

## Study Tip

Have students make Vocabulary flashcards by writing a Vocabulary word on one side of a card and its definition on the other side.

## Thinking Visually

1. glucose
2. glucose and oxygen
3. glycolysis, several others
4. glycolysis, Krebs cycle, electron transport
5. either carbon dioxide and alcohol or lactic acid
6. carbon dioxide, water
7. 2
8. 36

## Chapter 9 Assessment

## Reviewing Content

1. c
2. b
3. b
4. c
5. b
6. b
7. c
8. b
9. a
10. b

## Understanding Concepts

11. A calorie is the amount of energy needed to raise the temperature of 1 gram of water 1 degree Celsius. Cells break down high-calorie molecules in a series of steps, releasing the stored energy a small amount at a time.

12. During glycolysis, glucose is broken down into two molecules of pyruvic acid. The other products are ATP molecules and high-energy electrons that are picked up by  $\text{NAD}^+$ .

13. After glycolysis, if oxygen is available, a cell might carry out the rest of cellular respiration. If oxygen is not available, some cells carry out the rest of fermentation.

14.  $6\text{O}_2 + \text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy}$ ; oxygen + glucose  $\rightarrow$  carbon dioxide + water + energy

15. Student diagrams should be similar to Figure 9–2.

16.  $\text{NAD}^+$  picks up high-energy electrons produced during glycolysis, forming NADH. The large number of high-energy electrons quickly fill all of the cell's available  $\text{NAD}^+$  molecules. Without  $\text{NAD}^+$ , the cell cannot keep glycolysis going, and ATP production stops.

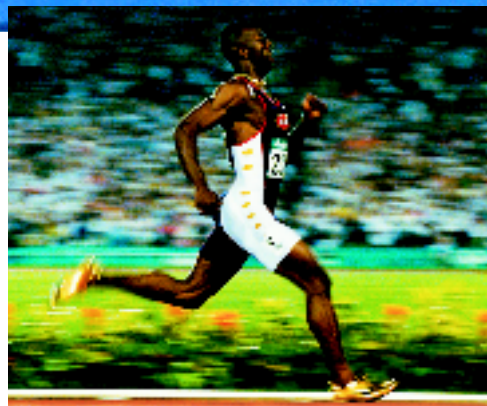
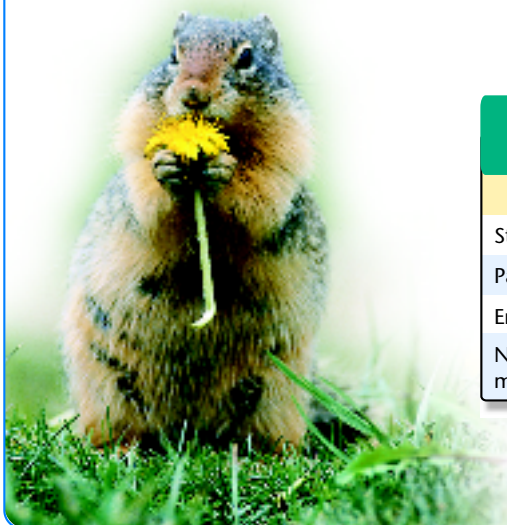
## 9-1 Chemical Pathways

## Key Concepts

- Cellular respiration is the process that releases energy by breaking down glucose and other food molecules in the presence of oxygen.
- Glycolysis is the process in which one molecule of glucose is broken in half, producing two molecules of pyruvic acid, a 3-carbon compound.
- Glycolysis captures two pairs of high-energy electrons with the carrier  $\text{NAD}^+$ . Because glycolysis does not require oxygen, it supplies chemical energy to cells when oxygen is not available.
- The two main types of fermentation are alcoholic fermentation and lactic acid fermentation.
- In the absence of oxygen, yeast and a few other microorganisms use alcoholic fermentation, forming ethyl alcohol and carbon dioxide as wastes.
- Animals cannot perform alcoholic fermentation, but some cells, such as human muscle cells, can convert glucose into lactic acid. This is called lactic acid fermentation.

## Vocabulary

calorie, p. 221  
glycolysis, p. 221  
cellular respiration, p. 222  
 $\text{NAD}^+$ , p. 223  
fermentation, p. 224  
anaerobic, p. 224



## 9-2 The Krebs Cycle and Electron Transport

## Key Concepts

- During the Krebs cycle, pyruvic acid is broken down into carbon dioxide in a series of energy-extracting reactions.
- The electron transport chain uses the high-energy electrons from the Krebs cycle to convert ADP into ATP.
- The products of photosynthesis are similar to the reactants of cellular respiration. The products of cellular respiration are the reactants of photosynthesis.

## Vocabulary

aerobic, p. 226  
Krebs cycle, p. 226  
electron transport chain, p. 228

## Thinking Visually

Using the information in this chapter, complete the following compare-and-contrast table about fermentation and cellular respiration:

Comparing Fermentation and Cellular Respiration

Characteristic	Fermentation	Cellular Respiration
Starting reactants	1	2
Pathways involved	3	4
End products	5	6
Number of ATP molecules produced	7	8



## CHAPTER RESOURCES

## Print:

- **Teaching Resources**, Chapter Vocabulary Review, Graphic Organizer
- **Chapter Tests: Levels A and B**, Chapter 9 Test

## Technology:

- **Computer Test Bank**, Chapter 9 Test
- **iText**, Chapter 9 Assessment

## Chapter 9 Assessment

### Reviewing Content

Choose the letter that best answers the question or completes the statement.

- In cells, the energy available in food is used to make an energy-rich compound called
  - water.
  - glucose.
  - ATP.
  - ADP.
- The first step in releasing the energy of glucose in the cell is known as
  - alcoholic fermentation.
  - glycolysis.
  - the Krebs cycle.
  - electron transport.
- The process that releases energy from food in the presence of oxygen is
  - synthesis.
  - cellular respiration.
  - ATP synthase.
  - photosynthesis.
- Which organisms perform cellular respiration?



- only c
  - only a and c
  - all of the above
  - only a and b
- The net gain of energy from glycolysis is
    - 4 ATP molecules.
    - 2 ATP molecules.
    - 8 ADP molecules.
    - 3 pyruvic acid molecules.
  - Because fermentation takes place in the absence of oxygen, it is said to be
    - aerobic.
    - anaerobic.
    - cyclic.
    - essential to oxygen production.
  - The Krebs cycle takes place within the
    - chloroplast.
    - nucleus.
    - mitochondrion.
    - cytoplasm.
  - The electron transport chain uses the high-energy electrons from the Krebs cycle to
    - produce glucose.
    - convert ADP to ATP.
    - produce acetyl-CoA.
    - produce GTP.

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- A total of 36 molecules of ATP are produced from 1 molecule of glucose as a result of
  - cellular respiration.
  - glycolysis.
  - alcoholic fermentation.
  - lactic acid fermentation.
- During heavy exercise, the buildup of lactic acid in muscle cells results in
  - alcoholic fermentation.
  - oxygen debt.
  - the Calvin cycle.
  - the Krebs cycle.

### Understanding Concepts

- What is a calorie? How do cells use a high-calorie molecule such as glucose?
- How is glucose changed during glycolysis? What products are produced as a result of glycolysis?
- What are the two pathways that might follow glycolysis? What factor can determine which of those pathways a cell might follow?
- Use formulas to write a chemical equation for cellular respiration. Label the formulas with the names of the compounds.
- Draw and label a mitochondrion surrounded by cytoplasm. Indicate where glycolysis, the Krebs cycle, and the electron transport chain occur.
- How is  $\text{NAD}^+$  involved in the products of glycolysis? What happens to a cell's  $\text{NAD}^+$  when large numbers of high-energy electrons are produced in a short time?
- Which two compounds react during fermentation? Which of these compounds passes high-energy electrons to the other?
- Write equations to show how lactic acid fermentation compares with alcoholic fermentation. Which reactant(s) do they have in common?
- How are fermentation and cellular respiration similar? What is the main difference between their starting compounds?
- Summarize what happens during the Krebs cycle. What happens to the high-energy electrons generated during the Krebs cycle?
- How is ATP synthase involved in making energy available to the cell?
- When runners race for about 20 minutes, how do their bodies obtain energy?



If your class subscribes to the iText, your students can go online to access an interactive version of the Student Edition and a self-test.

### (Continued from page 236)

17. Pyruvic acid and NADH react together as NADH passes high-energy electrons to pyruvic acid.

18. Lactic acid fermentation:  
glucose  $\rightarrow$  lactic acid  
Alcoholic fermentation:  
glucose  $\rightarrow$  alcohol +  $\text{CO}_2$   
Both have glucose as the reactant.

19. Fermentation and cellular respiration are both processes that break down glucose and release the energy stored in the molecule. Both start with the process of glycolysis, which produces pyruvic acid. Cellular respiration requires oxygen as a reactant. Fermentation occurs without oxygen.

20. During the Krebs cycle, pyruvic acid is broken down into carbon dioxide in a series of reactions that give off energy. The high-energy electrons that are produced are picked up by a series of electron carriers, and the energy is used to convert ADP into ATP.

21. ATP synthase is a large protein through which hydrogen ions ( $\text{H}^+$ ) pass, converting ADP into high-energy ATP.

22. At the beginning of a race, runners' energy comes from ATP that is present in their muscles and that is produced by lactic acid fermentation. When runners race for about 20 minutes, their bodies use cellular respiration to use stored carbohydrates to make ATP.



### HOMEWORK GUIDE

#### Section:

#### Questions:

Section 9-1: 1-6, 11-19, 25, 27, 29, 31

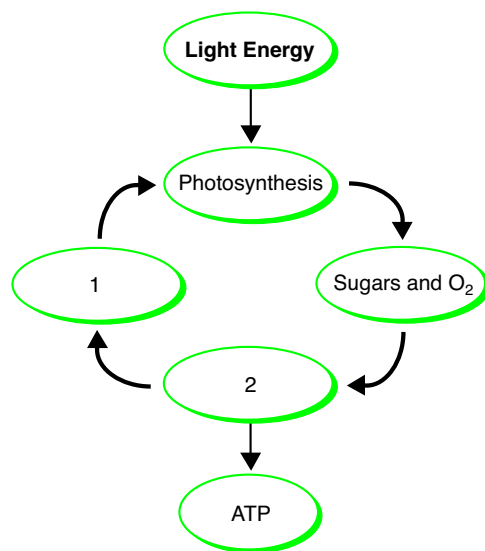
Section 9-2: 7-10, 20-24, 26, 28, 30

## Critical Thinking

23. 1.  $\text{CO}_2$  and  $\text{H}_2\text{O}$   
2. cellular respiration
24. In a eukaryotic cell, the electron transport chain is found in the inner membrane of the mitochondrion. In a prokaryotic cell, the electron transport chain is in the cell membrane.
25. Bacteria that live without oxygen probably obtain energy through fermentation, because that process releases energy without involving oxygen.
26. An increased number of mitochondria in muscle cells would enable an individual to obtain energy from cellular respiration at a faster rate, so the individual might perform energy-requiring activities more quickly than others or for a longer period.
27. Yeast cells would probably grow more rapidly when they perform cellular respiration, because 18 times more ATP can be generated in the presence of oxygen than in anaerobic conditions.
28. Sample answer: Start with two groups of healthy volunteers who do not exercise regularly. Test their initial responses during intense activity, using the same definition of muscle discomfort for all. Monitor one group as they exercise regularly for a specific period, and then test both groups again to see whether the groups differ.
29. Lactic acid is produced by muscles when the supply of oxygen is insufficient, so the presence of lactic acid indicates that the heart did not receive the oxygen it needed.
30. An organism cannot continue to live without a constant supply of energy, which is provided by the Krebs cycle and the electron transport chain. Any event that cuts off that energy supply will cause the death of the organism.
31. Students may sketch the carbon cycle in which plants absorb light, convert light energy to chemical energy, and store energy in sugars during photosynthesis. The sugars may be used by the plants or taken in as food by other organisms. Energy is extracted from the sugars during cellular respiration, and carbon dioxide is given off as a product.

## Critical Thinking

23. **Interpreting Graphics** Complete the following concept map showing the flow of energy in photosynthesis and cellular respiration.



24. **Comparing and Contrasting** Where is the electron transport chain found in a eukaryotic cell? In a prokaryotic cell?
25. **Inferring** Certain types of bacteria thrive in conditions that lack oxygen. What does that fact indicate about the way they obtain energy?
26. **Predicting** In certain cases, regular exercise causes an increase in the number of mitochondria in muscle cells. How might that situation improve an individual's ability to perform energy-requiring activities?
27. **Formulating Hypotheses** Yeast cells can carry out both fermentation and cellular respiration, depending on whether oxygen is present. In which case would you expect yeast cells to grow more rapidly? Explain.
28. **Designing Experiments** Would individuals who carry out regular aerobic exercise suffer less muscle discomfort during intense exercise than other individuals? Outline an experiment that could answer this question.

29. **Inferring** To function properly, heart muscle cells require a steady supply of oxygen. After a heart attack, small amounts of lactic acid are present. What does this evidence suggest about the nature of a heart attack?
30. **Applying Concepts** Carbon monoxide ( $\text{CO}$ ) molecules bring the electron transport chain in a mitochondrion to a stop by binding to an electron carrier. Use this information to explain why carbon monoxide gas kills organisms.
31. **Connecting Concepts** In Chapter 3, you learned that certain substances are involved in chemical cycles. Draw a sketch that illustrates how cellular respiration fits into one of those cycles.

## Writing in Science

Expand the analogy of deposits and withdrawals of money that was used in the chapter to write a short paragraph to explain cellular respiration. (Hint: You may wish to start out making a compare-and-contrast table that lists the similarities and differences between the two items.)

## Performance-Based Assessment

**Creating Diagrams** Make one or more diagrams with labels or captions to show how two athletes get energy when the first athlete runs for 30 seconds and the second athlete runs for 20 minutes. How are the processes similar? How are they different? Be sure to show whether the energy is produced by an aerobic process or by an anaerobic process.

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