Topic 02

The Root System of the Primary Plant body

(Photo Atlas: Figures 9.147, 9.148, 9.150, 9.1, 9.2, 9.5 – 9.23)

A. Ethnobotany of roots

Many nutritious and tasty items in our diet come from roots.

The delightfully fragrant roots (in addition to portions of the stem) of our native tree **sassafras** (*Sassafras albidum*) was reportedly the first export of North American colonies, and extracts/oils were historically used to treat or prevent scurvy, to kill lice, for the relief of insect bites, and in scent making. The roots, bark and twigs were used by Amerindians in NE North America to make a tea. Today, teas are still popular and extracts are sold in which the saffrole (a possible carcinogen) has been removed. Sassafras is a member of the Bay Laurel family, Lauraceae, which includes cinnamon and avocado.

The fragrant roots of the Mediterranean/Central Asian **licorice plant** (*Glycyrrhiza glabra*), a member of the legume family Fabaceae, are used to flavor licorice. These roots are also the source of glycyrrhizin, which is 50 times sweeter than sucrose, yet reportedly slows (rather than promotes) tooth decay! Too cool.

The roots of the shrubby **cassava** tree (*Manihot esculenta*), a member of the rubber family Euphorbiaceae, are a starch staple in the tropics. Reportedly, cassava yields more starch per hectare than any other crop. Cassava roots also are the source of **tapioca**.

B. Introduction

The root has the primary functions of **ABSORPTION** of water plus minerals, **ANCHORAGE** to the soil / substrate, **CONDUCTION** (via vascular tissue) of water plus minerals from area of absorption (or even of sugars from the shoot to root tissues in need), and **STORAGE** of food. All of the three tissue systems, and most of the cell and tissue types examined in our previous lab are present in the root and contribute to its function. However, the exact arrangement of these in the root may appear to be distinctly different than their arrangement in stems and leaves. The overall form and appearance of roots is also quite distinct from that of stems and leaves, and these differences are undoubtedly a reflection of the different functions of roots.

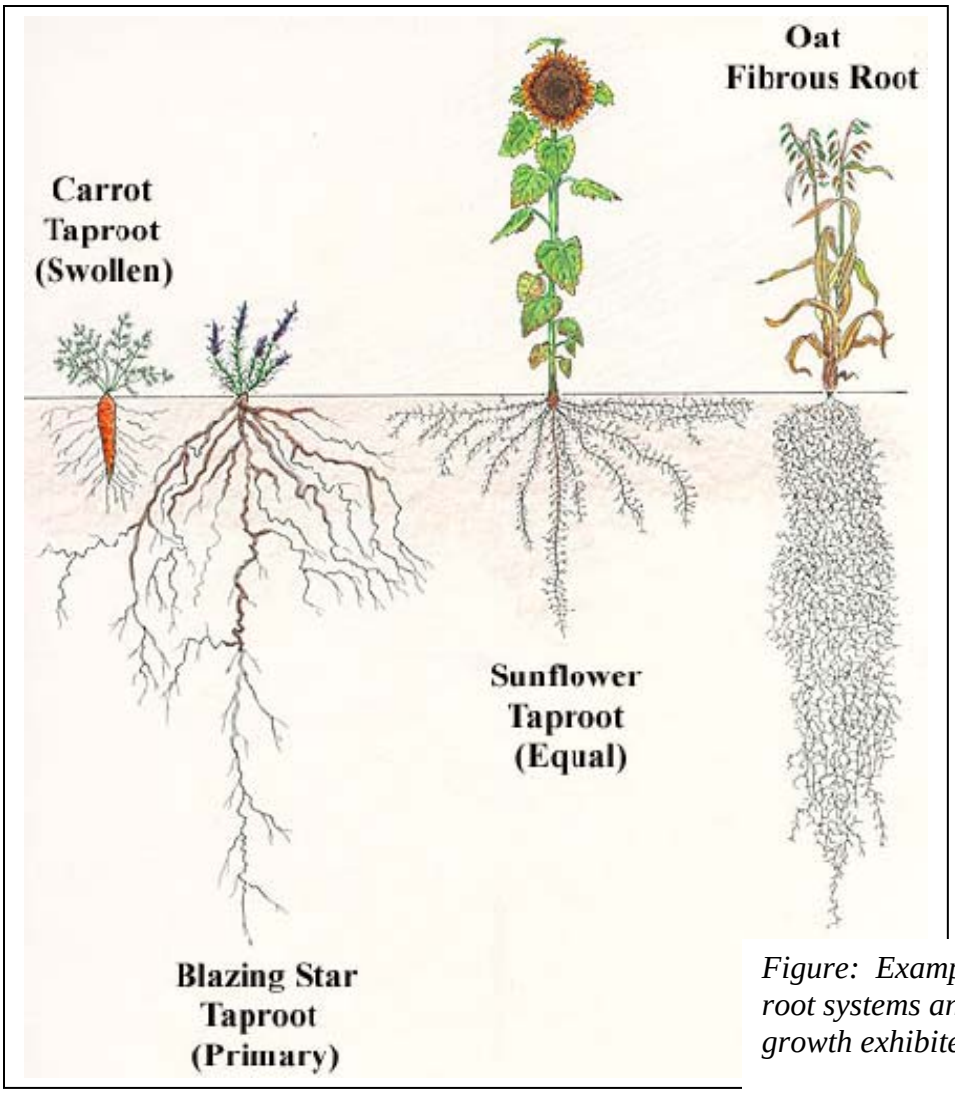

Figure: Examples of various root systems and the depth of growth exhibited by each.

C. Root Morphology

The **PRIMARY ROOT**, the plant's first root, develops from the **ROOT APICAL MERISTEM**. In gymnosperms and dicots, the primary root usually develops as a **TAPROOT**, which gives rise to **LATERAL ROOTS** (i.e., branch roots). These in turn branch, giving rise collectively to a **TAPROOT SYSTEM**. In monocots, the primary root is commonly short-lived or not dominant. Actually, the root system of the adult plant is largely **ADVENTITIOUS** (i.e., arising from the stem!). These **ADVENTITOUS ROOTS** give rise to a more or less homogeneous system called a **FIBROUS ROOT SYSTEM**.

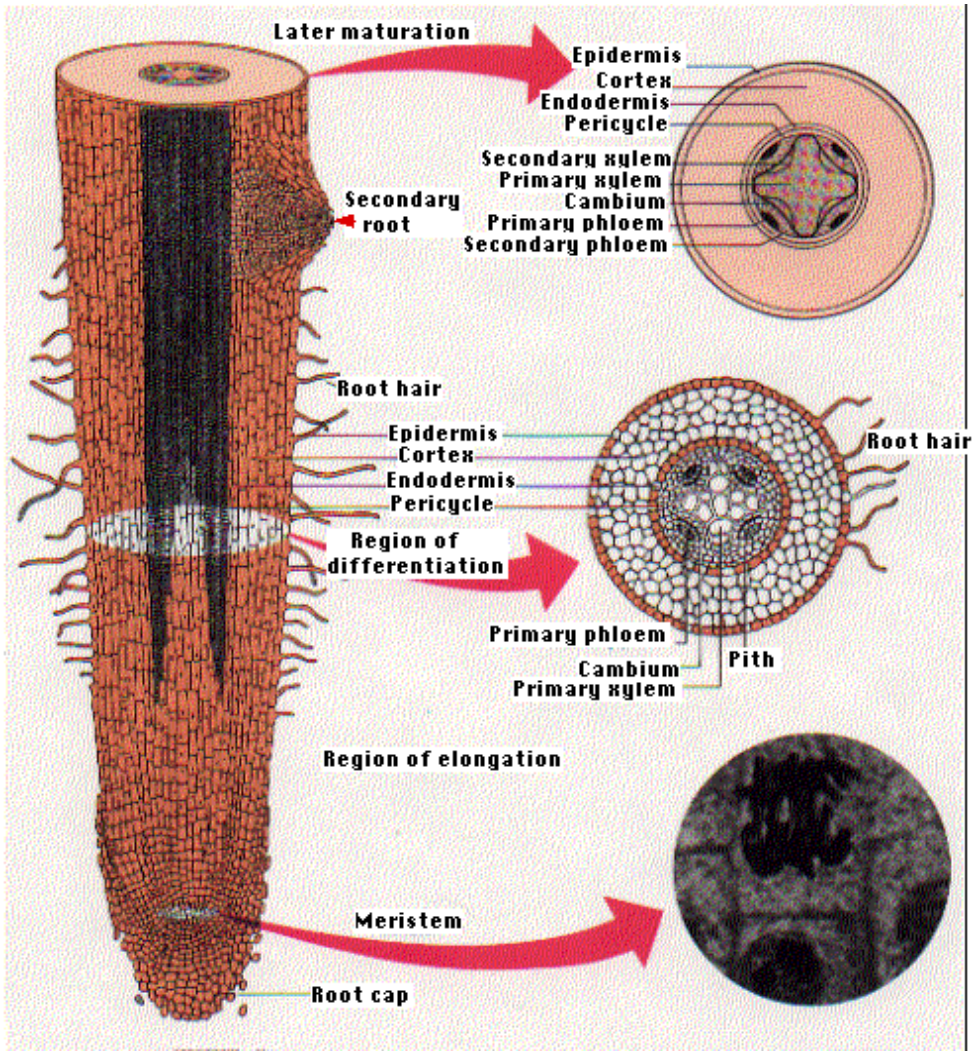

Figure: Illustration depicting a typical root with cross sections at various points along the root. The primary tissues are labeled as they arise in a radial fashion. The lower right image shows the occurrence of mitotic activity.

As you work through the following exercises, try to always relate what you see to the function of roots in anchorage, conduction, absorption, and storage.

C1. Compare and contrast the examples of a typical grass and a *Brassica* (mustard) root system.

Which has the fibrous root system and which has the taproot?

Can you identify the primary root in the fibrous root system?

What advantages would you expect from each of these types of root systems?

C2. Working in pairs, obtain a germinated Radish (*Raphanus*) seedling and examine it.
Use a dissecting scope for close observations at the tip. Draw the root and label the root hairs and the root cap.

What is the function of the root hairs?

Do the root hairs extend to the tip? Why?

Can you discern the root cap?

C3. Using an undamaged radish seedling,
cut the primary root in half longitudinally (i.e., a median longitudinal section), coat it with Toluidine Blue for 30 seconds, rinse it with water and mount in on a microscope slide. Observe with the compound light microscope.

Can you identify the files of cells in the root?

What primary tissue system gives rise to the root hairs?

Draw and label the tissues and meristematic regions:

D. Root Anatomy: Tissues and Cells.

The figure below depicts the radial patterning associated with a typical DICOT or GYMNOSPERM ROOT. Use this picture to help orient you when observing the root cross section specimens.

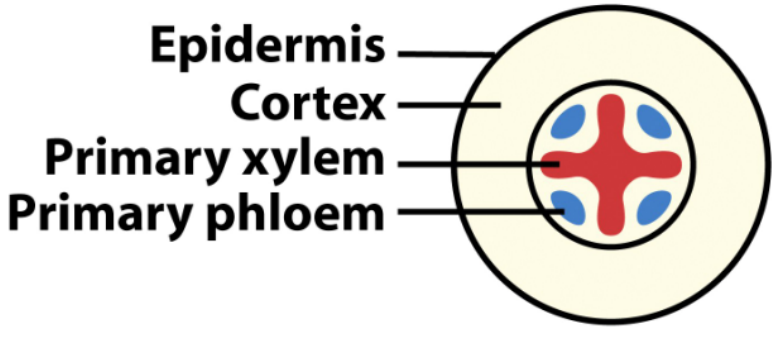

Fig 3. Typical dicot root cross-section. The "primary" adjective is used to indicate that these tissues form during "primary growth"; that is, from cells derived from the root apical meristem, before roots and stems get woody.

Note that the three tissue systems are represented as follows:

1. The Dermal Tissue System is represented by the epidermis,
2. The Vascular Tissue System is represented by a central cylinder (aka, the VASCULAR CYLINDER) of xylem plus phloem,
3. The Ground Tissue System is represented by the CORTEX, which is spatially defined as the region between the vascular cylinder and the epidermis.

What two types of vascular tissue are included in the vascular system? _____

D1. Now, inspect the vascular cylinder carefully in more detail (figure below). *Find the following structures and label the figure below accurately.*

(1) PRIMARY XYLEM,

(2) PRIMARY PHLOEM,

(3) CAMBIUM = region between the primary xylem and primary phloem that remains meristematic,

(4) ENDODERMIS = suberized (SUBERIN is a water-repellant substance), thick-walled cells; innermost layer of the cortex,

(5) PERICYCLE = thin-walled parenchyma cell layer just inside the endodermis; this is the outermost layer of the vascular cylinder.

(6) PASSAGE CELLS = cells of the endodermis opposite the protoxylem poles, which are not thick-walled or heavily suberized.

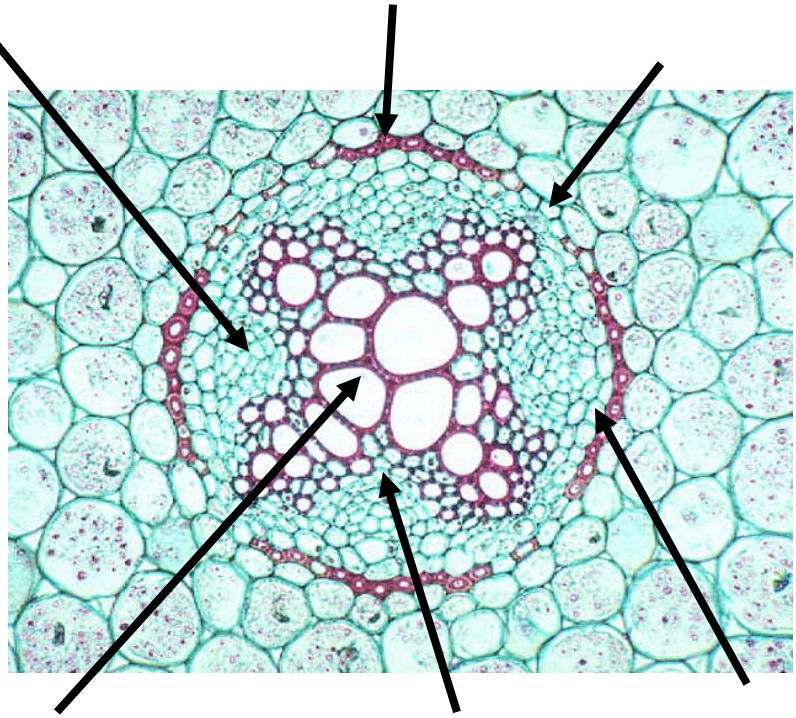

Figure: <u>Ranunculus</u> (buttercup); transverse-section. High-mag view of inner cortex and the vascular cylinder.

On the picture above, add in an arrow and a label to indicate a CASPARIAN STRIP. Endodermal cells (including the passage cells) have Casparian strips in their transverse and radial walls. Being made of suberin, Casparian strips are impermeable to water.

D2. Observe the prepared <u>*Ranunculus* (buttercup) root cross-section (c.s.)</u> slide. Use the figures above to orient yourself when observing the tissues. This slide depicts a typical DICOT primary root. Pay close attention to the organization of the primary tissues.

Draw your observations from the Ranunculus (buttercup) root cross-section (c.s.) slide and label the same structures and regions as above on your drawing.

In addition to the nucleus, what type of plastid can you observe in the cortex? Hint: they're important for the storage function of roots.

What tissue is the PERICYLE made of?

D3. Observe the prepared *Smilax* (catbrier; greenbrier) root cross-section (c.s.) slide. This is an example of a MONOCOT root cross section. Based on your knowledge of the dicot root anatomy, locate the same structures and regions.

Draw your observations from the Smilax root and label the structures and regions. Include any regions that are not part of the dicot root anatomy.

How is the monocot different?

Are there any additional tissues present in the center of the root?

If so, which tissue system does it belong to?

D4. Now test your knowledge! Use the prepared slide with cross sections of both a typical dicot and typical monocot present. *Identify them as monocot or dicot and DRAW a sketch of the RADIAL organization of each to support your claim.*

E. The Root Tip & The Root Apical Meristem

E1. Obtain a prepared slide of an onion (*Allium*) root tip. This slide is a longitudinal section (labeled as l.s.). Examine the cells along the root tip from the natural terminal end (rounded) to the cut end. The ROOT APICAL MERISTEM is at the tip behind the root cap and consists of small cells with densely staining cytoplasm and a high frequency of mitotic figures, indicating active cell division.

Notice the longitudinal files of cells. Can you trace the lineage of a cell from the middle of the root tip to a meristematic cell?

How does the meristem contribute to the growth of the plant?

Can you detect mitotic activity in any of the cells?

Where do you see the most amount of mitotic activity?

E2. Using the Onion (*Allium*) root tip longitudinal section (l.s.) slide, *draw what you see next to the figure of an onion root tip. Label both your drawing and the figure with the following regions:*

(1) ROOT APICAL MERISTEM,
(2) PROTODERM (young epidermis),
(3) GROUND MERISTEMATIC TISSUE (young cortex), the
(4) PROCAMBIUM (young vascular cylinder), and the
(5) ROOT CAP.

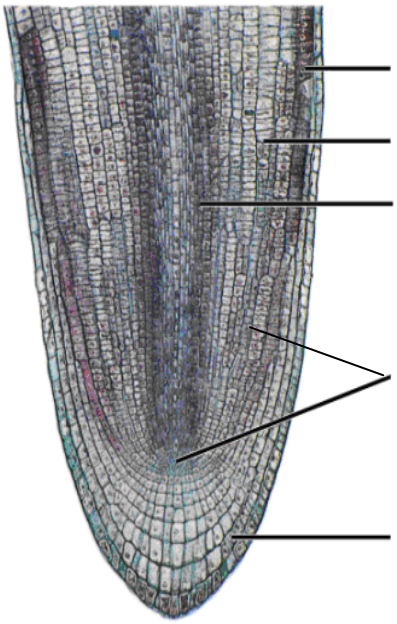

Figure 23-1b
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Place your onion root tip drawing here. Draw entire length of a single root in your slide.

F. Root Growth and Maturation

F1. Continue using the Onion (*Allium*) root tip longitudinal section (l.s.) slide and on your drawing above, label the Regions of CELL DIVISION, CELL ELONGATION, and MATURATION. Then complete this table to the best of your ability:

Zone/Region	relative cell length (short, intermediate, long)	frequency of mitotic cells (low, medium, high)	presence of mature xylem or phloem cells? (yes/no)	presence of root hairs? (yes/no)
3. Region of maturation				
2. Region of cell elongation				
1. Region of cell division				

F2. Go back to your observations of the Radish seedling and label the drawing with the maturation, elongation, cell division, root apical meristem regions/zones.

G. Origin of Lateral Roots

Root branches (lateral roots) are said to arise **ENDOGENOUSLY**. Closely examine the prepared slide of the ***Salix*** branch root origin and *DRAW your observations below*.

Label the tissues within the primary root cross section and the tissue regions of the lateral root.

Based on your observations, as well as a dissection of the word, what does endogenous mean?

What cell layer generates the lateral root?

Does the vascular tissue appear to be continuous from the primary root to the lateral root?

Compare the young branch root to the previously Examined primary root. Are there any differences?

What tissues are penetrated by the lateral root?

H. Adventitious Roots

H1. Observe the *Vanilla planifolia* (vanilla orchid), ***Philodendron, or Hedera*** **(English ivy) specimens provided.**
Examine the adventitious roots.

Do they arise from the internodes or nodes?

These plants typically grow as climbing vines. How do adventitious roots facilitate this type of growth form?

H2. (Optional) Make your own adventitious roots using a *Setcreasea* (purple heart) plant, which is a member of the spiderwort family.

Take a stem cutting that has at least three sets of leaves along the stem. Place the cutting in the tray containing moist vermiculite, peat, or a beaker of water so that the end that your cut plus two or more nodes are covered by the water. Label the cutting with your name and the date. Water them in weeks to come until roots form. Then take them home and start growing your own.

For Consideration:
Would it make any difference which end of the cutting was inserted into the soil?

What part of the stem will the adventitious roots arise from?

What tissue is most likely responsible for the regeneration of roots?

I. Differences between soil, water, and air roots

Examine the prepared slide with cross-sections of these types of roots. Consider the following:

1. How are these types of roots different in function (if any)?

2. What are some physiological stresses associated with being a root submersed in water (as with water lily) or totally exposed to air (as with epiphytic orchids and aroids or vining plants such as poison-ivy)?

3. How will "1" and "2" influence the anatomy of such roots?