Lesson Review

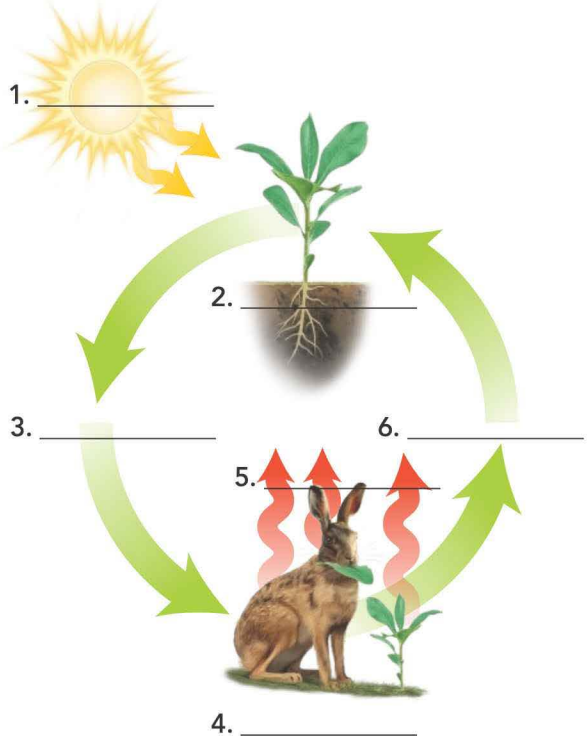
Go to your Biology Foundations Workbook for longer versions of these lesson summaries.

10.1 Cellular Respiration: An Overview

Organisms get the energy they need from food. Cellular respiration is the process that releases energy from food in the presence of oxygen. There are three stages of cellular respiration: glycolysis, the Krebs cycle, and the electron transport chain.

Photosynthesis removes carbon dioxide from the atmosphere, and cellular respiration puts it back. Photosynthesis releases oxygen into the atmosphere, and cellular respiration uses that oxygen to release energy from food.

- calorie
- cellular respiration
- aerobic
- anaerobic



Summarize Complete this diagram by filling in numbers 1 through 6.

10.2 The Process of Cellular Respiration

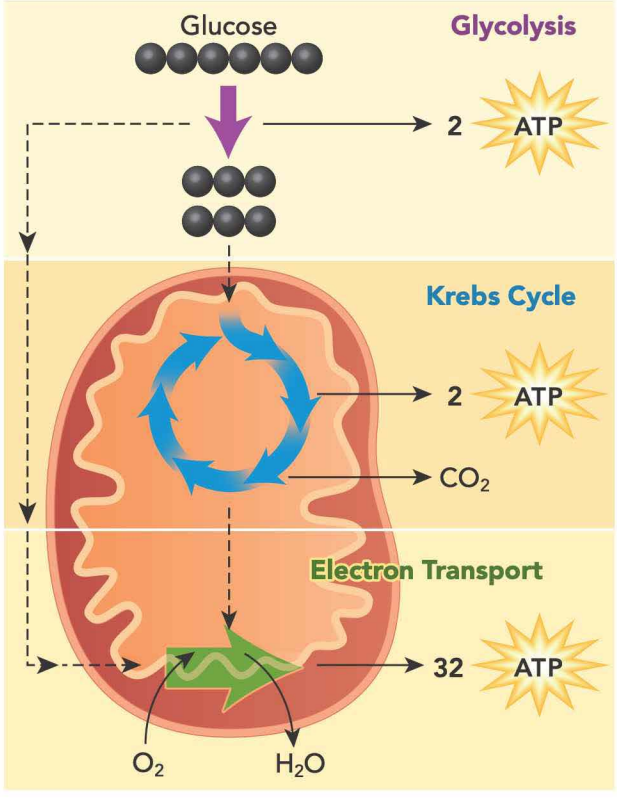
During glycolysis, 1 molecule of glucose is transformed into 2 molecules of pyruvic acid.

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 glycolysis and the Krebs cycle to convert ADP into ATP.

Together, glycolysis, the Krebs cycle, and the electron transport chain release about 36 molecules of ATP per molecule of glucose.

- glycolysis
- NAD^+
- Krebs cycle
- matrix



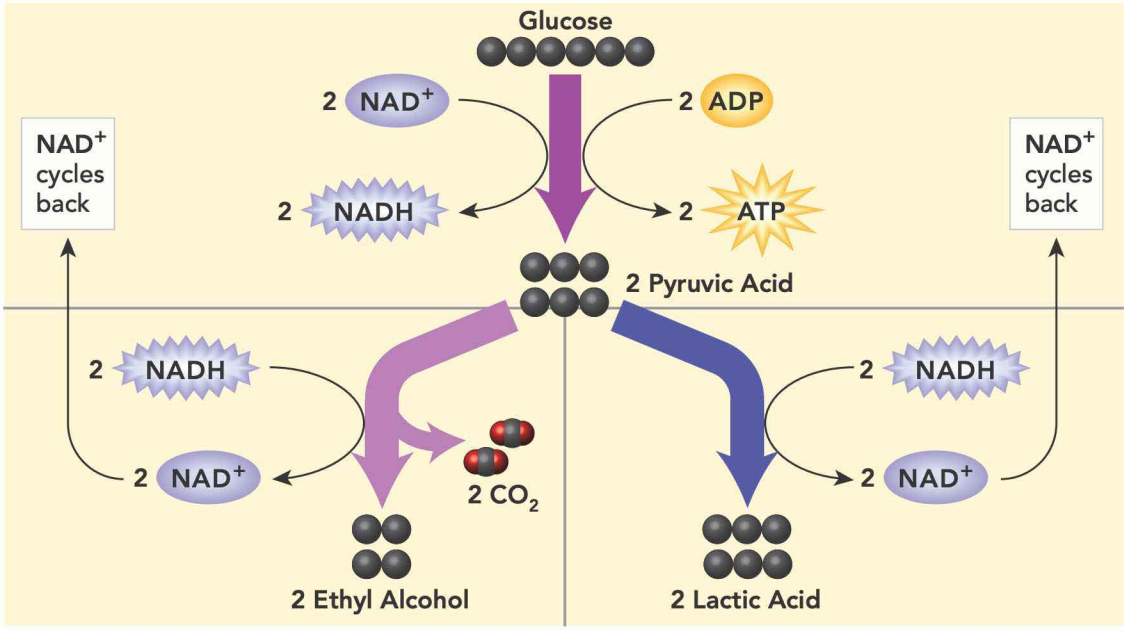
Use Visuals How many times more energy is produced by all three stages of cellular respiration than by glycolysis alone?

10.3 Fermentation

In the absence of oxygen, glycolysis is kept going by the pathway of fermentation, which releases energy from food molecules by producing ATP. There are two slightly different forms of the process: alcoholic fermentation and lactic acid fermentation.

For short, quick bursts of energy, the body uses ATP already in muscles as well as ATP made by lactic acid fermentation. For exercise longer than about 90 seconds, cellular respiration is the only way to continue generating a supply of ATP.

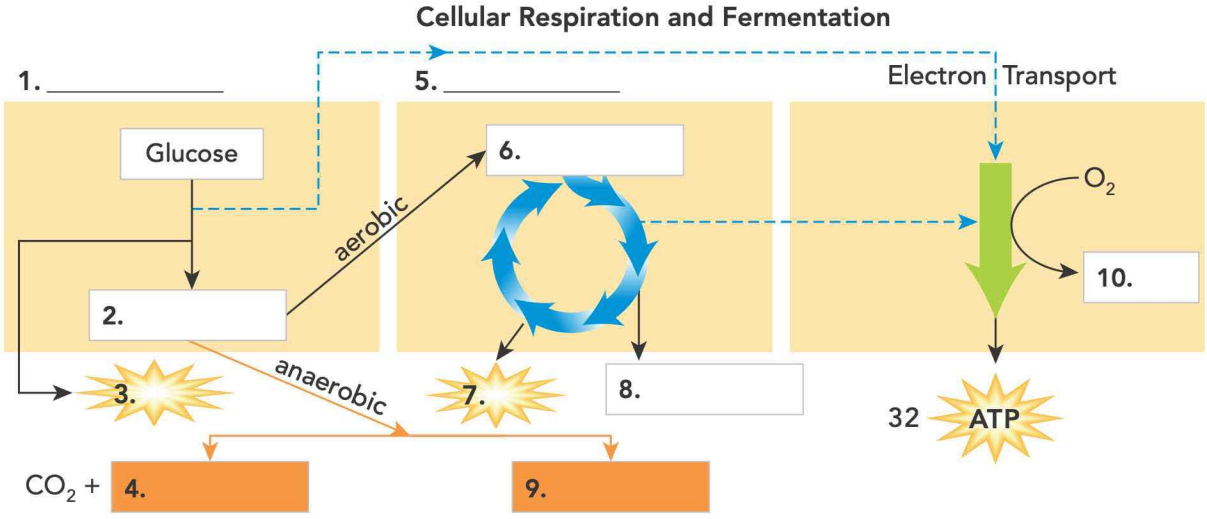
- fermentation



Compare and Contrast How are alcoholic fermentation and lactic acid fermentation similar? How are they different?

Organize Information

Complete the flowchart to show the stages of cellular respiration and fermentation.



PERFORMANCE-BASED ASSESSMENT

Making a Better Bread

Mastering Fermentation

Communicating Information

CCSS.MATH.CONTENT.MP2, CCSS.ELA-LITERACY.RST.9-10.3

STEM Professional bakers and cooks often try to develop new recipes for their favorite foods or dishes. Amateurs enjoy this process, too. For example, when following a recipe for bread, an enterprising baker might change the amount of sugar or salt, add new ingredients like raisins or sesame seeds, or change the timing of the different steps.

In many ways, developing a new recipe is an example of the engineering process in action. Engineers often try out a variety of plans and ideas to develop a working model, or prototype, of their invention or process. Then, when they have settled on the prototype, they produce it full size or in large amounts.

Read the recipe for sourdough bread shown here, and then answer these questions.

Sourdough Bread

Ingredients: 4 cups bread flour, 3 tablespoons sugar, 2 tablespoons salt, 1/4 ounce dry yeast, 1 cup warm milk, 2 tablespoons margarine, 1 1/2 cups sourdough starter

Steps

1. In a large bowl, combine 1 cup flour and the sugar, salt, and dry yeast. Add milk and margarine. Stir in starter. Gradually mix in 3 cups flour.
2. Turn dough out onto a floured surface and knead for 8 to 10 minutes. Place in a greased bowl, turn once to oil surface, and cover. Let the dough rise at room temperature for 1 hour or until doubled in volume.
3. Punch down, and let rest 15 minutes. Shape into 2 or 3 small loaves. Place on a greased baking pan. Allow to rise for 1 hour or until doubled.
4. Bake at 375°F (190°C) for 30 minutes.

SCIENCE PROJECT

1. **Construct an Explanation** How is fermentation important in the baking of sourdough bread? During which step does fermentation occur? To construct your answer, apply your knowledge of fermentation and scientific reasoning.
2. **Conduct Research** A sourdough starter is essential to making sourdough bread. Research how to make and maintain your own sourdough starter.
3. **Predict** Consider the following changes to the recipe. Predict the result of each change, and explain your reasoning. Assume that each change occurs individually, without enacting any of the other changes.
   a. Step 2 is eliminated.
   b. Before step 3, the dough is rolled into very thin sheets.
   c. In step 3, the dough rises for only 30 minutes.
   d. In step 2, the dough rises inside a refrigerator.
4. **Conduct Research** Bakers might follow many recipes or procedures for baking bread or related products. Select a recipe from a cookbook or the Internet, and research how it relies on fermentation.
5. **Communicate Information** Write a brief report to share your research findings and conclusions. Be sure to address the following points:
   - Describe the steps that are followed to produce the food. Explain how fermentation is used.
   - Which organisms are used to perform the fermentation process? Why are the organisms useful for the food?
   - How does the food-making process compare with the processes used for other foods that depend on fermentation?

Swiss cheese gets its unique flavor from lactic acid fermentation and the effects of bacteria on lactic acid. The holes in the cheese come from pockets of carbon dioxide gas that fermentation releases.

ASSESSMENT

KEY QUESTIONS AND TERMS

10.1 Cellular Respiration: An Overview

HS-LS1-7, HS-LS2-3, HS-LS2-5

1. Cells use the energy available in food to make a final energy-rich compound called
   a. water. **c.** ATP.
   b. glucose. **d.** ADP.
2. Each gram of glucose contains approximately how much energy?
   a. 9 calories **c.** 4 calories
   b. 9 Calories **d.** 4 Calories
3. The process that releases energy from food in the presence of oxygen is
   a. synthesis.
   b. cellular respiration.
   c. ATP synthase.
   d. photosynthesis.
4. The first step in releasing the energy of glucose in a cell is known as
   a. fermentation.
   b. glycolysis.
   c. the Krebs cycle.
   d. electron transport.
5. What is a calorie? Briefly explain how cells use a high-calorie molecule such as glucose.
6. Write a chemical equation for cellular respiration. Label the molecules involved.
7. What percentage of the energy contained in a molecule of glucose is captured in the bonds of ATP at the end of glycolysis?
8. What does it mean if a process is "anaerobic"? Which part of cellular respiration is anaerobic?

10.2 The Process of Cellular Respiration

HS-LS1-7, HS-LS2-3, HS-LS2-5

9. The net gain of energy in glycolysis from one molecule of glucose is
   a. 4 ATP molecules.
   b. 2 ATP molecules.
   c. 8 ADP molecules.
   d. 3 pyruvic acid molecules.
10. In eukaryotes, the Krebs cycle takes place within the
    a. chloroplast. **c.** mitochondrion.
    b. nucleus. **d.** cytoplasm.
11. The electron transport chain uses the high-energy electrons from the Krebs cycle to
    a. produce glucose.
    b. move H^+ ions across the inner mitochondrial membrane.
    c. convert acetyl-CoA to citric acid.
    d. convert glucose to pyruvic acid.
12. How is glucose changed during glycolysis?
13. What is NAD^+? Why is it important?
14. Summarize what happens during the Krebs cycle. What happens to high-energy electrons generated during the Krebs cycle?
15. How is ATP synthase involved in making energy available to the cell?

10.3 Fermentation

HS-LS1-7, HS-LS2-3

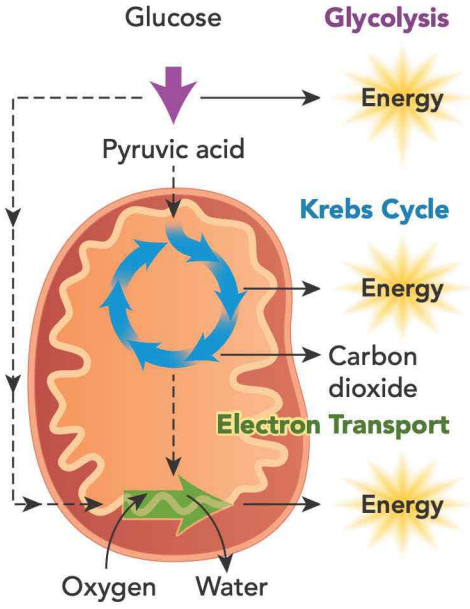
16. Because fermentation takes place in the absence of oxygen, it is said to be
    a. aerobic.
    b. anaerobic.
    c. cyclic.
    d. oxygen-rich.
17. Most of the time, the process carried out by yeast that causes bread dough to rise is
    a. alcoholic fermentation.
    b. lactic acid fermentation.
    c. cellular respiration.
    d. mitosis.
18. During heavy exercise, the buildup of lactic acid in muscle cells results in
    a. cellular respiration.
    b. oxygen debt.
    c. fermentation.
    d. the Krebs cycle.
19. How are fermentation and cellular respiration similar?
20. Write equations to show how lactic acid fermentation compares with alcoholic fermentation. Which reactant(s) do they have in common?

CRITICAL THINKING

HS-LS1-7, HS-LS2-5

21. Construct an Explanation Explain how cellular respiration and photosynthesis can be considered both opposite and interrelated processes.

The diagram shown is a model summarizing the stages of cellular respiration. Use the diagram to answer questions 22 and 23.



22. Use Models Suppose a chemical in a cell were to inhibit the function of mitochondria. Predict how the model would be affected, and explain why.

23. Evaluate Models The model shows the same image for energy during each stage. Explain how you could improve the model to better represent the energy released during each stage.

24. Identify What are the reactants of anaerobic cellular respiration? What are the products?

25. Identify What are the reactants of aerobic cellular respiration? What are the products?

26. Compare and Contrast How is the function of NAD^+ in cellular respiration similar to that of $NADP^+$ in photosynthesis?

27. Use Analogies Why is comparing cellular respiration to a burning fire a poor analogy?

28. Compare and Contrast Where is the electron transport chain found in a eukaryotic cell? Where is it found in a prokaryotic cell?

29. Use Models Explain how the products of glycolysis and the Krebs cycle are related to the electron transport chain. Draw a flowchart that shows the relationships between these products and the electron transport chain.

30. Use Models Draw and label a mitochondrion surrounded by cytoplasm. Indicate where glycolysis, the Krebs cycle, and the electron transport chain occur in a eukaryotic cell.

31. Infer Certain types of bacteria thrive in conditions that lack oxygen. What does that fact indicate about the way they obtain energy?

32. Design an Investigation 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.

33. Apply Scientific Reasoning 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?

34. Form a Hypothesis In certain cases, regular exercise causes an increase in the number of mitochondria in muscle cells. How might that change improve an individual's ability to perform activities that require great amounts of energy?

35. Predict 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.

36. Explain Explain how a sprinter gets energy during a 30-second race. Is the process aerobic or anaerobic? How does it compare to a long-distance runner getting energy during a 5-kilometer race?

CROSSCUTTING CONCEPTS

37. **Energy and Matter** Energy cannot be created or destroyed. Explain how energy is conserved in cellular respiration. Include in your explanation how energy is transferred and converted at the levels of a single cell and of an organism.

38. **Systems and System Models** Edie uses snap beads to model cellular respiration. She uses red beads for oxygen atoms, black beads for carbon atoms, and white beads for hydrogen atoms. How can she describe this reaction? What is one limitation of the model?

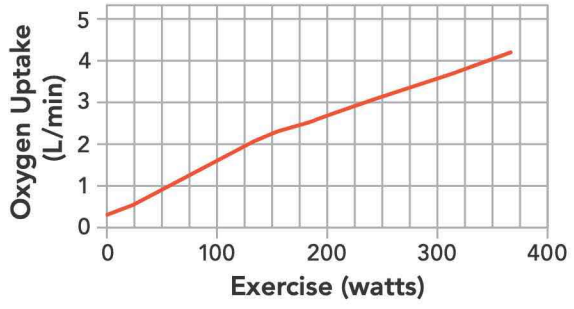
MATH CONNECTIONS

Analyze and Interpret Data

CCSS.MATH.CONTENT.MP2

Use the graph to answer questions 39 and 40. The graph shows data collected by a scientist who compared the volume of oxygen breathed per minute to the difficulty level of exercise, measured in watts.

Oxygen Uptake and Exercise Difficulty



39. **Interpret Graphs** Based on the graph, which increase in exercise difficulty level resulted in an increase in oxygen uptake of approximately 2 L/min?

40. **Draw Conclusions** Which of the following is a valid hypothesis for the trend shown on the graph? Evaluate the choices, and then explain why you selected the answer you did. Identify the criteria you used to select the answer, and describe how the other choices failed to meet your criteria.

a. As exercise becomes more difficult, the body relies more and more on lactic acid fermentation.

b. Exercise below a level of 100 watts does not require increased oxygen uptake.

c. Difficult exercise requires additional oxygen intake in order to generate extra ATP for muscle cells.

d. The human body cannot maintain exercise levels above 500 watts.

LANGUAGE ARTS CONNECTIONS

Write About Science

CCSS.ELA-LITERACY.WHST.9-10.2, CCSS.ELA-LITERACY.WHST.9-10.4

41. **Write Explanatory Texts** Expand the analogy of deposits and withdrawals of money that was used in the chapter to write a short paragraph to explain cellular respiration.

42. **Produce Clear Writing** Write a paragraph that explains the conditions under which fermentation occurs and differentiates between alcoholic and lactic acid fermentation.

Read About Science

CCSS.ELA-LITERACY.RST.9-10.1, CCSS.ELA-LITERACY.RST.9-10.10

43. **Cite Textual Evidence** Carbon monoxide (CO) molecules bring the electron transport chain in a mitochondrion to a stop by binding to an electron carrier. Use this information and cite additional information from the text to explain why carbon monoxide gas kills aerobic organisms.

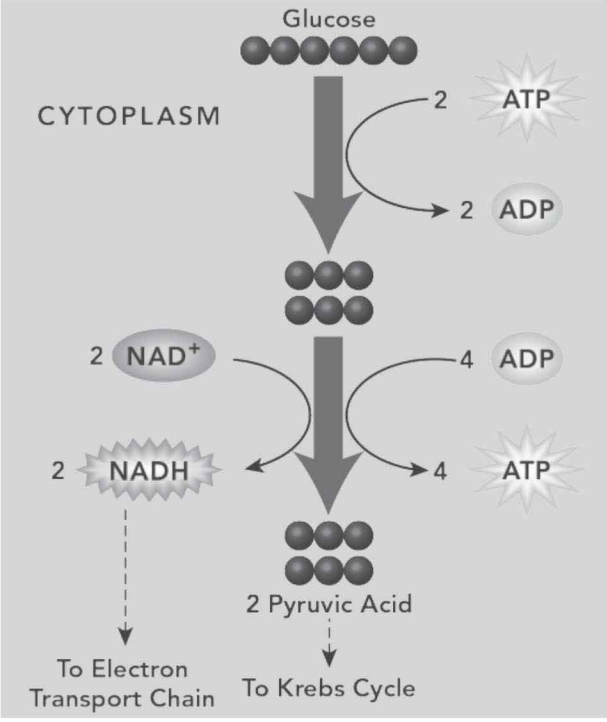
44. **Read and Comprehend** Review **Figure 10-5** and the text that accompanies it. How does the diagram illustrate the process described in the passage? How does the diagram relate to the information presented about the other stages of cellular respiration?

END-OF-COURSE TEST PRACTICE

1. In a model summarizing cellular respiration, which of the following must be represented as raw materials, or the reactants of the process?
   A. glucose and carbon dioxide
   B. glucose and oxygen
   C. carbon dioxide and oxygen
   D. oxygen and lactic acid
   E. water and oxygen

2. Which statement best describes an event represented in the model that contributes to the production of ATP?
   A. A net gain of 6 ATP molecules is achieved.
   B. Oxygen molecules are broken down and converted into pyruvic acid.
   C. High-energy electrons are passed to NAD^+ forming NADH.
   D. Carbon atoms in glucose are transformed into energy in the form of ATP.
   E. Pyruvic acid is broken down to form carbon dioxide.

The diagram shows a model of glycolysis. Use the diagram to answer question 3.



3. During glycolysis, what is the source of the chemical energy that is captured in ATP?
   A. the chemical bonds in pyruvic acid
   B. the chemical bonds in glucose
   C. the nuclei of atoms in glucose
   D. high-energy electrons in the cytoplasm
   E. high-energy electrons in mitochondria

4. What best describes the role of molecular oxygen (O_2) in cellular respiration?
   A. It is accepts electrons when reacting to form water.
   B. It combines with carbon and hydrogen to form glucose.
   C. It is released when water breaks apart.
   D. It is released when glucose breaks apart.
   E. It reacts to form carbon dioxide and water.

5. Which is a role of cellular respiration in cycling materials between the atmosphere and biosphere?
   A. It transfers carbon to the atmosphere as carbon dioxide.
   B. It transfers carbon to the biosphere as glucose.
   C. It transfers oxygen gas to the atmosphere.
   D. It transfers water from the atmosphere to the biosphere.
   E. It transfers carbon to the atmosphere as pyruvic acid.

ASSESSMENT

For additional assessment practice, go online to access your digital course.

If You Have Trouble With...					
Question	1	2	3	4	5
See Lesson	10.1	10.2	10.2	10.2	10.1
Performance Expectation	HS-LS1-7	HS-LS1-7	HS-LS1-7	HS-LS1-7	HS-LS2-5