Chapter 9 Organizer

Refer to pages 475-76 of the Teacher Guide for an explanation of the National Science Education Standards correlations.

Section 9.1
ATP in a Molecule
National Science Education Standards UCP2, UCP3: A.1, A.2; B.3, B.6; C.1, C.5
(1 session, 1/2 block)

1. Explain why organisms need a supply of energy.
2. Describe how energy is stored and released by ATP.

Problem-Solving Lab 9-1, p. 228

Section 9.2
Photosynthesis: Trapping the Sun’s Energy
National Science Education Standards UCP2, UCP3: A.1, A.2; B.3, B.6; C.1, C.5; G.1 (2 sessions, 1 block)

3. Relate the structure of chloroplasts to the energy in photosynthesis.
5. Explain the reactions and products of the light-independent Calvin cycle.

Problem-Solving Lab 9-2, p. 232
MiniLab 9-1: Use isotopes to understand photosynthesis, p. 234
Inside Story: The Calvin Cycle, p. 235
Careers in Biology: Biochemist, p. 236
Internet BioLab: What factors influence photosynthesis?, p. 244
Chemistry Connection: Plant Pigments, p. 246

Section 9.3
Getting Energy to Make ATP
National Science Education Standards UCP3-3: A.1, A.2; B.3, B.6; C.1, C.5; E.6
(3 sessions, 1/2 block)

6. Compare and contrast cellular respiration and fermentation.
7. Explain how cells obtain energy from cellular respiration.

Inside Story: The Citric Acid Cycle, p. 239
Problem-Solving Lab 9-3, p. 241
MiniLab 9-2: Determine if Apple Juice Ferments, p. 242

Energy in a Cell
Teacher Classroom Resources

Section 9.1
Reinforcement and Study Guide, p. 37
Tech Prep Applications, pp. 15-16
Content Mastery, pp. 41-42, 44

Section 9.2
Photosynthesis: Trapping the Sun’s Energy
Reinforcement and Study Guide, p. 38-39
Concept Mapping, p. 9
Critical Thinking/Problem Solving, p. 9
BioLab and MiniLab Worksheets, p. 39
Content Mastery, pp. 43-44

Section 9.3
Getting Energy to Make ATP
Reinforcement and Study Guide, p. 40
BioLab and MiniLab Worksheets, pp. 40-42
Laboratory Manual, pp. 61-68
Content Mastery, pp. 43-44

Assessment Resources
Chapter Assessment, pp. 49-54
MindJogger Videoquizzes
Performance Assessment in the Biology Classroom
Alternate Assessment in the Science Classroom
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 9 quiz

Additional Resources
Spanish Resources
English/Spanish Audiocassettes
Cooperative Learning in the Science Classroom
Lesson Plans/Block Scheduling

GLENCOE TECHNOLOGY
The following multimedia resources are available from Glencoe.

Biology: The Dynamics of Life
CD-ROM
Animation: The Light Reactions
Exploration: Parts of the Cell
Exploration: Phases of Mitosis
BioQuest: Cellular Pursuit
VideoDisc Program
The Light Reactions
The Infinite Voyage
Unseen World
The Champion Within
The Secret of Life Series
ATP Structure
A TP Function
ATP Serves as an Energy Carrier

Chapter 9 Organizer

Need Materials? Contact Carolina Biological Supply Company at 1-800-334-5551 or at http://www.carolina.com

Materials List

BioLab
p. 244 1000 mL beaker, Elodea plants (3), string, washers, colored cellophane, 150-watt light with reflector, 0.25% baking soda solution, watch with second hand

MiniLabs
p. 234 clay (various colors)
p. 242 small beaker, plastic pipe, large test tube, water, metal washers, baker’s yeast, apple juice

Alternative Lab
p. 240 black paper, labels, iodine solution, paper clips, hot plate, beaker, 95% ethanol, small bowl, Coleus plants

Quick Demos
p. 229 potato, water, beaker, Bunsen burner
p. 233 prism
p. 238 sugar (sucrose), water, flask, baker’s yeast
p. 251 potato, meat, vegetable oil, molecular model of lipid

Key to Teaching Strategies

Level 1 activities should be appropriate for students with learning difficulties.
Level 2 activities should be within the ability range of all students.
Level 3 activities are designed for above-average students.
ELL activities should be within the ability range of English Language Learners.
Cooperative Learning activities are designed for small group work.
These strategies represent student products that can be placed into a best-work portfolio.
These strategies are useful in a block scheduling format.

Teacher’s Corner

Products Available from Glencoe To order the following products, call Glencoe at 1-800-334-7344:
- CD-ROMs: NGS PictureShow: The Cell
- NGS PictureShow: Plants: What It Means to Be Green
- Curriculum Kit
- GeoKit: Cells and Microorganisms
- Transparency Sets
- NGS PicturePack: The Cell
- NGS PicturePack: Plants: What It Means to Be Green

Products Available from National Geographic Society
To order the following products, call National Geographic Society at 1-800-368-2728:
- Video
- Discovering the Cell
- Photosynthesis: Life Energy

Index to National Geographic Magazine
The following articles may be used for research relating to this chapter:
Chapter 9

Energy in a Cell

What You’ll Learn

- You will learn what ATP is.
- You will explain how ATP provides energy for the cell.
- You will describe how chloroplasts trap the sun’s energy to make ATP and complex carbohydrates.
- You will compare ATP production in mitochondria and chloroplasts.

Why It’s Important

Every cell in your body needs energy in order to function. The energy your cells produce and store is the fuel for basic body functions such as eating and breathing.

GETTING STARTED

The Source of Energy

Watch your teacher’s movements as he or she conducts the demonstration. Where does the energy for this activity come from?

To find out more about how cells use and produce energy, visit the Glencoe Science Web Site. www.glencoe.com/sec/science

If time does not permit teaching the entire chapter, use the BioDigest at the end of the unit as an overview.

Resource Manager

Section Focus Transparency 21

Assessment Planner

Portfolio Assessment

Assessment, TWE, p. 243
BioLab, TWE, pp. 244-245

Performance Assessment

Problem-Solving Lab, TWE, pp. 228, 232
MiniLab, TWE, p. 242
Assessment, TWE, p. 236
Alternative Lab, TWE, pp. 240-241
BioLab, SE, pp. 234, 242
BioLab, SE, pp. 244-245

Knowledge Assessment

Assessment, TWE, pp. 229, 230
MiniLab, TWE, p. 234
Section Assessment, SE, pp. 230, 236, 243
Chapter Assessment, SE, pp. 247-249

Skill Assessment

Assessment, TWE, pp. 233, 240
Problem-Solving Lab, TWE, p. 241

Prepare

Key Concepts

Students will examine the source of cellular energy—the ATP molecule. They will also learn about the processes in which cells use the energy stored in ATP.

Planning

- Obtain a potato, peanuts, a dissection needle, a cork, and a Bunsen burner for the Quick Demo and closing demonstration.
- Gather toothpicks, gumdrops, and construction paper for the modeling activities.

1 Focus

Bellringer

Before presenting the lesson, display Section Focus Transparency 21 on the overhead projector and have students answer the accompanying questions.
The name of this energy molecule is adenosine triphosphate (ATP). ATP is a small compound. Cellular proteins have a specific site where ATP can bind. Then, when the phosphate bond is broken and the energy is released, the cell can use the energy for activities such as making a protein or transporting molecules through the plasma membrane. This cellular process is similar to the way energy in batteries is used by a radio. Batteries sitting on a table are of little use. When the energy of ATP has been used, the chemical bond between phosphate groups in ATP is broken, energy is released and the resulting molecule is ADP. At this point, ADP is released from the binding site in the protein and the binding site may then be filled by another ATP stored in the cell. Therefore, if we store excess ATP, the protein and the binding site can once again bind ATP.

2 Teach

**Problem-Solving Lab 9.1**

**Purpose:** Students will determine that fat, rather than carbohydrates, is the preferred compound for energy storage in humans.

**Background:** Fats yield more ATP’s than carbohydrates because they have more C–H bonds. A six-carbon fat fragment has a molecular weight of about 100, while the same carbohydrate size has a molecular weight of 180. Fats are hydrophobic while carbohydrates are hydrophilic.

**Teaching Strategies**

- Emphasize that this lab discusses the storage of excess energy and reiterates that carbohydrates are also important compounds.
- Elicit from students if they believe early humans were typically very heavy. As body weight would not have been an asset to the survival of hunters. Therefore, if early humans were storing energy as fat, they were not likely very agile.

**Thinking Critically**

1. Because the metabolism of water yields zero ATP, water is “excess baggage.” Fat, with no water, carries less “excess baggage,” helping to make it more efficient.

2. Because we store excess energy as fat, we do not carry the weight of that which is associated with carbohydrates.

**Assessment**

- **Performance:** Have students research where fat is stored within the human body, including any differences between male and female.
- **Portfolio:** Have students write three questions about what they have learned. Use the Performance Task Assessment List for Asking Questions in PASc, p. 19.

**Quick Demo**

To demonstrate the transfer of energy in small amounts, heat a potato in boiling water or in a microwave oven in the school cafeteria. When it is cool enough to handle safely, have students pass the heated potato to another. Ask students who first handle the potato to describe its temperature and hotness, then coolness, and have a student near the center observe the same observation.

228 ENERGY IN CELLS

**Problem-Solving Lab 9.1**

**Recognizing Cause and Effect**

- Why is fat the first choice? Humans store their excess energy as fat rather than as carbohydrates. Why is this? From an evolutionary and efficiency point of view, fats are better for storing energy than carbohydrates. Find out why.

**Analysis**

- The following facts compare certain characteristics of fats and carbohydrates:
  - A. When broken down by the body, each six-carbon molecule of fat yields 1.5 ATP molecules. Each six-carbon carbohydrate molecule yields 2 ATP molecules.
  - B. Carbohydrates bind and store water. The metabolism of water yields zero ATP. Fat has zero grams of water bound to it.
  - C. An adult who weighs 70 kg can survive on the energy derived by breaking fat for 30 days without eating. The same person would have to weigh nearly 140 kg to survive 30 days on stored carbohydrates.

**Thinking Critically**

1. From an ATP production viewpoint, use fact B to make a statement regarding the efficiency of fats vs. carbohydrates.

2. Explain why the average weight for humans is close to 70 kg and not 140 kg.
3 Assess

Check for Understanding

Ask students why energy must be stored in small amounts and relate the answer to paying for a small purchase with a $1 bill rather than with a $50 bill.

Reteach

Kinesthetic Have students join like poles of four small magnets to simulate the storage of energy in ATP. Explain how energy is released when the magnets are pulled apart. 

Extension

Linguistic Have interested students write a report about a bioluminescent organism and include facts about that organism’s energy requirements.

Assessment

Knowledge Ask students to summarize how each organism and structure in Figure 9.4 uses energy.

4 Close

Demonstration

Burn a peanut to demonstrate that energy is stored in food. Impale a peanut on the end of a dissection needle. Stick the other end of the needle into a cork. Ignite the peanut with a Bunsen burner. Ask students to describe what energy is stored in food. That energy is stored in food.

Section Assessment

Understanding Main Ideas

1. What processes in the cell need energy from ATP?
2. How does ATP store energy?
3. How can ADP be “recycled” to form ATP again?
4. How do proteins in your cells access the energy stored in ATP?
5. Phosphate groups in ATP repel each other because they have negative charges.

Thinking Critically

6. Observing and Inferring: When animal fibers in the cold, muscles move almost uncontrollably. Suggest how shivering helps an animal survive in cold. Some organisms with cilia or flagella (left) use energy from ATP to move.

Some organisms with cilia or flagella (left) use energy from ATP to move.

Section 9.2 Photosynthesis: Trapping the Sun’s Energy

Trapping Energy from Sunlight

To use the energy of the sun’s light, plant cells must trap light energy and store it in a form that is readily usable by cell organelles—ATP. However, light energy is not available 24 hours a day, so the plant cell must store some of the energy for the dark hours. Photosynthesis is the process plants use to trap the sun’s energy and build carbohydrates, called glucose, that store energy. To accomplish this, photosynthesis happens in two phases. The light-dependent reactions convert light energy into chemical energy. The molecules of ATP produced in the light-dependent reactions are then used to fuel the light-independent reactions that produce glucose. The general equation for photosynthesis is written as follows:

\[ 6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2 \]

The BioLab at the end of this chapter describes an experiment you can perform to investigate the rate of photosynthesis. 

The chloroplast and pigments

Recall that the chloroplast is the cell organelle where photosynthesis occurs. It is in the membranes of the thylakoid discs in chloroplasts that the light-dependent reactions take place.

4.2 Photosynthesis: Trapping the Sun’s Energy

Meeting Individual Needs

Gifted

Linguistic The citric acid cycle is sometimes called the Krebs cycle. Have students research the work of Melvin Calvin and Hans Krebs and write a report.

Resource Manager

Section Focus Transparency 22 and Master

Concept Mapping, p. 230

Basic Concepts Transparency 12 and Master

Planning

Acquire a prism to use in the Quick Demo. Acquire colored lights for the plant growth project. Purchase Etoldea for the BioLab. Collect objects to model photosynthesis for MiniLab 9-1. Obtain leaves and acetone for the leaf pigmentation project.

Focus

Bellringer

Before presenting the lesson, display Section Focus Transparency 22 on the overhead projector and have students answer the accompanying questions.

3 Assess

Check for Understanding

Ask students why energy must be stored in small amounts and relate the answer to paying for a small purchase with a $1 bill rather than with a $50 bill.

Reteach

Kinesthetic Have students join like poles of four small magnets to simulate the storage of energy in ATP. Explain how energy is released when the magnets are pulled apart. 

Extension

Linguistic Have interested students write a report about a bioluminescent organism and include facts about that organism’s energy requirements.

Assessment

Knowledge Ask students to summarize how each organism and structure in Figure 9.4 uses energy.

4 Close

Demonstration

Burn a peanut to demonstrate that energy is stored in food. Impale a peanut on the end of a dissection needle. Stick the other end of the needle into a cork. Ignite the peanut with a Bunsen burner. Ask students to describe what energy is stored in food. That energy is stored in food.

Section Assessment

Understanding Main Ideas

1. What processes in the cell need energy from ATP?
2. How does ATP store energy?
3. How can ADP be “recycled” to form ATP again?
4. How do proteins in your cells access the energy stored in ATP?
5. Phosphate groups in ATP repel each other because they have negative charges.

Thinking Critically

6. Observing and Inferring: When animal fibers in the cold, muscles move almost uncontrollably. Suggest how shivering helps an animal survive in cold. Some organisms with cilia or flagella (left) use energy from ATP to move.

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Section 9.2 Photosynthesis: Trapping the Sun’s Energy

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The BioLab at the end of this chapter describes an experiment you can perform to investigate the rate of photosynthesis. 

The chloroplast and pigments

Recall that the chloroplast is the cell organelle where photosynthesis occurs. It is in the membranes of the thylakoid discs in chloroplasts that the light-dependent reactions take place.

4.2 Photosynthesis: Trapping the Sun’s Energy
increasing light intensity increases
dents work in groups to design
its the rate. Limiting factors
increases with increasing light
The rate of photosynthesis
Thinking Critically
avoids introducing another variable.

I
particularly during winter.
ists increase light intensity, espe-
Teaching Strategies
organic compounds from carbon
derived from light to synthesize
Plants depend on the energy
Process Skills
My
the rate of photosynthesis.
Thinking Critically
Considering the overall equation for photosynthesis, make a statement summarizing what the graph shows. Under normal field conditions, what factors may limit the relative rate of photosynthesis when the light intensity is increased and temperature remains constant?

![Figure 9.5](image)

**Figure 9.5** The red, yellow, and purple pigments are visible in the autumn when trees reabsorb chlorophyll.

**Home**
chlorophyll
From the Greek words algae meaning "pale yellowish-green," and phylos meaning "leaf." Chlorophyll is a green pigment found in leaves.

**Origin**
chlorophyll
Chlorophyll in
Figure 9.6.

The Light Reactions
Chlorophyll molecules absorb light energy and energize electrons for producing ATP or NADPH.

**Electron Transport Chains**
- Light energy transfers to chlorophyll
- Chlorophyll transfers energy down through the electron transport chain, providing energy that
  - Can be used to form ATP or NADPH.
- This expanded view shows energized electrons lose some energy as they are passed from protein to protein through the electron transport chain. This energy can be used to form ATP or NADPH.

**Problem-Solving Lab 9.2**
How does photosynthesis vary with light intensity? Photosynthesis varies by which green plants synthesize organic compounds from water and carbon dioxide using energy absorbed by chlorophyll from sunlight.

**Analysis**
Green plants were exposed to increasing light intensity, as measured in candelas, and the rate of photosynthesis was measured. The temperature of the plants was kept constant during the experiment. The graph shown here depicts the data obtained.

**Thinking Critically**
Considering the overall equation for photosynthesis, make a statement summarizing what the graph shows. Under normal field conditions, what factors may limit the relative rate of photosynthesis when the light intensity is increased and temperature remains constant?

![Graph](image)

**Rate of photosynthesis**
light intensity (candelas)
- 0
- 20
- 40
- 60
- 80
- 100
- 150
- 200
- 300
- 500
- 1000
- 1500
- 2000

**Conclusion**
To trap the energy in the sun's light, the thylakoid membranes contain pigments, molecules that absorb specific wavelengths of sunlight. The most common pigment in chloroplasts is chlorophyll. Chlorophyll in forms a so-called "light-harvesting complex" that absorbs most wavelengths of light except for green. Because chlorophyll has no means to absorb this wavelength, it is reflected, giving leaves a green appearance. In the fall, trees reabsorb chlorophyll from the leaves and other pigments are visible, giving leaves like those in Figure 9.5 a wide variety of colors. Read the Chemistry Connection at the end of this chapter to find out more about biological pigments.

**Light-Dependent Reactions**
The first phase of photosynthesis requires sunlight. As sunlight strikes the chlorophyll molecules in the thylakoid membrane, the energy in the light is transferred to electrons. These highly energized, or excited, electrons are passed from chlorophyll to an electron transport chain, a series of proteins embedded in the thylakoid membrane. Use the Problem-Solving Lab shown here to consider how light intensity affects photosynthesis.

Each protein in the chain passes energized electrons along from protein to protein, similar to a bucket brigade in which a line of people pass a bucket of water from person to person to fight a fire. At each step along the transport chain, the electron loses energy, just as some of the water might be spilled from buckets in the fire-fighting chain. The electron transport chain allows small amounts of the electron's energy to be released at a time. This energy can be used to form ATP from ADP, or to pump hydrogen ions into the center of the thylakoid disc.

After the electron has traveled down the first electron transport chain, it is passed down a second electron transport chain. Following the second electron transport chain, the electron is still very energized. So that this energy is not wasted, the electron is transferred into the energized site of the chloroplast. To do this, an electron carrier molecule called NADP⁺ (nicotinamide adenine dinucleotide phosphate) is used. When carrying the excited electron, NADP⁺ combines with a hydrogen ion and becomes NADPH. Just as proteins contain a binding site where they can bind ATP, so the NADP⁺ molecule and other electron carrier molecules like it have a binding site for energized electrons. However, in this case, NADPH does not use the energy present in the energized electron; it simply stores the energy until it can recombine it to another series of reactions that will take place in the stroma. There, NADPH will play an important role in the formation of carbohydrates. The light-dependent reactions are summarized in Figure 9.6.

**Chemistry Connection**
Use a prism to show how visible light can be separated into a spectrum. Students may recall from their study of physical science that the different colors of the visible spectrum represent different wavelengths of light.

**Assessment**
Skill: Have students write the equation that summarizes photosynthesis. Ask them to identify the raw materials (reactants) in the process and the products. Carbon dioxide and water are the raw materials; simple sugars and oxygen are the products. Guide students to an understanding of what the equation means in terms of energy capture and conversion.

**Quick Demo**
Use a prism to show how visible light can be separated into a spectrum. Students may recall from their study of physical science that the different colors of the visible spectrum represent different wavelengths of light.
The Calvin Cycle

The second phase of photosynthesis does not require light. It is called the Calvin cycle, which is a series of reactions that use carbon dioxide to form carbohydrates. The Calvin cycle takes place in the stroma of the chloroplast. What are the stages of the Calvin cycle? To find out, read the Inside Story.

Light-Independent Reactions

The second phase of photosynthesis does not require light. It is called the Calvin cycle, which is a series of reactions that use carbon dioxide to form carbohydrates. The Calvin cycle takes place in the stroma of the chloroplast. What are the stages of the Calvin cycle? To find out, read the Inside Story.

Analysis

1. Explain how an isotope can be used as a tag.
2. Using your model, predict:
   a. the fate of all oxygen molecules that originated from carbon dioxide.
   b. the fate of all carbon molecules that originated from carbon dioxide.
   c. the fate of all hydrogen molecules that originated from water.

Assessment

Check for Understanding

Students should know the general equation for photosynthesis and understand that the light reactions feed the Calvin cycle.

Reteach

Explain that the Calvin cycle uses CO₂ and hydrogen to form the simple sugars that make more complex carbohydrates.

Using Isotopes to Understand Photosynthesis

Use the Van Niel experiment to model what you learned in the MiniLab 9-1. Have the students incorporate into the model the six-carbon sugar formed in Step 1 that is split to form two molecules of phosphoglycolic acid (PGA). Some PGA molecules reform the five-carbon sugar with the help of energy from ATP. Each five-carbon RuBP is ready to begin the cycle again.

Stomata: Trapping the Sun's Energy

| Origin | Origin
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose production uses energy from the Calvin cycle.</td>
<td>Two carbon dioxide molecules from water.</td>
</tr>
<tr>
<td>Glucose production after several rounds of the Calvin cycle.</td>
<td>Two molecules of PGA leave the cycle to form glucose.</td>
</tr>
<tr>
<td>Carbon fixation: One carbon atom from CO₂ is added to a five-carbon sugar called ribulose biphosphate (RuBP).</td>
<td>ATP and PGA + NADPH -&gt; ATP + NADP + 3PGA + 4e⁻</td>
</tr>
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</tr>
</tbody>
</table>

Knowledge

Have students model the equation for photosynthesis starting with an isolate of hydrogen in the water molecule to the left of the arrow. Use the Performance Task Assessment List for Model in PASC, p. 51.

Assessment

Check for Understanding

Students should know the general equation for photosynthesis. They will understand that the light reactions feed the Calvin cycle.

Reteach

Explain that the Calvin cycle uses CO₂ and hydrogen to form the simple sugars that make more complex carbohydrates.
The Calvin cycle

The Calvin cycle, named after Melvin Calvin shown in Figure 9.8, is called a cycle because one of the last molecules formed in the series of chemical reactions is also one of the molecules needed for the first reaction of the cycle. Therefore, one of the products can be used again to initiate the cycle.

In the electron transport chain, you learned that an energized electron is passed from protein to protein and the energy is slowly released. You can imagine that making a complex carbohydrate from a molecule of CO₂ would be a large task for a cell, so the light-independent reactions in the stroma of the chloroplast break down the complicated process into smaller steps. Each sugar molecule made by the Calvin cycle contains six carbon atoms, and because only one molecule of CO₂ is added to the cycle each time, it takes a total of six rounds of the cycle to form one sugar.

Figure 9.8 Melvin Calvin

Cellular Respiration

The process by which mitochondria break down food molecules to produce ATP is called cellular respiration. There are three stages of cellular respiration: glycolysis, the citric acid cycle, and the electron transport chain. The first stage, glycolysis, is anaerobic—no oxygen is required. The last two stages are aerobic and require oxygen to be complete.

Glycolysis

Glycolysis (glik OLI ih sis) is a series of chemical reactions in the cytoplasm of a cell that break down glucose, a six-carbon compound, into two molecules of pyruvic (pie RUE vac) acid, a three-carbon compound. Because two molecules of ATP are used to start glycolysis, and only four ATP molecules are produced, glycolysis is not very efficient, giving a net profit of only two ATP molecules for each glucose molecule broken down.

In the electron transport chain of photosynthesis, an electron carrier called NADP⁺ was described as carrying energized electrons to another location in the cell for further chemical reactions. Glyceraldehyde also uses an

Severo Ochoa

Have students research the efforts of Spanish-American biochemist Severo Ochoa (1905–1993) toward the modern understanding of the citric acid cycle and photosynthesis. Ochoa showed how the oxidation of one glucose molecule could yield 38 ATP molecules. He also elucidated the mechanisms of the citric acid cycle and photosynthesis by identifying the function of key enzymes.

Ochoa’s research in cellular respiration in the 1930s and 1940s resulted ultimately in the discovery of the mechanisms of RNA and DNA synthesis, for which Ochoa and colleague Arthur Kornberg received a Nobel prize in 1959.

Cultural Diversity

Extension

Intrapersonal Have students research the difference between the chlorophyll of plants and the light-capturing pigments of photosynthetic bacteria.

Performance Ask students to write a paragraph summarizing their food comes from. Students

CAREERS IN BIOLOGY

Biotechnologist

If you are curious about what makes plants and animals grow and develop, consider a career as a bio- technologist. The basic research of biotechnologists is to understand how processes in an organism work to ensure the organism’s survival.

Skills for the job

A bachelor’s degree in chemistry or biochemistry will qualify you to be a lab assistant. For a more involved position, you will need a master’s degree; advanced research requires a Ph.D. Some technologists work with genes to create new plants and new chemicals from plants. Others research the causes and cures of diseases or the effects of poor nutrition. Still others investigate solutions for urgent problems, such as finding better ways of growing, storing, and caring for crops.

To find out more about careers in biology and related fields, visit the Glencoe Science Web site.

www.glencoe.com/sacc/sience
The citric acid cycle

The citric acid cycle is a series of chemical reactions similar to the Calvin cycle in that one of the molecules needed for the first reaction is also one of the end products. However, in the Calvin cycle, glucose molecules are formed; in the citric acid cycle, glucose is broken down. What is the first compound that acetyl-CoA combines with in the citric acid cycle? To learn the answer, look at the Inside Story.

In the process of breaking down glucose, one molecule of ATP is produced for every turn of the cycle. Two electron carriers are used, NAD+ and FAD (glutathione disulfide). A total of three NADH + H+ molecules and one FADH2 molecule are formed. These electron carriers pass the energized electrons along to the electron transport chain in the inner mitochondrial membrane.

Critical Thinking

How many ATP molecules are produced by a single turn of the citric acid cycle?

1. 1 ATP
2. 2 ATP
3. 3 ATP
4. 4 ATP

Purpose

To teach students the main events of the citric acid cycle that break down acetyl CoA to form ATP, NADH, FADH2, and carbon dioxide.

Background

Glycolysis initiates the breakdown of glucose. Pyruvate, the end product of glycolysis, undergoes a series of reactions to form acetyl CoA, which enters the citric acid cycle. The citric acid cycle is important for its large energy yield.

Teaching Strategies

• Ask students to describe the four stages of the citric acid cycle.
• Include the products for each stage.

Visual Learning

Make a table with the following headings: ATP, NADH, and FADH2. Under the headings list one round of the citric acid cycle. Have the students fill in the number of each molecule produced during one round.

Critical Thinking

Each round produces:
1. ATP = 1 ATP
2. 3 NADH = 3 ATP
3. 1 FADH2 = 2 ATP

TOTAL = 12 ATP

The citric acid cycle takes a molecule of acetyl-CoA and breaks it down, forming ATP and CO2. The electron carriers NAD+ and FAD pick up energized electrons and pass them to the electron transport chain in the inner mitochondrial membrane.
Purpose

Students will demonstrate that without light carbon fixation slows or stops. The covered part of the leaf was partially covered and take off the paper clip in 7 minutes.

Materials

- Black paper
- Iodine solution
- Coleus plants
- Paper clip
- Hot plate
- Beaker
- 95% alcohol
- Small bowl
- Iodine
- Water

Procedure

1. Cut out two identical pieces of black paper in the shape of a small square.
2. Stick a label on one piece and write your initials and the date on it.
3. Use a paper clip to fasten the black shapes to the top and bottom surfaces of a Coleus leaf so that they are matched up exactly.
4. Leave the plant in sunlight for 7 days.

Then remove the leaf that was partially covered and take off the paper clip and papers.

5. Place the leaf into a beaker of boiling 95% alcohol enclosed in a fume hood and boil it until it turns white.

6. Rinse thoroughly if iodine gets on skin or clothing.

7. Rinse the leaf with tap water and observe.

Analysis

1. What happens when the leaf is boiled in alcohol? Its chlorophyll dissolves.
2. In what part of the leaf, carbon fixation slow or stop? The covered part received no light and therefore could not carry on photosynthesis, which is a carbon fixation process.

Fermentation

There are times when your cells are without oxygen for a short period of time. When this happens, an anaerobic process called fermentation follows glycolysis and provides a means to continue producing ATP until oxygen is available again. Some organisms exist in anaerobic environments and use fermentation to produce energy. There are two major types of fermentation: lactic acid fermentation and alcoholic fermentation. Figure 9.12 and Table 9.1 compare the two processes. Perform the Problem-Solving Lab shown here to further compare and contrast cellular respiration and fermentation.

Lactic acid and alcoholic fermentation are comparable in the production of ATP, but compared to cellular respiration, it is obvious that fermentation is far less efficient in ATP production.

Lactic acid fermentation occurs in some bacteria, in plants, and in most animals, including humans.

Problem-Solving Lab 9.3

Acquiring Information

Is cellular respiration better than fermentation? The method by which organisms derive ATP from their food may differ; however, the production of ATP molecules, cellular respiration, and alcoholic fermentation.

Thinking Critically

1. Describe some of the reasons why cellular respiration produces much more ATP than fermentation.
2. Describe a situation when a human would use more than one of the above processes.
3. Think of an organism that might generate ATP only by fermentation and consider why fermentation is the best process for the organism.

Teaching Strategies

It will be necessary for students to review the sections dealing with aerobic respiration, lactic acid fermentation, and alcoholic fermentation before they attempt to complete this lab.

Thinking Critically

1. The chemical reactions of the citric acid cycle provide more ATP than does fermentation. Cellular respiration better meets the energy requirements of complex organisms.

2. Humans normally carry out cellular respiration. During a time of intense exercise, we revert to lactic acid fermentation.

3. For an organism that lives in anaerobic conditions and uses small amounts of energy, cellular respiration may not be economical if fermentation consistently provides sufficient energy.

Assessment

Performance Have students write a summary of the lab. Use the Performance Task Assessment List for Lab Report in PASC, p. 57.
Lactic acid fermentation

Lactic acid fermentation is one of the processes that supplies energy when oxygen is scarce. You know that under anaerobic conditions, electronic transport chain breaks down because oxygen is not present as the final electron acceptor. As NADH and FADH₂ arrive with energized electrons from the citric acid cycle and glycolysis, they cannot release their energized electrons to the electron transport chain. The citric acid cycle and glycolysis cannot continue without a steady supply of NAD⁺ and FAD.

The cell does not have a mechanism to replace FAD during anaerobic conditions; however, NAD⁺ can be replaced through lactic acid fermentation. In lactic acid fermentation, two molecules of pyruvic acid use NAD⁺ to form two molecules of lactic acid. This release NAD⁺ can be used in glycolysis, allowing two ATP molecules to be formed for each glucose molecule. The lactic acid is transferred from muscle cells, where it is produced during strenuous exercise, to the liver that converts it back to pyruvic acid. The lactic acid that builds up in muscle cells results in muscle fatigue.

Alcoholic fermentation

Another type of fermentation, alcoholic fermentation, is used by, among others, yeast cells to produce CO₂ and ethyl alcohol. When making bread, like that shown in Figure 9.13, yeast cells produce CO₂ that forms bubbles in the dough. Eventually the heat of the baking bread kills the yeast and the bubble pockets are left to lighten the bread. You can do the activity in the MiniLab on this page to examine fermentation in apple juice.

Comparing Photosynthesis and Cellular Respiration

The production and breakdown of food molecules are accomplished by distinct processes that bear certain similarities. Both photosynthesis and cellular respiration use electron carriers and a cycle of chemical reactions to form ATP. Both use an electron transport chain to form ATP and to create a chemical and a concentration gradient of H⁺ within a cell. This hydrogen gradient can be used to form ATP by an alternative process.

Although, despite using such similar tools, the two cellular processes accomplish quite different tasks. Photosynthesis produces high-energy carbohydrates and oxygen from the sun’s energy, whereas cellular respiration uses oxygen to break down carbohydrates to form ATP and compounds with a much lower level of energy.

Table 9.2 compares photosynthesis and cellular respiration.

Figure 9.14 compares photosynthesis and cellular respiration.

Practice

1. Predict what would happen to the rate of bubbles given off if more yeast were present in the mixture.
2. Why was the test tube placed in warm water?
3. On the basis of your observations, was this process aerobic or anaerobic?
4. CO₂
5. The rate would increase.
6. Warm water increases the metabolic rate of the yeast.
7. Anaerobic, because no oxygen is available in the bulb of the pipette covered with water.
8. The Performance Task Assessment LS
9. MiniLab 9-2
11. Content Mastery, pp. 41, 43-44
12. Biolab and MiniLab Worksheets, p. 40
13. Internet Address Book
14. GLENCOE TECHNOLOGY
15. VIDEO DISC
16. The Infinite Voyage: The Champi
17. On Physiology of Continuous Performance (Ch. 5)
18. 3 min. 30 sec.
19. Glycogen: Fuel for Muscles (Ch. 6)
20. 5 min. 30 sec.
**INTERNET BioLab**

# What factors influence photosynthesis?

Oxygen is one of the products of photosynthesis. Because oxygen is only slightly soluble in water, aquatic plants such as Elodea give off visible bubbles of oxygen as they carry out photosynthesis. By measuring the rate at which bubbles form, you can measure the rate of photosynthesis.

## Problem

How do different wavelengths of light a plant receives affect its rate of photosynthesis?

## Objectives

- In this BioLab, you will:
  - Observe photosynthesis in an aquatic organism.
  - Measure the rate of photosynthesis.
  - Observe how various wavelengths of light influence the rate of photosynthesis.
  - Use the Internet to collect and compare data from other students.

## Materials

- 1000-mL beaker
- three Elodea plants
- string washers
- colored cellophane, assorted colors
- lamp with reflector and 150-watt bulbs
- 0.25% sodium hydrogen carbonate (baking soda) solution
- watch with second hand

## Safety Precautions

- Always wear goggles in the lab.

## Skill Handbook

Use the Skill Handbook if you need additional help with this lab.

## Procedure

1. Construct a basic setup like the one shown opposite.
2. Create a data table to record your measurements. Be sure to include a column for each color of light you will investigate and a column for the control experiment.
3. Place the Elodea plants in the beaker, then completely cover the plants with water. Add some of the baking soda solution. The solution provides CO₂ for the aquarium plants. Be sure to use the same amount of water and solution for each trial.
4. Conduct a control experiment by directing the lamp (without colored cellophane) on the plant and notice when you see the bubbles.
5. Observe and record the number of oxygen bubbles that Elodea generates in five minutes.
6. Repeat steps 4 and 5 with a piece of colored cellophane. Record your observations.
7. Repeat steps 4 and 5 with a different color of cellophane and record your observations.
8. Go to the Glencoe Science Web Site at the address shown below to post your data.

## Data Table

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Color 1</th>
<th>Color 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bubbles observed in five minutes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Analyze and Conclude

1. Interpreting Observations: From where did the bubbles of oxygen emerge? Why?
2. Making Inferences: Explain how counting bubbles measures the rate of photosynthesis.
3. Using the Internet: Make a graph of your data and data posted by other students with the rate of photosynthesis per minute plotted against the wavelength of light you tested for both the control and experimental setups.
4. Write a sentence or two explaining the graph.

## Assessing Your Data

### Formulating a Hypothesis in Performance Task Assessment List for PASC, p. 21.

### Portfolio

Have students write an evaluation of the lab. Their evaluations should include an overview of the experiment, data analysis, and conclusion statements. Have them also write hypotheses about how photosynthesis might be affected if another condition, such as temperature, were changed. Use the Performance Task Assessment List for Formulating a Hypothesis in PASC, p. 21.

## Teaching Strategies

- Place the Elodea sprigs in a large bowl and place them under a lamp for about 10 minutes before students begin the lab. This reduces the time the students will wait to begin seeing evidence of photosynthesis.
- You may wish to circulate through the room during this activity to ensure that the setups are constructed properly and that the students are seeing evidence of photosynthesis.

## Data and Observations

Students should record data under control conditions and then under experimental conditions for the same amount of time—at least 5 minutes.

## Internet Connection

To navigate the Internet BioLabs, choose the Biology: The Dynamics of Life icon at the site. Click on the student site icon, then the BioLabs icon. The advantage of using the Internet for an experiment of this nature is that students can collect considerably more and varied data than they could collect on their own in the allotted time. They also gain the experience of communicating scientific information using a technology that was originally intended for the dissemination of scientific knowledge.
In photosynthesis, light energy is converted into chemical energy. To begin the process, light is absorbed by colorful pigment molecules contained in chloroplasts.

Pigments color cyanobacteria (andros) and red algae (rusti).

Carotenoids are also found in cyanobacteria and in brown algae. A particular carotenoid called fucoxanthin gives brown algae their characteristic brown or olive-green color.

Phycobilins are blue and red. Red algae get their distinctive blood-red coloration from phycobilins. Some phycobilins can absorb wavelengths of green, violet, and blue light that penetrate to deep water. One species of red algae that contains these pigments is able to live at ocean depths of 269 meters (844 feet). The algae’s pigments absorb enough of the incredibly faint light that penetrates to this depth—only 0.0005 percent of what is available at the water’s surface—to power photosynthesis.

In the Calvin cycle, the carbon dioxide is fixed to an acceptor molecule by the enzyme RuBisCO. The acceptor molecule is then reduced by ATP and NADPH with a phosphate group added. The carbohydrate product is released.

Chapter 9 Assessment

Main Ideas

- ATP is the molecule that stores energy for easy use within the cell.
- ATP is formed when a phosphate group is added to ADP. When ATP is broken down, ADP and phosphate are formed and energy is released.
- ATP is the main link between energy-releasing and energy-using reactions.

Summary

ATP (adenosine triphosphate) (p. 229) ADP (adenosine diphosphate) (p. 229)
NADP+ (p. 233) NAD+ (p. 237)

Chapter Assessment, pp. 49-54 MindJogger Videouizzes Computer Test Bank BDOL Interactive CD-ROM, Chapter 9 quiz

Vocabulary

- aerobic respiration (p. 245)
- alcoholic fermentation (p. 242)
- anaerobic respiration (p. 245)
- cellular respiration (p. 245)
- citric acid cycle (p. 230)
- glycolysis (p. 237)
- lactic acid fermentation (p. 245)

Connection

Plant Pigments

A pigment is a substance that can absorb the various wavelengths of visible light. You can observe the colors of these wavelengths by letting sunlight pass through a prism to create a “rainbow,” or spectrum, that has red light on one end, violet on the other, and orange, yellow, green, and blue light in between.

Every photosynthetic pigment is distinctive in that it absorbs certain wavelengths in the visible light spectrum.

Chlorophylls a and b

The principal pigment of photosynthesis is chlorophyll. Chlorophyll exists in two forms designated as a and b. Chlorophyll a and b both absorb light in the violet to blue and red to red-orange parts of the spectrum, although at somewhat different wavelengths. These pigments also reflect green light, which is why plant leaves appear green.

When chlorophyll b absorbs light, it transfers the energy it acquires to chlorophyll a, which then feeds that energy into the chemical reactions that lead to the production of ATP and NADPH. In this way, chlorophyll b acts as an “accessory” pigment by making it possible for photosynthesis to occur over a broader spectrum of light than would be possible with chlorophyll a alone.

Carotenoids and phycobilins

Carotenoids and phycobilins are other kinds of accessory pigments that absorb wavelengths of light different from those absorbed by chlorophyll a and b, and so extend the range of light that can be used for photosynthesis.

Carotenoids are yellow-orange pigments. They are found in all green plants, but their color is usually masked by chlorophyll.

Carotenoids are also found in cyanobacteria and in brown algae. A particular carotenoid called fucoxanthin gives brown algae their characteristic brown or olive-green color.

Phycobilins are blue and red. Red algae get their distinctive blood-red coloration from phycobilins. Some phycobilins can absorb wavelengths of green, violet, and blue light that penetrate to deep water. One species of red algae that contains these pigments is able to live at ocean depths of 269 meters (844 feet). The algae’s pigments absorb enough of the incredibly faint light that penetrates to this depth—only 0.0005 percent of what is available at the water’s surface—to power photosynthesis.

How do you think accessory pigments may have helped the evolution of photosynthetic organisms to use a broader range of the visible light spectrum, and in so doing, survive in places where the amount or quality of visible light is minimal?

Purpose

Students should recognize the role that pigments such as chlorophyll play in the process of photosynthesis.

Connection

Background

There are far more chlorophyll molecules in a green leaf than carotenoids, and for most of the growing season, chlorophyll masks the presence of those accessory pigments. In the autumn, however, chlorophyll breaks down and the other pigments in leaves are visible as “fall colors.” The cause of this chlorophyll breakdown is not completely understood, but it seems to be tied to the gradual reduction in daylight that takes place as summer ends.

Teaching Strategies

- Have students examine live (or preserved) specimens of green, brown, and red algae to observe the difference in pigments.

Connection to Biology

Accessory pigments have made it possible for photosynthetic organisms to use a broader range of the visible light spectrum, and in so doing, survive in places where the amount or quality of visible light is minimal.

Understanding Main Ideas

1. Which of the following is a product of the Calvin cycle?
   a. carbon dioxide
   b. NADP+
   c. oxygen
   d. FADH2

2. ________ processes require oxygen, whereas ________ processes do not.
   a. anaerobic—anaerobic
   b. aerobic—anaerobic
   c. photosynthesis—phototrophs
   d. aerobic—respiration
23. Photosynthesis stores energy, 22. During physical activity, muscle 
21. Pigments 19. Lactic acid fermentation; alcohol fermentation; 
18. phosphates; repel 17. Electron transport chain 16. Citric acid cycle 

Interpreting Data Use the graph to answer the questions below.
1. What process was the yeast using to digest the sucrose at the beginning of the experiment?
   a. photosynthesis
   b. anaerobic respiration
   c. aerobic respiration
   d. light-dependent reactions

2. Which of the following would be left in the solution after 24 hours?
   a. sucrose
   b. oxygen
   c. lactic acid
   d. ethyl alcohol

3. What gas would be found in the top of the tube?
   a. carbon dioxide
   b. oxygen
   c. carbon monoxide
   d. nitrogen

4. Making a Table Construct a table from the graph showing the oxygen levels and carbon dioxide levels. 

Assessing Knowledge & Skills

Yeast cells and sucrose were placed in a test tube, and the tube was then plugged. The yeast-sucrose mixture incubated for 24 hours. Gas bubbles began to rise to the top of the tube. After 24 hours, no sucrose was left in the solution.

Chapter 9 Assessment

25. If you were planning on studying the compounds that could possibly be the source of the oxygen released during photosynthesis, which compounds would you need to consider?

Thinking Critically

26. Formulating Hypotheses Elodea spigs were placed under a white light, and the rate of photosynthesis was measured by counting the number of oxygen bubbles per minute for ten minutes. Predict the rate of photosynthesis if a piece of red cellophane were placed over the white light.

27. Observing and Inferring Yeast cells must be forced to ferment by placing them in an environment without any oxygen. Why would the yeast cells carry out aerobic respiration rather than fermentation when oxygen is present?

28. Recognizing Cause and Effect A window plant native to the desert of South Africa has leaves that grow almost entirely underground with only the transparent tip of the leaf protruding above the soil surface. Suggest how this adaptation aids the survival of this plant.

29. Concept Mapping Make a concept map using the following vocabulary terms: cellular respiration, glycolysis, citric acid cycle, electron transport chain.

30. For additional review, use the assessment options for this chapter found on the Biology: The Dynamics of Life Interactive CD-ROM and on the Glencoe Science Web Site. www.glencoe.com/sec/science
The Life of a Cell

All organisms are made up of cells, and each cell is like a complex, self-contained machine that can perform all of the life functions of the cell. Yet as small as they are, all of the mechanisms and processes of these little machines are not fully known, and scientists continue to unravel the marvelous mysteries of the living cell.

The Chemistry of Life

Although you are studying biology, chemistry is fundamental to all biological functions. Understanding some of the basic concepts of chemistry will enhance your understanding of the biological world.

Elements and Atoms

Every substance in and on Earth is a combination of elements. An atom, the smallest component of an element, is formed by layers of electrons around a nucleus made of protons and neutrons. Atoms combine together to form molecules.

VITAL STATISTICS

Carbon Isotopes

Isotopes of carbon contain different numbers of neutrons.

Carbon 12: six protons and six neutrons
Carbon 13: six protons and seven neutrons
Carbon 14: six protons and eight neutrons

Organic Compounds

Carbohydrates are chemical compounds made up of carbon, hydrogen, and oxygen molecules. Common carbohydrates include sugars, starches, and cellulose. Lipids, known as fats and oils, contain a glycerol backbone and three fatty acid chains. Proteins are a combination of amino acids connected by peptide bonds.

Lipids are made up of a glycerol backbone and three fatty acid chains.

A prokaryotic cell does not contain membrane-bound organelles.

A eukaryotic cell contains membrane-bound organelles.

Amino acids can be joined with peptide bonds to form proteins.

Portfolio Assessment

Portfolio Have students cut out pictures of trees from magazines and place them in their portfolios. Then have them write about the tree from a cellular point of view. They should include details such as whether the cells of the trees are eukaryotic or prokaryotic, a list of organelles that may be present, information about cells and photosynthesis, ideas on cellular growth and reproduction, and cellular differentiation within the tree. Then have the students write a comparison with an animal cell, using the same information.

Bring in food items to demonstrate organic compounds. A potato or bread can demonstrate carbohydrates, meat can demonstrate proteins, and vegetable oil or shortening can demonstrate lipids. Combine this experience with a molecular model of a lipid and relate the model to the example lipid and to the overall structure of the plasma membrane.

Assessment Planner

Portfolio Assessment

Assessment, TWE, p. 251
Performance Assessment

Assessment, TWE, p. 252
Knowledge Assessment

BioDigest Assessment, SE, p. 255
Skill Assessment

Assessment, TWE, p. 255

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Assessment, TWE, p. 255
The Life of a Cell

Cell Organelles

The organelles of a cell work together to carry out the functions necessary for cell survival.

Plasma Membrane

According to the fluid mosaic model, the plasma membrane is formed by two layers of phospholipids with the fatty acid chains back-to-back; the phosphate groups face the external environment, and proteins are embedded in the membrane.

Assembly, Transport, and Storage

The plasma membrane suspends the cell’s organelles, including endoplasmic reticulum, Golgi apparatus, vacuoles, and lysosomes. The endoplasmic reticulum and Golgi apparatus transport and modify proteins.

Energy Transformers

Chloroplasts are found in plant cells and serve to capture the sun’s light energy so it can be transformed into usable chemical energy. Mitochondria are found in both animal and plant cells and transform the food you eat into a usable energy form.

Support and Locomotion

A network of microfilaments and microtubules attaches to the plasma membrane to give the cell structure. Cilia are short, numerous projections that move like a wave. Flagella are longer projections that move in a whiplike fashion to propel a cell.

Diffusion and Osmosis

The selectively permeable plasma membrane allows only certain substances to pass. Diffusion is the movement of a substance from an area of higher concentration to an area of lower concentration. Diffusion of water across a selectively permeable membrane is called osmosis.

Simple diffusion across a membrane occurs by random movement. Facilitated diffusion requires proteins to bind and help move molecules across the membrane. Active transport requires energy to move molecules across a concentration gradient.

Mitosis

As cells grow, they reach a size where the plasma membrane cannot transport enough nutrients and wastes to maintain cell growth. At this point, the cell undergoes mitosis and divides.

Cell Organelles

<table>
<thead>
<tr>
<th>Mitochondrion</th>
<th>Nucleus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroplast</td>
<td>Ribosomes</td>
</tr>
<tr>
<td>Cell wall</td>
<td>Lysosomes</td>
</tr>
<tr>
<td>Vacuole</td>
<td>Rough endoplasmic reticulum</td>
</tr>
</tbody>
</table>

Transport

Products and wastes are exchanged with the environment, and organelles regulate the intake of necessary materials and the export of products and wastes.

Cell Organelles

<table>
<thead>
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</tr>
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</tr>
</tbody>
</table>

Support and Locomotion

In telophase the nucleus divides arates the daughter cells. Followed by cytokinesis, which separates the daughter cells.

Demonstration

Linguisitic Use this demonstration to simulate osmosis in hypertonic, isotonic, and hypotonic solutions. Fill three pieces of dialysis tubing with red 15% sucrose solution. Tie the top of each dialysis bag around a hollow piece of glass tubing. Clamp each bag/tubing apparatus to a ring stand and place in one of three solutions: distilled water (hypotonic), 15% clear sucrose solution (isotonic), and a 30% sucrose solution (hypertonic). At the beginning of the demonstration, mark the initial level of the red sucrose in the glass tubing. At regular intervals, such as the end of each class period, again mark the level of the red sucrose solution. Use the changes in volume of the three dialysis bags to quantify osmosis in hypertonic, isotonic, and hypotonic solutions.

Microscopy Activity

Visual-Spatial Set up a series of microscopes with prepared slides of onion root tip demonstrating the stages of mitosis. Have students look at the slides before discussing the stages of mitosis. After naming and discussing the stages, have students look at the slides again and ask them to explain what they see.
Energy in a Cell

Adenosine triphosphate (ATP) is the most commonly used source of energy in a cell. Two organelles are involved in forming ATP from other sources of energy. Chloroplasts in plant cells harvest energy from the sun’s rays and convert it to ATP using light-dependent reactions. Light-independent reactions convert energy into carbohydrates such as starch through the Calvin cycle.

Mitochondria, found in both plant and animal cells, convert food energy into ATP through a series of chemical reactions that include glycolysis, the citric acid cycle, and the electron transport chain.

Classroom Activity

Use play money to demonstrate the analogy that ATP is the currency for energy. Assign a cost to several objects in the classroom and point out that some items “cost” more than others. Have students purchase these objects using large bills such as $100s or $500s to demonstrate that large denominations of energy currency are a larger expense to perform cellular activity. A cell that does not contain internal, membrane-bound structures is a prokaryote. A cell with a cell wall and an internal, membrane-bound nucleus is an eukaryote.

Visual Learning

Display overheads of the Calvin cycle and the citric acid cycle. Explain that the cycles can be repeated again and again to produce different products.

FOCUS ON HEALTH

Cancer

Cancer is a condition that can result when a cell can no longer control the rate of mitosis. Cancer may be due to factors inside the cell, such as any enzyme overproduction or production at the wrong time. Cancer can also be a result of environmental factors. In recent years, much emphasis has been placed on healthy lifestyles that can help prevent cancer. Eating diets rich in fruits and vegetables, exercising regularly, and quitting or avoiding smoking can all help reduce the incidence of cancer.

Understanding Main Ideas

1. What is a starch?
   a. a lipid
   b. a carbohydrate
   c. a protein
   d. a peptide

2. The building blocks of proteins are:
   a. fatty acids
   b. monosaccharides
   c. amino acids
   d. glycerol

3. A cell that does not contain internal, membrane-bound structures is:
   a. prokaryote
   b. eukaryote
   c. vacuol
   d. a cell with organelles

4. The organelle that produces proteins is the:
   a. nucleus
   b. lysosome
   c. ribosomes
   d. vacuole

5. What structure is part of the cell’s skeleton?
   a. Golgi apparatus
   b. nucleus
   c. endoplasmic reticulum
   d. microfilaments

6. The movement of a substance across the plasma membrane by the concentration gradient by binding to a protein is:
   a. facilitated transport
   b. osmosis
   c. simple diffusion
   d. active transport

Thinking Critically

1. Chloroplasts trap light energy and store it by producing complex sugars. Mitochondria break down sugars to release ATP. Both are involved in energy production for the cell.

2. Most organelles of a eukaryotic cell are surrounded by a membrane. This membrane allows very different chemical reactions to be carried out in a cell at the same time.

3. In an isotonic solution, the concentration of solutes on both sides of the membrane is the same, so there will be no net movement across the membrane and the cell shape will not change.

In a hypertonic solution, there is a greater concentration of solutes outside the cell, there is a net movement of water from the cell into the surrounding fluid, and the cell size will shrink.

In a hypotonic solution, there is a greater concentration of solutes inside the cell; therefore, water will flow into the cell and the cell size will increase.

Understanding Main Ideas

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   c. endoplasmic reticulum
   d. microfilaments

6. The movement of a substance across the plasma membrane by the concentration gradient by binding to a protein is:
   a. facilitated transport
   b. osmosis
   c. simple diffusion
   d. active transport

Thinking Critically

1. Chloroplasts trap light energy and store it by producing complex sugars. Mitochondria break down sugars to release ATP. Both are involved in energy production for the cell.

2. Most organelles of a eukaryotic cell are surrounded by a membrane. This membrane allows very different chemical reactions to be carried out in a cell at the same time.

3. In an isotonic solution, the concentration of solutes on both sides of the membrane is the same, so there will be no net movement across the membrane and the cell shape will not change.

In a hypertonic solution, there is a greater concentration of solutes outside the cell, there is a net movement of water from the cell into the surrounding fluid, and the cell size will shrink.

In a hypotonic solution, there is a greater concentration of solutes inside the cell; therefore, water will flow into the cell and the cell size will increase.