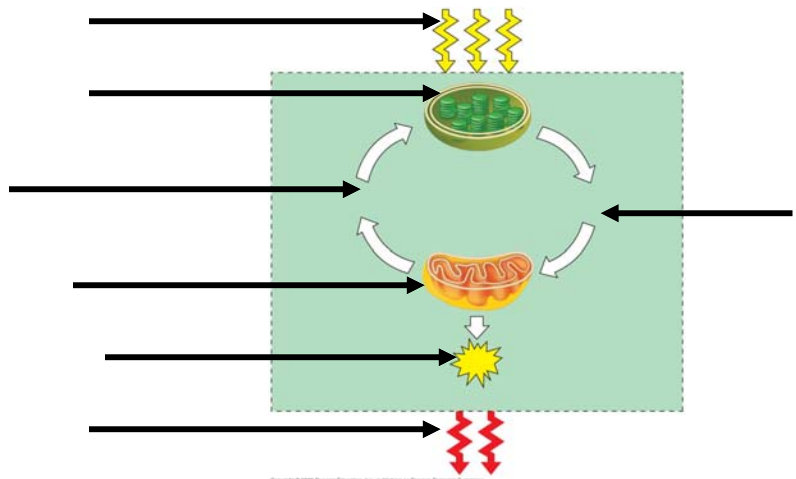
Name______________________Period__________

Chapter 9: Cellular Respiration: Harvesting Chemical Energy

Overview: Before getting involved with the details of cellular respiration and photosynthesis, take a second to look at the big picture. Photosynthesis and cellular respiration are key ecological concepts involved with energy flow. Use Figure 9.2 to label the missing parts below.



Concept 9.1 Catabolic pathways yield energy by oxidizing organic fuels

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:

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

Draw an arrow showing which part of the reaction is oxidized and which part is reduced.

___________ 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. Each electron is coupled with a proton to form a hydrogen atom. 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?

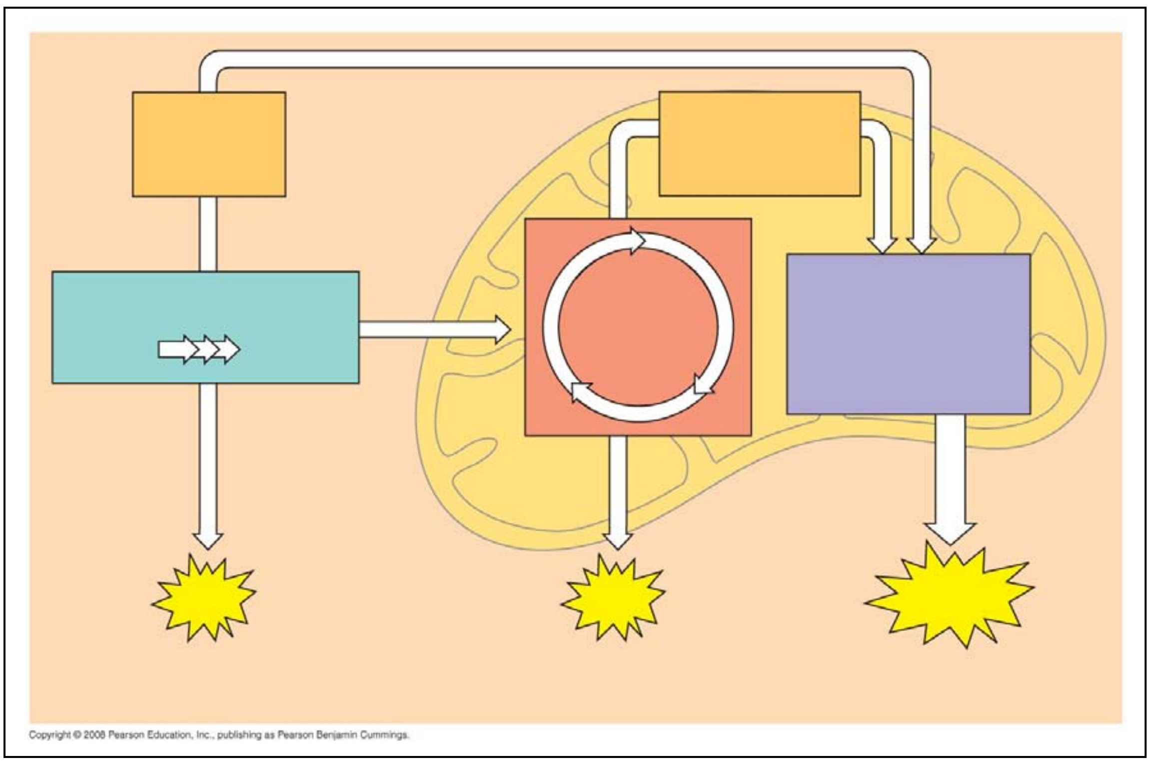
   What is a coenzyme? (If you have forgotten, look back to a few pages in Chapter 8.)

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

8. Show the normal, downhill route most electrons follow in cellular respiration:

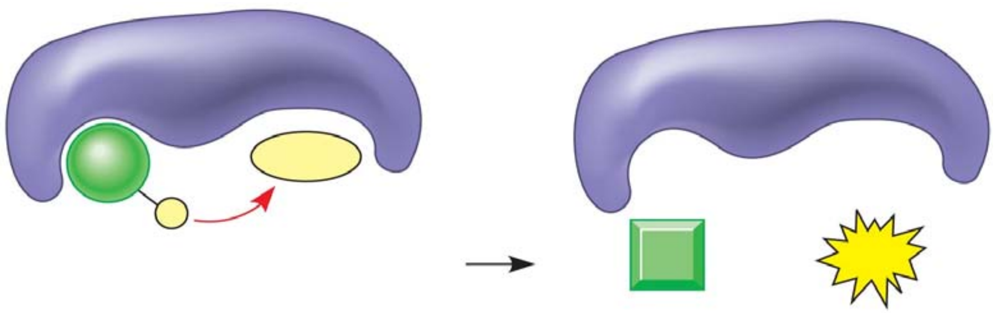
   Glucose → ______________________ → ____________________ → oxygen

9. Understanding the overall map of how cellular respiration works will make the details easier to learn. Use Figure 9.2 to label the missing information in the figure below.



10. 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*.

11. The second form of phosphorylation is *substrate level*. Label the figure below to show the direct transfer of a phosphate from a substrate to ADP to form ATP.

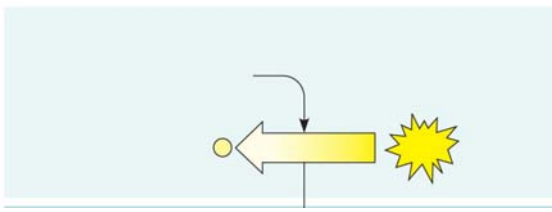


Concept 9.2 Glycolysis harvests chemical energy by oxidizing glucose to pyruvate

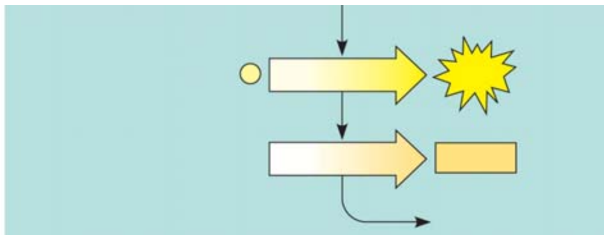
12. Why is glycolysis an appropriate term for this step of cellular respiration?

13. The starting product of glycolysis is the six-carbon sugar ________________, and the ending product is two ____________ carbon compounds termed ____________________.

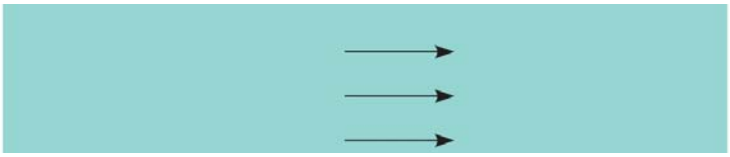
14. The ten individual steps of glycolysis can be divided into two stages: *energy investment* and *energy payoff*. Label the *energy investment stage* below; then use Figure 9.9 to find the two specific stages where ATP is used.



15. The second step in glycolysis is the *energy payoff phase*. Label this stage. Note that it provides both ATP and NADH. Look at Figure 9.9 to locate the two stages where ATP is formed and the one stage where NADH is formed.



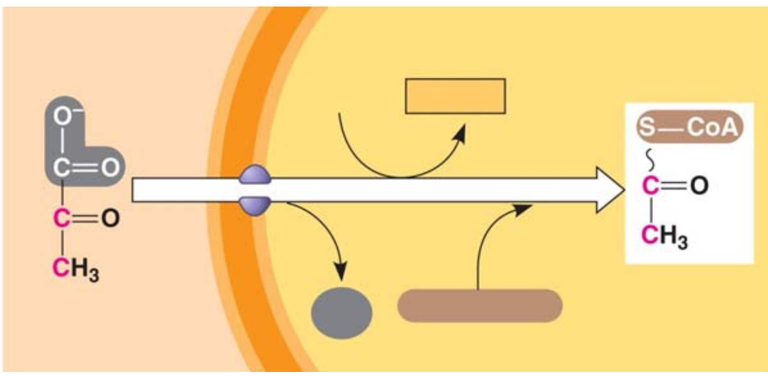
16. This final figure shows the net gain of energy for the cell after glycolysis. Most of the energy is still present in the two molecules of pyruvate. Fill in the chart below and show the net energy gains.



17. Notice that glycolysis occurs in the ____________________ of the cell. What is the relationship concerning glycolysis and oxygen?

Concept 9.3 The citric acid cycle completes the energy-yielding oxidation of organic molecules

18. To enter the citric acid cycle, pyruvate must enter the mitochondria by active transport. Three things are necessary to convert pyruvate to acetyl CoA. Complete the missing parts of the chart below and then explain the three steps in the conversion process.



(1)

(2)

(3)

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

20. Use Figure 9.11 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?

21. The diagram covers only one pyruvate, although two pyruvates are formed from a single glucose. How many molecules of the following are formed from the breakdown of glucose?

    a. NADH = ___________

    b. $FADH_2$ = ___________

    c. ATP = ___________

22. The step that converts pyruvate to acetyl CoA at the top of the diagram also occurs twice per glucose. This step accounts for two additional reduced _____________ molecules and two carbon dioxide molecules.

23. Explain what has happened to the six-carbon molecules found in the original glucose molecule.

Concept 9.4 During oxidative phosphorylation, chemiosmosis couples electron transport to ATP synthesis

24. Oxidative phosphorylation involves two components: the electron transport chain and ATP synthesis. Referring to Figure 9.13, 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.

25. Explain why oxygen is the ultimate electron acceptor. 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

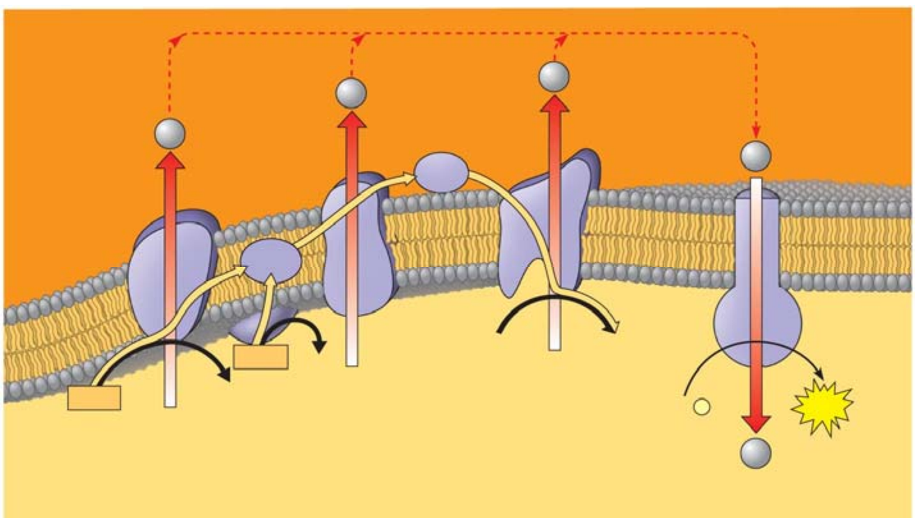
________________ and __________________.

27. Using Figure 9.14, 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?

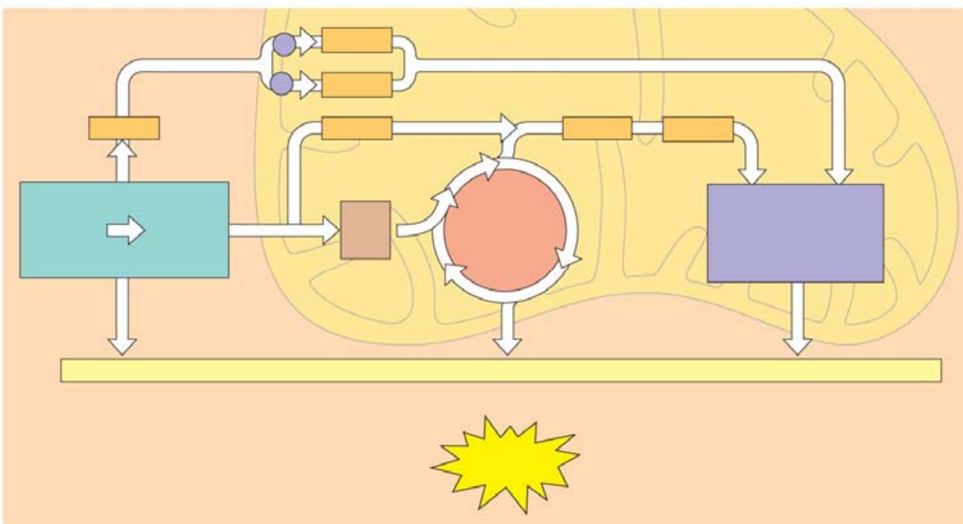
29. Two key terms are *chemiosmosis* and *proton-motive force*. Relate both of these terms to the process of oxidative phosphorylation.

30. Figure 9.16 is a key to understanding the production of ATP in the mitochondria. In the figure below, label all locations and molecules. Then use one color to trace the flow of electrons and another color to show the flow of protons.



31. 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 substrate-level ATPs from 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.

32. Use the figure to account for all the ATP molecules formed during cellular respiration. Use the text to be sure you understand how each subtotal on the bar below the figure is reached.



33. Why is the total count about 36 or 38 ATP molecules rather than a specific number?

Concept 9.5 Fermentation enables some cells to produce ATP without the use of oxygen

34. Fermentation allows for the production of ATP without using either __________ or any ___________ ______________________________.

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

36. Explain how alcohol fermentation starts with glucose and yields ethanol. Be sure to stress how NAD^+ is recycled.

37. Explain how lactic acid fermentation starts with glucose and yields lactate. Be sure to stress how NAD^+ is recycled.

38. Using Figure 9.19 as a guide, draw and explain why pyruvate is a key juncture in metabolism.

Concept 9.6 Glycolysis and the citric acid cycle connect to many other metabolic pathways

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

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

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

TestingYour Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

1.______ 2.______ 3._______ 4.______ 5._______ 6._______ 7._______ 8.______ 9._______