Name: _____ **AP Biology**

Chapter 7 Active Reading Guide
Cellular Respiration and Fermentation

Overview: Before getting involved with the details of cellular respiration and photosynthesis, take a second to look at the big picture (Figure 7.2). Photosynthesis and cellular respiration are key ecological concepts involved with energy flow.

Section 1

1. Explain the difference between *fermentation* and *cellular respiration*.

2. Give the formula (with names) for the catabolic degradation of glucose by cellular respiration.

3. Both cellular respiration and photosynthesis are *redox reactions*. In redox, reactions pay attention to the flow of electrons. What is the difference between oxidation and reduction?

4. The following is a generalized formula for a redox reaction. Draw an arrow showing which component (X or Y) is oxidized and which is reduced.

   $$Xe^- + Y \rightarrow X + Ye^-$$

   _____ is the reducing agent in this reaction, and _____ is the oxidizing agent.

5. When compounds lose electrons, they _____ energy; when compounds gain electrons, they _____ energy.

6. In cellular respiration, electrons are not transferred directly from glucose to oxygen. Following the movement of hydrogens allows you to follow the flow of electrons. The hydrogens are held in the cell temporarily by what electron carrier? What *electron carrier* is hydrogen transferred to first?

7. The correct answer to question 6 is ***NAD$^+$***. It is a coenzyme. What are coenzymes? (If you have forgotten, look back to a few pages in Chapter 6.)

8. Describe what happens when NAD^+ is reduced. What enzyme is involved?

9. It is essential for you to understand the concept of oxidation/reduction and energy transfer. For the following pair, which molecule is the oxidized form, and which is reduced? Which molecule holds higher potential energy? Which is lower in potential energy?

   NAD^+ _____

   NADH _____

10. What is the function of the *electron transport chain* in cellular respiration?

11. Electron transport involves a series of electron carriers.

    a. Where are these found in eukaryotic cells? _____

    b. Where are these found in prokaryotic cells? _____

12. What strongly electronegative atom, pulling electrons down the electron transport chain, is the final electron acceptor?

13. Three types of *phosphorylation* (adding a phosphate) are covered in the text, and two of these occur in cellular respiration. Explain how the electron transport chain is utilized in *oxidative phosphorylation*.

14. The second form of phosphorylation is *substrate level*. Explain the direct transfer of a phosphate from an organic substrate to ADP to form ATP.

Section 2

15. What is the meaning of *glycolysis*? What occurs in this step of cellular respiration?

16. The starting product of glycolysis is the six-carbon sugar _____, and the ending products are two _____-carbon molecules of _____.

17. The ten individual steps of glycolysis can be divided into two stages: *energy investment* and *energy payoff*. These steps are shown in Figure 7.9, which details the enzymes and reactions at each of the ten steps. While you are not expected to memorize these steps and enzymes, you *should* study the figure carefully. The next few questions will help you focus your study.

    a. What are the two specific steps where ATP is used? _____ _____

    b. The second step in glycolysis is the *energy payoff phase*. Note that it provides both ATP and NADH.
    What are the two steps where ATP is formed? _____ _____

    What is the one step where NADH is formed? _____ _____

    The final figure shows the net gain of energy for the cell after glycolysis. Most of the energy is still present in the two molecules of pyruvate.

18. Notice that glycolysis occurs in the _____ of the cell. Is oxygen required? _____

Section 3

19. To enter the citric acid cycle, pyruvate must enter the mitochondria by active transport. Three things are necessary to convert pyruvate to acetyl CoA. Explain the three steps in the conversion process.
    a.

    b.

    c.

20. Use Figure 7.11 to help you answer the following summary questions about the citric acid cycle:

    a. How many NADHs are formed? _____

    b. How many total carbons are lost as pyruvate is oxidized? _____

    c. The carbons have been lost in the molecule _____.

    d. How many $FADH_2$ have been formed? _____

    e. How many ATPs are formed? _____

    f. How many times does the citric acid cycle occur for each molecule of glucose? __

21. The step that converts pyruvate to acetyl CoA at the top of the diagram occurs twice per glucose. This oxidation of pyruvate accounts for two additional reduced _____ molecules and two molecules of CO_2.

22. Explain what has happened to each of the six carbons found in the original glucose molecule.

Section 4

23. *Oxidative phosphorylation* involves two components: the electron transport chain and ATP synthesis. Referring to Figure 7.12, notice that each member of the electron transport chain is lower in free _____ than the preceding member of the chain, but higher in _____. The molecule at zero free energy, which is _____, is lowest of all the molecules in free energy and highest in electronegativity.

24. Oxygen is the ultimate electron acceptor. Why is this?

25. Oxygen stabilizes the electrons by combining with two hydrogen ions to form what compound? _____

26. The two electron carrier molecules that feed electrons into the electron transport system are _____ and _____.

27. Using Figure 7.13, explain the overall concept of how *ATP synthase* uses the flow of hydrogen ions to produce ATP.

28. What is the role of the electron transport chain in forming the H^+ gradient across the inner mitochondrial membrane?

29. Two key terms are *chemiosmosis* and *proton-motive force*. Relate both of these terms to the process of oxidative phosphorylation.

30. At this point, you should be able to account for the total number of ATPs that could be formed from a glucose molecule. To accomplish this, we have to add the ATPs formed by substrate-level phosphorylation in glycolysis and the citric acid cycle to the ATPs formed by chemiosmosis. Each NADH can form a maximum of ____ ATP molecules. Each $FADH_2$, which donates electrons that activate only two proton pumps, makes ____ ATP molecules.

31. Using Figure 7.15, summarize the production of NADH and $FADH_2$. How is ATP formed, and for each step indicate whether it is by substrate-level or oxidative phosphorylation? Use the text to be sure you understand how each subtotal on the bar below the figure is reached.

32. Why is the total count about 30 or 32 ATP molecules rather than a specific number?

Section 5

33. Fermentation allows for the production of ATP without using either _____ or any _____.

34. For aerobic respiration to continue, the cell must be supplied with oxygen—the ultimate electron acceptor. What is the electron acceptor in fermentation? _____

35. *Alcohol fermentation* starts with glucose and yields ethanol. Explain this process, and be sure to describe how NAD^+ is recycled.

36. Lactic *acid fermentation* starts with glucose and yields lactate. Explain this process, and be sure to describe how NAD^+ is recycled.

37. Explain why pyruvate is a key juncture in metabolism.

Section 6

38. What three organic macromolecules are often utilized to make ATP by cellular respiration?

39. Explain the difference in energy usage between the catabolic reactions of cellular respiration and anabolic pathways of biosynthesis.

40. Explain how AMP stimulates cellular respiration while citrate and ATP inhibit it.

41. *Phosphofructokinase* is an allosteric enzyme that catalyzes an important step in glycolysis. Explain how this step is a control point in cellular respiration.