produced for secondary growth. Most dicots have open bundles, but some, such as *Ranunculus*, the buttercup, have closed vascular bundles.

Obtain a prepared slide containing a cross section of a corn stem. Examine the section under the microscope's scanning objective. Compare the distribution of the vascular bundles in the corn stem with that in the alfalfa or other dicot stem. Switch to the high power objective and study an individual **vascular bundle,** which resembles a clown face with eyes and nose. Each vascular bundle, which is surrounded by a **bundle sheath** composed of thick-walled sclerenchyma cells, consists of phloem toward the exterior and xylem toward the interior of the stem. The **phloem** consists of sieve tubes and small, dense companion cells. The **xylem** consists of vessels with thick walls and much smaller parenchyma cells. Most of the vessels are intact, but some vessels have been stretched or destroyed during maturation of the stem. This destruction of vessels often results in the formation of a large air space (the "nose" of the "face").

The ground tissue of the corn stem cannot be distinguished as cortex and pith, since the vascular bundles are scattered throughout.



Monocot Stem Cross Section



Monocot Stem Vascular Bundle