Lecture and Text Coverage:

Chapters 3–7, 9, 10, and 11(parts). The progression of these chapters emphasizes primarily plant anatomy and then plant physiology with reference to water relationships (Ch. 9), photosynthesis (Ch. 10), and growth & development (Ch. 11, gravitropism). Use your Study Outline and lecture-study notes for SA #26, 28; and #30 to 36. BLIP Oral reports reinforce many of the concepts (#6 below).

Laboratory:

Review lab notes and labeled graphics which addresses plant anatomy and physiology (Lab Ex. #11-14). Then, relate cell-tissue structure and location to physiological processes such as water movement through the soil-plant-air continuum (SPAC), gravitropism, photosynthesis, phloem translocation, and stomatal regulation of water and gas exchange. The study questions below emphasize this integration of the plant anatomy with the physiological processes.

1. Explain your understanding of water potential(Ψw) and why it is a useful concept in plant physiology. Then, sketch a simple osmometer and explain how an equilibrium of water potential can be reached across the DPM even without an equilibrium of solute concentration.

2. Explain how an osmometer (See #1) can be used as a physical model to simulate each of the following processes:
a) existence of pressure (+Ψp,) in the xylem forcing water to drip from leaves in the morning;
b) how pressure (+Ψp,) causes expansion of cells in the elongation region of roots, stems and leaves.
c) opening of stomata when the sun rises in the morning.

3. A farmer has two fields. One has clay loam soil, and the other, sandy soil. After a very dry month of June, you notice the effect of drought on growth rates of corn in the two fields. What differences would you observe and how would you explain to the farmer in physiological terms the cause-and-effect relationships? Your answer should demonstrate an understanding of the effects of water relations upon each of the following: (a) stomata and leaf gas exchange, (b) photosynthesis (photochemical and biochemical phases), and c) the role of turgor pressure in causing cell enlargement (see #2,b).

4. Describe the path of a molecule of CO_2 as it moves by diffusion from the atmosphere to the stroma of a chloroplast within a potato leaf palisade cell. Include all cellular structures that would be contacted or crossed in this "odyssey". What factors influence rate of diffusion of CO_2 into leaves of (a) *Elodea*, (b) *Zea mays*, (c) *Pinus*, and (d) *Bryophyllum* (Family Crassulaceae)?

5. Describe the "odyssey" of a calorie of energy originating from the sun as a photon (λ = 600 nm), absorbed by a potato leaf (item #4), and ending up in a chemical bond of starch down in the potato tuber. Assume it meets the CO_2 molecule in the stroma (item #4). Integrate anatomy and physiology along the odyssey, and include the phloem transport system.

6. Plant growth is influenced both by genetic factors (*e.g.* differences in pollen morphology, chlorophyll content; or between C_3 and C_4 species) and by environmental factors (*e.g.* light intensity, light quality, light duration (photoperiod), touch or vibration, or soil moisture). Review your notes and what you have learned from our "BLIP Symposium" and be able to discuss these relationships.

7. Compare / contrast within each of the following pairs:

SOIL TEXTURE -- SOIL STRUCTURE	PHOTOCHEMICAL -- BIOCHEMICAL (Reactions)
SOLUTE POTENTIAL -- PRESSURE POTENTIAL	FLUORESCENCE -- REFLECTION
TRANSPIRATION -- GUTTATION	PRIMARY PIGMENT -- ACCESSORY PIGMENT
PLASMODESMATA -- CASPARIAN STRIPS	ELECTRON TRANSPORT -- PHOTOPHOSPHORYLATION
TURGOR PRESSURE -- TENSION	STOMA -- STROMA ADP -- NADP
OSMOSIS -- ACTIVE TRANSPORT	C_3 PLANT --C_4 PLANT – CAM PLANT
CELL ELONGATION -- ROOT, STEM CURVATURE	RUBISCO – PEP CARBOXYLASE
EXODERMIS – ENDODERMIS	PHOTOSYNTHESIS - - PHOTOMORPHOGENESIS

Photosynthesis Unscramble[1] – Environmental Aspects Included BIO 2500

Note: These exercises are intended to assist you as you develop a comprehensive understanding of the two major physiological processes, absorption of CO_2 and biochemical fixation by a C_4 plant. Please do not allow this study aid to give you a false sense of understanding of the process and significance each of the components. You should be able to discuss/explain each of them as well.

Absorption of CO_2 by leaf – *Number events in chronological order:*

_____A. Lower CO_2 levels activates H+/K+ pump in guard cell membranes

_____B. CO_2 diffuses into the mesophyll cells and mesophyll chloroplast stroma

_____C. Photosynthesis decreases levels of CO_2 in leaf mesophyll

_____D. CO_2 diffuses into the leaf through stomata

_____E. Water enters the guard cells by osmosis

_____F. Sunlight enters the leaf and stimulates photosynthesis

_____G. Turgor pressure opens stomata

_____H. K+ concentration in guard cells increases, thus lowering Ψs

Biochemical fixation of CO_2 by a C4 plant – *Number events in chronological order:*

_____A. 4-carbon organic acids diffuse into bundle sheath cells

_____B. Organic acids (4-C) are decarboxylated to release CO_2 and form pyruvate (3-C)

_____C. CO_2 reacts with PEP carboxylase to form 4-carbon organic acids

_____D. CO_2 reacts under catalytic activity of Ribulase bisphosphate carboxylase (Rubisco) to form phosphoglyceric acid (PGA)

_____E. Glucose may be converted to starch which is stored in the chloroplasts for night-time use in the leaves or for export from the leaf as sucrose via phloem

_____F. Glyceraldehyde 3-phosphate is converted to ribulose bisphosphate (to regenerate the CO_2 acceptor) or to glucose and sucrose for export via phloem

_____G. Pyruvate diffuses back out to the mesophyll cells where it is converted to PEP, the substrate for PEP carboxylase to continue the shuttling of CO_2 (see C.)

_____H. With the help of ATP and $NADPH_2$, PGA is converted to glyceraldehyde 3-phosphate (GA3P).

[1] Constructed by Angela Dutton, Fall, 2006

“Which Is Greater?” Exercises

For each of the following, select the choice representing the greater size, quantity, *etc*. and then explain your answer and identify the general concept or principle underlying the comparison:

1. Wall thickness is greater in a. parenchyma cell b. sclerenchyma cell

2. Cell diameter; and, range of sizes of openings for water entry/escape in
   a. xylem vessel
   b. xylem tracheid

3. Flexibility of cell walls is greater in a. collenchyma b. sclerenchyma

4. Elasticity of cell walls is greater in
   a. elongating cells on under side of gravistimulated root
   b. elongating cells on the upper side of gravistimulated root

5. Gibberellic acid content in elongating cells is greater in the stems of
   a. Genetic dwarf corn plants
   b. Normal corn plants

6. Starch content in chloroplasts of sunflower leaves is greater in the
   a. Early morning
   b. Late afternoon

7. Water solubility is greater for
   a. Anthocyanins (e.g. found in apple peel cell vacuoles)
   b. Carotenoids (e.g. lycopene found in pericarp of red bell peppers)

8. All other factors being equal, the temperature of a soybean leaf is greater when
   a. Stomata are open
   b. Stomata are closed

9. Pressure potential within guard cells is greater when
   a. Leaves are receiving adequate water (favorable Ψw)
   b. Leaf Ψw decreases and abscisic acid (ABA) moves in the apoplast to the guard cells

10. Distance of outward displacement of Elodea cell walls is greater when leaves in aquarium water are exposed to
    a. hypotonic solution
    b. hypertonic solution

11. Distance between primary xylem and the phelloderm is greater in a woody stem that is
    a. 2 years old
    b. 4 years old

12. On a sunny summer day, the concentration of sucrose is greater in sieve tubes of
    a. an actively photosynthesizing leaf
    b. an actively growing potato tuber

13. Pressure potential (Ψp) within the xylem of the stems of a sunflower plant is greater during
    a. the morning after the rain
    b. the following afternoon which is sunny with low humidity

14. Stomatal conductance in cactus
    a. at 2:30 pm
    b. at 11:00 pm

15. Proportion of growth constituents transported to roots *versus* that which isretained in the shoots is greater when soybeans are
    a. grown in optimal soil moisture
    b. grown in soil of lower water potential

16. On a bright sunny day, the concentration of oxygen is greater in corn leaf
    a. mesophyll cells
    b. bundle sheath cells

17. In chloroplasts of soybean leaves on a sunny afternoon, the pH is greater
    a. inside the thylakoids
    b. in the stroma surrounding the thylakoids

18. Rate of oxygen production is greater as a result of
    a. cyclic photophosphorylation
    b. noncyclic photophosphorylation

19. Rate of PGA synthesis is greater when
    a. stomata are open
    b. stomata are closed

20. Stomatal conductance in soybean plants at 8:30 am is greater in soybean plants growing in soil with a
    a. Ψw of -0.1 Mpa
    b. Ψw of -1.2 Mpa

21. Rate of leaf growth/expansion in sunflower seedlings is greater when grown in soil with a
    a. Ψw of -0.1 Mpa
    b. Ψw of -1.2 Mpa

22. Rate of lateral root elongation in soybean plants is greater when grown in soil with a
    a. Ψw of -0.1 Mpa
    b. Ψw of -1.2 Mpa

23. During the operation of the Calvin Cycle, which is greater in quantity
    a. the total number of moles of PGA synthesized
    b. the total number of moles of PGA converted to sucrose and starch

24. Degree of phototropic bending of grass seedlings is greater when exposed to unidirectional
    a. red light (660 nm)
    b. blue light (450 nm)

25. Dry mass is greater in
    a. bean seeds prior to imbibition
    b. bean seeds plus young roots formed in the first 2 days before emergence from the soil