Name__________ Course/Section__________

Date__________ Professor/TA__________

Activity 10.1 Modeling photosynthesis: How can cells use the sun's energy to convert carbon dioxide and water into glucose?

Activity 10.1 is designed to help you understand:

1. The roles photosystems I and II and the Calvin cycle play in photosynthesis, and
2. How and why C_4 and CAM photosynthesis differ from C_3 photosynthesis.

Using your textbook, lecture notes, and the materials available in class (or those you devise at home), model photosynthesis as it occurs in a plant cell.

Your model should be a dynamic (working or active) representation of the events that occur in the various phases of C_3 photosynthesis.

Building the Model

- Use chalk on a tabletop or a marker on a large sheet of paper to draw the cell membrane and the chloroplast membranes.
- Use playdough or cutout pieces of paper to represent the molecules, ions, and membrane transporters or pumps.
- Use the pieces you assembled to model the processes involved in C_3 photosynthesis. Develop a dynamic (claymation-type) model that allows you to manipulate or move carbon dioxide and water and its breakdown products through the various steps of the process.
- When you feel you have developed a good working model, demonstrate and explain it to another student or to your instructor.

Yo model of C_3 photosynthesis should include what occurs in photosystems I and II and in the Calvin cycle. For **photosystems I and II**, be sure your model includes and explains the roles of the following:

$NADP^+$	ATP	chemiosmosis
NADPH	water and oxygen	ATP synthase
ADP	H^+	e^- carriers in thylakoid membranes
P_i	e^-	

Also indicate where in the plant cell each item is required or produced.

For the **Calvin cycle,** be sure your model includes and explains the roles of the following:

glucose	NADPH
C_3 or 3C sugars	ATP
carbon dioxide	

Also indicate where in the plant cell each item is required or produced.

After you've modeled C_3 photosynthesis, indicate how the system would be altered for C_4 and CAM photosynthesis.

- Indicate where in the cells of the leaf PEP carboxylase exists and how it reacts to capture CO_2. Be sure to indicate the fate of the captured CO_2.
- Do the same for PEP carboxylase in CAM plants.

Use your model and the information in Chapter 10 of *Biology*, 8th edition, to answer the questions.

1. The various reactions in photosynthesis are spatially segregated from each other within the chloroplast. Draw a simplified diagram of a chloroplast and include these parts: outer membrane, grana, thylakoid, lumen, stroma/matrix.

a. Where in the chloroplast do the light reactions occur?	
b. Where in the chloroplast is the chemiosmotic gradient developed?	
c. Where in the chloroplast does the Calvin cycle occur?	

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2. 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?	b. What is/are the overall function(s) of photosystem II?	c. What is/are the overall function(s) of the Calvin cycle?

3. 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 + (P$_i$)			
NADPH			
$NADP^+$			

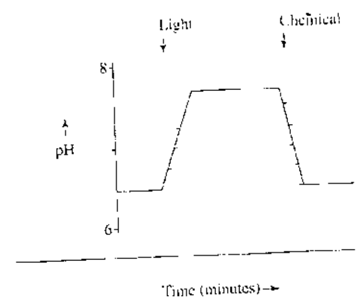
4. Which light reaction system (cyclic or noncyclic) would a chloroplast use in each situation?

a. Plenty of light is available, but the cell contains little $NADP^+$.	b. There is plenty of light, and the cell contains a high concentration of $NADP^+$.

5. All living organisms require a constant supply of ATP to maintain life. If no light is available, how can a plant make ATP?

10.1 Test Your Understanding

Chloroplast thylakoids can be isolated and purified for biochemical experiments. Shown below 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 I and II
   v. Rubisco