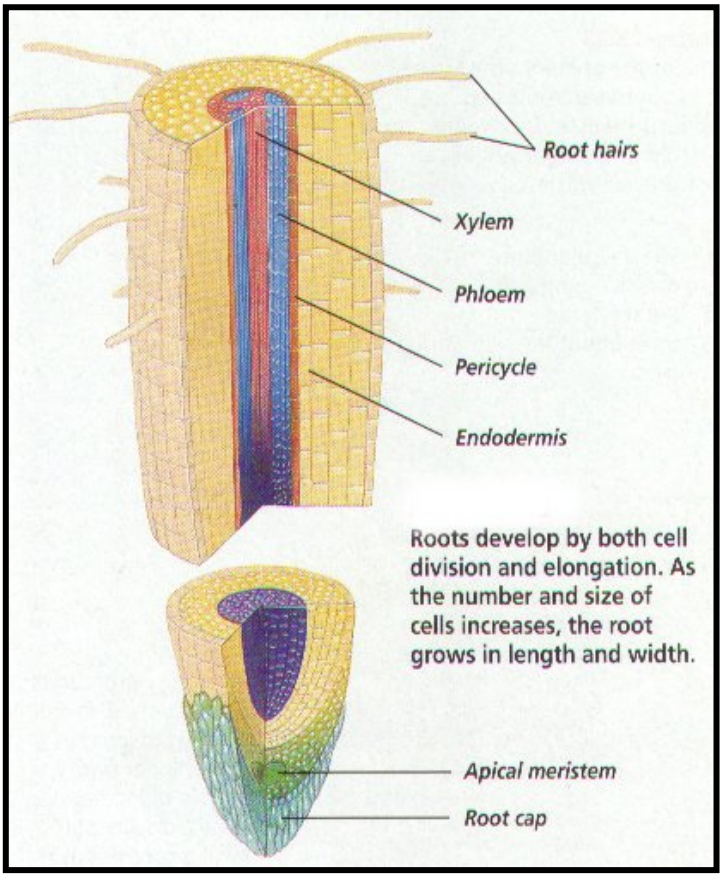
The process of photosynthesis enables a plant to make its own food. But, how does the plant get the water and minerals it needs to stay hydrated and healthy? In order to answer this question, we have to look at the structure of the root and the stems.

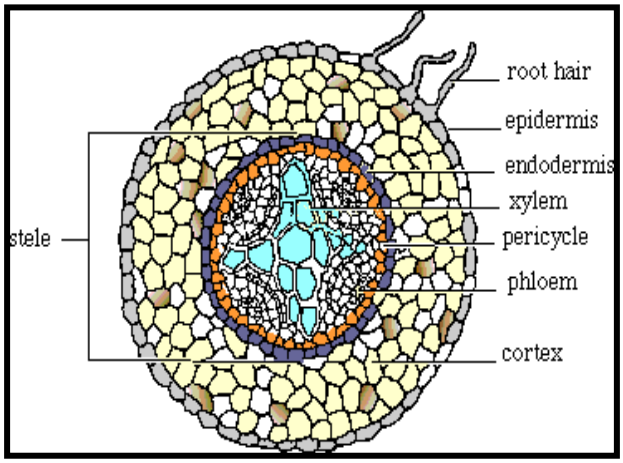
Structure of the Root

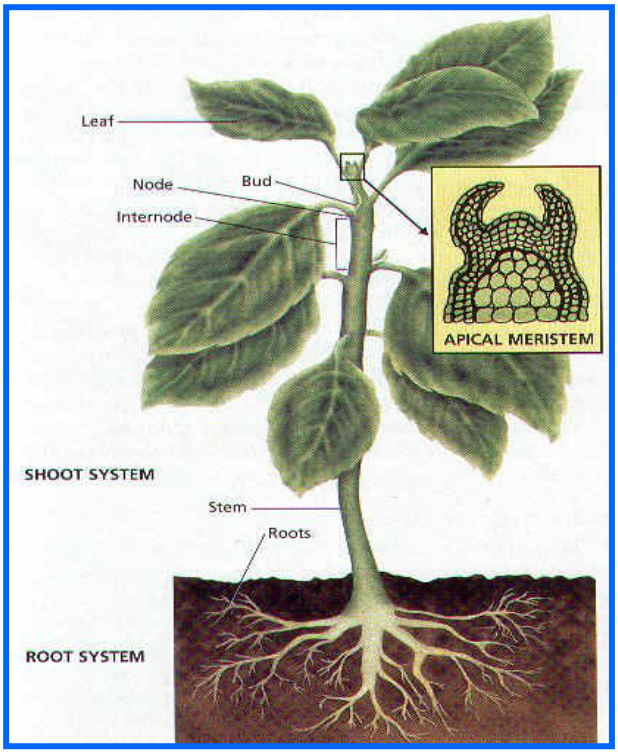
1. Roots are specialized structures that anchor the plant, store nutrients, absorb water, nitrates, and other dissolved minerals and carries these materials to the stem.
2. Growth of the root into the soil occurs through the cell division at the root tip.
3. **Root Functions:**
   a. anchor plants into the soil (remember ecology – when trees are removed, soil is washed away, because there is nothing to hold it in place.
   b. absorb water and dissolved minerals
   c. may store carbohydrates (i.e. carrot, turnip, potato all contain starch)
   d. may store water during dry periods
4. **Root Cap:**
   a. forms a protective covering for the ***embryonic cells*** of the root tip
   b. the root tips is pushed through the soil by the addition of embryonic cells behind it.
   c. the outer cells of the root tip are crushed in this process, releasing a lubricating fluid that aids in the passage of the root tip through the soil.
   d. new cells are continuously being formed at the embryonic region. As they elongate and grow, they begin to differentiate and become specialized.
5. **Root Hairs:**
   a. the root has an **outer layer, *the epidermis***, which is one cell layer thick, so that materials and water can pass through by diffusion, osmosis, and active transport.
   b. some epidermal cells produce hairlike extensions of their cell membranes. These ***root hairs*** penetrate the soil and increase the **<u>surface area for greater absorption of water and dissolved minerals.</u>**

   --water and dissolved minerals from the soil enter the root hairs and epidermis of the root by diffusion, osmosis, and active transport.
6. **Cortex:** located just beneath the epidermis of the root.
   --consists of loosely packed cells which store food and transport water and minerals absorbed through the epidermis and root hairs to the xylem and phloem.
7. **Central Cylinder:** consists primarily of xylem and phloem cells.
   a. **xylem:** specialized vascular tissue that extends from the roots to the leaves.
      --transports water and dissolved minerals upward in the plant.
      --Composed of continuous tubes of thickened cell walls of dead cells.
   b. **phloem:** vascular tissue that is involved in the transport of organic food materials (like glucose) from the leaves throughout the rest of the plant (in both directions) for immediate use or storage as starch.
      --made up of living cells that for continuous conducting tubes.



Cross-Section of a Root



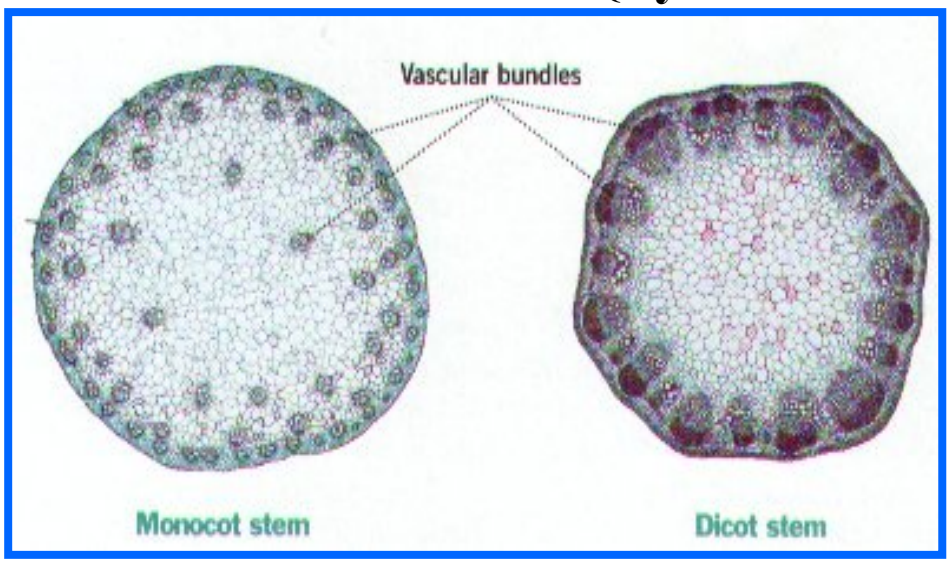


Stems

Function of stems

a. Stems are adapted to support leaves and expose them to light
b. Stems transport water & minerals between the roots and the leaves and the various other tissues of the plant
c. Plants grow vertically from the tips of their stems and the tips of their roots.

Vascular Bundles in Stems (Xylem and Phloem)



- Vascular Tissue is arranged in bundles with xylem toward the inside & phloem toward the outside.
- Vascular bundles are scattered throughout monocot stems (monocot - flowering plants with seeds that have 1 cotyledon (stored food source for the developing embryo ex. corn, grass)
- Vascular bundles are arranged in rings in dicot stems (dicot - flowering plants with seeds that have 2 cotyledons ex. beans, oak)

So, how does water move against gravity, traveling from the roots to stems in vascular plants (plants that have xylem and phloem)?

In a process that is familiarly called *transpirational pull,* it is believed that upward water movement in the xylem is driven by the help of the following forces:

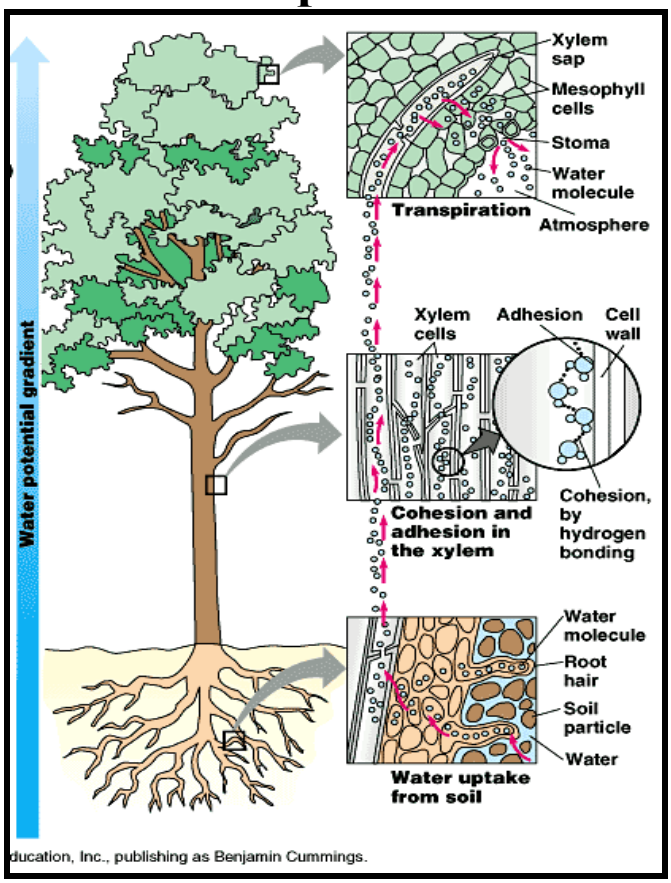
a. **transpiration:** the evaporation of water from leaves & stems

b. **capillary action**: remember the "magic tube" the pediatrician used to take a sample of your blood when you were younger? Your doctor would prick your finger and put the glass tube against the opening in your finger and the blood would "magically" go up the tube. This "magic" was actually due to two forces:
   --***cohesive forces*** of water molecules attraction for each other (like--like)
   --***adhesive forces*** of water molecules attraction for the glass tube (like—unlike).

c. In the xylem, the water molecules enter by osmosis into the root. The water molecules stick together (like-like). The water molecules also stick to the sides of the xylem (like-unlike). As the water evaporates (transpiration) out of the leaves, the water column in the xylem is pushed upward with the help of these cohesive and adhesive forces.

See diagram on the next page……

"Transpirational Pull"



Transport in Leaves

- The ***veins*** of leaves are extensions of the xylem and phloem from the stem.
- The ***veins*** transport materials to and from the tissues of the leaf.

Gas Exchange in Plants

Leaves:

- gas exchange takes place in the spongy layer of the leaf where interior air spaces connect with the environment through the stomates.

Roots:

- Gas exchange occurs in the moist membranes of the root hairs and other epidermal cells.

Woody Stems (bark)

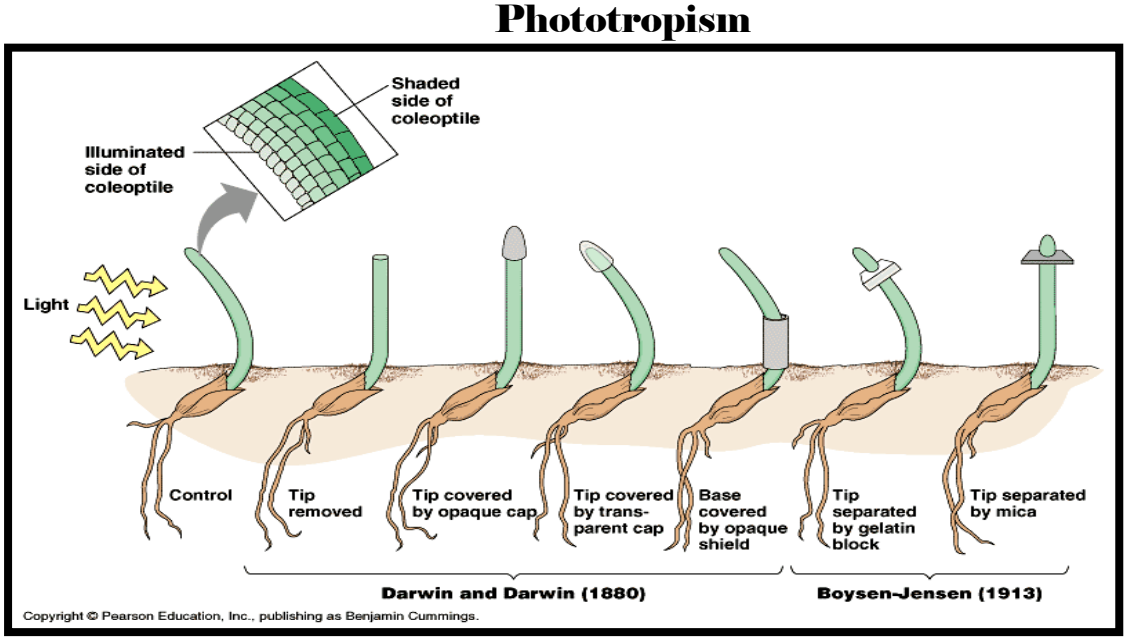
- There are areas in bark were loosely packed cells allow gas exchange to occur

As you all know, plants cannot locomote, so they cannot run away from danger or change their location if they are in shade too much of the day. So how do they survive?

Plants use hormones for cell to cell communication in order to adapt to their environment and increase their chances for survival. Plants' responses to external stimuli are known as ***TROPISMS*** and usually involve hormones to help them to respond. Plants have many hormones that help them to respond to external stimuli, but the group of hormones we are going to look at are ***AUXINS***, ***plant hormones responsible for helping plants to grow.***

Phototropism

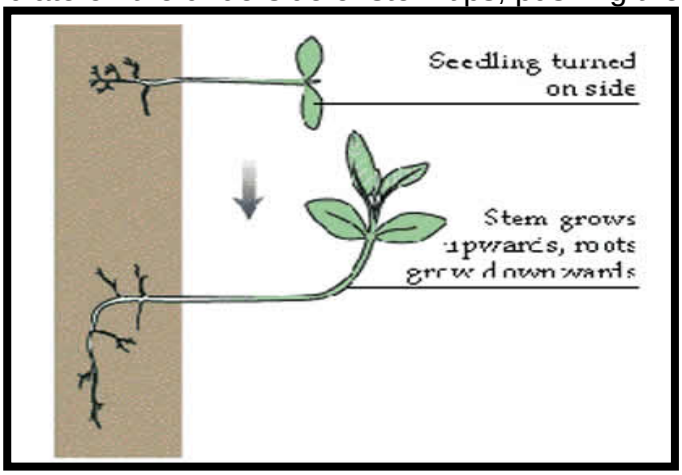
- Let's say you put a plant on a window sill and water every day. But, you forget to rotate the plant, so the side facing the window gets sunlight and the side away from the window, never gets any light.
- The plant will take matters in its own hands, by manufacturing auxin hormones, which accumulate in the cells on tips of the stems (where a plant grows from) on the unlit side of the plant.
- The dark side of the plant starts to grow faster than the lit side, making the plant bend toward the light.



In looking at the diagram above, remember that plants grow from the tips of their stems and the tips of their roots. So if you cover the tips of the stems or cut them off, they cannot respond. If you cover the stems part way down, this does not affect the response of the plant.

Geotropism

- Plants also respond to gravity with the help of auxins.
- If a plant is turned on its side, auxins accumulate on the top side of the root tips, elongating the cells, causing them to grow downward.
- Auxins will also accumulate on the underside of stem tips, pushing the stem upward.



After reading this packet, please answer the following questions on separate paper:

1. Describe the function of the root cap.
2. Why are roots necessary for the survival of a plant?
3. How does a root hair enhance the absorption of water and nutrients?
4. Differentiate between the structure of xylem and phloem.
5. Describe the function of xylem and phloem.
6. Discuss the forces that aid in pulling water through the xylem.
7. Describe the functions of the stem.
8. How does gas exchange take place in leaves?
9. Why are hormones necessary for plant survival?
10. Describe phototropism and the role auxins play in this tropism.
11. Briefly discuss geotropism and its role in helping maintain homeostasis for a plant.