NAME ____ Period ________

AP Biology – Photosynthesis Work Sheet

1. In photosynthesis, the reduction of carbon dioxide to form glucose is carried out in a controlled series of reactions. In general, each step or reaction in the sequence requires the input of energy. The sun is the ultimate source of this energy.

a. What is/are the overall function(s) of photosystem I? ____________________________

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b. What is/are the overall function(s) of photosystem II? ____________________________

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c. What is/are the overall function(s) of the Calvin cycle? ____________________________

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2. Are the compounds listed here used or produced in:

	Photosystem I?	Photosystem II?	The Calvin cycle?
Glucose			
O_2			
CO_2			
H_2O			
ATP			
ADP + Pi			

4. Which light reaction system (cyclic or noncyclic) would a chloroplast use in each situation?
   a. Plenty of light is available, but the cell contains little NADP+.

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   b. There is plenty of light, and the cell contains a high concentration of NADP+.

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5. All living organisms require a constant supply of ATP to maintain life. If no light is available, how can a plant make ATP? ____
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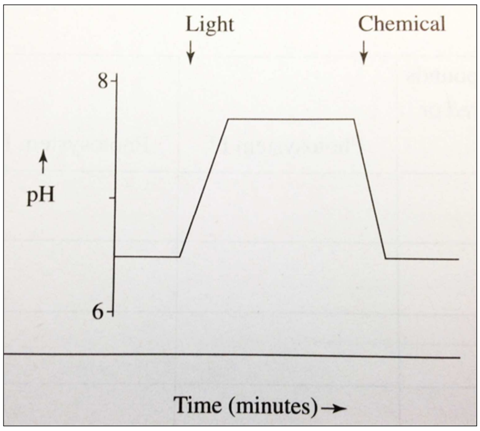
6. Chloroplast thylakoids can be isolated and purified for biochemical experiments. Shown to the right is an experiment in which pH was measured in a suspension of isolated thylakoids before and after light illumination (first arrow). At the time indicated by the second arrow, a chemical compound was added to the thylakoids. Examine these data and address the following questions.



a. Based on your understanding of the function of the chloroplasts, why does turning on the light cause the pH in the solution outside the thylakoids to increase?

b. Given the response, the chemical added was probably an inhibitor of:

i. oxidative phosphorylation
ii. ATP synthase
iii. NADPH breakdown
iv. Electron transport chain between photosystems II and I
v. Rubisco

7. Carbon dioxide enters plant leaves through the stomata, while oxygen (the photosynthetic waste product) and water from the leaves exit through the stomata. Plants must constantly balance both water loss and energy gain (as photosynthesis). This has led to the evolution of various modifications of C3 photosynthesis.

	C_3	C_4	CAM
Draw simplified diagrams of the cross sections of a leaf from a C3, a C4 and a CAM plant.			
a. How are the leaves similar?			
b. How are the leaves different? .			
c. How and when does carbon dioxide get into each leaf?			
d. Which enzyme(s) (1) capture carbon dioxide and (2) carry it to the Calvin cycle?			

e. What makes C4 photosynthesis more efficient than C3 photosynthesis in tropical climates?

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f. How is CAM photosynthesis advantageous in desert climates?

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8. Photosynthesis evolved very early in Earth's history. Central to the evolution of photosynthesis was the evolution of the enzyme rubisco (an abbreviation for ribulose bisphosphate carboxylase oxidase). To the best of our knowledge, all photosynthetic plants use rubisco. Rubisco's function is to supply carbon dioxide to the Calvin cycle; however, it does this only if the ratio of carbon dioxide to oxygen is relatively high. (For comparison, a relatively high ratio of carbon dioxide to oxygen is 0.03% carbon dioxide to 20% oxygen.) When the carbon-dioxide-to-oxygen ratio becomes low, the role of

rubisco switches and it catalyzes photorespiration, the breakdown of glucose to carbon dioxide and water.

a. Why could we call photorespiration a “mistake” in the functioning of the cell?

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b. Rubisco is thought to have evolved when Earth had a reducing atmosphere. How does this help explain the photorespiration “mistake?”

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9. The metabolic pathways of organisms living today evolved over a long period of time—undoubtedly in a stepwise fashion because of their complexity. Put the following processes in the order in which they might have evolved, and give a short explanation for your arrangement.

__ Krebs cycle __ Electron transport __ Glycolysis __ Photosynthesis

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10. Photosynthesis may be studied in a number of ways. In the experiment described here, a dye-reduction technique was used. The dye-reduction experiment tests the hypothesis that light and chloroplasts are required for the light reactions to occur. In place of the electron accepter, NADP+, the compound DPIP (2.6-dichlorophenol-indophenol), was substituted. When light strikes the chloroplasts, electrons boosted to high energy levels will reduce DPIP. It will change from blue to colorless.

In this experiment, chloroplasts were extracted from spinach leaves and incubated with DPIP in the presence of light. As the DPIP is reduced and becomes colorless, the resultant increase in light transmittance is measured over a period of time using a spectrophotometer. The experimental design matrix is shown below.

	Cuvettes				
	1 **Blank**	**2** **Unboiled Chloroplasts Dark**	**3** **Unboiled Chloroplasts Light**	**4** **Boiled Chloroplasts Light**	**5** **No Chloroplasts**
Phosphate Buffer	1 ml.	1 ml.	1 ml.	1 ml.	1 ml.
Distilled Water	4 ml.	3 ml.	3 ml.	3 ml.	3 ml + 3 drops
DPIP	----	1 ml.	1 ml.	1 ml.	1 ml.
Unboiled Chloroplasts	3 drops	3 drops	3 drops	----	----
Boiled Chloroplasts	----	----	----	3 drops	----

Experimental data (% transmittance) is shown in the table below.

	Time			
Cuvette	0 min.	5 min.	10 min.	15 min.
2 (Dark)	31.3	32.5	35.5	34.8
3 (Unboiled)	32.7	54.5	63.7	65.1
4 (Boiled)	32.7	32.9	33.1	32.5

Plot the percent transmittance from the four cuvettes on the graph below.

1. What is the purpose of DPIP in this experiment? ______________________________

2. What molecule found in chloroplasts does DPIP "replace" in this experiment? ____________

3. What is the source of the electrons that will reduce DPIP? ________________________

4. What was measured with the spectrophotometer in this experiment? _________________

5. What is the effect of darkness on the reduction of DPIP? _________________________

6. What is the effect of boiling the chloroplasts on the subsequent reduction of DPIP? Explain.

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7. What reasons can you give for the difference in the percent transmittance between the live chloroplasts that were incubated in the light and those that were kept in the dark?

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