

## Plant Cells, Tissues, & Meristems

(Photo Atlas: Figures 1.3, 1.5, 1.6, 1.11, 1.13, 1.16, 1.17, 1.21, 1.22, 1.23 1.29)

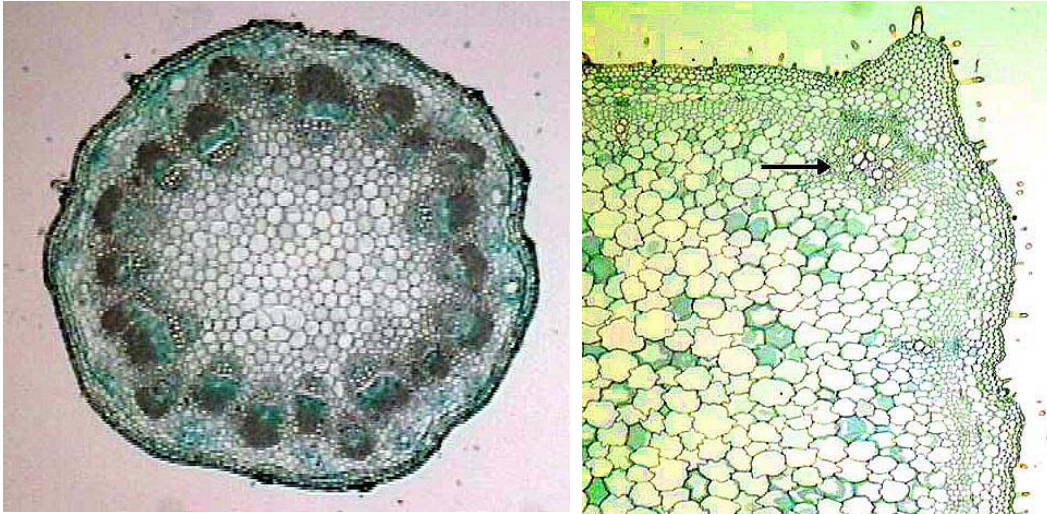


Figure 1. Plant cross-sections depicting various tissue and cell types.

### A. Introduction to Plant Cells

Cells are the structural and functional units of living organisms. The plant cell has essentially everything that an animal cell does AND MORE.

Namely, plants are distinguished by their 1) cellulosic cell walls external to the living protoplast, 2) plastids (which can be chloroplasts, amyloplasts or leucoplasts, and chromoplasts), 3) large central vacuole, and 4) intercellular cytoplasmic connections called plasmodesmata.

The following is a more comprehensive list of the cellular structures (including organelles) that you will find in plant cells.

**NUCLEUS** – houses the chromosomes and is bound by a double membrane.

**CHLOROPLAST** – plastid, site of photosynthesis and is bound by a double membrane.

**CHROMOPLAST** – type of plastid containing carotenoid pigments, no chlorophyll.

**AMYLOPLAST** – type of plastid with no pigments, stores starch.

**MITOCHONDRIA** – double-membrane-bound organelle, site of respiration.

**VACUOLE** – large membrane-(tonoplast)-bound structure; stores water, chemicals, etc.

**CELL WALL** – relatively permeable, non-living barrier constraining the protoplast.

**ENDOPLASMIC RETICULUM** – complex membrane systems throughout protoplast.

**GOLGI APPARATUS** – site of protein processing; part of the endomembrane system.

**PEROXISOME** – small organelle with roles in photorespiration and lipid catabolism.

**PLASMODESMATA** – intercellular, cytoplasmic connections channels through cell walls that connect plant cell symplast.

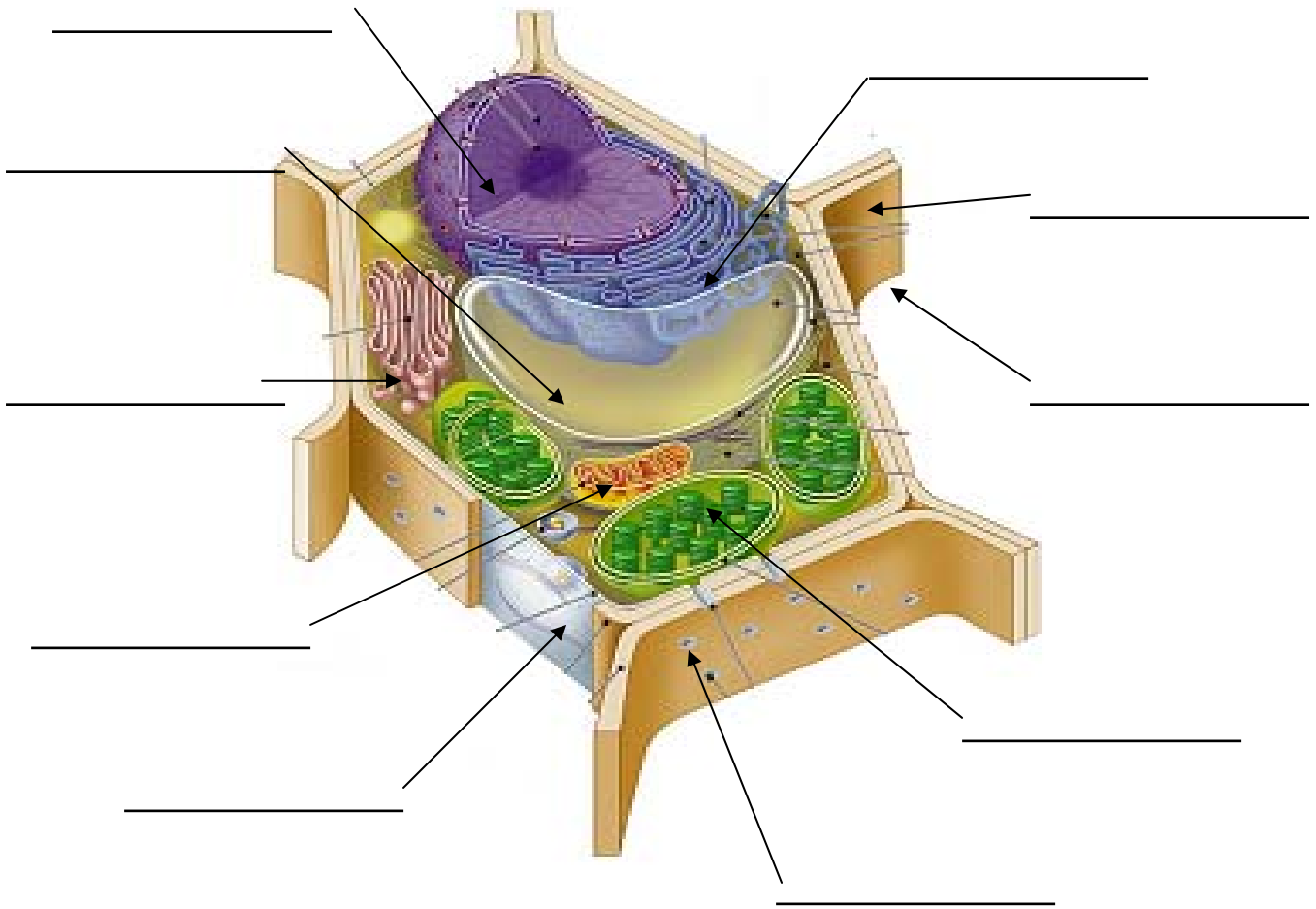


Figure 2. Identify the indicated structures of the plant cell in the figure below. Try to name all of the structures based on what you observed in lab and the descriptions given before referring to the Photo Atlas (pg. 4), the text, or the various lab poster aids available.

## **B. Investigation of Plant Cells**

### **1. Nucleus and cell wall: Onion, yellow or white**

Prepare a wet mount of a living (fleshy) onion bulb epidermis (often referred to as an onion peel). Take a length of onion tissue and snap it in half and without tearing the outer (abaxial) epidermis, pull one half toward you and push one half of the onion away from you. You will see a thin, one-celled layer of epidermal tissue pulling away from the onion tissue. Place it in a drop of water on a slide, cut off any remaining portion of the onion tissue and cover with a cover slip.

*Identify the cell wall boundaries and the presence of a nucleus. Can you see nucleoli? The partitions separating the cells are the cell walls of adjacent cells. Although they look separate, they are connected via small plasmodesmata.*

Stain the tissue with  $I_2KI$  to darken the nuclei by adding a drop to one side of the coverslip and placing a paper towel on the other side of the coverslip. The  $I_2KI$  will then wick in under the coverslip and into the tissue.

*Draw several cells with nuclei. Can you see any other organelles present?*

## **2. Chloroplast: Elodea**

Prepare a wet mount of an Elodea leaf by removing a single leaf from near the shoot tip and placing it in a drop of water on a slide. Cover it with a coverslip. Avoid the presence of a large air bubble on or next to the leaf by adding more water if needed. Draw a region with several cells and make the following observations (also include the mentioned organelles in your drawing):

*Using the fine focus, determine how many cell layers are present (Hint, as you move the objective up or down, the top, middle and bottom regions of the cell will come into focus).*

*Can you identify the chloroplasts? What is their general shape and color? How are they organized?*

*Can you detect any cytoplasmic streaming? Try to determine what “cytoplasmic streaming” means and what its function may be. Examine the entire leaf until you can detect the cytoplasmic streaming. Does the streaming appear orderly or random?*

*Identify the mitochondria. They are about 10X smaller than the chloroplasts. They appear to be in constant motion. How does this motion compare to the streaming? This is called Brownian Motion.*

*Can you identify the nucleus?*

### **3. Vacuole: Beet or Red Onion**

Prepare a wet mount of the beet root or red onion bulb. The red onion can be prepared as described for the onion in the first section. To prepare the beet, use a razor blade to cut a very thin section. You should be able to see light through it. The section should be as close to paper thin as possible. Too large and the coverslip will not lay right. Make your observations near the edge of the tissue slice where you are more likely to encounter a 1-2 cell thick layer. Make the following observations, and draw your observations:

*Are the cells clear or colored? The water-soluble pigment is in the cells' large central vacuole.*

*Notice the size of the vacuole relative to the cell wall. How much of the cell does the vacuole occupy?*

*What organelles can you identify in this tissue?*

### **4. Chromoplasts: red pepper (intact); carrot (pigment bodies)**

Prepare a paper thin wet mounts of red pepper and carrot for comparison (internal tissues, not an epidermis). Keep in mind that the thinner the tissue, the better success you will have in seeing the cells. Ask your instructor for assistance if needed. Draw several cells of each and make the following observations:

*Do you see any pigmentation in the cells?*

*Where do you see the pigmentation (i.e. is it contained in a structure or not)?*

*How do the carrot and red pepper cells compare to each other?*

*How do they compare to the beet or red onion cells?*

*Do the chromoplasts have a general shape?*

## 5. Amyloplasts: Potato

Prepare a paper thin wet mount from the **potato** avoiding the skin. Again avoid the tissue being too thick or the coverslip will not lay correct and you may damage the objective lens. Notice that the freshly cut potato extrudes a milky substance. We will look at that later. Prepare drawings of several cells from the potato illustrating the structure present. Make the following observations:

Identify a single cell by locating a cell wall outline and studying what happens when you move up and down with the fine focus knobs. You should see the cell wall come in and out of focus as the focal distance changes. Use this skill to observe the components of the cell.

*Do you see any structures inside the cell?*

*What can you identify?*

*What shape do the internal organelles have?*

Prepare a second potato section and stain it with  $\text{IKI}_2$  OR stain the already existing section by drawing a drop of  $\text{IKI}_2$  under the coverslip with a wicking action. In either scenario, you should be able to see a change in the amyloplasts.

*What happened to the amyloplasts with the addition of the  $\text{IKI}_2$ ? Why?*

Take a look at the area near the tissue under the coverslip.

*Do you see anything there? What are the stained structures? What you see represents that earlier milky substance that exuded from the potato upon cutting it. Why is it present?*

### C. The 3 Plant Tissue Systems

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During embryonic development three primary tissue systems become distinct: the **dermal**, **ground**, and **vascular tissue systems**. In the primary plant body, the dermal system consists of the epidermis; the vascular system consists of vascular tissues arranged in bundles (i.e., vascular bundles); and the ground tissue system (the “cortex” and “pith” in Fig. 4) consists of all other tissues between the vascular and dermal tissues.

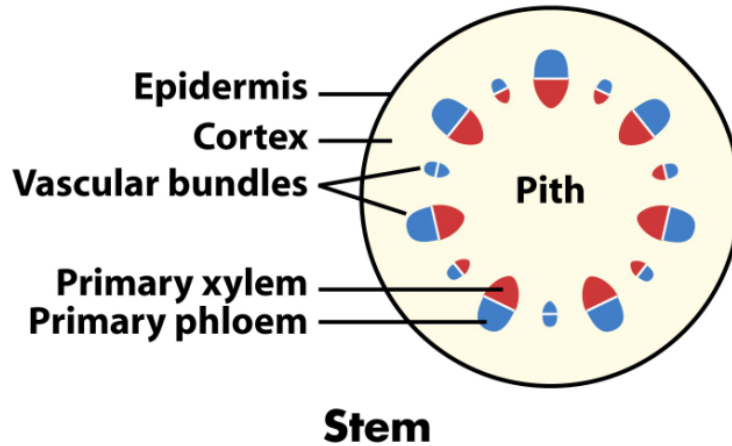


Figure 23-4b  
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Fig. 3. Typical dicot arrangement of the 3 tissue systems (i.e., dermal, ground, & vascular).

#### C1. Dermal Tissue System Basics (see Fig. 3)

The external cell layer of the plant has a function similar to our skin in that it provides a physical separation from the environment. Only a single tissue makes up the dermal tissue: the **EPIDERMIS**. This tissue is generally **COMPLEX** in that various cell types can be present, such as guard cells of stomatal complexes, the cells of trichomes, etc.

1. Prepare a wet mount of an onion bulb epidermis (often referred to as an onion peel) as describe earlier. Observe the nature of the tissue as a whole instead of the individual cells.

*Make a sketch of what you see:*

*How many different types of cells can you distinguish?*

2. Observe a prepared slide of *Sedum epidermis* (w.m.) and compare it to what you saw with you onion peel. This section is similar to the onion peel in that it represents a surface view of the *Sedum epidermis*. Aside from the color, how are they different?

3. Observe a prepared slide depicting a cross section of a typical monocot leaf. This section shows the different cells and tissues that make up a leaf. Focus on the EPIDERMAL layer, make observations and draw several cells.

*Does the epidermis appear to be continuous or are there occasional gaps present? What might be the reason for the presence of the gaps?*

*Can you identify more than one type of cell? If so, which kinds?*

## **C2. Ground Tissue System Basics (see Fig. 3)**

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The bulk of the plant body is filled with ground tissue, of which the most common and generalized type is parenchyma. Although parenchyma, collenchyma, and sclerenchyma can be found in the vascular tissues as well, they are very typically found in the ground tissue system, depending on the species.

**PARENCHYMA.** Living at functional maturity. Thin-walled, apparently nonspecialized cells functioning in photosynthesis, storage, or secretion

**COLLENCHYMA.** Living at functional maturity. Consists of elongate cells with unevenly thickened, flexible primary cell walls, typically occurring in strands beneath the epidermis. Collenchyma functions in flexible support and usually is found in petioles or beneath leaf ribs and stem angles.

**SCLERENCHYMA.** Dead at functional maturity. Cells have very thick, inflexible secondarily thickened, usually lignified, cell walls. Their cell walls function in support and protection. Sclerenchyma can be elongate and fibrous (**FIBERS**), occurring in networks or strands, or the cells can be of irregular shapes forming isolated or nests of stone cells (**SCLERIDS**).

1. Observe a prepared slide depicting a cross section of *Ranunculus* roots. Draw the root and identify the three primary tissue regions. *What type of ground tissue is present in this organ (the root)? How do you know?*

2. Review the prepared cross section of a typical monocot leaf. Draw and identify the three primary tissues regions in the leaf. Examine the leaf along its entire length. *Which of the ground tissues can you identify as being present?*

3. Obtain a celery petiole and break it in half (feel free to eat part of it). Notice the presence of strands that can be peeled from the celery. These strands are made of collenchyma tissue. Make a cross section wet mount of the celery petiole to observe the collenchyma. Draw several cells of the collenchyma. Take a look at the strand under the microscope also.

4. Sclerenchyma cells can sometimes be seen associated with vascular tissue of some species or strengthening the stem of other species. In some plants like pear, the fruit contains sclerenchyma cells known as stone cells. These cells give the fruit a gritty texture. Make a wet mount of pear fruit tissue and identify, draw the stone cells.

5. Observe a prepared cross section of a Helianthus (Sunflower) stem. The center of the stem is the pith.

Which type of ground tissue cell is the pith made of? The cortex?

Draw a typical cell from the pith. Do you see any intercellular spaces?

Can you recognize all three tissue systems in this slide?



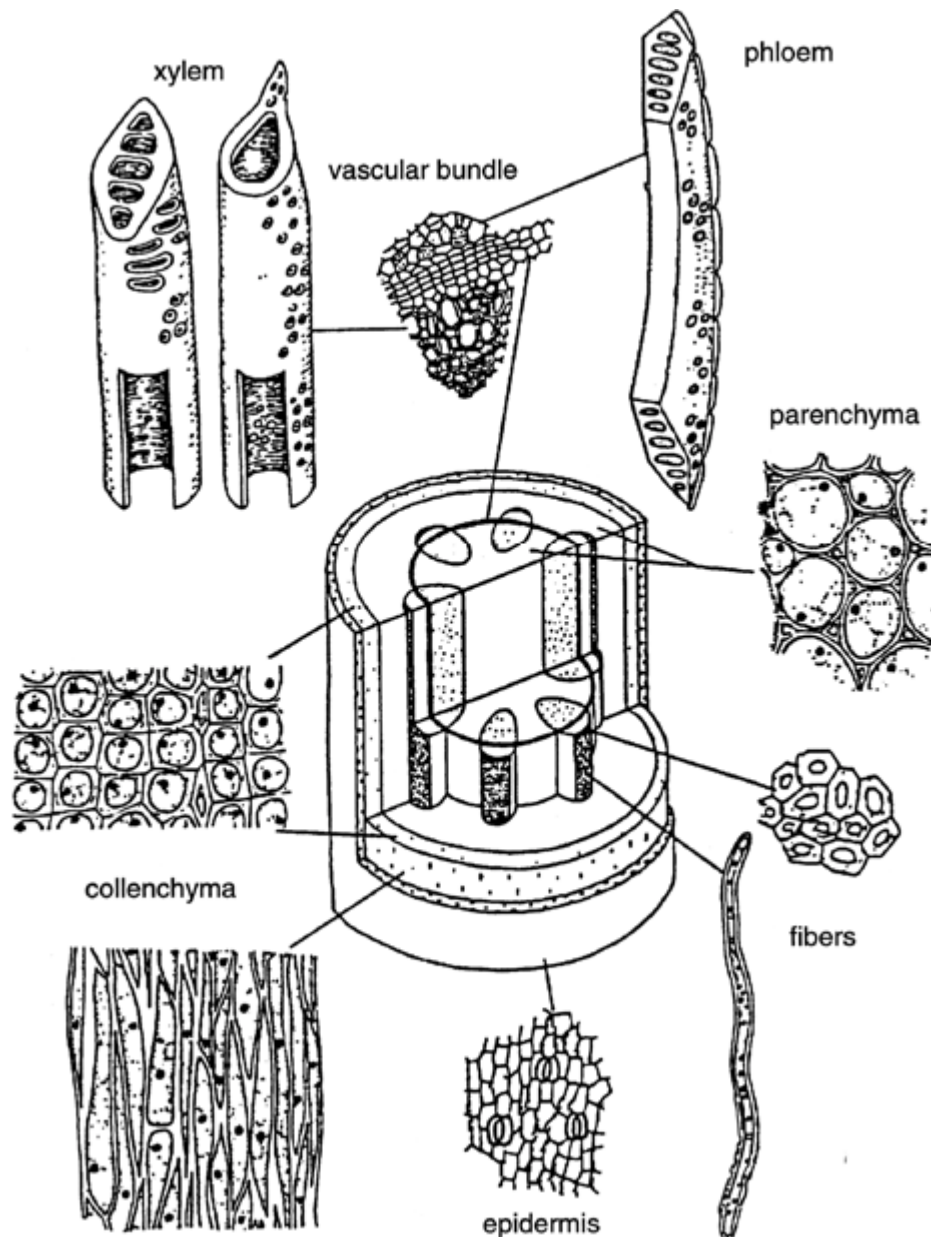


Fig. 3. Idealized three-dimensional diagram of sections through a typical dicot stem (with no secondary growth), illustrating the locations and general morphologies of various cell and tissue types. (Adapted from Niklas, *Plant Biomechanics*, p. 267, University of Chicago Press, 1992).

### **C3. Vascular Tissue System Basics (see Figs. 3, and Fig. 4)**

The vascular tissue has the role of long distance transport of nutrients and water throughout the plant. This tissue system is critical for the survival of the plant. There are two different complex types of vascular tissue, **XYLEM** and **PHLOEM**.

**XYLEM.**     **TRACHEIDS** – The primary conducting elements in gymnosperms (e.g., pine). Cell with pitted walls and dead at maturity. They also function in support.

**VESSEL ELEMENTS** – The primary conducting elements of angiosperms. Broad empty, tube-like cells connected end-to-end to form **VESSELS**.

**Xylem FIBERS**--Very long cells with very thick walls. Vessels function in transport and fibers provide support; both are dead and empty cells at maturity.

**Xylem PARENCHYMA**—relatively unspecialized, thin-walled cells rather more abundant in the ground tissue.

**PHLOEM** The conducting cells of phloem are **SIEVE CELLS** in gymnosperms. **SIEVE-TUBE MEMBER** in angiosperms.

The above two are essentially the counterparts of tracheids and vessel elements, but they are living at maturity.

**COMPANION CELLS**—parenchyma cells associated with and facilitating the function of sieve-tube members.

**PHLOEM FIBERS** (e.g., *Helianthus*!!!; next section).

1. Using the **Helianthus** slide, locate the vascular tissue and draw a single bundle. Locate the xylem (water, mineral) and phloem (sugar solution, signaling molecules) conducting tissues in each bundle. Note their appearance (e.g., cell types and forms). See Fig. 4 as a reference. Note that xylem is not homogeneous in cell size or type.

2. Obtain a **Zea (corn) cross-section**. Locate several vascular bundles and note that they are arranged differently than in *Helianthus*. Find the xylem and, in particular, see if you can identify 1 or more relatively wide-diameter vessel elements! Also note that the *Zea* vascular bundles are surrounded by red-staining (lignified) fibers for added support. Draw this.

Note: Cross-sections do not show you the wall thickening patterns of xylem cells. But they do show you how xylem cells differ in girth (diameter). Metaxylem cells have larger diameters than protoxylem cells and they are further away from the pith than are protoxylem cells.

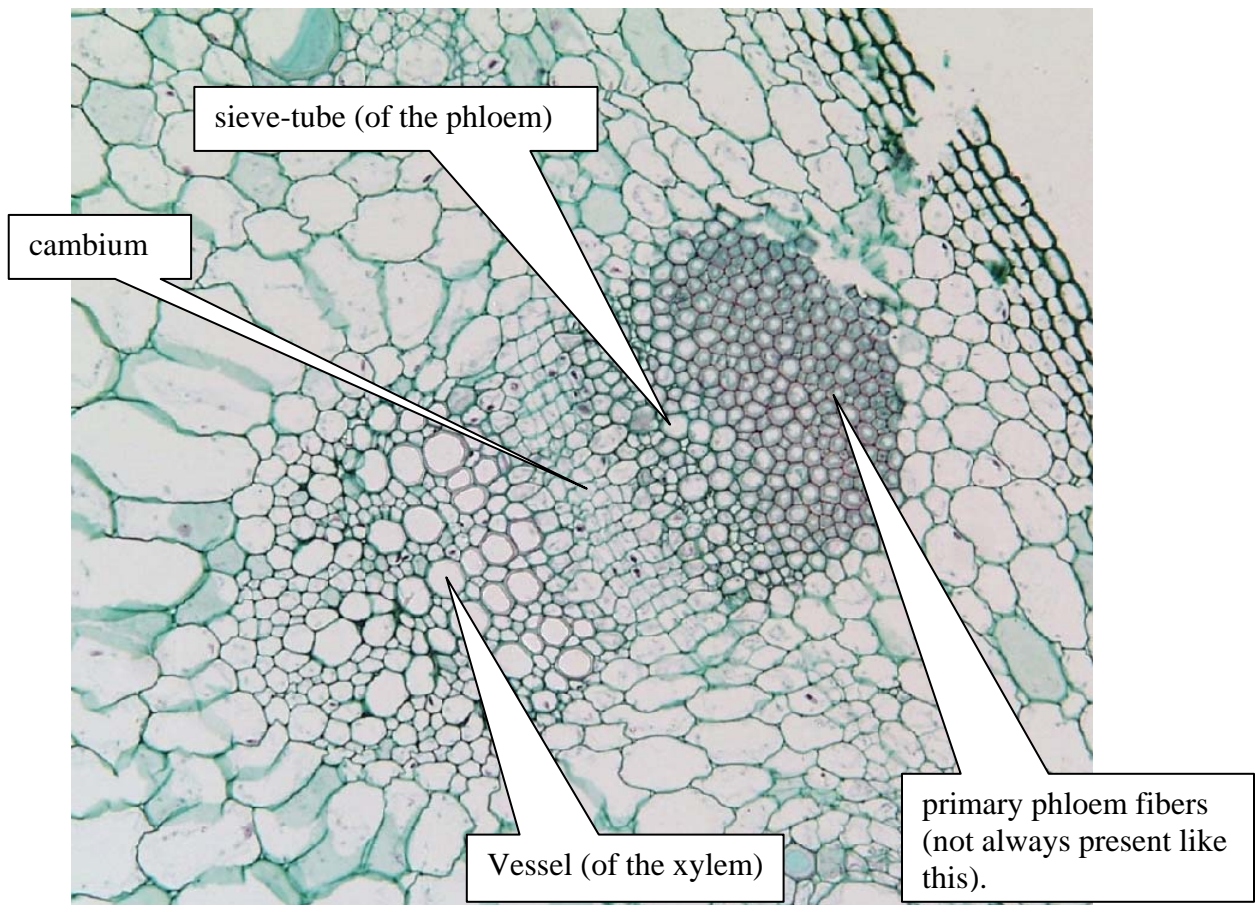


Fig. 4. *Helianthus* (sunflower) vascular bundle, close-up. The blue stain is picking up the cellulose of the primary cell wall. The red stain is picking up the lignified.

3. **Zea (corn) longitudinal section.** Now identify vascular bundles in long section. again, xylem will be in the bundle closest to the center of the stem, phloem farthest. Can you identify xylem vessels and any secondary, irregular and lignified cell wall thickenings?

4. Check out the prepared *Asclepias* stem longitudinal section to see an excellent example of the primary tissues as they appear lengthwise along the stem. Pay particular attention to the vascular bundles and pick out the xylem cells. Notice the secondary wall thickenings that appear as rings. You may be able to pick out other structures also. Also notice the ground and dermal tissues in this section. Draw and label the different tissues.

5. *Cucurbita* (pumpkin) longitudinal section, prepared slide.

This shows PHLOEM in long section in exquisite detail. Locate sieve tubes and their respective sieve tube elements. Also note where these elements meet at SIEVE PLATES. Note also the presence of callose or P-protein collected around these sieve plates. This callose and/or P-protein accumulation is an artifact of the histological procedure to make this slide. Explain this...

6. Wet mount. *Helianthus* (sunflower) seedling hypocotyl cross-section. Prepare a wet mount of an extremely thin cross-section (using a razor blade) of the hypocotyl of the seedlings in the back. Optional: Use toluidine blue instead of water for staining.

Simply locate the organization of the 3 tissue systems. The organization in the hypocotyl may be different than that of the normal stem you saw above.

## D. Apical Meristem Basics

The meristematic tissues contain cells that have the ability to divide thus contributing to the overall growth of the plant. **APICAL MERISTEMS** are found at the terminus of both the root (**ROOT APICAL MERISTEM**) and the shoot (**SHOOT APICAL MERISTEM**) and are the source of all root and shoot tissue respectively. From the apical meristem, three types of **PRIMARY MERISTEMS** develop that give rise to specific regions of the plant body: the **PROTODERM**, the **PROCAMBIUM**, and the **GROUND MERISTEM**. The primary meristems give rise to the **PRIMARY TISSUES**, each of which has a specific function and predictable location within the plant body.

The **DERMAL TISSUE (EPIDERMIS)** is the primary tissue generated from the protoderm and serves as a protective covering for the plant. The **GROUND TISSUE** is generated from the ground meristem and makes up most of the internal structures in the plant. The procambium in turn gives rise to the **VASCULAR TISSUE** that facilitates long-distance transport.

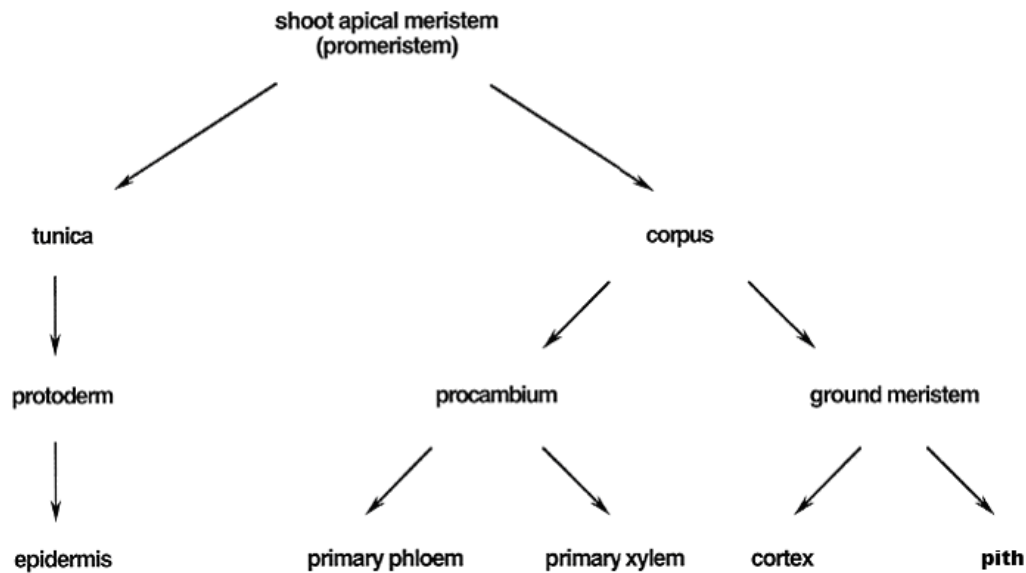


Fig. 5. Flow chart illustrating the primary tissues derived from the apical meristem.