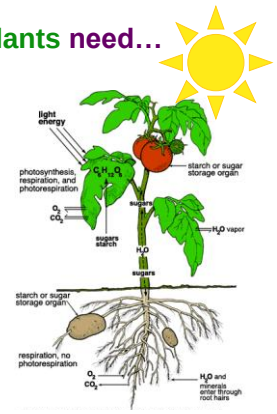
Chapter 10.4, 10.5

Regulation and Transport in Plants

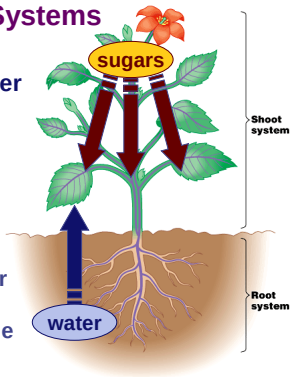
Remember what plants need…

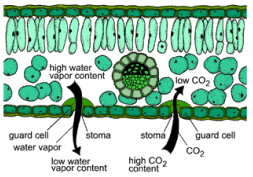
- Photosynthesis
  - light reactions
  - Calvin cycle
    - light ← sun
    - H_2O ← ground
    - CO_2 ← air



Interdependent Systems

- Both systems depend on the other
  - roots receive sugars & other nutrients from photosynthetic parts
  - shoot system depends on water & minerals absorbed from the soil by roots





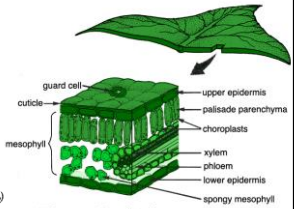
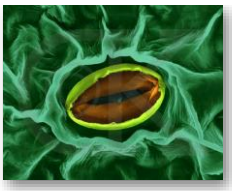
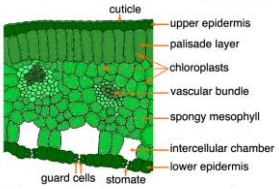


Figure 25. Stomata open to allow carbon dioxide (CO_2) to enter a leaf and water vapor to leave.





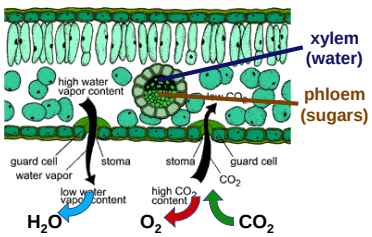
A look at stomates…

- Gas exchange
  - CO_2 in → for Calvin cycle
  - O_2 out → from light reactions
  - H_2O vapor out (TRANSPIRATION)

photosynthesis

O_2 CO_2

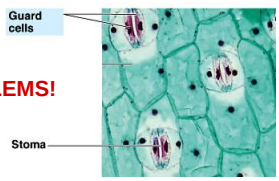
gas exchange water loss



Controlling water loss from leaves

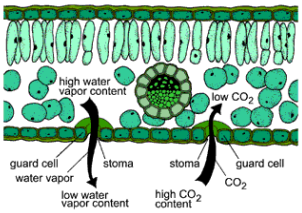
- Hot or dry days
  - stomates close to conserve water
  - when guard cells:
    - gain H_2O = stomates open
    - lose H_2O = stomates close
  - adaptation to living on land, but…

creates PROBLEMS!



Stomates

- closed stomates lead to…
  - O_2 builds up (from light reactions)
  - CO_2 is depleted (in Calvin cycle)
    - causes problems in Calvin Cycle



Inefficiency of Rubisco: CO_2 vs O_2

- Rubisco in Calvin cycle
  - carbon fixation enzyme
    - normally bonds C to RuBP
    - reduction of RuBP
    - building sugars

photosynthesis

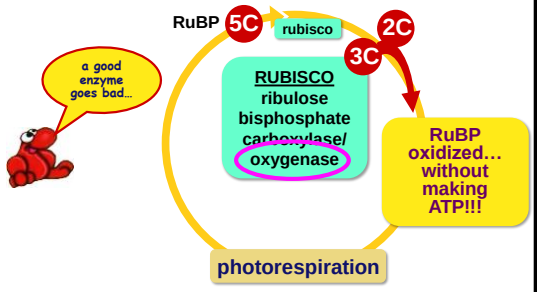
  - when O_2 concentration is high
    - Rubisco bonds O to RuBP
    - O_2 is alternative substrate
    - oxidation of RuBP
    - breakdown sugars

photorespiration

RUBISCO: ribulose bisphosphate carboxylase/oxygenase

Calvin Cycle—with ↑[O_2]

RuBP = ribulose bisphosphate



Impact of Photorespiration

- Oxidation of RuBP
  - short circuit of Calvin cycle
  - decreases photosynthetic output by siphoning off carbons
    - no ATP (energy) produced
    - no $C_6H_{12}O_6$ (food) produced
  - loss of carbons
    - can lose 50% of carbon fixed by Calvin cycle
  - if photorespiration could be reduced, plant would become 50% more efficient
    - strong selection pressure

Why the C3 problem?

- Possibly evolutionary baggage
  - Rubisco evolved in high CO_2 atmosphere
    - there wasn't strong selection against active site of Rubisco accepting both CO_2 & O_2
- Today it makes a difference
  - 21% O_2 now vs. 0.03% O_2 then
  - photorespiration can drain away 50% of carbon fixed by Calvin cycle on a hot, dry day
  - strong selection pressure to evolve better way to fix carbon & minimize photorespiration
    - C4 variation, CAM variation of carbon fixation

Control of Transpiration

- Stomate function
  - always a compromise between photosynthesis & transpiration
    - leaf may transpire more than its weight in water in a day…this loss must be balanced with plant's need for CO_2 for photosynthesis
      - a corn plant transpires 125 L of water in a growing season