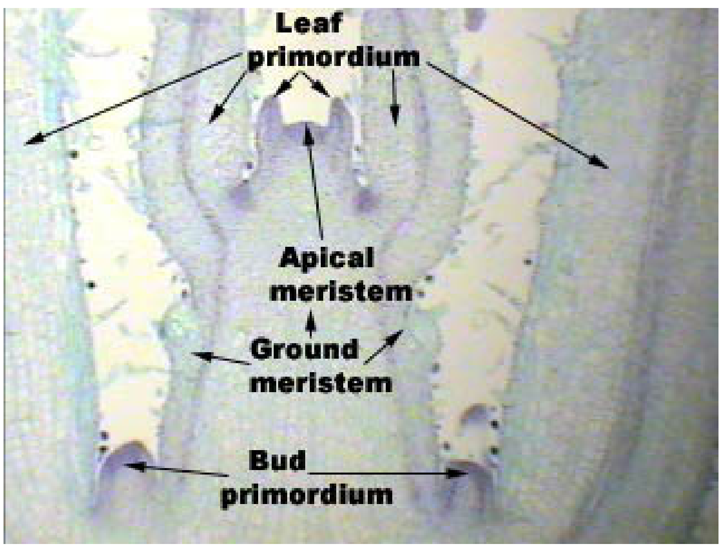
BOTANY LAB II
Stems

Herbaceous Plant Stems

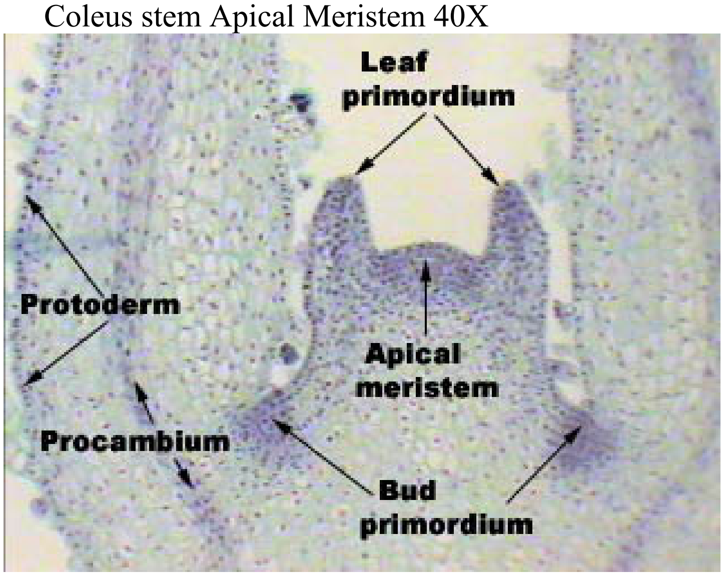
Herbaceous plants are those with little or no woody tissue. The stem of a plant is that part of a vascular plant that bears leafs and flowers.

Primary growth – takes place at the stem or root tip and leads to an increase in the length of the plant. At the very tip of a plant stem is an area called the **Apical Meristem.** The apical meristem is dormant during the winter but becomes active during the growing season. The apical meristem is protected by bud scales and the developing leaf primordial (after the bud scales drop off the leaf primordial develop into new leaves).

The Stem Apical Meristem



Coleus stem Apical Meristem 40X



Coleus stem Apical Meristem 100X

Note: on the photomicrographs above:

(1) The three leaf primordium (the leaf at its earliest stage of development) help to protect the apical meristem within.

(2) Three primary meristems develop on the stem:

[1] The **Protoderm** gives rise to the epidermis.

[2] The **Procambium** gives rise to the primary xylem and primary phloem cells.

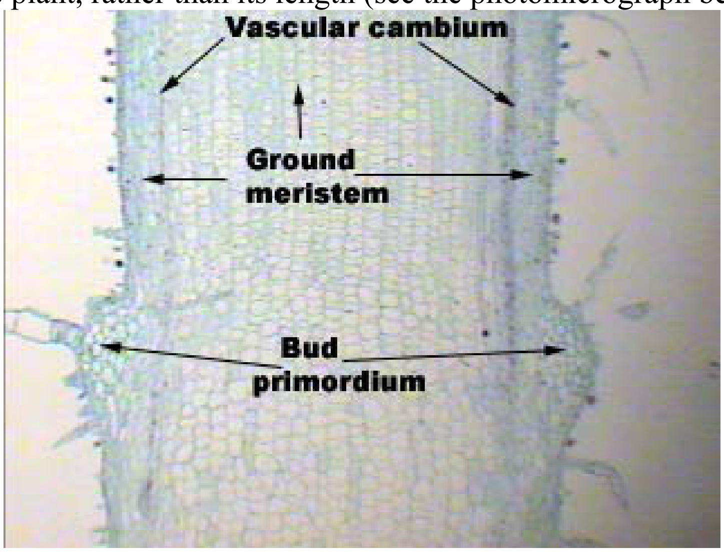
[3] The **Ground Meristem** gives rise to two types of parenchyma cells:

{1} The **Pith** in the center of the stem.

{2} The **Cortex** on the outer portion of the stem.

The five tissues produced by the apical meristem (epidermis, primary xylem, primary phloem, pith, and cortex) make up the ***Primary Tissues***.

(3) The Procambium retains its meristematic nature and becomes the vascular cambium (one of two lateral meristems). The lateral meristem tissue adds to the girth of the plant, rather than its length (see the photomicrograph below).



Coleus stem below the Apical Meristem 100X

The vascular cambium divides and forms many different types of cells:

Tracheids – an elongated, spindle-shaped xylem cell with thick walls containing pits.

Vessels – a water conducting tube or duct in the xylem.

Fibers – a long thick-walled cell with dead cytoplasm.

Secondary xylem – xylem inside of the meristem (transports water).

Secondary phloem – phloem outside of the meristem (transports food)

<u>Lab Protocol 1</u>

Find the live plant labeled Coleus. Note the opposite leaf arrangement and the presence of lateral buds in the leaf axil.

Find the microscope slide labeled as "Coleus Stem Tip, l.s." On low magnification (40X and medium magnification (100X) located the structures illustrated on the photomicrographs above.

Histology of the Stem

The central portion of the stem (the stele) is composed of:

- Primary Xylem
- Primary Phloem
- Pith

The Protostele is a simple form of a stele. It consists of a simple core of xylem and phloem, where the phloem surrounds the xylem. This type of stem is common to club mosses and whisk ferns.

The Eustele is a stem in which the primary xylem and phloem occur in specialized areas called **Vascular Bundles.** This type of stem is common to modern flowering plants and conifers.

Plants that only have primary tissue

Primary tissue is that tissue produced by an apical meristem. Most monocots (e.g. grasses, lilies etc.) are herbaceous plants. The stems of these plants do not have a vascular cambium (meaning that they have no secondary vascular tissues or cork).

Herbaceous Monocotyledonous Stem

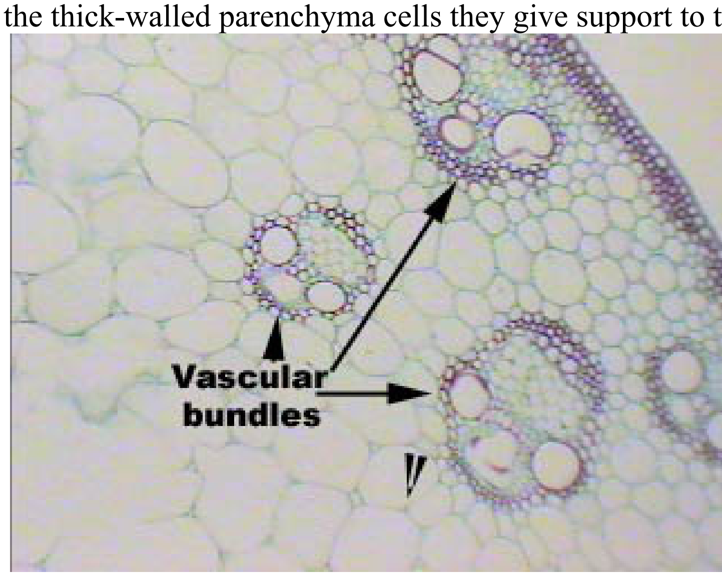
In this part of the lab we will examine a monocot; the corn plant (***Zea mays***). Look for small clusters of xylem and phloem cells called **Vascular Bundles.**

The vascular bundle contains two obvious vessel elements and a nonfunctional air space (usually larger than the two vessel elements).

The phloem consists of sieve tubes and vessel elements and is found toward the outside of the stem relative to the large vessel elements.

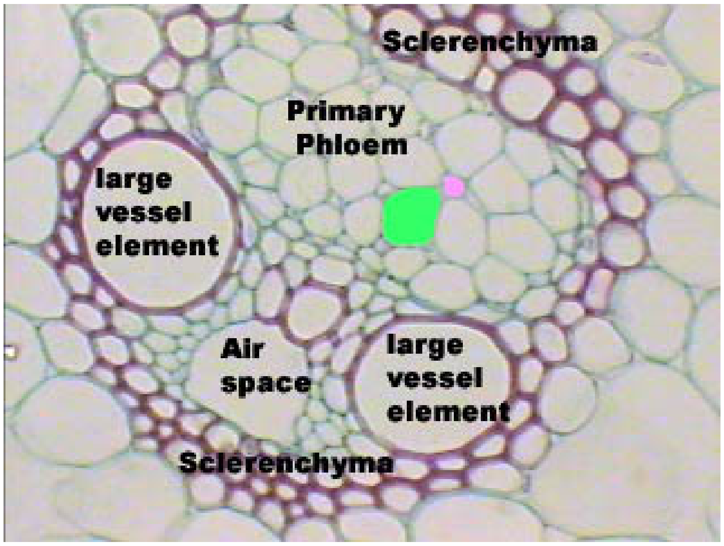
The tissue around the vascular bundle is parenchyma but it is not separated into a cortex and pith in monocots.

Sclerenchyma cells are found several layers thick just under the epidermis. Together with the thick-walled parenchyma cells they give support to the plant.



Corn vascular bundles 40X

Most of the stem is composed of parenchyma cells and is referred to as the **ground tissue.** The photomicrograph below is of one vascular bundle.



Corn vascular bundle 100X

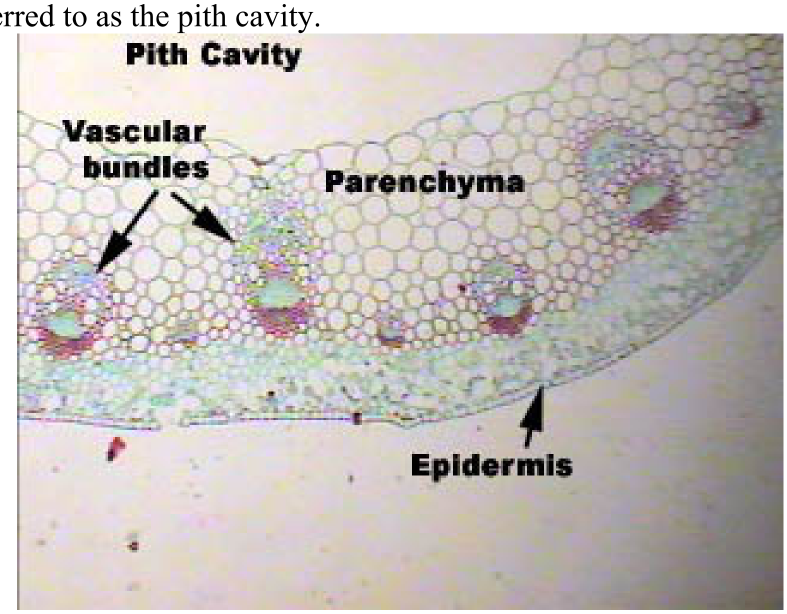
On the photomicrograph above the sieve tube is labeled with green/yellow and the companion cell is labeled with blue. The primary phloem is parenchyma, as is the tissue around the outside of the vascular bundle. Notice that the corn vascular bundle contains two obvious vessel elements and a non-functional air

Lab Protocol 2 - find the prepared microscope slide labeled as :Zea mays stem X.S. and the identify the structures indicated on the photomicrographs above.

Herbaceous Dicotyledonenous Stem

_In this part of the lab we will examine a Buttercup (Ranunculus) dicot stem.

Ranunculus has a stem with vascular bundles oriented in a circular fashion like Zea mays. Both of these plants (Zea mays and Ranunculus) have only primary tissues. One difference between the two is that the buttercup has a hollow stem. The central cavity is referred to as the pith cavity.



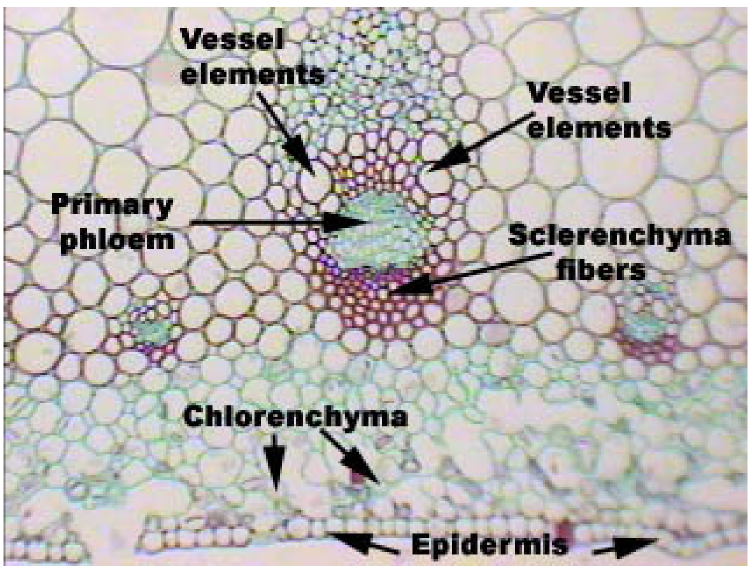
Ranunculus stem cross section 40X

Most herbaceous plants are small. The stems lack a vascular cambium (that functions for lateral growth) or a cork cambium, and henceforth do not produce secondary vascular tissues or cork. These plant have an epidermis. The xylem and phloem are not found in a ring (like woody stems) but occur in specialized areas called Vascular Bundles.

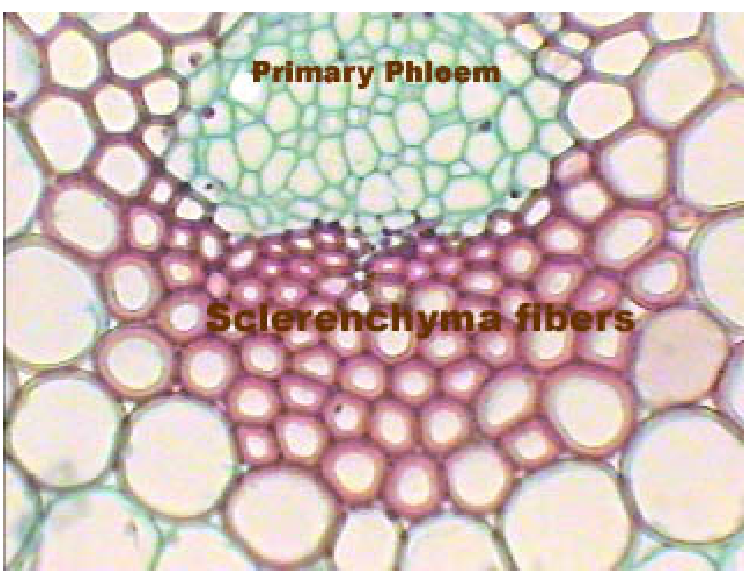
Notice the circular arrangement of the vascular bundles around the outside of the hollow stem. The vascular bundles are surrounded by mature ground tissue composed of parenchyma cells. The vascular bundles are positioned as such that the xylem is more toward the center of the stem and the phloem is more towards the outside of the stem.

Xylem is made from parenchyma cells and is composed of long tubes (vessels) made up of dividing cells called vessel elements. Xylem transports water.

Phloem is made from parenchyma cells and is composed of two types of cells; sieve tubes and companion cells. Phloem transports dissolved food materials.



Ranunculus stem cross section (vascular bundle) 100X



Ranunculus stem cross section (vascular bundle) 400X

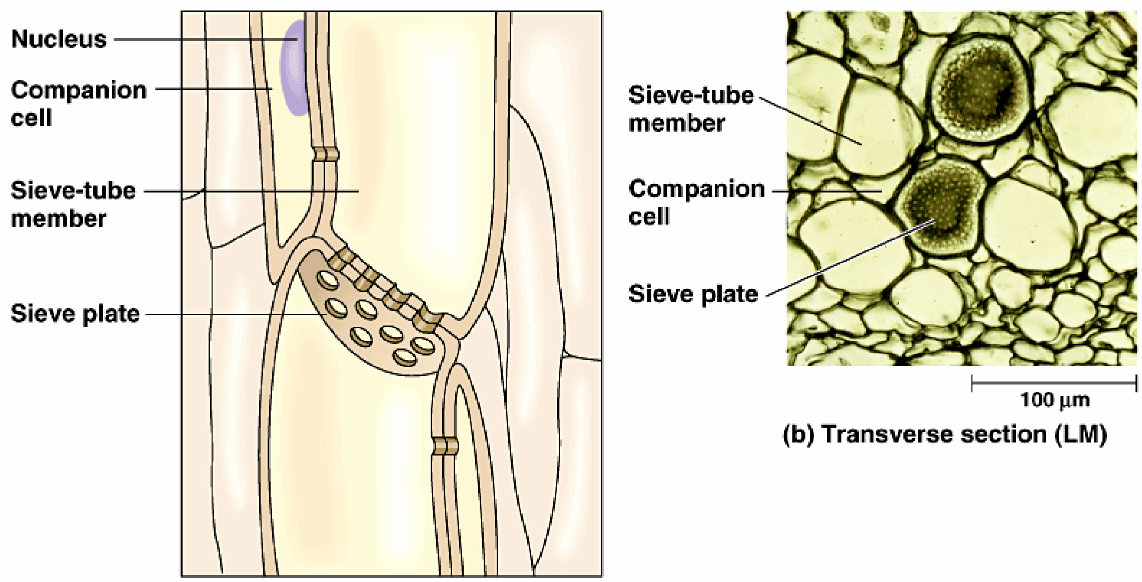
Lab Protocol #3

Find the slide labeled as Ranunculus stem X.S. and identify the structures indicated on the photomicrographs above.

Sieve Tube Members and Companion cells

Phloem tissue is adapted to transport dissolved food material produced by the process of photosynthesis. Phloem tissue is composed of two types of cells. The larger of the two cells are the cylindrical **sieve tube members.** **Companion** cells are found in close association with sieve tube members and are smaller and tapered.

Sieve tube members are laid down end to end to form sieve tubes. The end plates of the sieve tube elements are full of small pores through which the cytoplasm can flow from cell to cell.



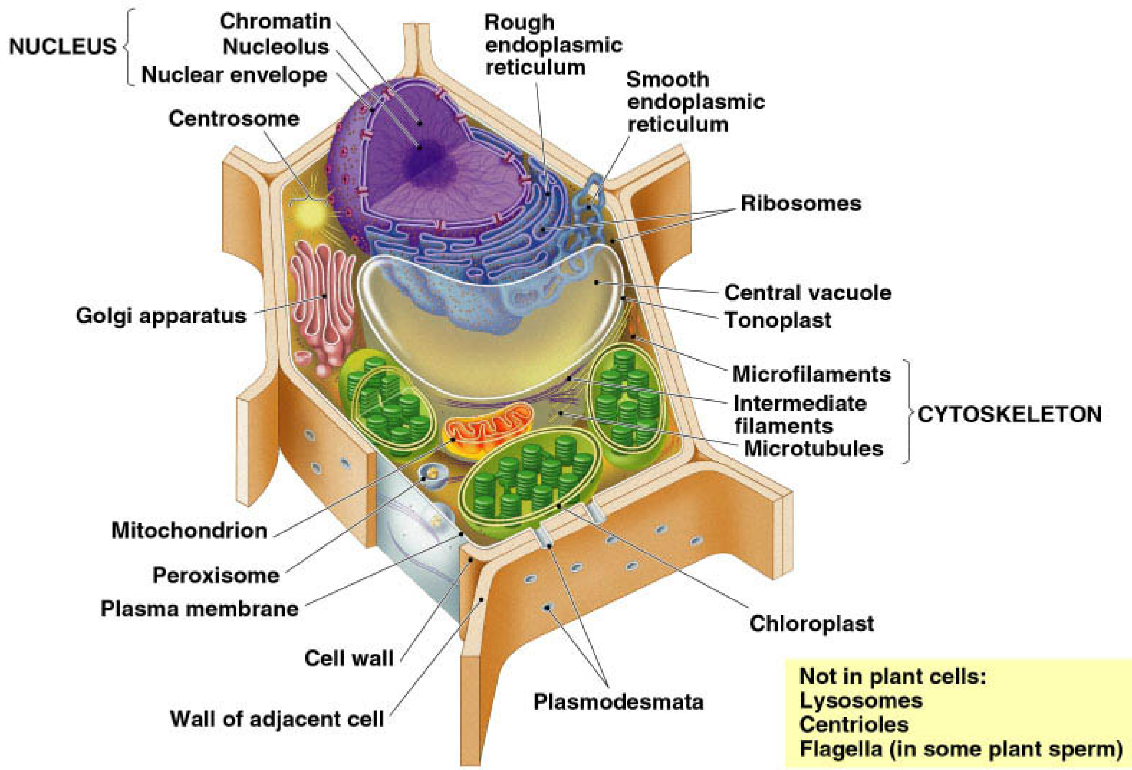
(a) Longitudinal view

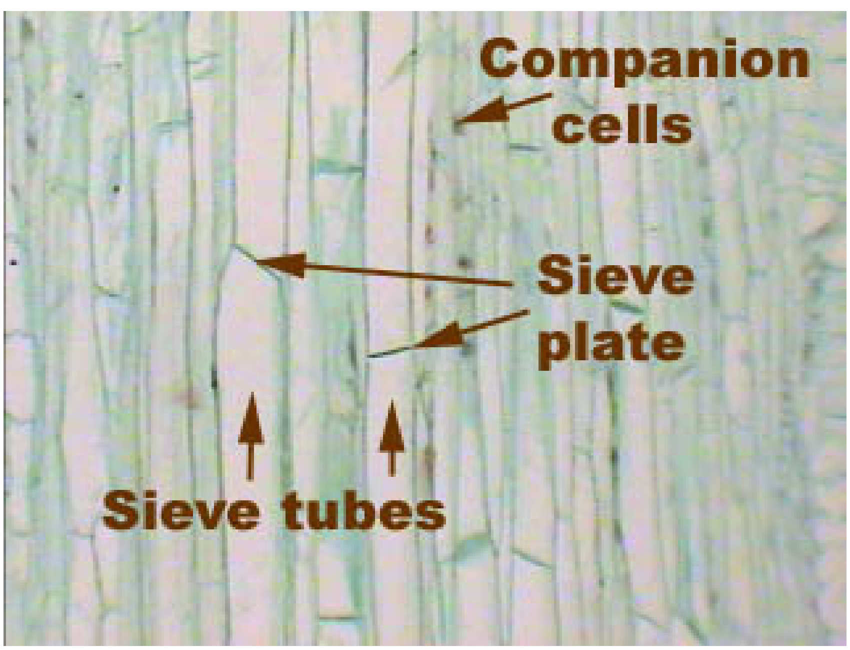
(b) Transverse section (LM)

The diagram above (from your text) illustrates how the sieve tube members are arranged end to end with porous walls (sieve plates) between them. The companion cells can be seen running parallel to the sieve tubes.

Sieve tube elements are still alive at maturity but they lack nuclei and a distinct vacuole. The companion cells are non-conducting. They are connected to the sieve tube elements via plasmodesmata (see the diagram below).

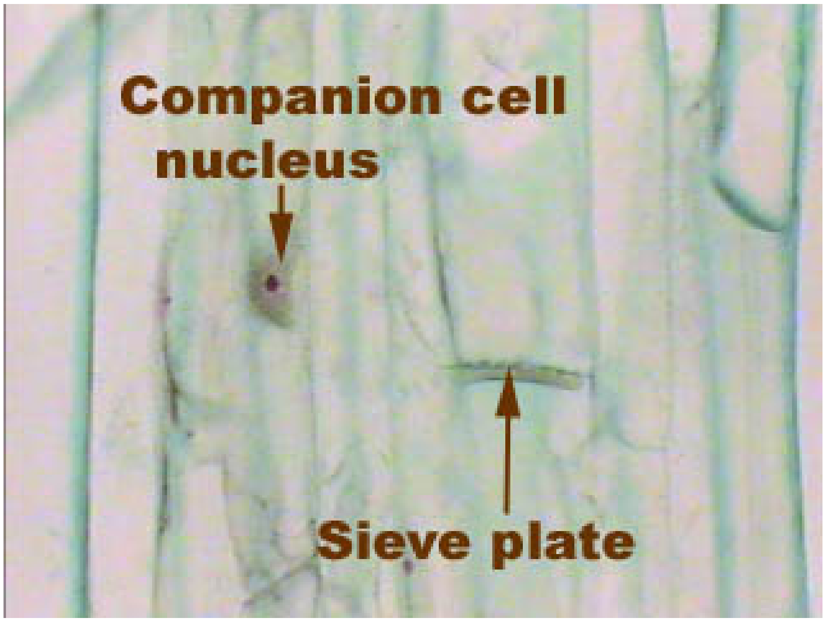
The companion cells have prominent nuclei that may function for both the companion cell and its attached sieve tube element. Companion cells may help load sugar into the sieve tube elements.





Sieve tube elements (40X)

Sieve plates are obvious all over the micrograph above. Remember that the sieve plates are found between the sieve tube elements. Companion cells with their nuclei can be seen adjacent to the sieve tubes.



Sieve plates (l.s.) and companion cell nucleus (100X)

Lab Protocol #4

Find the microscope slide labeled as "Cucurbita stem l.s." and identify the structures indicated on the photomicrographs above.

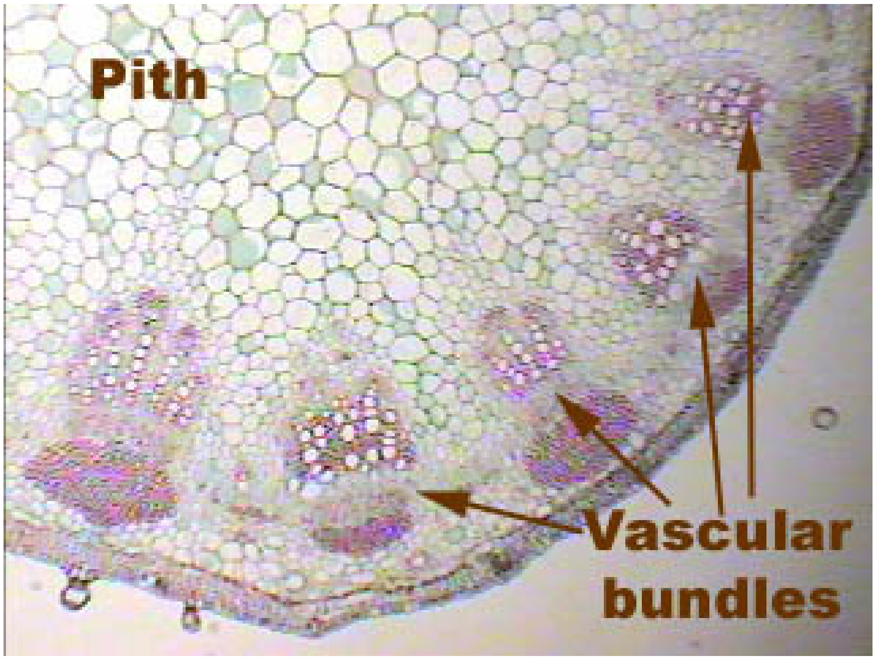
HERBACEOUS STEMS WITH SOME SECONDARY GROWTH

Remember that primary tissue is produced by the apical meristem (i.e epidermis, cortex, primary xylem, and primary phloem). Secondary tissue is produced by the vascular cambium (or the cork cambium). A good example of secondary tissue is all the xylem and phloem found in the trunk of a tree (we will examine this later in this lab). Cell divisions in the vascular cambium result in an increase in diameter of the stem (or root). Those cells produced toward the center of the stem are called **secondary xylem**. Those cells produced toward the outside of the vascular cambium are called **secondary phloem.**

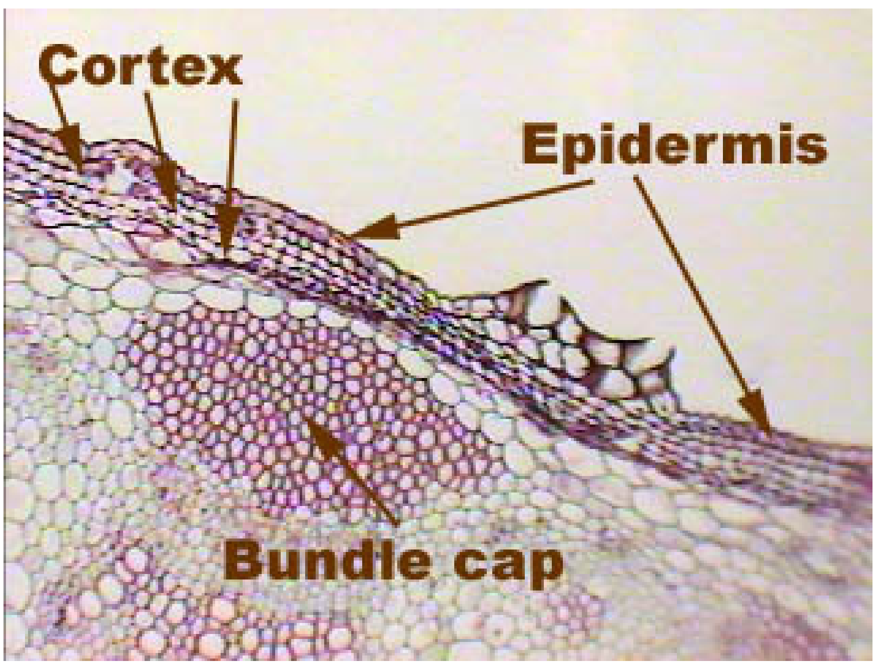
In this portion of the lab we will examine the stem of the sunflower (Helianthus). Recall that we examined this same slide in the first lab of this series to see sclerenchyma tissue. We are going to look for the following primary and secondary tissues:

- Primary Phloem
- Secondary Phloem
- Primary Xylem
- Secondary Xylem
- Vascular cambium
- Pith
- Epidermis
- cortex
- bundle cap
- vessel element.

Look at the sunflower (Helianthus) stem on low magnification and observe how the vascular cambium tissue is arranged in a circular fashion around the outside of the pith, just below the cortex.

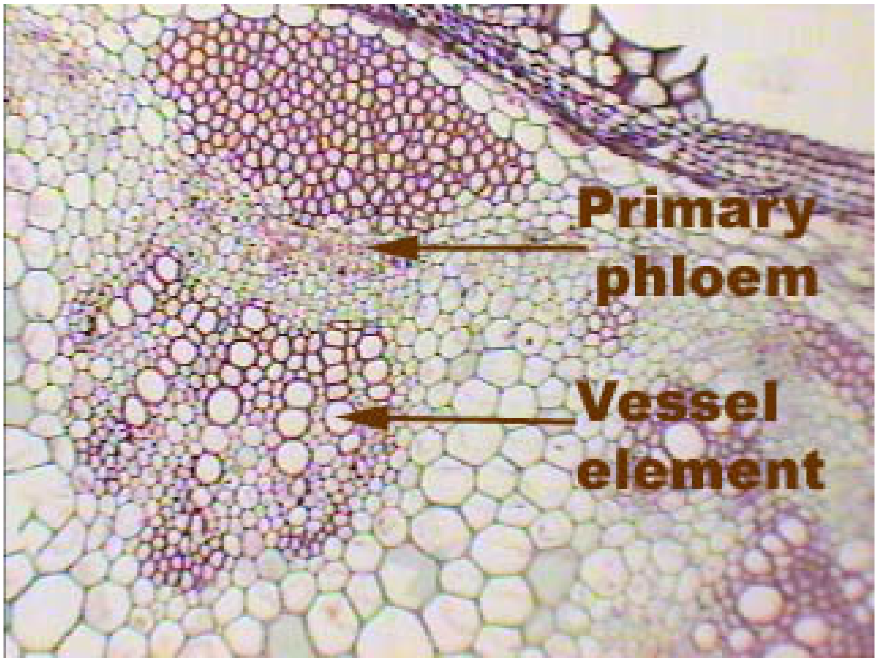


Sunflower (Helianthus) stem (40X)



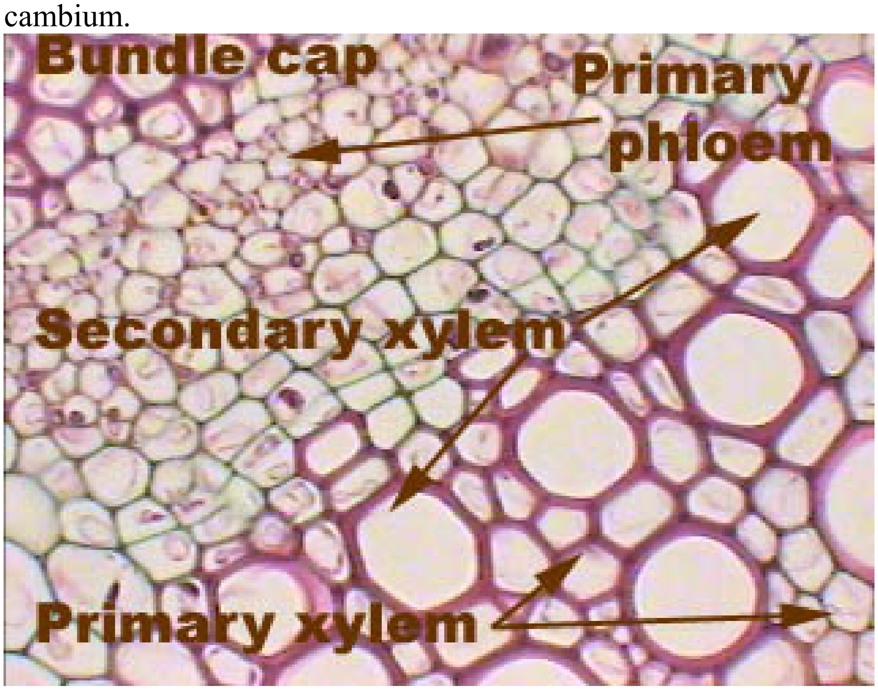
Sunflower (Helianthus) stem (100X) epidermis and cortex

The epidermis is one cell layer thick. Some stomata can be seen on the slide. The group of cells with a red-stain of phloem fibers that make up the **bundle cap**.



Sunflower (Helianthus) stem (100X)

The primary phloem can be seen in the vascular bundle next to the bundle cap. Secondary phloem can not be seen on the slide. Vessel elements (the large red cells) of the primary xylem can be easily seen. Secondary xylem is next to the fascicular cambium.



Sunflower (Helianthus) stem (400X)

Lab Protocol #5

Find the slide labeled as "Helianthus stem c.s." and identify the structures indicated on the photomicrographs above.

WOODY DICOT STEMS

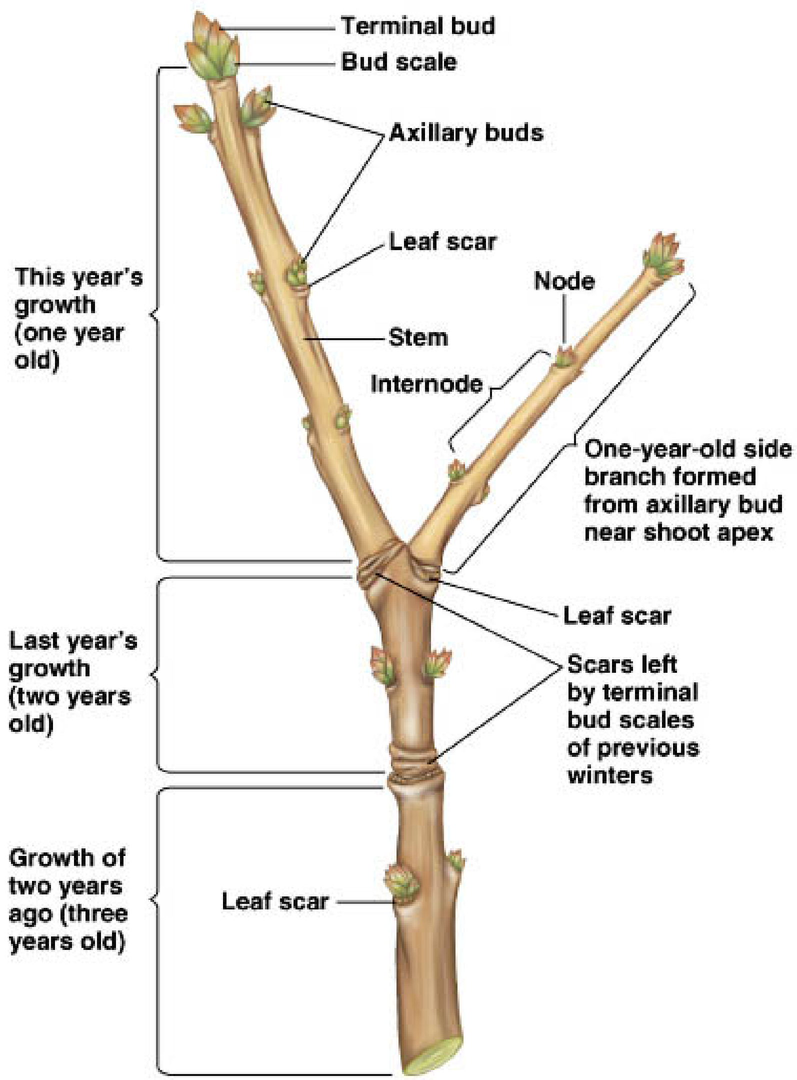
The stems we have examine so far have been herbaceous stems. They were composed mostly of primary tissues that allow the plant to increase its length via growth that originates in the apical meristem.

Woody stems have prominent secondary tissues that allow the plant to grow to increase its diameter. These tissues come from the mitotic activity of the lateral meristems or cambiums. There are two types of cambiums:

(1) Vascular cambium which is a narrow, cylindrical sheath of cells that produces secondary xylem and phloem in stems and roots.

(2) Cork cambium which is a narrow cylindrical sheath of cells between the exterior of a woody stem and the central vascular tissue. It produces cork to its exterior and phelloderm to its interior.

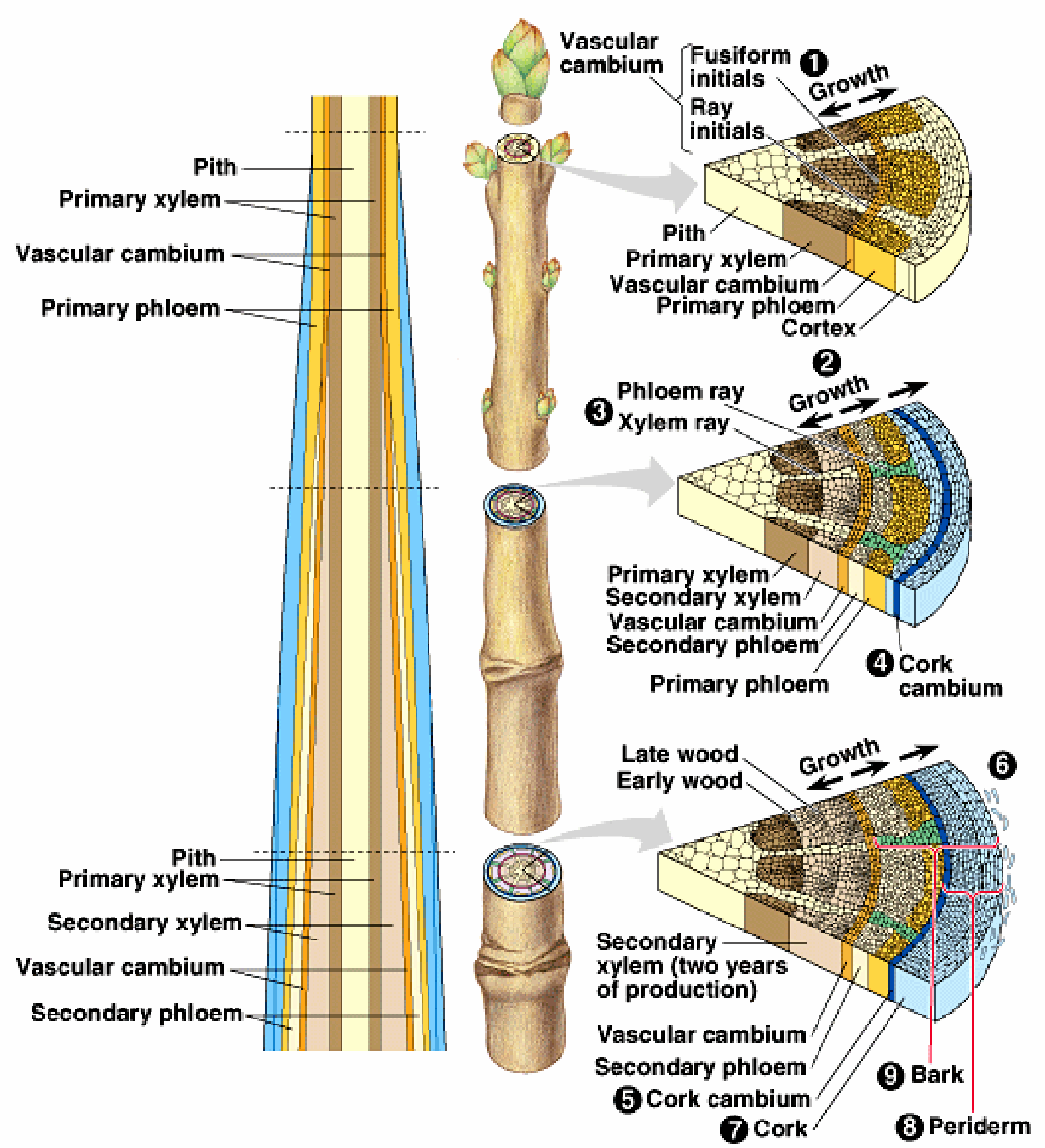
External features of woody stems

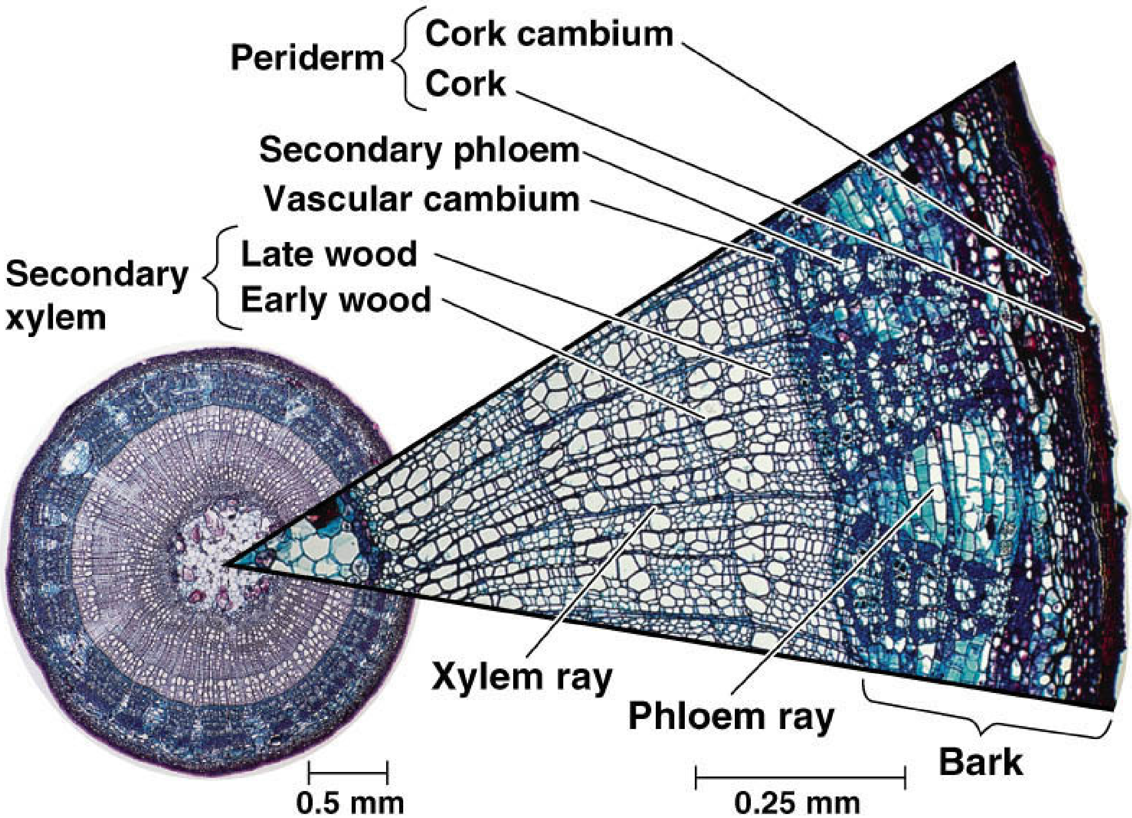


Lab Protocol #6

On horse chestnut twigs provided in lab identify as many of the external twig structures that are possible.

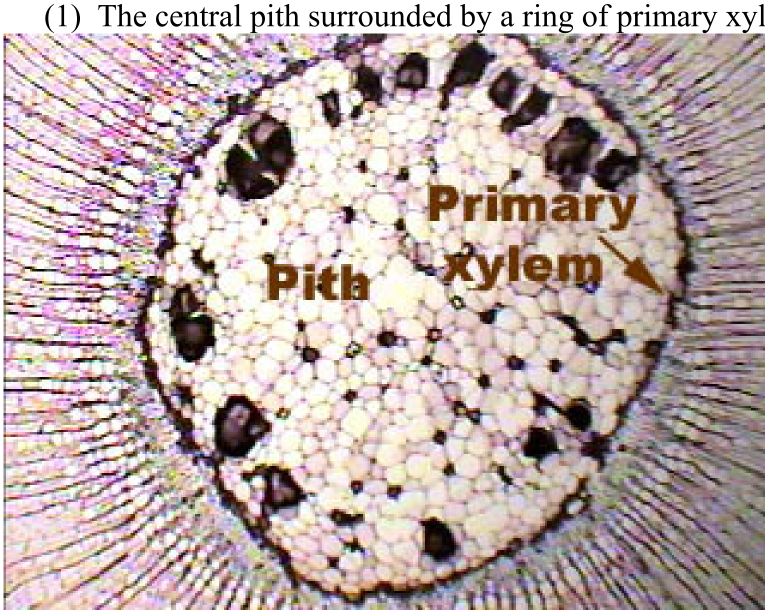
Internal Anatomy of a Woody Twig





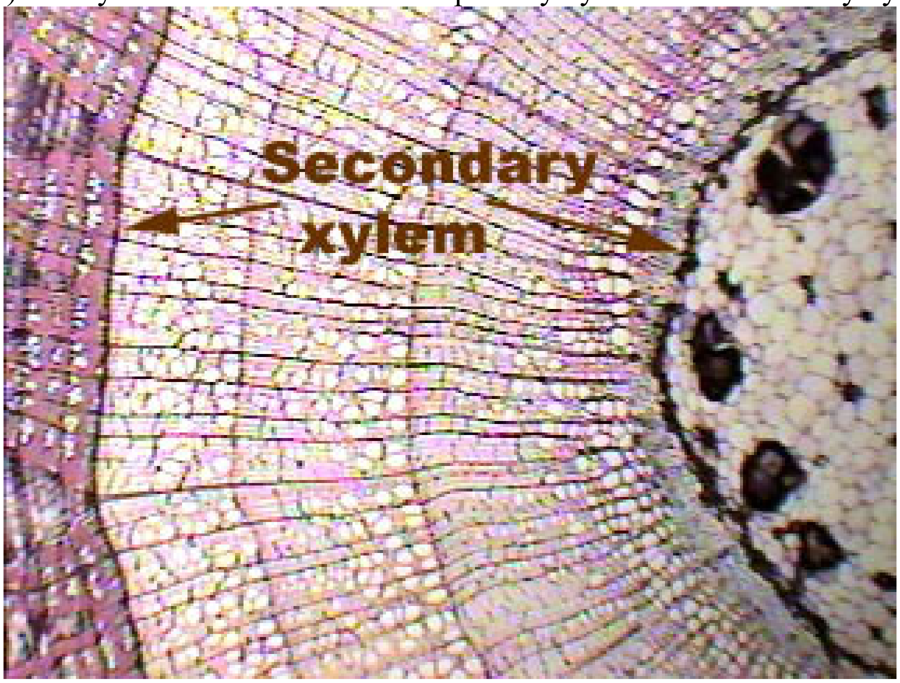
Working from the center of the stem outward you should observe:

(1) The central pith surrounded by a ring of primary xylem.



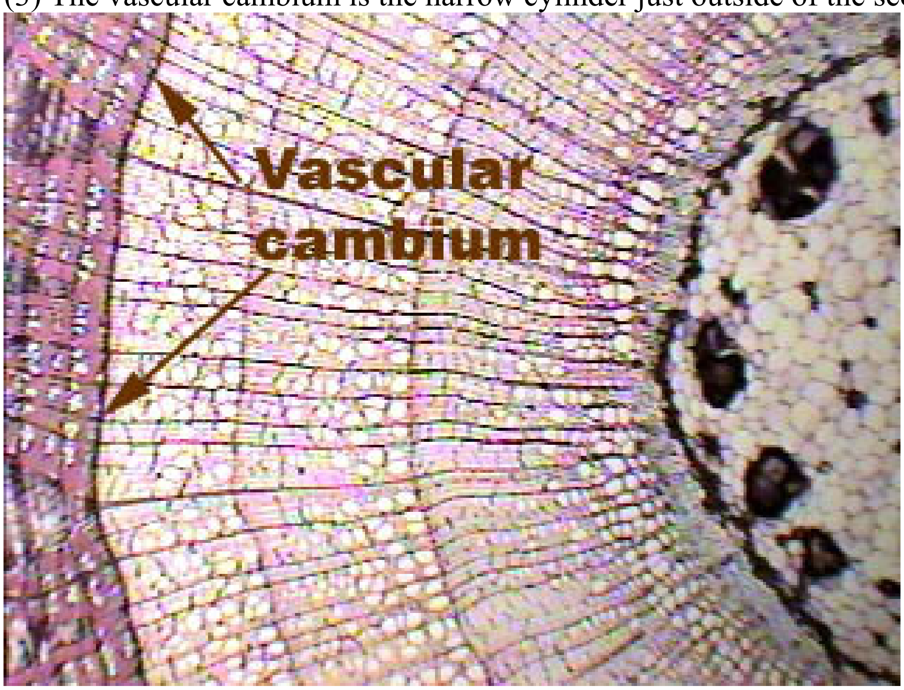
Basswood (Tilia) stem (40X)

(2) The cylinder of tissue next to the primary xylem is the secondary xylem.



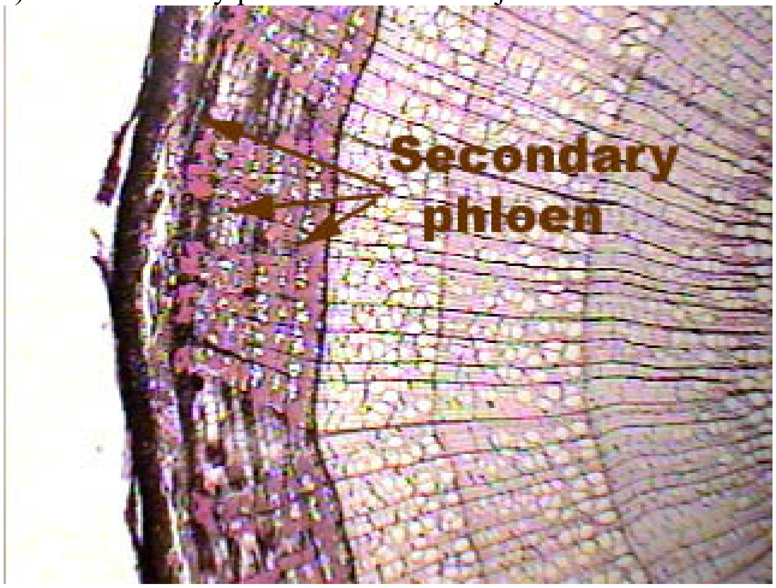
Basswood (Tilia) secondary xylem (40X)

(3) The vascular cambium is the narrow cylinder just outside of the secondary xylem.



Basswood (Tilia) vascular cambium (40X)

(4) The secondary phloem can be seen just outside of the vascular cambium.

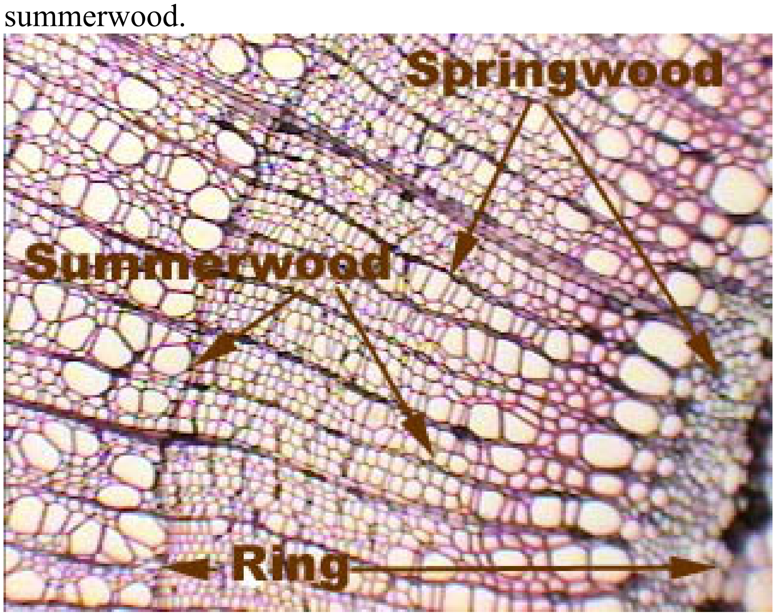


Basswood (Tilia) secondary phloem (40X)

(5) The primary phloem is at the outermost part of the phloem tissue and is hard to differentiate from the secondary phloem.

(6) The cortex lies outside of the phloem.

Examine the secondary xylem in more detail. Look for the annual rings. Each ring contains both springwood and summerwood. Springwood has larger cells than summerwood.



Basswood (Tilia) annual rings (100X)

Lab Protocol #7

Find the microscope slides labeled "Tilia stem c.s." and identify the structures indicated on the photomicrographs above.