Lecture 8 Plant growth

<u>Key terms</u>
Nodes
Internodes
Taproot
Fibrous root
Buds
Apical bud
Auxiliary bud
Blade
Petiole
Simple leaves
Compound leaves
Vascular tissue system
Dermal tissue system
Ground tissue system
Tracheids
Vessel
Xylem
Sieve tube elements
Phloem
Herbaceous
Woody
Epidermis
Periderm
Stomata
Parenchyma
Collenchyma
Sclerenchyma
Cell division
Cell elongation
Cell differentiation
Primary growth
Secondary growth
Meristems
Apical meristems
Lateral meristems
Bark
Cork cambium
Vascular cambium
Guard cells
Mesophyll
Parlisade mesophyll
Spongy mesophyll
Transpiration

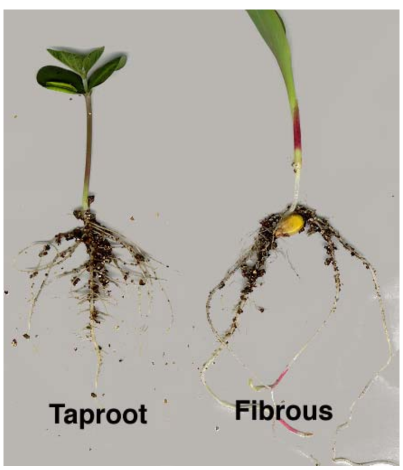
Bud scales
Cortex
Pith
Secondary xylem
Secondary phloem
Annual rings
Tension cohesion model/Transpiration cohesion model
Root pressure
Translocation
Pressure flow model

Plant body: vegetative organs
There are three vegetative organs in plants: root, stem, and leaves that are organized into two systems: the root system and the shoot system. Shoot system is composed of stems, leaves and flowers. Leaves are the main photosynthetic organ, stems holds and displays the leaves to the sun and provide connection for transport of materials. Root system is composed of roots that anchor plants in place and provides nutrition.

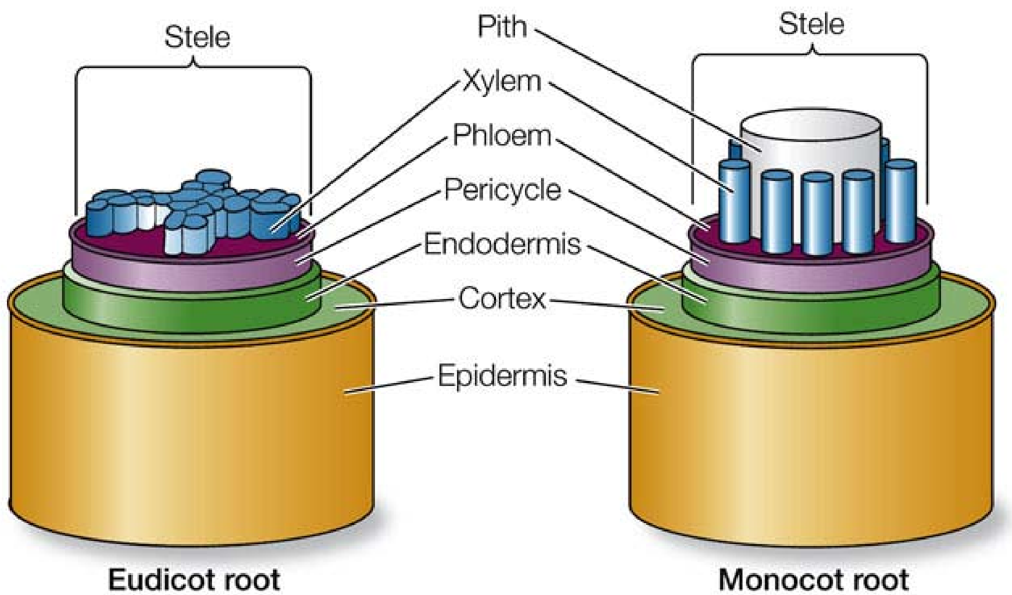
Roots
Roots lack the capacity for photosynthesis. They provides anchorage, absorbs water and minerals and serves as storage. (i.e. carrots) There are two main types of root systems: **taproot** system and **fibrous** root system.

Taproot : single large, deep-growing primary root accompanied by lateral roots. Can function as nutrient storage organ.

Fibrous: composed of numerous roots that are equal in diameter. They cling to soil very well.



The vascular tissue lies deep in the interior, with the xylem at or near the very center. In dicot root, the xylem has a star shape with phloem beween it. In monocots, the xylem surround a region of parenchyma cells called the pith that lies at the center of the root.



***LIFE 8e*, Figure 34.15**

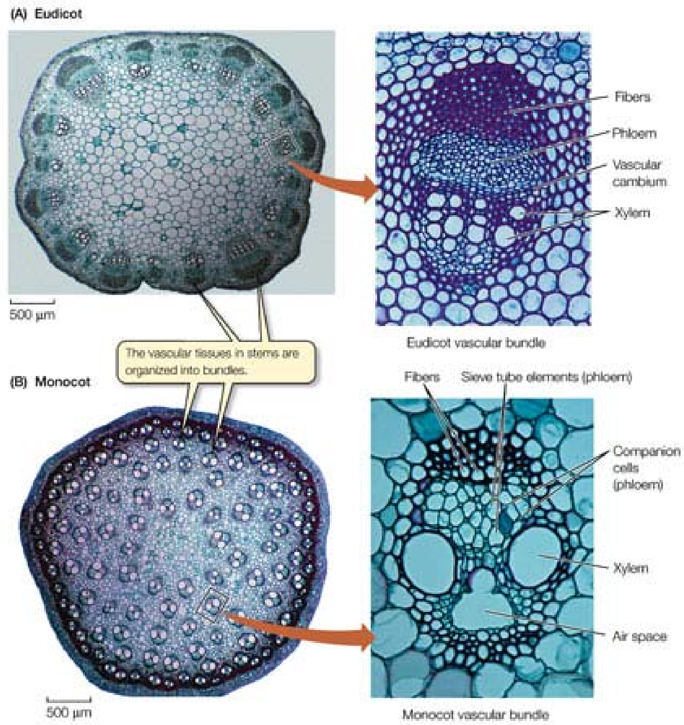
Stems
Stems have **buds**, which are embryonic shoots that provide cells for upward and outward growth. Buds can be apical buds, existing on the top of stems, or auxiliary buds, existing at places where the leaves join the stem.

Nodes are places where the stem bear leaves. The spaces between nodes are called internodes.

Bud scales are modified leaves that cover terminal bud when it is dormant. (i.e. during winter) When bud scales fall off, bud scale scars remain on the stem. The age of a twig determined by looking at the number of bud scale scars on it.

In dicots, there is an outer layer of epidermis. Inside is a layer of cortex, made up of ground tissues (parenchyma, collenchyma, and sclerenchyma cells) that conduct photosynthesis, storage and support. The vascular tissues in dicots are arranged in bundles in a circle. (When looked from the cross section) At the center of the stem, where are more ground tissues called pith. It is composed of parenchyma cells that function in storage.

In monocots, there are no distinction between the pith and the cortex. Also, the vascular bundles are not arranged in circle. They are scattered throughout the stem.



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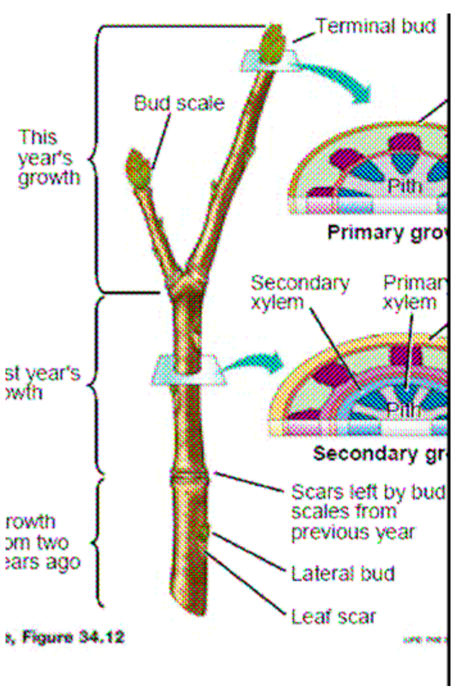
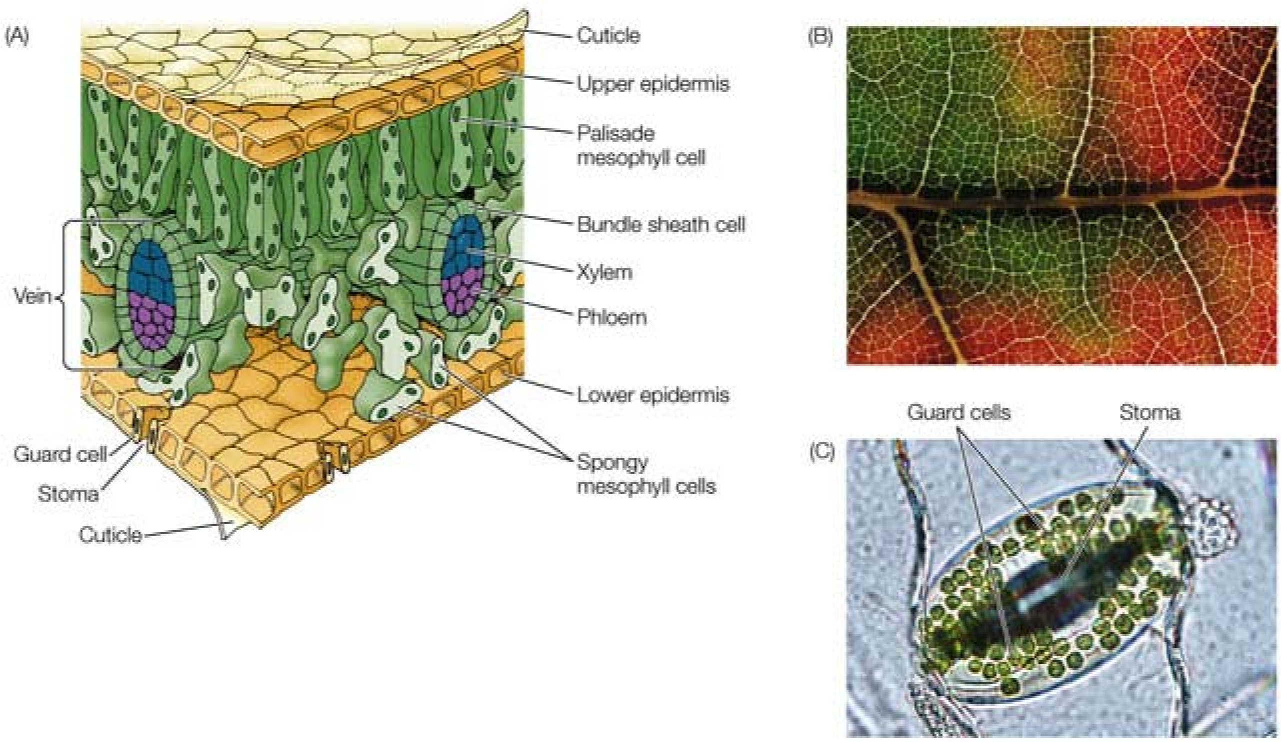


Leaves
Leaves are the primary site of photosynthesis for seed plants. The **blade** is a thin flat structure and the **petiole** is a stalk that the blade attach to and connect to the stem.

Simple leaves have a single blade while **compound** leaves have multiple blades called leaflets arranged along an axis or radiating from a central point. Only the place where leaves join the stem have an auxiliary bud, this can be used to distinguish simple leaves from compound leaves.



LIFE 8e, **Figure 34.23**

Each leaf have two **epidermis** (complex tissue composed of relatively unspecialized living cells. Usually single layer of flattened cells) layers, the upper epidermis layer and the lower epidermis layer. The epidermis layers are usually transparent to allows light to penetrate inside. The epidermal cells on the outside secrete a waxy layer called **cuticle**, which helps prevent water loss.

Since leaves need carbon dioxide for photosynthesis, they need to let them in. Cuticle blocks the entry of carbon dixode but stomata, pores on the epidermis layer, controlled by two **guard cells** can open and close to let carbon dioxide in and water/oxygen out.

The **mesophyll** is the main photosynthetic tissue. There are two kinds, palisade and spongy. **Palisade** is near the upper epidermis and is closely packed. Most of the photosynthesis takes place here. **Spongy** is near the lower epidermis and is more loosely and irregularly arranged with air spaces in between. This is done to allow the diffusion carbon dioxide to the palisade mesophylls. Veins, composed of xylem and phloem extends through the mesophyll with the xylem near the upper epidermis and the phloem near the lower epidermis. The xylem and phloem are surrounded by **bundle sheath**, non vascular cells.

In dicots, the leaves have a netted vein arrangement and have broad, flattened blades and a petiole.

In monocots, the leaves have a parallel vein arrangement with narrow leaves that wrap around the stem. (No petiole)

Tissue systems
All the organs are made up of 3 tissue systems: ground tissue system, vascular tissue system, and dermal tissue system.

Ground tissue system is made up of three types of tissue. **Parenchyma**, **collenchyma,** and **sclerenchyma**. **Parenchyma** is the most common type of tissue and it can do photosynthesis, storage and secretion. It is made largely of cellulose. **Collenchyma** is a flexible structural tissue that provides support in non wood plant organs. It is a living cell at maturity. **Sclerencyma** is a hard and strong tissue due to extreme thickening. It can not stretch nor elongate. It is also rich in lignin, a strengthing polymer.

Vascular tissue system is the transport system inside plants. It is made up of xylem and phloem. Xylem is made up of tracheid and vessel tube cells that undergo programmed death to form a hollow tube. Phloem is made up of sieve tube members that are kept alive by **companion cells.** Angiosperms can have both tracheids and vessel tubes in their xylem while gymnosperms only have the tracheids. (Exception is the Gnetale)

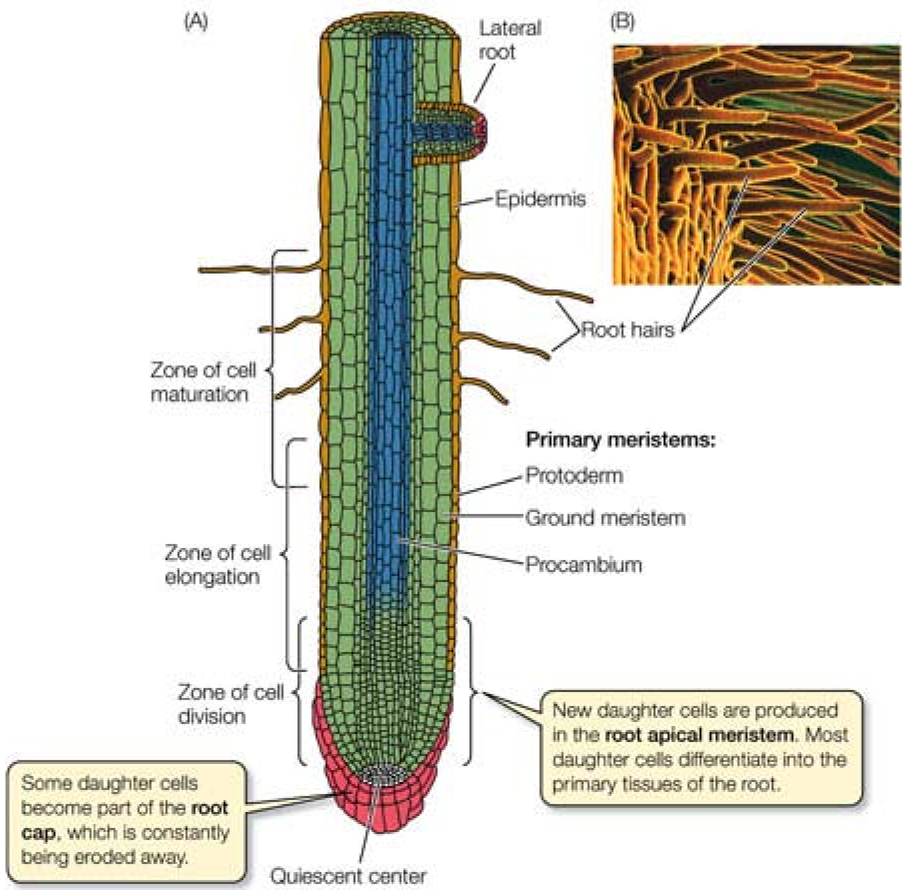
Dermal tissue system is the system responsible for the outer covering in plants. It is composed of epidermis, stomata and a few others.

Herbaceous and woody plants
Herbaceous plants have an epidermis while woody plants initially produce epidermis but that layer splits apart as the production of additional woody tissues (Periderm) beneath the epidermis occurs. Herbaceous plants only have primary growth while woody plants have both primary growth and secondary growth where older stems/roots increase in girth.

Primary and secondary growth

Unlike humans, plants only grow at certain areas called **meristems.** Meristems are composed of undifferentiated cells whose sole purpose is to form new cells by performing mitosis. This growth is active during the entire lifespan of the plant.

Primary Growth occurs as a result of activity at **apical meristems.** These are the area at tips of root and shoots, and buds of stems. There are three steps in primary growth: cell division, cell elongation, and cell differentiation. In **cell division,** the cells simply divide to multiply their numbers. In **cell elongation,** the cytoplasm inside the newly formed cells grows and the vacuoles are filled. Finally, in **cell differentiation,** the cells are differentiate into specialized cells. The apical meristems give rise to the primary meristems that develop the tissue system within plants. In roots, they are the protoderm that produces epidermis (dermal tissue system) ground meristem that produces cortex (ground tissue system) and procambium that produces the vascular cylinder, or **stele**. All plants have primary growth.



***LIFE 8e*, Figure 34.14**

In this root, the **root cap** is made of daughter cells from the apical end of the apical meristem that protects the delicate growing region of the root as it pushes through the soil. The **quiescent center** is a place where cell division are rare.

Secondary growth occur at **lateral meristems.** Lateral meristems are areas extending along entire length of stems and roots except at tips. There are two lateral meristems responsible for secondary growth: vascular cambium and cork cambium. **Vascular cambium,** located between xylem and phloem, divides and produce two conducting/supporting tissues: secondary xylem and secondary phloem, that replace the primary xylem and primary phloem in function.

Cork cambium, located on the outer cortex, divides to produce cork cells, which becomes periderm, water proof cells Periderm is the outer bark that replaces epidermis.

Bark is secondary phloem and the periderm while wood is secondary xylem. (Primary xylem and phloem is the part before the thickening begins)

Only dicots/eudicots have secondary growth.

Transportation in the xylem

It was originally thought that the xylem transport water by an active pumping action, Strasburg, however, proved this wrong by a single experiment where he cut down giant trees and put them in solution of poison. His experiment proved three things:

1) water is not pumped by living. The poison would kill the living cells but water still got to the leaves.
2) Leaves played an important role in water transport; as long as they were alive, water moved up
3) Movement not caused by roots because roots were cut off.

This lead to the **transpiration-cohesion-tension** model. This is purely physical process that requires no energy input. This is explained by the difference in water potential. The leaves at the top of trees release water through stomata in a process called **transpiration.** This creates negative water potential that would create **tension** due to water's **cohesive** property. Water enters the root due to root's high solute concentration compared to the rest of the soil in a process known as osmosis. The tension pulls the water that entered up through the xylem and into the leaves.

Minerals ions are dissolved in the xylem sap and are distributed as they were pulled up.

The overall process, simplified is soil → root tissues → root xylem → stem xylem → leaf xylem → leaf mesophyll → atmosphere with each step having more negative water potential.

Water in xylem only goes from the root to the leaves. It is unidirection.

Translocation in the phloem

Phloem moves sugars produced by the mesophylls around. The dissolved sugar can go both ways but it is a lot slower than the transport mechanism in the xylem. (Both ways in that different sieve tubes move the sap around in different directions. Not both ways in a single tube) This is an active process that requires the input of ATP energy.

At the source, the companion cells load sugar into sieve tubes by an pumping protons out (Active process that requires ATP). As the protons diffuse back in via the proton gradient, it brings in the sugar. As the concentration of sugar increases, it decreases the water potential. Thus, water flows in, creating and increasing hydrostatic pressure.

This hydrostatic pressure pumps the sugar to its destination, where it is unloaded by passive or active mechanism. Translocation itself requires no energy, but loading and unloading does.

Nutrients

Plants need nutrients to survive. These nutrients includes nitrogen, potassium, phosphorus, carbon etc..

Nutrients like nitrogen can be obtained in a number of ways, including:

1) Using roots to actively pump water and the nutrients in them.
2) Symbiosis with fungal mycorrhizae
3) Symbiosis with bacterial Rhizobia (nitrogen only)
4) Carnivory (occur mostly in bogs, mostly nitrogen)