Tissues and Stems and Roots LAB

In this Lab you will be

1) recognizing **primary and secondary growth** and associated tissues. You will also be differentiating between eudicots, monocots and in some cases gymnosperms.
2) You'll be looking at **roots**, and differentiating between different **kinds of roots**, and **growth regions** of roots.

Specifically:

1. *Know the general difference in stem vascular bundle arrangement in monocots and Eudicots*
2. *How can you differentially a pine from a woody angiosperm? Hint: look at the xylem*
3. *Know the difference between primary (apical meristem) and secondary (lateral meristems) growth in plants.*
4. *Know the structure of a woody stem including the two lateral meristems, and what they do*
5. *Know how to age a piece of wood*
6. *Know root types, which are typical of monocots and of eudicots, and recognize parts of a root*
7. *Name the external features of roots.*
8. *Recognize and name the merisematic tissues in roots' sections.*
9. *Recognize and name the mature primary tissues in the cross section of a root.*
10. *Recognize and name the secondary tissues in the cross section of a root*

Terms and Concepts

<u>*Primary* Meristematic Tissue</u> (new growth). Occurs at roots and shoots

- Apical meristem
- Early primary tissues:
    - Protoderm = will become dermal tissue
    - Procambium = will become vascular tissue
    - Ground meristem = will become ground tissue

<u>Epidermal Tissue</u>

- Epidermal cells
- Guard cells
- Cuticle
- Compare roots, shoots and leaves – different epidermal tissue?

<u>Cork (phellem)</u>

- What is it? From where is it derived?

Herbaceous stems (primary growth)

- Look at the slides carefully and be able to pick out the structures bolded in the lab handout (Topic 11)
- Be able to recognize monocots and eudicots and their differences

Woody stems (*secondary* growth via lateral meristems)

- Be able to recognize the 'parts' of a woody twig
- Find these and know what they do:
    - Cork
    - Cork cambium (lateral meristem)
    - Primary and secondary phloem and phloem rays
    - Primary and secondary xylem
    - The Vascular cambium (lateral meristem)
    - Xylem rays
    - Phloem rays
    - Summer wood
    - Spring wood
- Be able to age a cross section of wood

Modified stems

- Look at modified underground and aerial stems. Be able to recognize them and their primary functions

Roots. Identify and distinguish the following, as well as know the function

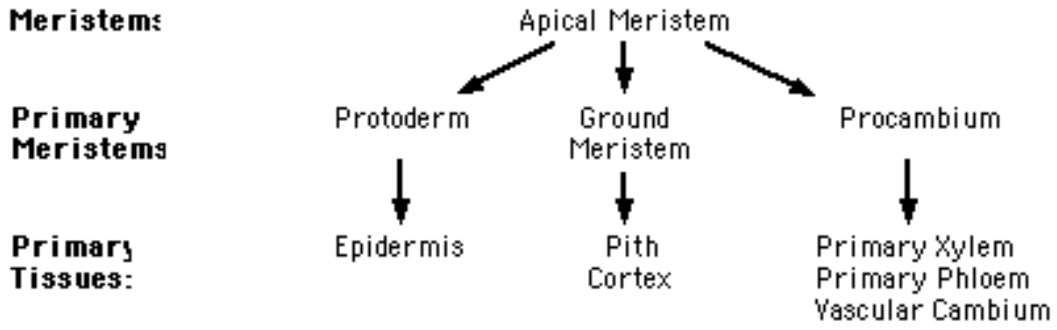
- Root types:
    - Fibrous (monocot)
    - Taproots (eudicots)
- Radicle
- Taproot
- Branch/lateral roots
- Root cap
- Root hairs
- Zone of maturation, elongation and apical (root) meristem
- Protoderm, procambium, ground meristem
- Pericycle
- Stele
- Primary phloem, xylem
- Woody roots: phloem and xylem rays, primary and secondary xylem, secondary phloem, vascular cambium, pericycle, cork
- What is a branch root?
- Types of specialized roots

**for monocots *and* eudicots

GROWTH

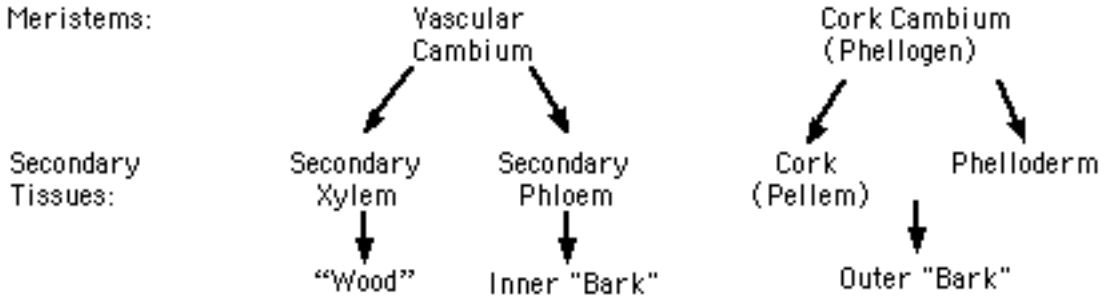
The bodies of plants have three kinds of organs: roots, stems, and leaves. All three are composed of the tissue types and cell types studied earlier. The stem and leaves make up the shoot system and the roots make up the root system. Some plants have only primary growth in the stems and roots and are said to be "herbaceous", others have secondary growth and are said to be "woody".

Primary growth:



Herbaceous plants have only primary growth and therefore grow only in length. Secondary growth which develops in woody plants after primary growth, includes the following:

Secondary Growth:



Woody plants have both primary and secondary growth and therefore grow both in length (primary tissues) and in diameter (secondary tissues).

Procedure: *Draw and label!!*

I. Meristematic Tissue. This is growth tissue: Mitosis!

1. Study the longitudinal sections of the stem tips of *Coleus* or *Elodea* and note terminal (or apical) **meristematic** tissue near the tip of the stem composed of small, isodiametric cells with large nuclei. The meristematic tissue is protected by young leaves which grow up around it. (Do not confuse these with the meristematic tissue.)

2. Examine **the terminal meristematic tissue** near the tip of a longitudinal section through an onion root. Note that this is not right at the tip but is back behind a mass of tissue called the root cap. (To be studied later). In the onion tip, not that you can see the cells in various stages of mitosis. See if you can ID some of the stages (ie. anaphase, telophase etc.)

II. Epidermal Tissue. Protective outer tissue

1. Peel a piece of the epidermis (the outer "skin") from the leaf of a succulent plant and make a wet mount for observation under the microscope. The epidermis is one cell layer thick and has two kinds of cells: the **epidermal cells** and the **guard cells**.
The epidermal cells fit together in species specific patterns. They have no chloroplasts but you should see a nucleus in some cells if you manipulate the light. The guard cells come in pairs around a pore, the **stoma**, and they have chloroplasts and nuclei which should be visible under good light conditions. The outer surface of all these cells is very waxy; therefore you may trap bubbles of air in your wet mount, particularly in the stomata (plural of stoma) so if they look very black you probably are not seeing the stomata clearly.

2. Make a similar preparation from an onion bulb which is composed of the swollen bases of many leaves and examine the preparation under the microscope. Are the epidermal cells the same shape as the succulent cells? Are there guard cells and stomata?

3. Study a prepared slide of a cross section of a lilac leaf, observing the epidermis, both upper and lower and note the heavy, continuous **waxy layer** or **cuticle** particularly well developed on the upper epidermis. Locate a cross section through **guard cells** and note how they relate to the neighboring epidermal cells.

III. Herbaceous Stems – primary growth

1. Examine the external features of the shoot system of an herbaceous plant. Note that the stem is branched and that it bears leaves in arrangements that are typical of specific species (opposite, alternate, whorled). The **node** is the part of a stem where one or more leaves are attached. The **intertnode** is the region between two successive nodes. The

branches always originate in the **axiles** of the leaves (between the leaf and the stem, although that may not be obvious if the leaf has fallen.

2. Examine the slide of a longitudinal section through the growing tip of a *Coleus* stem. Note the **apical meristem** which is well protected by the overlapping young leaves which surround it. These young leaves look like flaps that grow upward from behind the tip (note nodes and internodes). Small lumps of tissue in the axils of these young leaves are **branch buds** (lateral buds). Below the apical meristem find the primary meristems: the **protoderm** (pre epidermal tissue) which is a single layer of cells on the outside of the young plant; the **procambium** (pre-vascular tissue) which can be seen as two slightly darker staining strands developing back from the tip; and the **ground meristem** (pre-ground tissue) which is all the rest of the tissue. If the section goes far enough down the stem, note the mature primary tissues: The single layer of **epidermis** which developed from the protoderm, the **primary xylem**, which often stains red and shows thickenings in the vessel elements and tracheids, the **primary phloem** which is just external to the primary xylem and often stains greenish and is composed of elongate living cells. The rest of the tissue is **cortex** (**parenchyma**) if it lies between the epidermis and vascular tissue, and **pith** (**parenchyma**), if it is to the inside.

3. Obtain a prepared slide of a cross section of a Buttercup stem showing mature primary tissues. The Buttercup or *Ranunculus* is an example of an herbaceous **dicotyledon** (EUDICOT) which has no secondary growth.
Under the microscope note the **epidermis** which is covered on the outside by a layer of waxy **cutin**. Note any **guard cells**. Internal to the epidermis is the **cortex** composed of parenchyma tissue which has chloroplasts, particularly in the regions of the stem nearest the light. The xylem and phloem are arranged in primary **vascular bundles** arranged in a ring around the pith. Each vascular bundle has **primary xylem** on the pith side and **primary phloem** on the outside. Locate the **seive tubes** and **companion cells**. Note that the pith is composed of parenchyma and is continuous with the cortex by way of pith rays that run between the vascular bundles.

4. Obtain a prepared slide of a cross section through a corn stem (*Zea mays*). This is an example of an herbaceous **monocotyledonous** (MONOCOT) stem. Under the microscope note that the **vascular bundles** are distributed throughout the ground tissue (parenchyma), which is more difficult to divide into 'pith' and 'cortex'. Under a higher power study a single vascular bundle and note that each is surrounded by **sclerenchyma** tissue called the **bundle sheath**. Within the bundle find the primary phloem of **seive tubes** and **companion cells** and the **primary xylem** of large **vessels** which may be organized as a "mouth" and "two eyes". The bundle is often torn around the "mouth" as a result of stem elongation.

IV. Woody Stems – secondary growth

1. Select a dormant twig and note the **terminal bud** which is enclosed in protective **bud scales** which last over winter. Along the length of the twig, note the **leaf scars** which are

somewhat triangular and contain the scars of vascular bundles that ran out to the leaf. Some of the leaf scars will have **branch buds** clearly visible in axils. As you go back down the twig you will come to a place where there is scar tissue encircling the stem. This is a ring of **bud scale scars** and marks the position of last year's **terminal bud** so you can see how much the stem has grown in one year. Keep going back along the stem and determine how many years growth are present in the twig. Other tiny light spots all over the bark are **lenticels** which allow for an exchange of gases with the interior cells of the stem.

2. Get a slide of a cross section of a woody stem of the Linden or Basswood, *Tilia*. It may have sections of one, two and three year old stems. Beginning on the outside note the **cork cambium**, a single layer of living cells that cuts off cork cells on the outside and phelloderm on the inside. The cork cambium is difficult to identify exactly, but you can come close. As you go in, find the **cortex** which gradually gets squashed out of existence as the plant grows in diameter. It should, therefore, be visible in young stems. As you go inward you come to tissue divided into almost triangular pieces. The triangles pointing outward contain **secondary phloem** with a bit of primary phloem near the point and much **sclerenchyma** tissue. The triangular shaped parenchymatous tissue that points inward and seems to separate the secondary phloem is a **phloem ray**.

The **vascular cambium** is a single layer of living cells between the secondary xylem and phloem. Again, you may not be certain exactly which layer it is, but you can come close. Inward from the vascular cambium is the **secondary xylem** (or wood) that makes up most of the volume of the stem. In the three year old stem note the annual rings, each made up of a **spring wood** in which the xylem units are large in diameter, and a **summer wood**, in which they are more compact. The xylem is divided by radiating lines of living parenchyma cells called **xylem rays**. The primary xylem is visible in young stems as scalloped bulges of xylem facing into the **pith**.

3. Examine several of the sections of branch that are cut to show three surfaces: **Transverse** (cross section), **Radial** (vertical through the center) and **Tangential** (vertical section off center). Note in the transverse section the cross sectional view of the xylem and the xylem rays. In the radial section the xylem units are cut longitudinally and the xylem rays are also cut longitudinally and appear as a vertical sheet. In the tangential section the xylem units are cut longitudinally and the xylem rays are cut across and appear as elongate, fusiform ‘gaps’ between the xylem units.

IV. Modified Stems

1. Underground stems are common in some plants. Look at the stems labelled **rhizome**, **tuber**, **bulb**, and **corm**

Rhizomes - are horizontal underground stems (not roots because they have nodes and internodes)

Tubers - are the tips of rhizomes that are swollen with storage tissue.

Bulbs - are large buds with a small central system surrounded by fleshy leaves.

Corms - are the swollen bases of stems full of stored food and surrounded by papery thin, dry leaves.

2. Modified aerial stems may serve a variety of functions Note the plants bearing the following labels: **Tendrils**, **runners**, **thorns**.

Tendrils - are often stems modified for climbing

Runners - creep over the surface and give rise to a new plant where they touch down.

Thorns - are modified twigs that grow in the axils of leaves.

IV. Roots

External Morphology

1. Examine the germinating bean seeds and note the **emerging root** and the direction of its growth. This is the primary root or **radicle** developed from the apical meristem in the root of the embryo in the seed. In gymnosperms and dicots it is a **taproot** which will later give rise to **branch** or **lateral** roots. (Note: roots have no nodes or internodes like stems.)

2. Examine the mature roots on display showing **taproots** and **fibrous root systems**. The latter are in most monocots and some dicots.

3. Place a germinating grass seedling germinating grass seedling in a drop of water on a slide and look at it under the dissecting scope. Identify the **root cap** and the **root hairs**.

Mature Primary Tissues of Young **Dicot** Root

Obtain a prepared slide of a cross section of a mature *Ranunculus* herbaceous (or other dicot) root and observe the following under the microscope starting from the outside:

The **epidermis** - a single layer of cells which may show root hairs (would you expect it to be cutinized? Why/why not?

The **cortex** - with stored food in the parenchymatous cells and with air spaces between the cells.

The **endodermis** - a ring of generally thick-walled cells around the central vascular tissue.

The **pericycle** - a single layer of thin-walled cells just inside the endodermis.

The **primary xylem** - fills the center of the root and in cross section is star-shaped. This is xylem arrangement typical of dicot roots.

The **primary phloem** - lies between the "arms" of the star-shaped xylem.

Internal Structure of Tip of Young **Monocot** Root

Obtain a prepared slide of a longitudinal section of the growing tip of an onion root. Identify the following, starting from the tip and proceeding up the root: **root cap** which protects the meristem as the root pushes through the ground; the **apical meristem** or region of actively dividing, isodiametric cells which has given rise to the three primary meristems; the **protoderm**, the **ground meristem** and the **procambium** which in roots forms a central core as there is no pith in roots. If the section is long enough you will find the mature primary tissues, the **epidermis** with **root hairs**, **cortex**, **primary xylem and primary phloem**. Also find the 4 zones: the **root cap zone**, the **zone of cell division**, the **zone of elongation** and the **zone of maturation** (marked by the root hairs). these zones correspond roughly to the root cap, apical meristem region, primary meristem region and primary tissue region. This is all primary growth and is where the root grows in length.

Secondary Tissues in woody roots

Examine a slide of a woody dicot root which has cross sections of roots at 1, 2, 3 years of age and note that it has secondary growth much like the secondary growth of stems (what is the difference?) and is produced in the same way. Beginning at the outside of a 1 or 2 year old root, note the **cork** (periderm tissue) which is formed in the cortex and causes the epidermis and part of the cortex to die and slough off. There may be some **cortex** left in the young root.

The **pericycle** of living parenchyma cells lies within the cork tissue. (The endodermis is not present in roots with secondary growth.) Locate the **secondary phloem** and **phloem rays**. There may be small knots of **primary phloem** in young stems that have been pushed to the outside of the secondary phloem as growth has progressed but they will be squashed out of existence as they are pushed against the periderm with continued secondary growth.

Inward from the secondary phloem is the vascular cambium, a single layer of cells which gives rise to the secondary xylem and phloem. As in the stem, you can approximate its location. The vascular cambium originated in parenchyma between the primary xylem and primary phloem. The **secondary xylem** (wood) makes up the bulk of the root. Note the xylem rays. Can you distinguish the **primary xylem**? Now look at the oldest section of the root on the slide and compare it with the youngest. How old is it?

Branch roots

Examine a slide of a cross section of a root giving rise to a branch or **lateral** root. What tissue is giving rise to the branch root? How does the origin of branch roots differ from the origin of branch stems?

Specialized Roots
Note the examples of:

Adventitious roots - which develop from some structure other than the primary root system (stem or leaf).

Prop roots - adventitious roots from the stem to the ground supporting the plant.

Climbing roots - adventitious roots which anchor the stems of climbing plants.
Storage roots - which store large quantities of carbohydrate.