Topic 13. Cells and Tissues of the Plant Body

I. Identifying Tissue and Cell Types in Cross Sections of Eudicot Stems

Introduction: In this exercise you will make observations of various tissues and cells found in the stem of herbaceous eudicots: specifically a freehand section of *Coleus* stem, and the stained cross section of *Medicago* (Alfalfa) stem on a prepared slide. There are labelled images of these in our computer bank of images which your TAs can use to assist you. Further these same images are available on the course page for review.

Making a make freehand section of *Coleus*:

Coleus plants are available on each student bench. Cut pieces of stem should be placed in the bowls of water on each student bench for others to use. Before cutting into the stem, rub it between your fingers. Notice the square shape of the stem. This is a characteristic of all members of the Lamiaceae (the mint family).

There are several techniques that you may use to make a thin sections for wet mounts. You may consult with your TA about how to proceed, but whatever method used requires care and common sense. You should use stainless steel razor blades, available on each bench, which are sharper than your standard blade. If someone at your table has the knack for making good sections, have that person share with others.

Preliminary Observations: After preparing a wet mount, observe the cross section with your 4x objective. The stem is made up of three different tissue systems. Please identify these in turn:

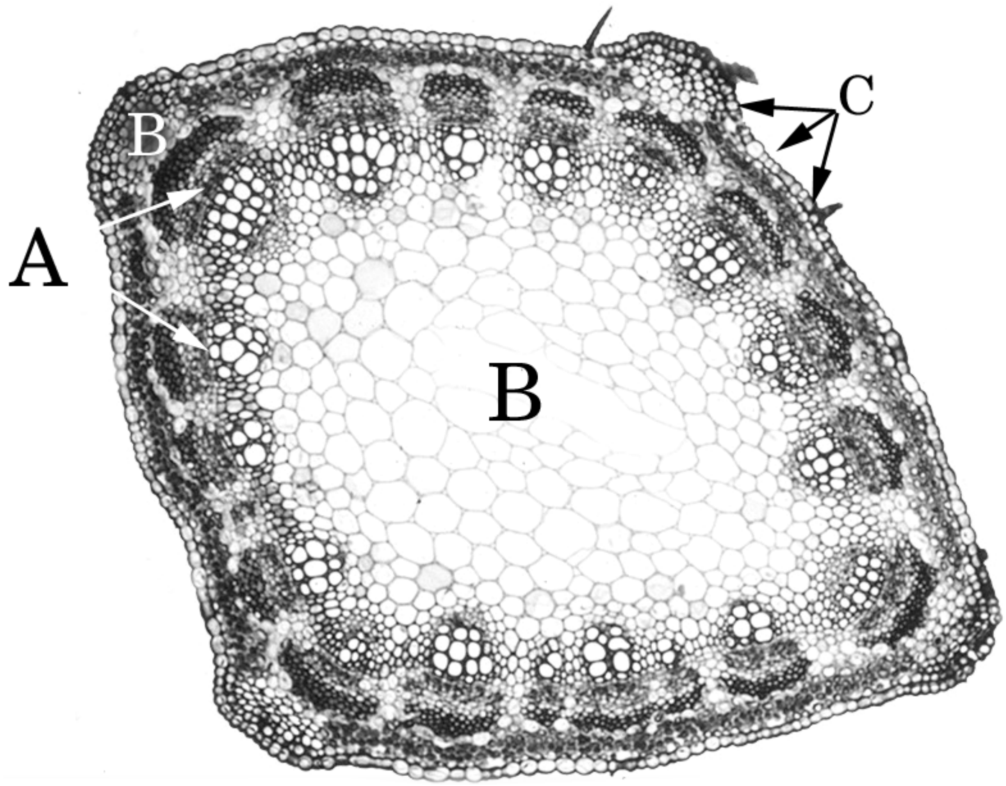
The **dermal tissue system** consists of the outer layer of cells of the stem. These cells make up the epidermis. Note the obvious hairs which are **trichomes**.

The **vascular tissue system** is represented by vascular bundles embedded in the ground tissue. These are arranged in a circular pattern as seen in cross section.

The **ground tissue system** consists of everything enclosed by the epidermis except the vascular bundles. The arrangement of the vascular tissues divides the ground tissue into two regions: the **pith** and the **cortex**.

After a preliminary overview of your free hand section of a *Coleus* stem, **switch to a prepared slide of *Medicago*** and again identify these three tissue systems.

Identify the Three Tissue Systems



A = ______

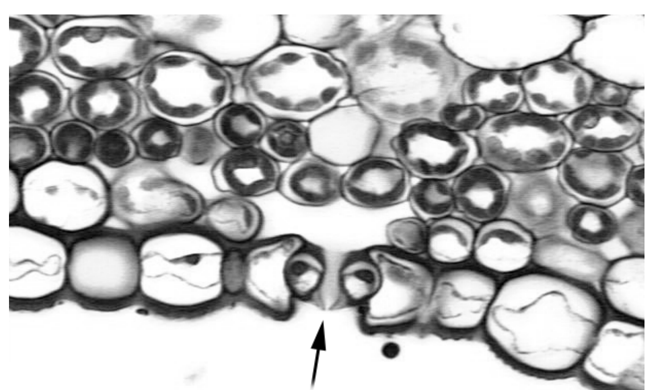
B = ______

C = ______

Cross section of *Medicago* Stem

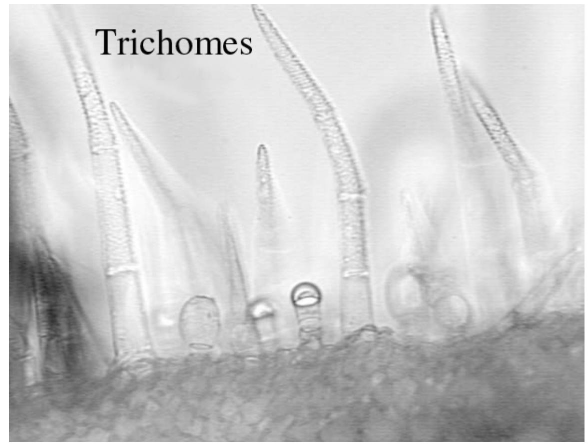
Ia. The Epidermis: The epidermis functions to control the loss of water from the plant. It accomplishes this primarily through the excretion of a waxy layer called the cuticle. Like a sheet of wax paper, the cuticle limits the passage of water. In doing this it also blocks the passage of gasses between the plant and its environment. To keep the tissues from suffocating, the epidermis must have openings. These openings are called stomata (singular = stoma).

Stomata: Stomata are not easily seen in a freehand section, hence, look for these using the *Medicago* cross section. First identify large intercellular spaces directly below an area of epidermis using low power. These are substomatal chambers and they are positioned directly below each stoma. Switch to 400x and observe the stoma and its two guard cells. The level of turgor of these two cells serves to open and close the stoma controlling the movement of gasses and water into and out of the underlaying tissue.



Stoma with Guard Cells

Trichomes: Another way the epidermis limits the plant's loss of water is through the growth of hairs called trichomes. Switch back to your section of *Coleus* and observe these hairs projecting from the epidermis. Can you think of any other adaptive function of trichomes?



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Function of the Guard Cells

Guard cells must react to environmental conditions. It is adaptive for stomata to open in the light during times when the plant is not water stressed. It is generally maladaptive for the stomata to be open at other times. The closing of a stoma by its guard cells is ultimately a phenomenon of osmosis, and mechanisms exist to translate environmental conditions to the turgor pressure of the guard cells. In the following exercise, we will demonstrate the relationship between the turgor pressure of the guard cells and their closure.

Procedure: Work in pairs. Set aside your section of *Coleus* stem and prepared slide of *Medicago* for use next section.

1. Make an epidermal peel from the lower surface of a *Setcreasea* leaf. Mount the peel in pure water and cover with a coverslip. Avoid trapping air bubbles under your wet mount!

2. Scan your slide to find an area with few air bubbles and with open stomata.

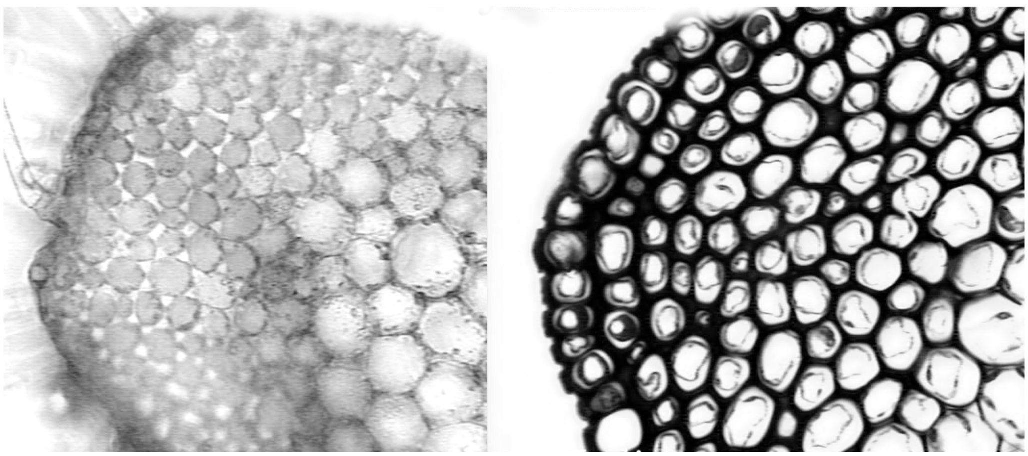
3. Switch to high power. Draw an open stoma including guard cells and subsidiary cells.

4. While viewing an open stoma, place a large drop of 10% solution of NaCl next to one side of your coverslip. On the other slide, place a piece of tissue to wick up the the salt solution under the coverslip. Observe any changes. Make all drawings of the stomata below.

Ib. Ground Tissue

<u>Collenchyma in the Cortex</u>

Retrieve your section of *Coleus* stem. Place it on the stage of your microscope and carefully observe the cells of the cortex at the corners of the stem. These regions of the ground tissue are made up of **collenchyma** tissue. Collenchyma has thickened primary walls. Primary walls are elastic and collenchyma provides static resistance to turgor pressure. This balance of forces in herbaceous stems and leaves provides support. Switch to your *Medicago* slide. This stem also has collenchyma positioned at the ribs. Note, however, that the cells are dehydrated and this makes their walls are uniformly thick. Collenchyma is both a cell type and a type of tissue consisting of collenchyma cells.



Collenchyma Tissue

Coleus (living) — *Medicago* (prepared slide)

<u>Collenchyma in the Petioles of Celery</u>

The strands that can be peeled from celery are made of collenchyma tissue. Get a piece of celery from the sealed container. You may eat this tissue, but before you do, break a piece of it and peel out these stands. Note that they are elastic.

Make a cross section of a celery petiole from the open bowl and make a wet mount to observe this collenchyma tissue.

Draw collenchyma and parenchyma cells at a boundary between the two tissue types.

Parenchyma of the Pith

Using your *Coleus* section observe the **pith** (the region of the ground tissue inside the ring of vascular bundles). In *Coleus*, this region is composed entirely of parenchyma tissue consisting of **parenchyma cells**. Parenchyma is both a cell type and a tissue type made up of parenchyma cells. Unlike collenchyma, parenchyma cells have uniformly thin primary walls.

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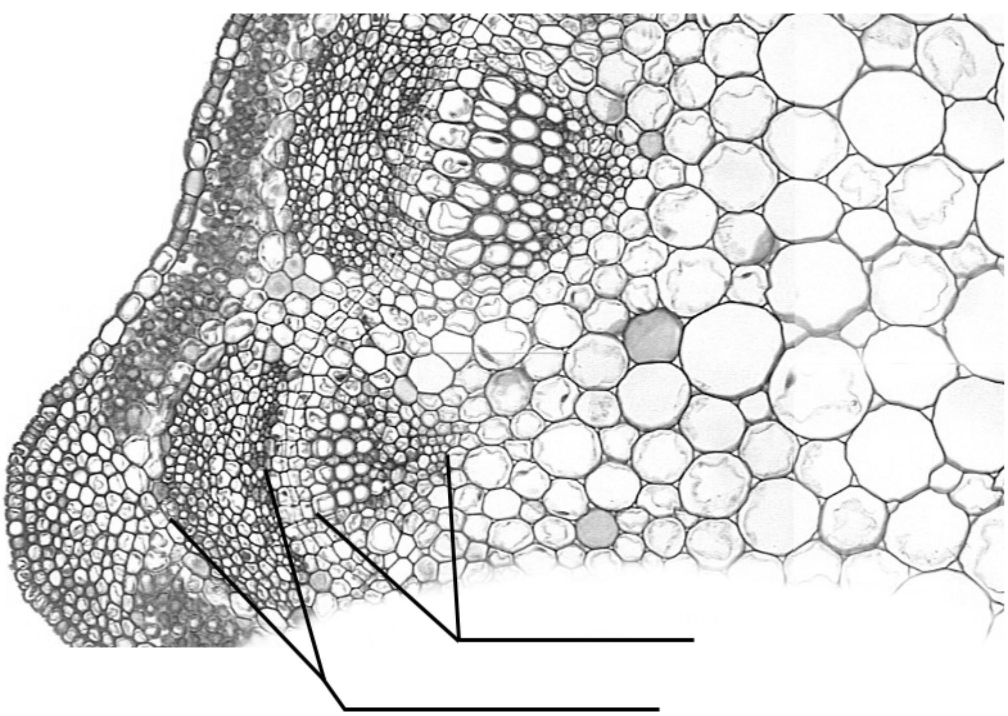
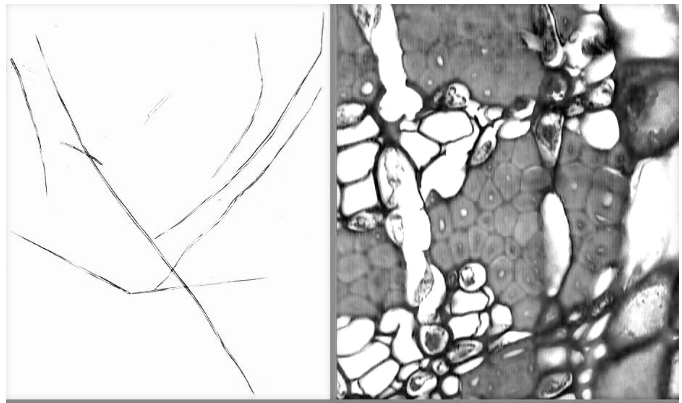
Ic. Vascular Tissue: Switch to the slide of *Medicago* stem. Vascular tissue includes **xylem** and **phloem** both of which are complex tissues: that is they each consist of more than one cell type. In these stems, **xylem** occupies the region of each vascular bundle facing the pith. The prominent cells in the xylem are **vessel elements**. These are large dead cells with red-stained secondary walls. Vessel elements function as pipes through which water moves by mass flow. These are surrounded by **parenchyma cells** which are also part of the xylem tissue. The **phloem** is positioned towards the cortex. The phloem includes **sieve-tube elements**, **companion cells**, **parenchyma cells**, and **fibers**. Identify as many cell types as you can.

Label the figure - include xylem and phloem; use you own arrows to label epidermis, pith, cortex, and collenchyma.



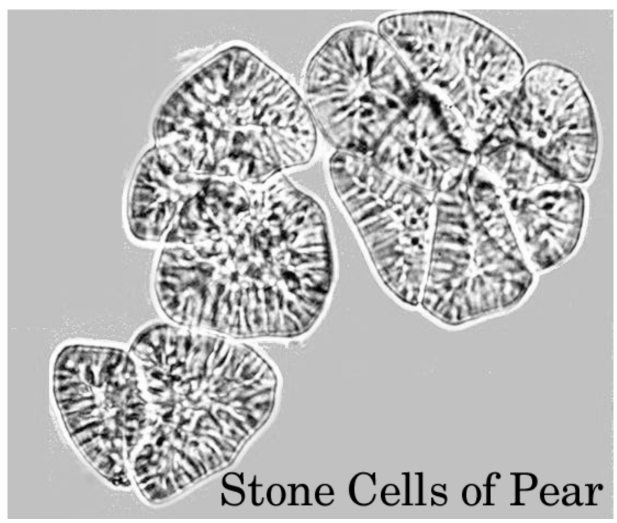
II. Sclerenchyma Cells.



Macerated Bark | Cross Section of Bark

IIa. Fibers: Observe the two views of fiber cells at the demonstration bench. One microscope has a prepared slide of a woody *Tilia* stem. Fibers on this slide can be seen in cross section in the bark. Note their thick secondary walls. Compare this view with that of the second microscope. with a slide of macerated *Tilia* bark. Here the fibers have been physically disassociated from the bark and can be seen on their side. Note their length. Fibers are like cables, and lend strength to plant tissues.

IIb. Sclereids (stone cells): Stone cells have an irregular shape like a pebble with massive secondary walls. Observe the preparation on the third microscope of the macerated pear flesh. The cells have simple pits which are also forked. Stone cells give pear fruit its gritty texture.



Stone Cells of Pear

III. Cell Types of the Vascular Tissue System.

Take a prepared slide of *Cucurbita* stem and examine it by holding it up to the light. Note that there is both a cross section and longitudinal section on the slide. Now observe the slide under your microscope.

IIIa. The Xylem

Cross Section: Survey the cross section of the stem at 40x. Note the ring of vascular bundles arranged around a hollow pith. Observe a vascular bundle at 100x. Note the huge empty cells with the red-stained secondary walls. These are vessel elements. The xylem tissue is made up of vessel elements together with the parenchyma cells around them.

Longitudinal Section: Move your stage to view the stem in longitudinal section. <u>Note</u>, because of the hollow pith, the section is divided in two. In this view, vessels can be seen as continuous tubes running longitudinally through the stem. The most prominent vessels are those with continuous, **pitted secondary walls**. These differentiated from procambium after elongation of the growing stem ended and are called **metaxylem vessel elements**. If you look carefully you should also see vessels with incomplete secondary walls. The secondary walls here consist of either hoops or spirals. These are **protoxylem vessel elements**. **Protoxylem** differentiates while elongation is occurring. The incomplete secondary walls inside the primary walls prevents the vessel from collapsing, while allowing it to be stretched without ripping. Protoxylem vessels with hoops are said to have **annular thickenings**. Those with spirals are said to have **helical thickenings**. See each type (pitted, annular and helical) through the demonstration scopes on the demonstration bench.

IIIb. The Phloem

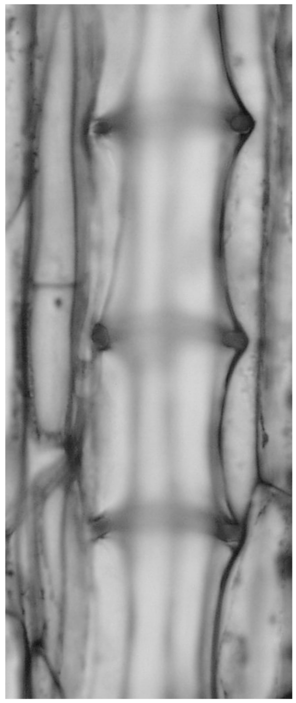
Cross Section: Look again at a vascular bundle in cross section. Note that in *Cucurbita,* phloem lies both to the inside and outside of the xylem. Carefully search the area of the phloem for views of **sieve-tube elements** with a **sieve plate**. Locating a sieve plate is the surest way of identifying this cell type. Once you locate a sieve tube element note its size relative to the other cells. Also note that, in *Cucurbita*, these cells have primary walls that seem thicker than that of their neighbors. If you have difficulty locating a sieve tube element after three minutes ask your TA for help. The smaller cells with the dense cytoplasm associated with the sieve tube elements are **companion cells**. *Cucurbita* phloem includes not only sieve tube elements and companion cells, but also parenchyma cells.

Longitudinal Section: Switch back to the longitudinal section of this stem. Phloem tissue is adjacent the xylem. Note the arrangement of the sieve tube elements. These are stacked directly one on the other to form a continuous structure, the **sieve tube**. Look for sieve plates at the junctures the cells to confirm their identity. Also look for companion cells in this section.

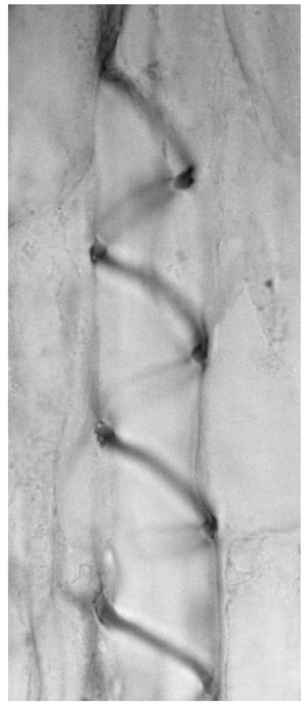
Observe and label the figures on the next two pages.

Cucurbita: Longitudinal Sections of Vascular Tissue

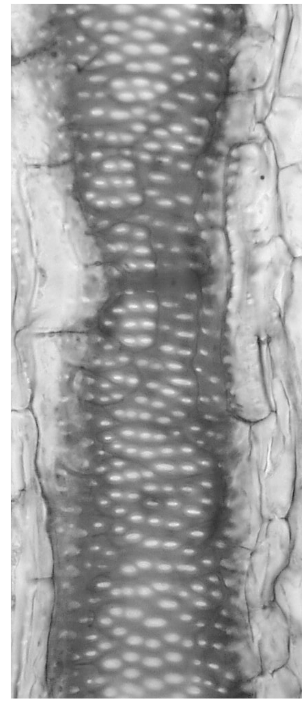
Vessels in the Xylem



Annular Secondary Wall Thickenings

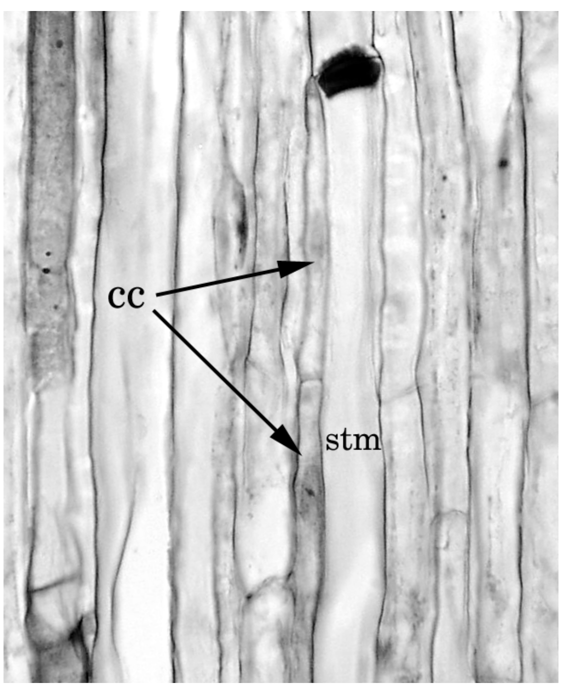


Helical Secondary Wall Thickenings

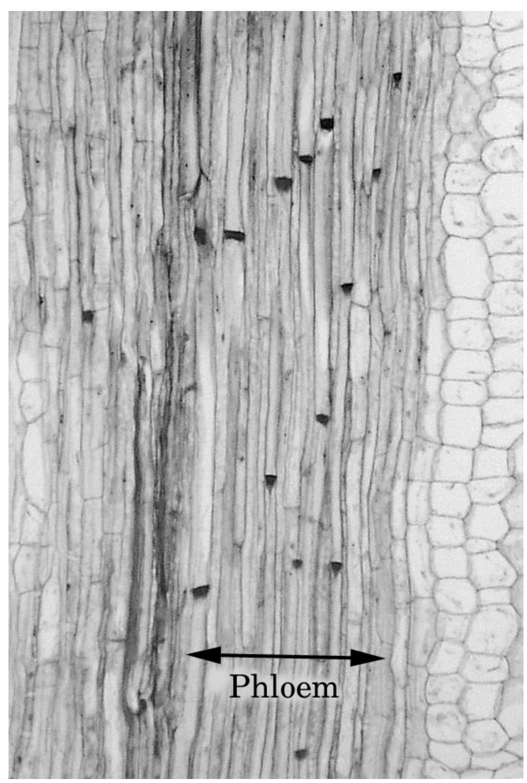


Pitted Secondary Wall Thickenings

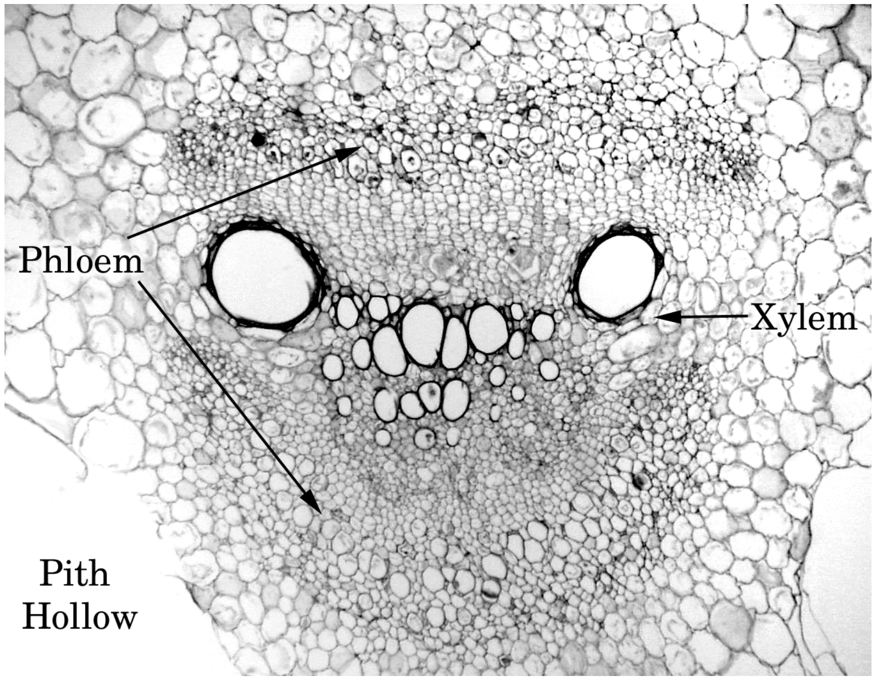
Phloem Tissue

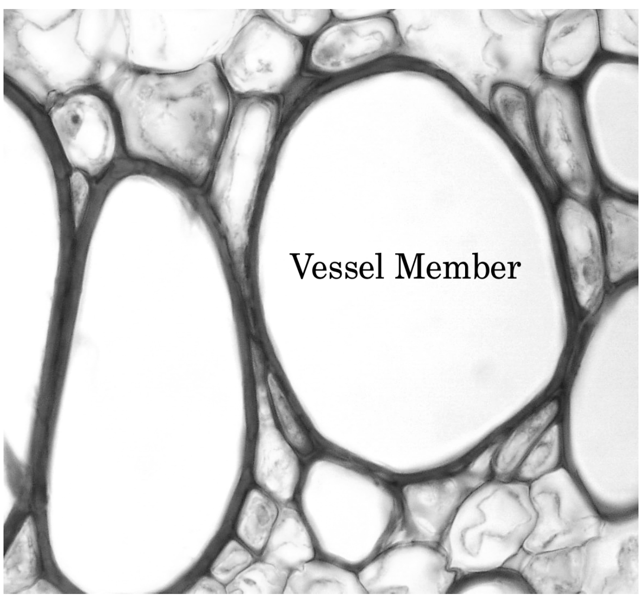


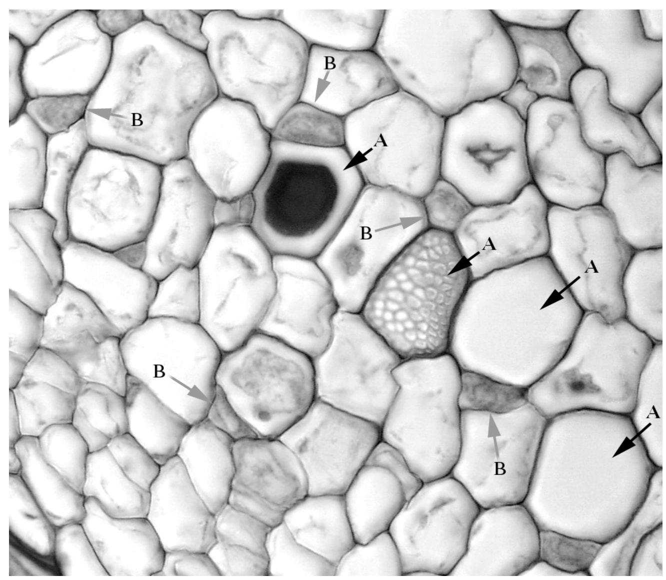
cc = companion cells
stm = sieve tube element



Cucurbita: Cross Sections of Vascular Tissue







Xylem

Phloem:

A = _______________

B = _______________

IV. Function of Vascular Tissues

IVa. Movement of Water Through the Xylem

In xylem, water moves through tracheary elements which are dead at maturity. Earlier in the period, your TA placed a shoot of *Coleus* into a dye solution containing a poisonous salt, $CuSO_4$. The copper ions have killed all cells contacted and the dye will stain the areas to which the water is drawn demonstrating that the movement of water does not require living cells.

Procedure: Work in a group, three groups per section. You will work in this same group during future labs.

Take the shoot at your table and determine if the dye was drawn up the stem and how far. Then make a cross section of the stem stained with the dye and determine in what tissue the dye is located. Record the distance the dye moved up the stem. Also record the results from the other two tables.

One group will study a shoot placed in moving air (from a fan); another will a shoot exposed to ambient room conditions, and the third will evaluate a shoot covered with a plastic bag. Circle how your stem was treated:

Your stem was - in Moving Air   in Ambient Air   Was Covered

Did the dye move up the stem ? ___________________________

If so, how far?   ______________________

In what tissue did you view the dye in your cross section?

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Record your observations and those of your classmates in the table below.

Distance the Stain Moved up Each Stem

Moving Air	Ambient Air	Covered

Explain the differences in the rate of movement, if any, among the three conditions. ______________________________________

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IVb. Movement through the phloem

The most widely accepted theory to explain the movement of photosynthate from source to sink (often from leaf to root) is the pressure flow hypothesis. By this idea, substances move through the sieve-tube elements along a pressure gradient generated osmotically. This is created by the active transport of sucrose into the phloem at the source and by its active export out at the sink. The loading and unloading of sucrose results in the osmotic movement of water into the phloem at the source and out of the phloem at the sink. For this mechanism to work, an area bounded by living membranes is necessary, hence, sieve elements must be alive to function.

If the pressure flow hypothesis is true would you expect the pressure in the phloem at the hypocotyl of a squash seeding to be (check one):

At ambient (air) pressure __________

Less than ambient pressure __________

Greater than ambient pressure __________

In this activity we will see which is correct.

Procedure:

- Work in pairs.

- On the side bench is a flat of squash seedlings with a cylinder of alcohol in front of the flat. While both you and your partner are observing, quickly cut off the shoot at the ground level, and place the cut stump into the alcohol and observe the emersed stump. What do you observe?

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Make a second cut above the first, and again place the stump into the alcohol.

What do you observe?

Based on your observations, is the phloem under pressure relative to air in the room?

Discuss your observations with your TA.

Notes: