**Name Period**

**Chapter 10: Photosynthesis**

*This chapter is as challenging as the one you just finished on cellular respiration. However, conceptually it will be a little easier because the concepts learned in Chapter 9—namely, chemiosmosis and an electron transport system—will play a central role in photosynthesis.*

1. As a review, define the terms *autotroph* and *heterotroph*. Keep in mind that plants have mitochondria and chloroplasts and do both cellular respiration and photosynthesis!

***Concept 10.1 Photosynthesis converts light energy to the chemical energy of food***

2. Take a moment to place the chloroplast in the leaf by working through Figure 10.4. Draw a picture of the chloroplast and label the *stroma, thylakoid, thylakoid space, inner membrane*, and *outer membrane*.

3. Use both chemical symbols and words to write out the formula for photosynthesis (use the one that indicates only the net consumption of water). Notice that the formula is the opposite of cellular respiration. You should know both formulas from memory.

4. Using 18O as the basis of your discussion, explain how we know that the oxygen released in photosynthesis comes from water.

5. Photosynthesis is not a single process, but two processes, each with multiple steps.

a. Explain what occurs in the *light reactions* stage of photosynthesis. Be sure to use *NADP+* and

*photophosphorylation* in your discussion.

b. Explain the *Calvin cycle*, utilizing the term *carbon fixation* in your discussion.

***Concept 10.2 The light reactions convert solar energy to the chemical energy of ATP and NADPH***

This is a long and challenging concept. Take your time, work through the questions, and realize that this is the key concept for photosynthesis.

7. Some of the types of energy in the electromagnetic spectrum will be familiar, such as X-rays, microwaves, and radio waves. The most imporant part of the spectrum in photosynthesis is visible light. What are the colors of the *visible spectrum*?

8. Notice the colors and corresponding wavelengths. Explain the relationship between wavelength and energy.

9. Study Figure 10.9 carefully; then explain the correlation between an *absorption spectrum* and an

*action spectrum.*

10. Describe how Englemann was able to form an action spectrum long before the invention of a spectrophotometer.

11. A *photosystem* is composed of a protein complex called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ complex surrounded by several \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ complexes.

16. The following set of questions deals with linear electron flow:

a. What is the source of energy that excites the electron in photosystem II?

 b. What compound is the source of electrons for linear electron flow?

c. What is the source of O2 in the atmosphere?

d. As electrons fall from photosystem II to photosystem I, the cytochrome complex uses the energy to pump \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ions. This builds a proton gradient that is used in chemiosmosis to produce what molecule?

e. In photosystem I, NADP+ reductase catalyzes the transfer of the excited electron and H+ to NADP+ to

form \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

*\*Notice that two high-energy compounds have been produced by the light reactions: ATP and NADPH. Both of these compounds will be used in the Calvin cycle*.

17. *Cyclic electron flow* can be visualized in Figure 10.16. Cyclic electron flow is thought to be similar to the first forms of photosynthesis to evolve. In cyclic electron flow no water is split, there is no production of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and there is no release of \_\_\_\_\_\_\_\_\_\_\_\_\_.

18. The last idea in this challenging concept is how chemiosmosis works in photosynthesis. Describe four ways that chemiosmosis is *similar* in photosynthesis and cellular respiration.

19. Explain how chemiosmosis is *different* in photosynthesis and cellular respiration.

22. To summarize, note that the light reactions store chemical energy in \_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_, which shuttle the energy to the carbohydrate-producing \_\_\_\_\_\_\_\_\_\_\_ cycle.

***Concept 10.3 The Calvin cycle uses ATP and NADPH to convert CO2 to sugar***

The Calvin cycle is a metabolic pathway in which each step is governed by an enzyme, much like the citric acid cycle in cellular respiration. However, keep in mind that the Calvin cycle uses energy (in the form of ATP and NADPH) and is therefore anabolic. In contrast, cellular respiration is catabolic and releases energy that is used to generate ATP and NADH.

23. The carbohydrate produced directly from the Calvin cycle is not glucose, but the three-carbon compound \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

24. Explain the important events that occur in the *carbon fixation* stage of the Calvin cycle.

25. The enzyme responsible for carbon fixation in the Calvin cycle, and possibly the most abundant protein on Earth, is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

26. In phase two, the *reduction stage*, what molecule will donate electrons, and so is the source of the reducing power?

27. In this *reduction stage,* the low-energy acid 1, 3-bisphosphoglycerate is reduced by electrons from

NADPH to form the three-carbon sugar \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

***Concept 10.4 Alternative mechanisms of carbon fixation have evolved in hot, arid climates***

31. Explain what is meant by a *C3 plant*.

32. What happens when a plant undergoes *photorespiration*?

34. Explain what is meant by a *C4 plant*.

35. Explain the role of *PEP carboxylase* in C4 plants, including key differences between it and

*rubisco*.

36. Conceptually, it is important to know that the C4 pathway does not replace the Calvin cycle but works as a CO2 pump that prefaces the Calvin cycle. Explain how changes in leaf architecture help isolate rubisco in regions of the leaf that are high in CO2 but low in O2 .

37. Using Figure 10.19 in your text as a guide, explain the three key events in the C4 pathway.

38. Compare and contrast C4 plants with CAM plants. In your explanation, give two key similarities and two key differences.

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| SIMILARITIES | DIFFERENCES |
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39. Explain this statement: “Only the green cells of a plant are the autotroph while the rest of the plant is a heterotroph.”