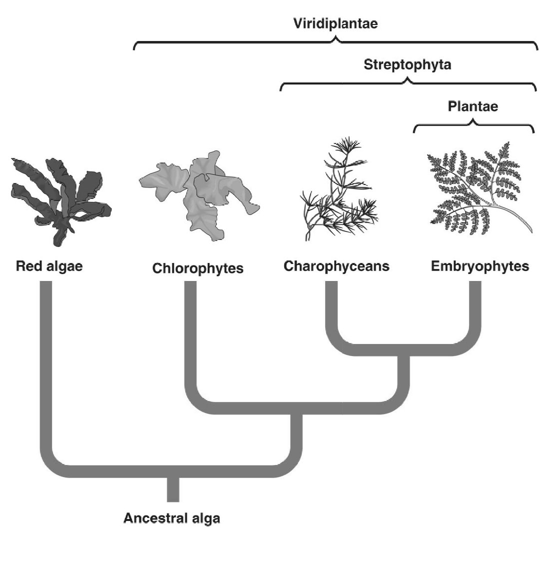
Plants I - Water and Nutrient Management:
Plant Adaptations to Life on Land

Objectives:

- Understand the evolutionary relationships between plants and algae.
- Know the features that distinguish plants from algae.
- Be able to identify chloroplasts
- Know the phylogeny of plants
- Be able to identify all of the plants you observe in the lab, and identify the group to which they belong.
- For each of the features in the list below, you should be able to identify them and know the following: where they first appear in the embryophyte phylogeny, what their structure and function(s) is/are, and what new capabilities they made available to plants.
  - apical meristems (tissue producing)
  - lignified vascular tissue
  - true roots
  - true leaves (with stomata and a waxy cuticle)
- Be able to understand the structure of and identify the components of true leaves
- Be able to understand the structure of and identify the components of shoots and roots
- Know how vascular tissue is arranged in monocots vs. dicots.
- Understand how water is transported up through a plant despite the pull of gravity.

Introduction:



Plants are fascinating organisms with diverse morphology and life histories. They belong to a larger clade that contains **chlorophytes** and **charophyceans** (See figure on right). Both green algae and charophyceans are aquatic, whereas **embryophytes** (plants) are primarily terrestrial. Abundant sunshine and CO_2 in the terrestrial environment allows for high rates of photosynthesis. This makes the land a favorable environment for plants to live in. Much like the first animals that made the terrestrial environment their home, early plants were still very dependent on water. Water was required for sexual reproduction, and without vascular tissue plants were generally small and lived in moist environments. Many adaptations to living on land have occurred in plants since they first arose more than 460 million years ago. Features like vascularization (which allowed for greater height), roots for anchorage and water absorption, and leaves (which provide a larger surface area for photosynthesis) will be covered in next week's lab. This week we will investigate several topics First, you will observe **chloroplasts**, and their closest living relatives – the **cyanobacteria**. Then you will observe some of the diversity that exists in the green algae (chlorophytes & charophyceans). Next, we will examine one of the synapomorphies for plants – a tissue producing **apical meristem**. For the remainder of the lab we will turn our attention to the reproductive lives of plants with an emphasis to changes that have reduced or eliminated the dependency on water for successful sexual reproduction.

Evolution of Chloroplasts:

As you have learned in lecture, the chloroplasts arose due to an endosymbiotic event between a unicellular eukaryote and a cyanobacterium.

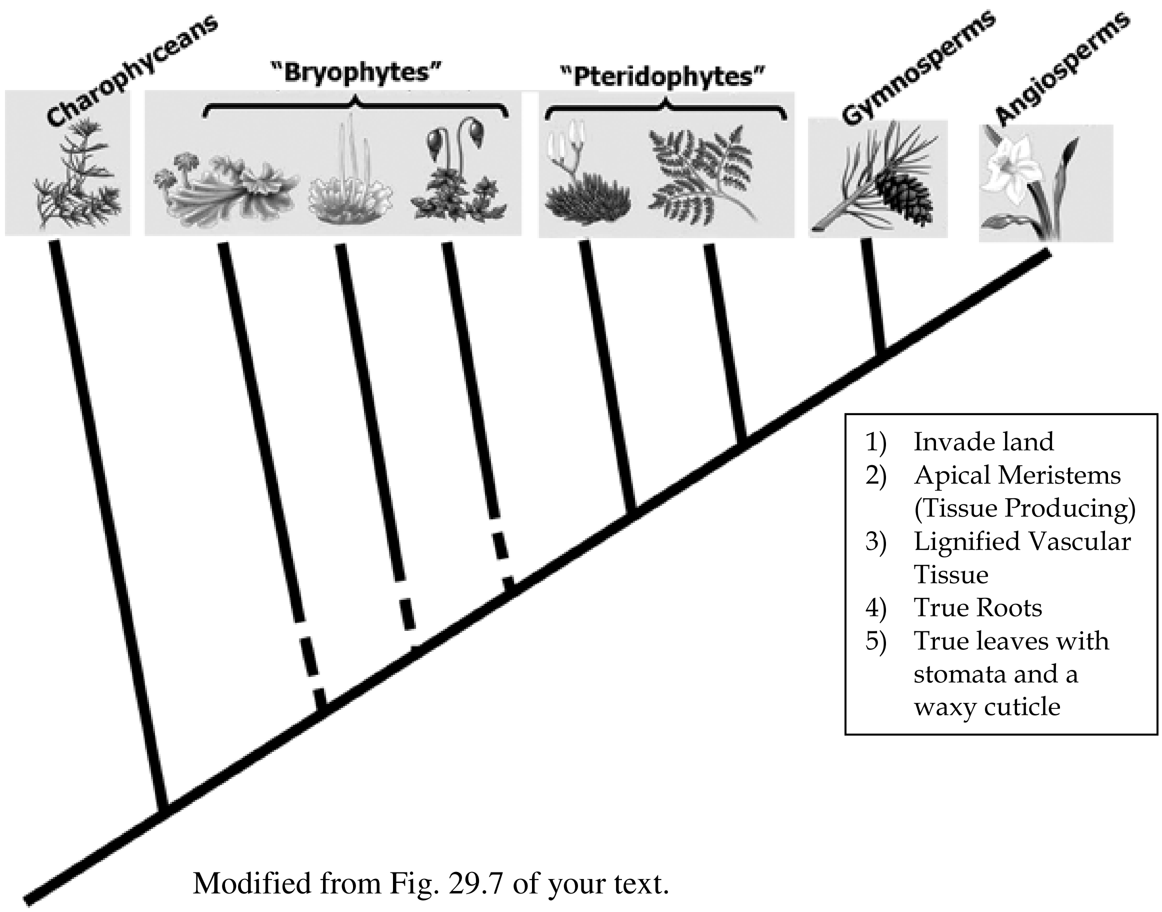
►**Observe the mixed cyanobacteria slide.**

►**Remove a single leaf from the aquatic plant *Elodea* and make a wet mount. Sketch what you see below and label the following structures: cell wall, nucleus and chloroplasts.**

Needless to say, the needs for water management are quite different in an aquatic versus a terrestrial habitat. Furthermore, the requirements for acquiring and distributing nutrients are different for a single celled alga versus a multicellular plant. This week we will explore some of the changes that occurred in land plants that allowed them to move away from moist habitats and allowed them to grow quite tall instead of remaining low to the ground.

Streptophyta Phylogeny:

As you work through this lab, place the events/features given in the list to the right of the phylogeny in the appropriate spots on the cladogram.



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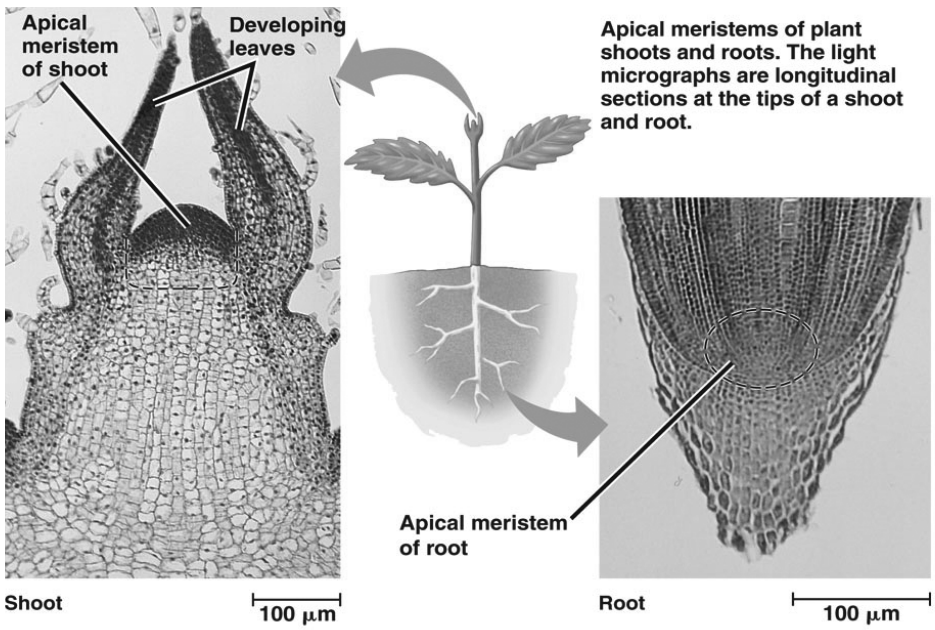
Apical Meristems:

Apical meristems that give rise to tissues are a synapomorphy for plants.



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►**Besides tissue formation (we will look more at plant tissues shortly), how are apical meristems useful in a terrestrial environment?**

►**Observe the prepared slide of a plant shoot (*Coleus*). Sketch what you see and label the apical meristem:**

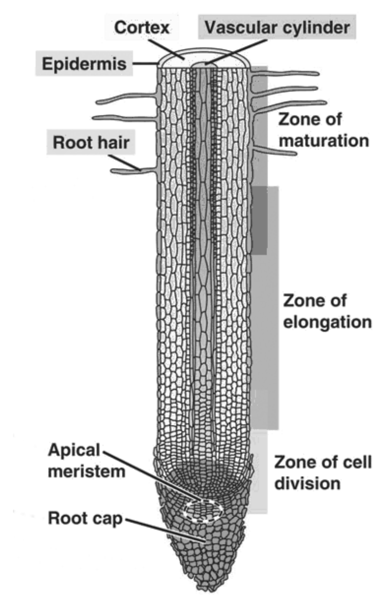
True Roots, True Leaves & Vascularization:

True leaves, roots and lignified vascular tissue are all found in "Pteridophytes", Gymnosperms and Angiosperms. "Bryophytes" have small root-like structures (rhizoids) that anchor them to the soil, and the "leaves" of bryophytes lack a cuticle (a key feature of true leaves). Some bryophytes have vascular tissue, but it is not lignified.

►**Observe the bryophyte(s) on display. Note their small size. They are short in stature and they are only one to a few cells thick. Given these attributes, how do you think water and nutrients are obtained by the cells of a bryophyte?**

True Roots:

Roots are the site of water and nutrient absorption and provide anchorage or support for the plant. They are also the site of energy storage (in the form of starch). Plants that take more than a single growing season to produce seeds will often store a large amount of starch in their roots. The root cap protects the root's meristem as the root grows and pushes through the soil. The cells produced by the meristems undergo a maturation process and eventually become specialized for different tasks. The root hairs that develop as outgrowths of the epidermis in newly mature regions of the root are the site of water and nutrient uptake.



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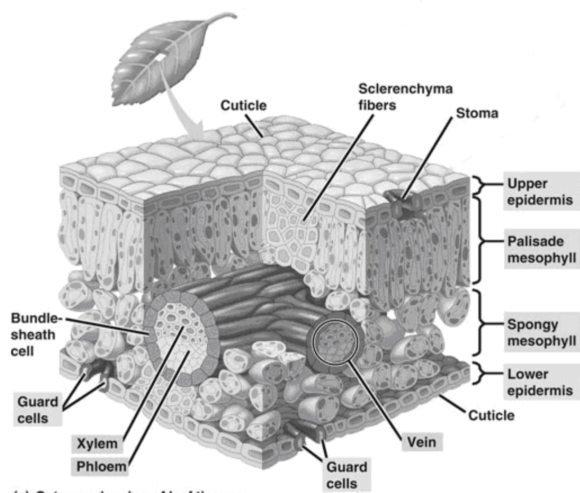
►**Observe the l.s. of an *Alium* (onion) root under the microscope. Make a sketch of the root and label the following parts: Root Cap, Apical Meristem, Zone of Cell Division, Zone of Elongation, Zone of Maturation, Root Hair, Vascular Cylinder, Cortex and Epidermis.**

True Leaves:

True leaves are made up of several tissue layers – see figure on right.

►**Observe the x.s. of a *Syringa* (lilac) leaf under the microscope. Sketch what you see and label the following: Cuticle, Epidermis, Mesophyll, Stoma, Guard Cells and Vein.**



(a) Cutaway drawing of leaf tissues

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Leaves are the primary site of photosynthesis, and the chloroplasts are located in the cells of the palisade and spongy **mesophyll**. Moisture is required for the gas exchange that is necessary for photosynthesis to take place. However, if the mesophyll cells were left exposed to the environment the plant would suffer too much water loss. The waxy **cuticle** provides a protective barrier against water loss. However, as you can well imagine, the cuticle also prevents adequate gas exchange. Therefore, **stomata** (singular – stoma) are scattered across the surfaces of the leaf.

These openings allow for gas exchange, but can also be routes for water loss. The **guard cells** regulate gas exchange and water loss by changing shape so as to open or close a stoma. When the guard cells are turgid (full of water) they bend so as to keep the stoma open. When they are flaccid (from lack of water) they close the stoma. Therefore, if plants are under water stress the stomata close and reduce further water loss. Plants can also self-regulate the opening and closing of the stomata by using a potassium ion pump to draw water into or out of the guard cells. Plants will often open their stomata at night and keep them closed during the day to further reduce potential water loss.

►Using forceps, carefully remove the epidermis from the ventral side (underside) of the leaf from a *Zebrina* (Wandering Jew) plant and make a wet mount. Observe your wet mount under the microscope and sketch what you see. Identify and label a stoma and its guard cells.

►Most plants have far more stomata on the ventral surface of their leaves. Why do you think this is so?

►Many plants are specially adapted to xeric (dry) climates. Look at the leaves from three different plants and fill in the table below.

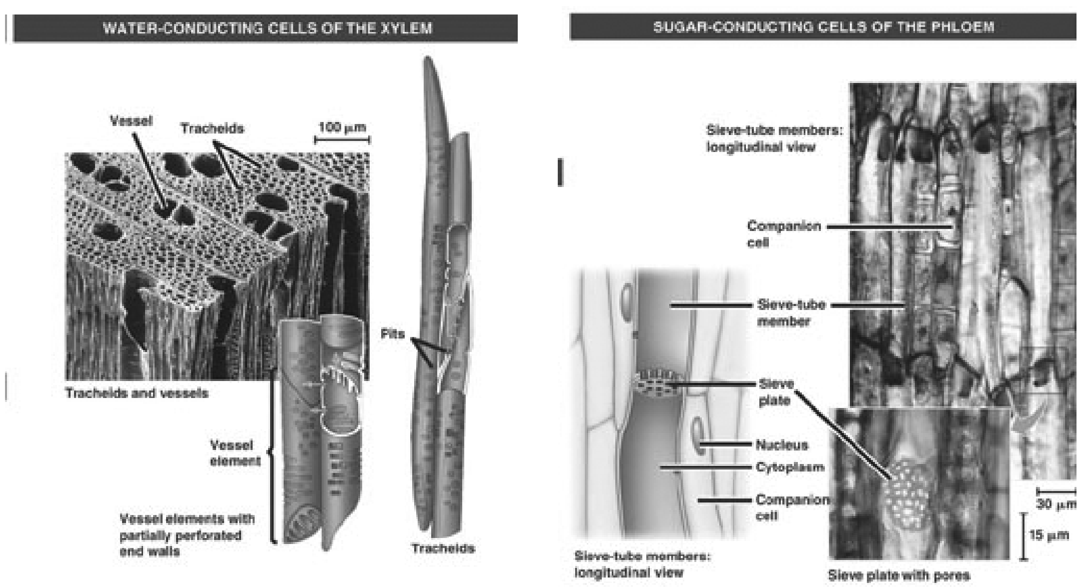
	Climate/When is Dry?	Leaf Modification(s)
Rhododendron (Angiosperm)		
Pinus (Gymnosperm)		
Cactaceae		

Lignified Vascular Tissue:

Vascular tissue transports water, sugars and other nutrients throughout the plant. While some bryophytes posses vascular tissue, it is not lignified. Lignin is an extremely strong substance, and its presence allows for plants to grow quite tall. While you may not think of ferns as very tall, there are tree ferns in the tropics and Pteridophytes (ferns and club mosses) dominated the forests during the Carboniferous period.

►Why is growing tall important for plants?

There are two types of vascular tissue in plants; **xylem** and **phloem**. Xylem transports water and minerals up from the roots, and phloem transports sugars (produced primarily in the leaves) throughout the plant.



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►**Observe the slide of a transverse section through the vascular tissue of *Quercus borealis* (red oak), sketch what you see and label tracheids, vessel elements and sieve-tube members.**

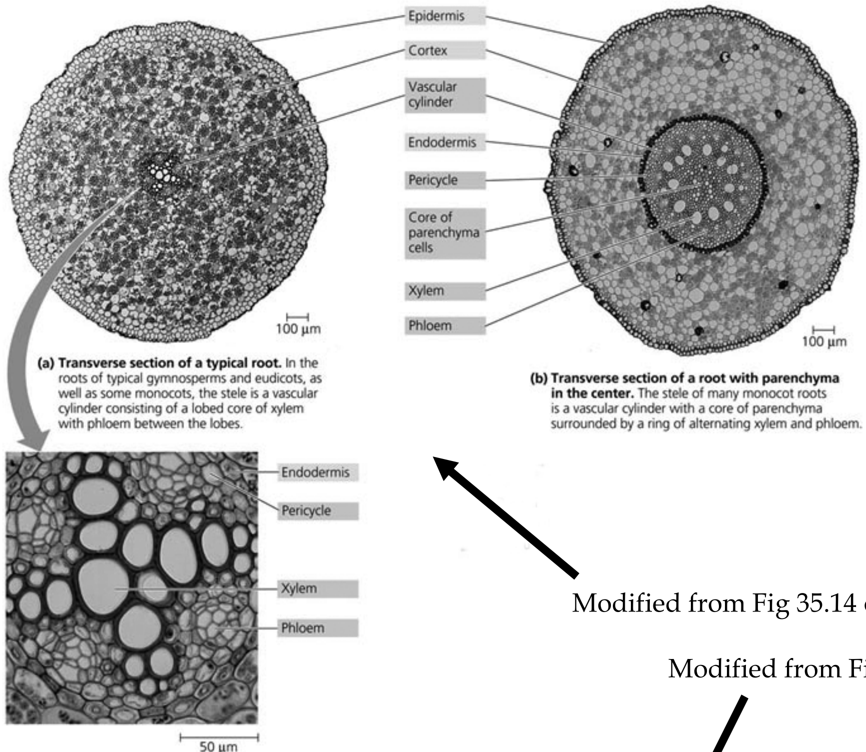
Within the Angiosperms, plants are grouped into two groups **Monocots** and **"Dicots"**. They have a number of differences in their structure (some of which we will cover in the plant reproduction lab). One of the major differences between the two groups is in how the vascular tissue is arranged. The veins in the leaves of monocots tend to be parallel where as they form a network in "dicots". The arrangement of the vascular tissue in the roots and stems also differs between monocots and "dicots."

►**Observe the cross section of a root and stem of a dicot – *Ranunculus* (buttercup), and the stem of a monocot – *Zea mays* (corn). Sketch what you see and label the Xylem, Phloem, Epidermis and Endodermis (endodermis in the root only).**
Transpiration and the movement of water through Xylem:

In order for water to move from the roots to the leaves it must defy the pull of gravity. Plants are able to do this without a mechanical pump (such as the heart in vertebrates). The cohesive properties of water make this gravity defying feat possible. As water is lost from the leaves via transpiration, it literally pulls more water molecules up with it. In this way water is pulled up from the roots as it is lost from the leaves.

►**Observe the demonstrations of transpiration and the flow of water through xylem. Record the information and your observations below.**

Identification and Classification of Pants: Observe all of the plant material available in lab. Make drawings and take notes about each one such that you can identify these plants on a practical exam. You should also be able to identify which of the major plant groups it belongs to.



(a) Transverse section of a typical root. In the roots of typical gymnosperms and eudicots, as well as some monocots, the stele is a vascular cylinder consisting of a lobed core of xylem with phloem between the lobes.

(b) Transverse section of a root with parenchyma in the center. The stele of many monocot roots is a vascular cylinder with a core of parenchyma surrounded by a ring of alternating xylem and phloem.

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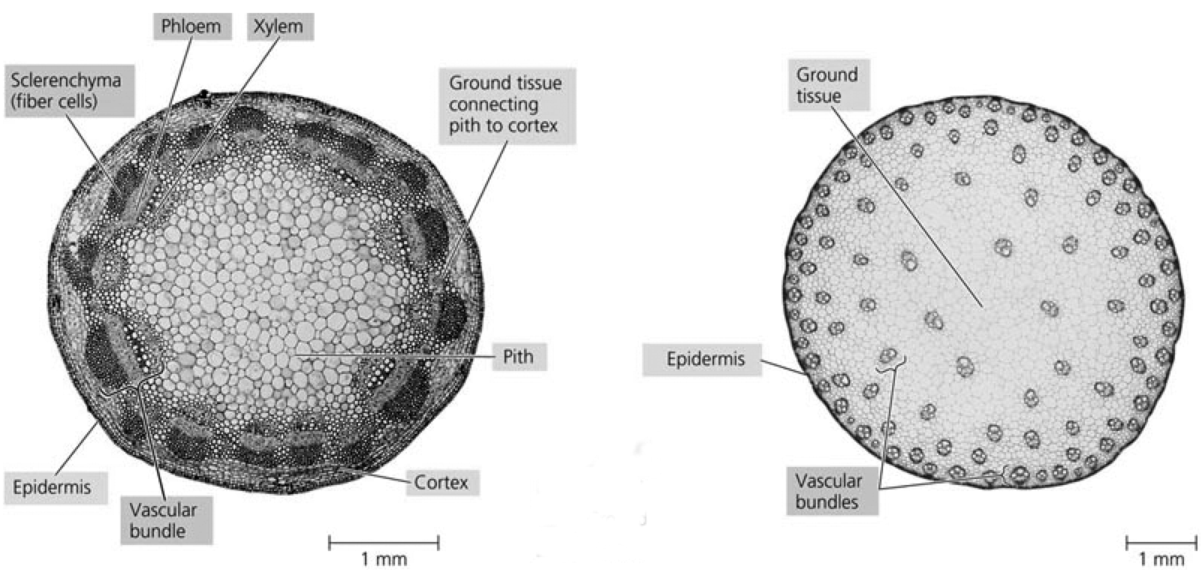
Modified from Figure 35.17 of your text



(a) A eudicot stem. A eudicot stem (sunflower), with vascular bundles forming a ring. Ground tissue toward the inside is called pith, and ground tissue toward the outside is called cortex. (LM of transverse section)

(b) A monocot stem. A monocot stem (maize) with vascular bundles scattered throughout the ground tissue. In such an arrangement, ground tissue is not partitioned into pith and cortex. (LM of transverse section)