Review for Exam III
PHOTOSYNTHESIS
Chemistry 462
Spring 2003

Structures and Enzymes:

electron flow in PS II and PSI
pathway from glycerate to fructose-1,6-BPi and regeneration of ribulose-1,5-bisphosphate
mechanism of ribulose-1,5-diphosphate carboxylase (Rubisco)
mechanism of O_2 formation from 2 H_2O with Mn_4 center (using Mn_2 notation is simplified scheme)
mechanism of transketolase
mechanism of transaldolase

Concepts:

functions of PS II and PS I, cytchrome bf complex, plastoquinone, phylloquinone, and other components of both photosystems
stoichiometry of noncyclic photosynthesis: O_2/8hv, 12 H^+ pumped in/8hv, 3 H^+/ATP, ~ 2.5 ATP/H^+ or ~4 ATP/O_2 or 0.5 ATP/hv
stoichiometry of cyclic photosynthesis: 8 H^+ pumped in/4hv, 3 H^+/ATP, ~ 2.5 ATP/H^+, 0.67 ATP/hv
calculations for $\Delta G^{o'}$, $\Delta E^{o'}$
differences between C_4 and C_3 plants
differences between cyclic (2 H^+/hv) and noncyclic (1.5 H^+/hv) photophosphorylation (photosynthesis)

QUESTIONS

1. Calculate $\Delta E^{o'}$ and $\Delta G^{o'}$ for the reduction of $NADP^+$ by ferredoxin (Fd): What processes leads to the reduction of ferredoxin in photosynthesis? In what photosystem does this process occur?

	$E^{o'}$ (volts)
$NADP^+ + 2\ e^- + 2\ H^+ \text{ ======= } NADPH + H^+$	-0.32
ferredoxin(ox) + 2 e- ======= ferredoxin(red)	-0.43

2. Sedoheptulose 1,7 bisiphosphate is an intermediate in the Calvin cycle but not in the pentose phosphate pathway? What is the basis of this difference? Look up the pentose phosphate pathway to discover why.

3. Apply your knowledge: Suppose that an illuminated suspension of *Chlorella* was actively carrying out photosynthesis when the light was suddenly switched off. How would the levels of 3-phosphoglycerate and ribulose 1,5 diphosphate change during the next minute?

4. Apply your knowledge: Suppose that an illuminated suspension of Chlorella was actively carrying out photosynthesis in the presence of 1 % CO_2 when the concentration of CO_2 was abruptly reduced to 0.003 %. What effect would this have on the levels of 3-phosphoglycerate and ribulose 1,5-diphosphate during the next minute?

5. Apply your knowledge: Chloroplasts illuminated in the absence of ADP and Pi form ATP in a subsequent dark period on addition of ADP and Pi. The amount of ATP synthesized in the dark is markedly increased if pyridine is added before illumination. Why?

6. Apply your knowledge: Dichlorophenyldimethylurea (DCMU), an herbicide, interferes with photophosphorylation and O_2 evolution. However, it does not block the Hill reaction. Propose a site for the inhibitory action of DCMU. The Hill reaction is the evolution of O_2 in the presence of artificial electron acceptors.

7. The compound, 2-Carboxyarabinitol 1,5-diphosphate (CABP) has been useful in studies of ribulose 1,5-diphosphate carboxylase. Write the formula for CABP and determine which intermediate it resembles. Predict the effect of CABP on the carboxylase activity. Is there a biological function for this compound/

8. Write a balanced equation (not a mechanism) for the transamination of glyoxylate to yield glycine (using serine as the amino donor). What is the pathway for the formation of glyoxylate? In what pathway is this conversion to glycine taking place and what is the function of this pathway?

9. Consider the relation between the energy of a photon and its wavelength. Some bacteria are able to harvest 1000 nm light. What is the energy in kJ of a mole of 1000 nm photons? What is the maximum increase in redox potential that can be induced by the 1000 nm photon? What is the minimum number of 1000 nm photons needed to form ATP from ADP and Pi? Assume 59 kJ/mol are needed for ATP synthesis under these physiological conditions)

10. Why is chlorophyll green in color when it absorbs in the red and the blue regions of the spectrum?

11. Calculate the energy efficiency (energy conserved in ATP) of the cyclic and nonclclic photosynthesis in chloroplasts using 680 nm light. What would this efficiency be with 500 nm light. Assume that ATP formation requires 59 kJ/mol under these physiological conditions.

12 Consult your text and determine the average Calvin cycle labeling pattern in ribulose-5- phosphate after two rounds of exposure to $^{14}CO_2$.

13 If a C_3 and a C_4 plant are placed together in a sealed illuminated box with sufficient moisture, the C_4 plant thrives while the C_3 plant sickens and eventually dies. Explain.

14. The leaves of some species of desert plants tast sour in the early morning but as the day wears on they become tasteless then bitter. Explain.

15. What is the function of the C_4 cycle in some tropical plants?

16 Briefly explain why 6 moles of ribulose 5-phosphate are required to make 1 mol of fructose 6-phosphate from 6 CO_2.

17 Light energy is changed into what kind of energy in photosynthesis? What is the name of the chemical process that occurs at the cholorphyll center after the absorption of hv? By what process is energy transmitted to the reaction center chl's? Why do the reaction center chl molecules trap energy and not transmit it on?

18. What is the function of the light harvesting complex in photosynthesis? What regulates its binding to the two different photosystems? What structural features of the antenna Mg^{+2}-chl molecules lead to 100% of the energy absorbed by them being transmitted on?

19. What is the difference between cyclic and noncyclic photosynthesis? Show calculations to demonstrate the differences in ATP/hv for these two processes using your knowledge of the amount of H^+ pumped per hv. Discuss briefly why one yield of ATP is higher than the other.