Name_____ Biol 211 - Group Number_____

Active Learning Exercise 6. Photosynthesis

Reference: Chapter 10 (*Biology* by Campbell/Reece, 8th ed.)

Note: See the last page of this ALE for a diagram that summarizes the two stages of photosynthesis.

1. How are autotrophs different from heterotrophs? *Give an example of each*.

2. Give the current hypothesis that explains how eukaryotic heterotrophs are believed to have evolved to possess chloroplasts and thus become autotrophs. (Look up the endosymbiotic theory in the index of your textbook.)

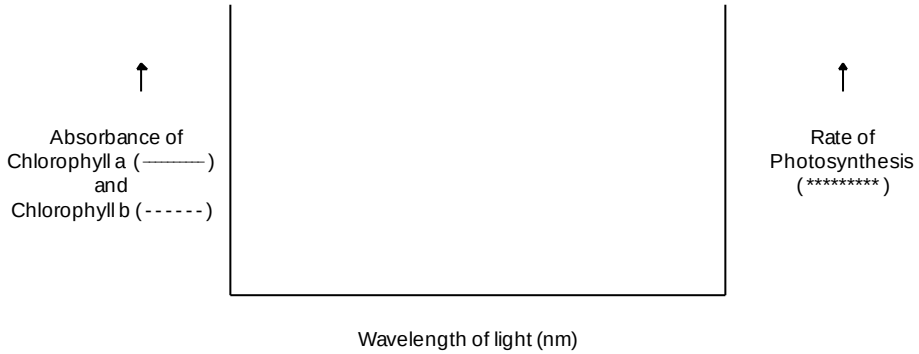
3. a.) What special molecule evolved in photosynthetic autotrophs that **never** appeared in heterotrophs? Hint: This molecule is has a green color!!

   b.) What can this molecule do? *Be specific*!

   c.) What arrangement **inside** the chloroplast allows for a large surface area for the ***light dependent*** reactions of photosynthesis? *Name the part of the chloroplast involved*.

4. a.) List the *approximate* wavelengths of light and their respective colors that most plants absorb to energize chlorophyll for photosynthesis.

4. (cont.)
   b.) Use the graph below to sketch the absorption spectra for chlorophyll a (solid line) and chlorophyll b (dashed line), and the action spectrum (starred line) for photosynthesis. Start by labeling the x-axis from 400 to 700 nm in increments of 100 nm.



   c.) Explain why the combined absorption spectra for chlorophyll a and b differ from the action spectrum for photosynthesis.

   d.) Keeping in mind the absorption spectra of chlorophyll a and b, explain why most leaves are green.

5. The chemical equations for cellular respiration and photosynthesis are closely related. Write down the *balanced* net chemical equations for each and explain how they are related and how this relationship is handy for the continuation of all life on Earth.

   Cellular Respiration

   Photosynthesis

6. **Name the first stage of photosynthesis** (it uses light!): _____

   In your own words (not the books!!) describe what happens in this stage of the process. Include in your description**:** what is required, what is produced, what becomes of these end products, and where in the cell all this occurs.

7. ***Name the second stage of photosynthesis***: _____

   In your own words (not the books!) write down what happens during this stage. Include in your description**:** what materials are required, where they come from, what becomes of the products of this stage, and where in the cell this all occurs.

8. Why is the production of ***G3P*** (glyceraldehydes-3-phosphate) during the ***Calvin Cycle*** important to a plant, and hence all life on earth? What does a plant do with the G3P made during photosynthesis?

9. a.) What two *major* energy-related metabolic processes do plants do during the day? Hint: one is catabolic, the other anabolic.

   b.) Because plants cannot store or stockpile the ATP they make during the light dependent reactions on a sunny day, what energy-related metabolic process must they do both at night and during the day to generate ATP to power cellular activities?

10. a.) Could the plant kingdom exist without animals? *Explain*.

    b.) Is it possible for just members of the plant kingdom to exist on Earth? If they could not exist without other species, what are the minimal species/kingdoms that plants would need to survive? *Explain*.

11. Could land animals exist without photosynthetic organisms? *Explain why of why not*.

12. a.) Where does the oxygen produced during photosynthesis come from, carbon dioxide or water?

    b.)What observations and experimental evidence supports this?

13. a.) What is ***photorespiration***? What role does ***Rubisco*** (ribulose bisphosphate carboxylase) play in photorespiration?

b.) Under what conditions does photorespiration occur?

c.) Is photorespiration beneficial or wasteful for plants? *Explain*.

14. a.) How have ***C_4 plants*** evolved to minimize ***photorespiration***? Use a *labeled diagram* to clarify your explanation.

14. (cont.)
    b.) How have ***CAM plants*** evolved to ***minimize photorespiration***? Use a labeled diagram to clarify your explanation.

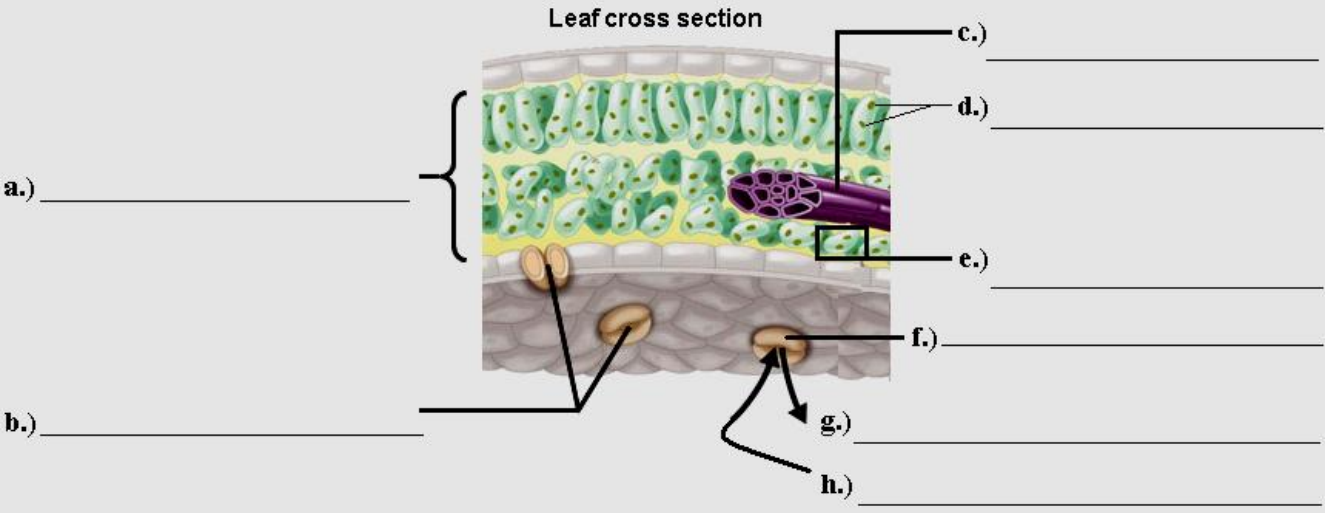
15. Complete the following chart about the process of photosynthesis.

Stage of Photosynthesis	Inputs	Outputs	Location in chloroplast
Light Dependent Reactions			
Light Independent Reactions (Calvin Cycle)			

16. In the Calvin cycle, ***12 G3P*** molecules are produced per one molecule of glucose produced. Only two of the twelve G3P molecules are siphoned off from the Calvin cycle to make glucose and other organic compounds, while the other ten G3P molecules remain in the Calvin cycle. *Why aren't all 12 G3P molecules used to make glucose*? (Note: your response should address the following questions: What substance is synthesized from the ten G3P molecules? Why is it necessary to produce this substance? How many molecules of this substance are made per 10 molecules of G3P?)

17. Does every plant cell carry out photosynthesis? *Clearly defend your answer*.

18. a.) Identify the labeled structures in the leaf cross section below. (*Hint*: see figures 10.3 and 35.18 on pages 187 and 751, respectively in Campbell 8th ed.)



b.) *In the figure above*, use labeled arrows to show the route taken by the reactants of photosynthesis as they make their way to the chloroplasts in photosynthetic cells, and indicate the path taken by the products of photosynthesis

Let's now address how the structure of a leaf is efficiently adapted to perform its various functions by answering the questions that follow:

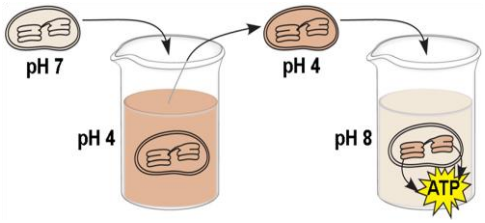
c.) Why is it advantageous to have many ***air spaces*** between the photosynthetic cells in the lower layer of the leaf (i.e. the spongy mesophyll), but not in the densely packed upper layer of photosynthetic cells (i.e. the palisade mesophyll)?

d.) Why are the majority of ***stomata*** located on the underside of most leaves?

e.) What role do the ***guard cells*** play?

19. Only a very small amount (< 1%) of the water that is used by a plant is used for photosynthesis. What then happens to almost all of the water that enters a plant??

20. The diagram to the right represents an experiment with isolated chloroplasts. The chloroplasts were first made acidic by soaking them in a solution at pH 4. After the thylakoid space reached pH 4, the chloroplasts were transferred to a basic solution at pH 8. The chloroplasts then *made ATP in the dark*.



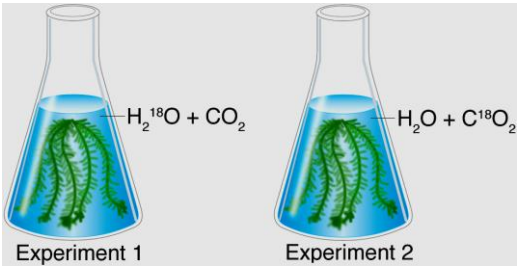
a.) Draw an enlargement of part of the thylakoid membrane in the beaker with the solution at pH 8. *Include and label the following in your drawing*: ATP synthase, the areas of high [H^+] and low [H^+], the direction protons flow through ATP synthase, the reaction where ATP is synthesized (consider if ATP ends up inside or outside of the thylakoid).

b.) Explain why the chloroplasts in the experiment were able to *make ATP in the dark*.

Multiple Guess Questions (Circle the letter of the correct choice.)

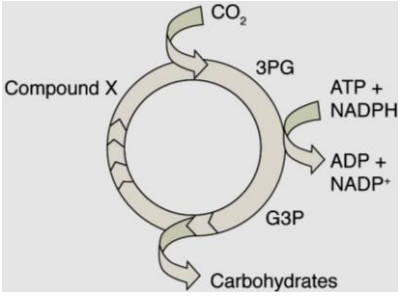
21. The organic carbon in a tree comes primarily from…
a.) soil. b.) water. c.) air. d.) organic fertilizer (manure, detritus). e.) light.

22. Which experiment will produce $^{18}O_2$?
a.) experiment 1
b.) experiment 2
c.) both experiment 1 and experiment 2
d.) neither



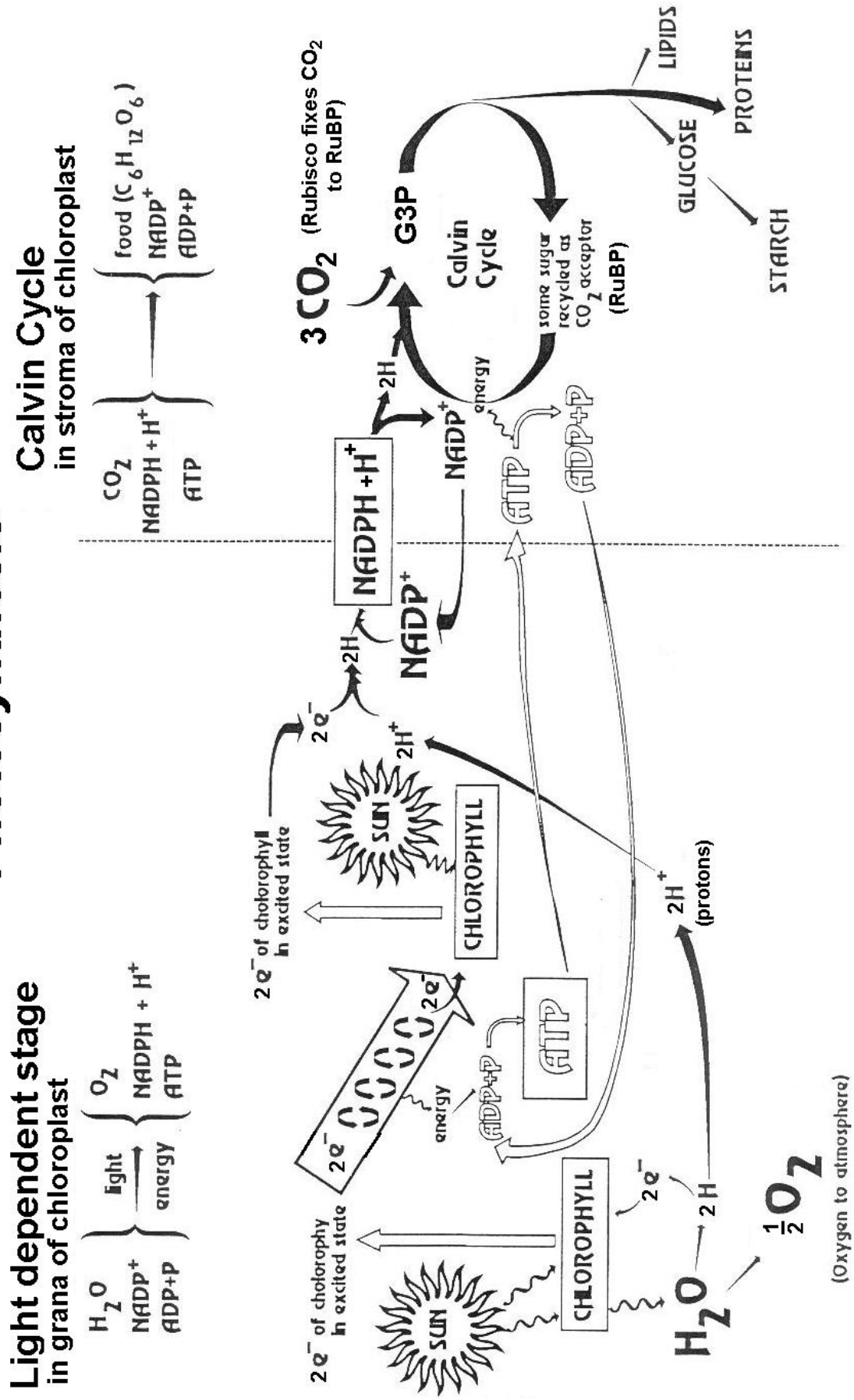
23. Photosynthetic bacteria that have only ***Photosystem I…***
    a.) can split water molecules to produce oxygen.
    b.) cannot fix carbon dioxide.
    c.) generate ATP but not NADPH.
    d.) can reduce NADP+ to NADPH but cannot make ATP through photophosphorylation.
    e.) can reduce NADP+ to NADPH and make ATP through cyclic photophosphorylation.

24. In this diagram, compound X is the CO_2 acceptor. If light is cut off, then…
    a.) X and 3PG will both increase.
    b.) X will increase, 3PG decrease.
    c.) X will decrease, 3PG increase.
    d.) X and 3PG will both decrease.



25. A flask of duckweed in water is placed under a bank of lights on a 12-hour light, 12-hour dark cycle, next to a control flask containing only water. Assuming no change in water temperature, which flask will have the lowest dissolved oxygen (DO) concentration, at what time?
    a.) DO will be the same between the control and the duckweed-containing flask.
    b.) DO will always be higher in the flask with duckweed compared to the control.
    c.) DO will always be lower in the flask with duckweed compared to the control.
    d.) The flask with duckweed will have the lowest DO at the end of the dark cycle and the highest DO at the end of the light cycle.

26. Which metabolic pathways are in plants? (*Select all that apply*.)
    a.) Calvin cycle b.) glycolysis c.) citric acid cycle d.) chemiosmotic ATP synthesis


Photosynthesis
Light dependent stage
in grana of chloroplast
H2O
NADP+
ADP+P
light
energy
O2
NADPH + H+
ATP
Calvin Cycle
in stroma of chloroplast
CO2
NADPH + H+
ATP
food (C6H12O6)
NADP+
ADP+P
3 CO2
(Rubisco fixes CO2 to RuBP)
G3P
Calvin Cycle
some sugar recycled as CO2 acceptor (RuBP)
LIPIDS
PROTEINS
GLUCOSE
STARCH
NADPH +H+
NADP+
2H
energy
ATP
ADP+P
2e− of chlorophyll in excited state
SUN
CHLOROPHYLL
2H+
2e−
2H+ (protons)
2 H
H2O
½O2
(Oxygen to atmosphere)