




Cell Processes

chapter preview

sections

- 1** Chemistry of Life
 - 2** Moving Cellular Material
Lab Observing Osmosis
 - 3** Energy for Life
Lab Photosynthesis and Respiration
-  **Virtual Lab** Under what conditions do cells gain or lose water?

The Science of Gardening



Growing a garden is hard work for both you and the plants. Like you, plants need water and food for energy. How plants get food and water is different from you. Understanding how living things get the energy they need to survive will make a garden seem like much more than just plants and dirt.

Science Journal Describe two ways in which you think plants get food for energy.

Start-Up Activities



Why does water enter and leave plant cells?

If you forget to water a plant, it will wilt. After you water the plant, it probably will straighten up and look healthier. In the following lab, find out how water causes a plant to wilt and straighten.  

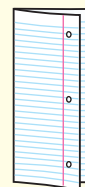
1. Label a small bowl *Salt Water*. Pour 250 mL of water into the bowl. Then add 15 g of salt to the water and stir.
2. Pour 250 mL of water into another small bowl.
3. Place two carrot sticks into each bowl. Also, place two carrot sticks on the lab table.
4. After 30 min, remove the carrot sticks from the bowls and keep them next to the bowl they came from. Examine all six carrot sticks, then describe them in your Science Journal.
5. **Think Critically** Write a paragraph in your Science Journal that describes what would happen if you moved the carrot sticks from the plain water to the lab table, the ones from the salt water into the plain water, and the ones from the lab table into the salt water for 30 min. Now move the carrot sticks as described and write the results in your Science Journal.

FOLDABLES™ Study Organizer

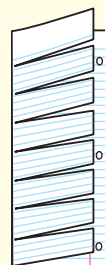
How Living Things Survive

Make the following vocabulary Foldable to help you understand the chemistry of living things and how energy is obtained for life.

- STEP 1** Fold a vertical sheet of notebook paper from side to side.



- STEP 2** Cut along every third line of only the top layer to form tabs.



Build Vocabulary As you read this chapter, list the vocabulary words about cell processes on the tabs. As you learn the definitions, write them under the tab for each vocabulary word. Write a sentence about one of the cell processes using the vocabulary word on the tab.



Preview this chapter's content and activities at green.msscience.com



Chemistry of Life

as you read

What You'll Learn

- **List** the differences among atoms, elements, molecules, and compounds.
- **Explain** the relationship between chemistry and life science.
- **Discuss** how organic compounds are different from inorganic compounds.

Why It's Important

You grow because of chemical reactions in your body.



Review Vocabulary

cell: the smallest unit of a living thing that can perform the functions of life

New Vocabulary

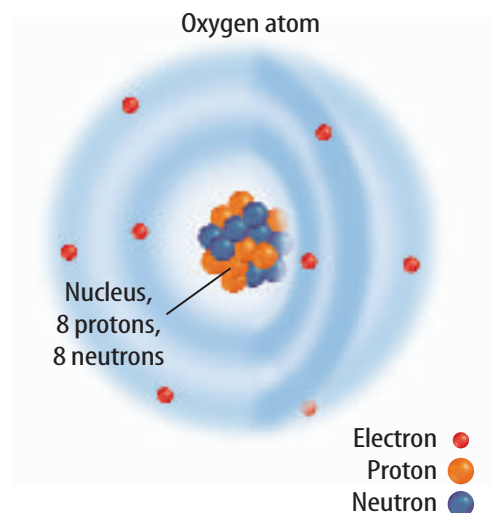
- mixture
- organic compound
- enzyme
- inorganic compound

The Nature of Matter

Think about everything that surrounds you—chairs, books, clothing, other students, and air. What are all these things made up of? You're right if you answer “matter and energy.” Matter is anything that has mass and takes up space. Energy is anything that brings about change. Everything in your environment, including you, is made of matter. Energy can hold matter together or break it apart. For example, the food you eat is matter that is held together by chemical energy. When food is cooked, energy in the form of heat can break some of the bonds holding the matter in food together.

Atoms Whether it is solid, liquid, or gas, matter is made of atoms. **Figure 1** shows a model of an oxygen atom. At the center of an atom is a nucleus that contains protons and neutrons. Although they have nearly equal masses, a proton has a positive charge and a neutron has no charge. Outside the nucleus are electrons, each of which has a negative charge. It takes about 1,837 electrons to equal the mass of one proton. Electrons are important because they are the part of the atom that is involved in chemical reactions. Look at **Figure 1** again and you will see that an atom is mostly empty space. Energy holds the parts of an atom together.

Figure 1 An oxygen atom model shows the placement of electrons, protons, and neutrons.



**Table 1 Elements in the Human Body**

Symbol	Element	Percent
O	Oxygen	65.0
C	Carbon	18.5
H	Hydrogen	9.5
N	Nitrogen	3.2
Ca	Calcium	1.5
P	Phosphorus	1.0
K	Potassium	0.4
S	Sulfur	0.3
Na	Sodium	0.2
Cl	Chlorine	0.2
Mg	Magnesium	0.1
	Other elements	0.1

Elements When something is made up of only one kind of atom, it is called an element. An element can't be broken down into a simpler form by chemical reactions. The element oxygen is made up of only oxygen atoms, and hydrogen is made up of only hydrogen atoms. Scientists have given each element its own one- or two-letter symbol.

All elements are arranged in a chart known as the periodic table of elements. You can find this table at the back of this book. The table provides information about each element including its mass, how many protons it has, and its symbol.

Everything is made up of elements. Most things, including all living things, are made up of a combination of elements. Few things exist as pure elements. **Table 1** lists elements that are in the human body. What two elements make up most of your body?

Six of the elements listed in the table are important because they make up about 99 percent of living matter. The symbols for these elements are S, P, O, N, C, and H. Use **Table 1** to find the names of these elements.

**Reading Check**

What types of things are made up of elements?

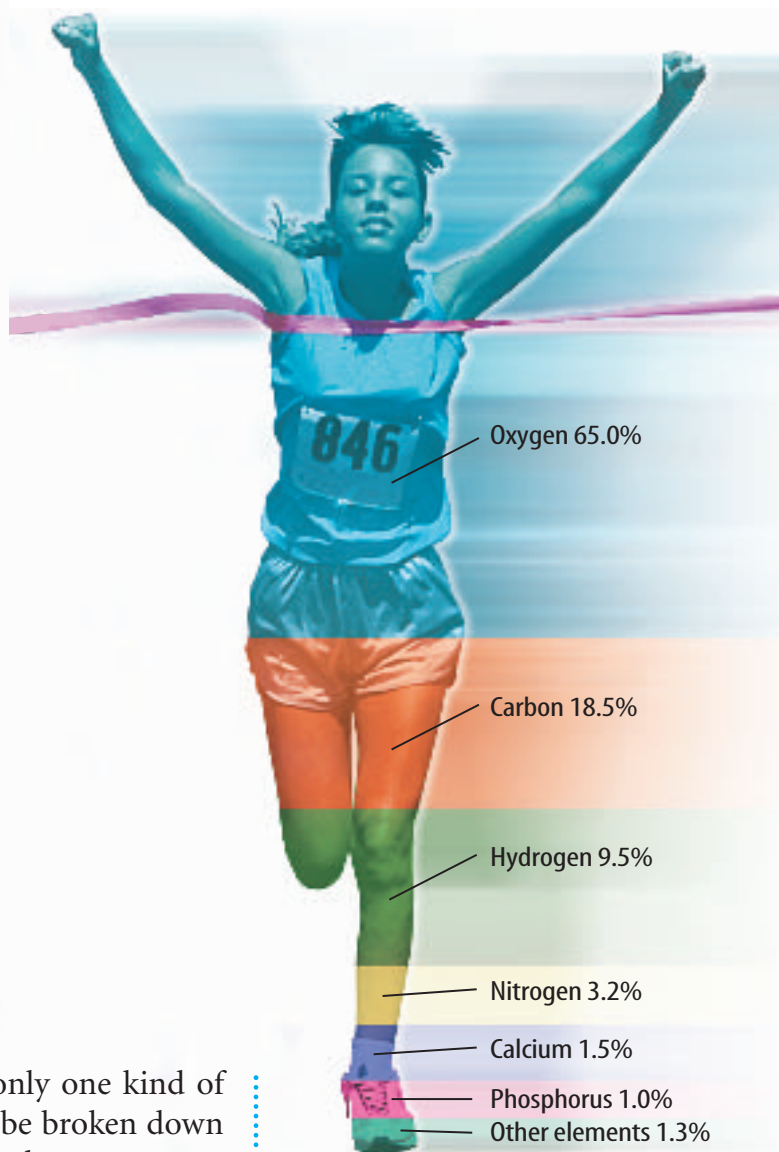
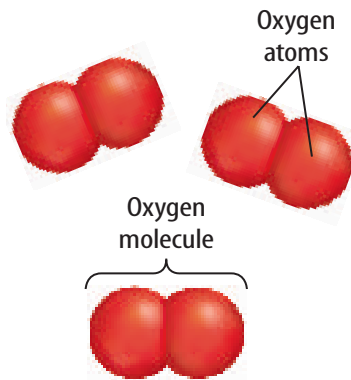


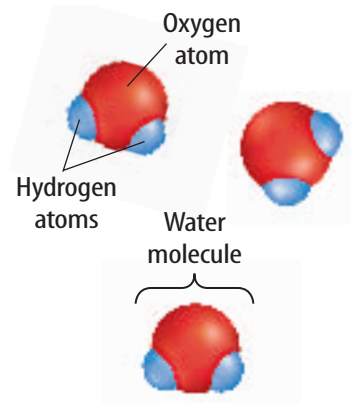


Figure 2 The words *atoms*, *molecules*, and *compounds* are used to describe substances.

Explain how these terms are related to each other.



A Some elements, like oxygen, occur as molecules. These molecules contain atoms of the same element bonded together.



B Compounds also are composed of molecules. Molecules of compounds contain atoms of two or more different elements bonded together, as shown by these water molecules.

Compounds and Molecules

Suppose you make a pitcher of lemonade using a powdered mix and water. The water and the lemonade mix, which is mostly sugar, contain the elements oxygen and hydrogen. Yet, in one, they are part of a nearly tasteless liquid—water. In the other they are part of a sweet solid—sugar. How can the same elements be part of two materials that are so different? Water and sugar are compounds. Compounds are made up of two or more elements in exact proportions. For example, pure water, whether

one milliliter of it or one million liters, is always made up of hydrogen atoms bonded to oxygen atoms in a ratio of two hydrogen atoms to one oxygen atom. Compounds have properties different from the elements they are made of. There are two types of compounds—molecular compounds and ionic compounds.

Molecular Compounds The smallest part of a molecular compound is a molecule. A molecule is a group of atoms held together by the energy of chemical bonds, as shown in **Figure 2**. When chemical reactions occur, chemical bonds break, atoms are rearranged, and new bonds form. The molecules produced are different from those that began the chemical reaction.

Molecular compounds form when different atoms share their outermost electrons. For example, two atoms of hydrogen each can share one electron on one atom of oxygen to form one molecule of water, as shown in **Figure 2B**. Water does not have the same properties as oxygen and hydrogen. Under normal conditions on Earth, oxygen and hydrogen are gases. Yet, water can be a liquid, a solid, or a gas. When hydrogen and oxygen combine, changes occur and a new substance forms.

Ions Atoms also combine because they've become positively or negatively charged. Atoms are usually neutral—they have no overall electric charge. When an atom loses an electron, it has more protons than electrons, so it becomes positively charged. When an atom gains an electron, it has more electrons than protons, so it becomes negatively charged. Electrically charged atoms—positive or negative—are called ions.



Ionic Compounds Ions of opposite charges attract one another to form electrically neutral compounds called ionic compounds. Table salt is made of sodium (Na) and chlorine (Cl) ions, as shown in **Figure 3B**. When they combine, a chlorine atom gains an electron from a sodium atom. The chlorine atom becomes a negatively charged ion, and the sodium atom becomes a positively charged ion. These oppositely charged ions then are attracted to each other and form the ionic compound sodium chloride, NaCl.

Ions are important in many life processes that take place in your body and in other organisms. For example, messages are sent along your nerves as potassium and sodium ions move in and out of nerve cells. Calcium ions are important in causing your muscles to contract. Ions also are involved in the transport of oxygen by your blood. The movement of some substances into and out of a cell would not be possible without ions.

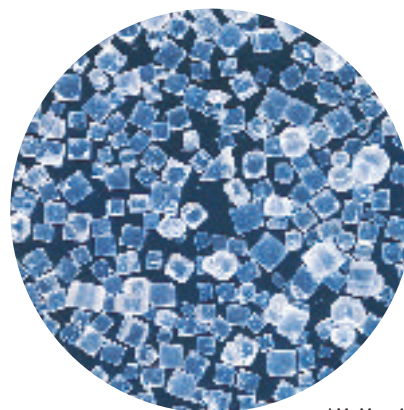
Mixtures

Some substances, such as a combination of sugar and salt, can't change each other or combine chemically. A **mixture** is a combination of substances in which individual substances retain their own properties. Mixtures can be solids, liquids, gases, or any combination of them.

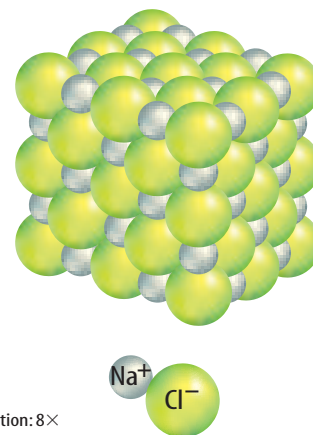
 **Reading Check** *Why is a combination of sugar and salt said to be a mixture?*

Most chemical reactions in living organisms take place in mixtures called solutions. You've probably noticed the taste of salt when you perspire. Sweat is a solution of salt and water. In a solution, two or more substances are mixed evenly. A cell's cytoplasm is a solution of dissolved molecules and ions.

Living things also contain mixtures called suspensions. A suspension is formed when a liquid or a gas has another substance evenly spread throughout it. Unlike solutions, the substances in a suspension eventually sink to the bottom. If blood, shown in **Figure 4**, is left undisturbed, the red blood cells and white blood cells will sink gradually to the bottom. However, the pumping action of your heart constantly moves your blood and the blood cells remain suspended.



A Magnified crystals of salt look like this.



LM Magnification: 8×

B A salt crystal is held together by the attractions between sodium ions and chlorine ions.

Figure 3 Table salt crystals are held together by ionic bonds.



Figure 4 When a test tube of whole blood is left standing, the blood cells sink in the watery plasma.

**Table 2 Organic Compounds Found in Living Things**

	Carbohydrates	Lipids	Proteins	Nucleic Acids
Elements	carbon, hydrogen, and oxygen	carbon, oxygen, hydrogen, and phosphorus	carbon, oxygen, hydrogen, nitrogen, and sulfur	carbon, oxygen, hydrogen, nitrogen, and phosphorus
Examples	sugars, starch, and cellulose	fats, oils, waxes, phospholipids, and cholesterol	enzymes, skin, and hair	DNA and RNA
Function	supply energy for cell processes; form plant structures; short-term energy storage	store large amounts of energy long term; form boundaries around cells	regulate cell processes and build cell structures	carry hereditary information; used to make proteins

Organic Compounds

You and all living things are made up of compounds that are classified as organic or inorganic. Rocks and other nonliving things contain inorganic compounds, but most do not contain large amounts of organic compounds. **Organic compounds** always contain carbon and hydrogen and usually are associated with living things. One exception would be nonliving things that are products of living things. For example, coal contains organic compounds because it was formed from dead and decaying plants. Organic molecules can contain hundreds or even thousands of atoms that can be arranged in many ways. **Table 2** compares the four groups of organic compounds that make up all living things—carbohydrates, lipids, proteins, and nucleic acids.

Carbohydrates Carbohydrates are organic molecules that supply energy for cell processes. Sugars and starches are carbohydrates that cells use for energy. Some carbohydrates also are important parts of cell structures. For example, a carbohydrate called cellulose is an important part of plant cells.

Lipids Another type of organic compound found in living things is a lipid. Lipids do not mix with water. Lipids such as fats and oils store and release even larger amounts of energy than carbohydrates do. One type of lipid, the phospholipid, is a major part of cell membranes.



Reading Check

What are three types of lipids?



Topic: Air Quality

Visit green.msscience.com for Web links to information about air quality.

Activity Organic compounds such as soot, smoke, and ash can affect air quality. Look up the air quality forecast for today. List three locations where the air quality forecast is good, and three locations where it is unhealthy.



Proteins Organic compounds called proteins have many important functions in living organisms. They are made up of smaller molecules called amino acids. Proteins are the building blocks of many structures in organisms. Your muscles contain large amounts of protein. Proteins are scattered throughout cell membranes. Certain proteins called **enzymes** regulate nearly all chemical reactions in cells.

Nucleic Acids Large organic molecules that store important coded information in cells are called nucleic acids. One nucleic acid, deoxyribonucleic acid, or DNA—genetic material—is found in all cells at some point in their lives. It carries information that directs each cell’s activities. Another nucleic acid, ribonucleic acid, or RNA, is needed to make enzymes and other proteins.

Inorganic Compounds

Most **inorganic compounds** are made from elements other than carbon. Generally, inorganic molecules contain fewer atoms than organic molecules. Inorganic compounds are the source for many elements needed by living things. For example, plants take up inorganic compounds from the soil. These inorganic compounds can contain the elements nitrogen, phosphorus, and sulfur. Many foods that you eat contain inorganic compounds. **Table 3** shows some of the inorganic compounds that are important to you. One of the most important inorganic compounds for living things is water.

Table 3 Some Inorganic Compounds Important in Humans

Compound	Use in Body
Water	makes up most of the blood; most chemical reactions occur in water
Calcium phosphate	gives strength to bones
Hydrochloric acid	breaks down foods in the stomach
Sodium bicarbonate	helps the digestion of food to occur
Salts containing sodium, chlorine, and potassium	important in sending messages along nerves



Observing How Enzymes Work

Procedure

1. Get two small cups of **prepared gelatin** from your teacher. Do not eat or drink anything in lab.
2. On the gelatin in one of the cups, place a piece of **fresh pineapple**.
3. Let both cups stand undisturbed overnight.
4. Observe what happens to the gelatin.

Analysis

1. What effect did the piece of fresh pineapple have on the gelatin?
2. What does fresh pineapple contain that caused it to have the effect on the gelatin you observed?
3. Why do the preparation directions on a box of gelatin dessert tell you not to mix it with fresh pineapple?



Importance of Water Some scientists hypothesize that life began in the water of Earth's ancient oceans. Chemical reactions might have occurred that produced organic molecules. Similar chemical reactions can take place in cells in your body.

Living things are composed of more than 50 percent water and depend on water to survive. You can live for weeks without food but only for a few days without water. **Figure 5** shows where water is found in your body. Although seeds and spores of plants, fungi, and bacteria can exist without water, they must have water if they are to grow and reproduce. All the chemical reactions in living things take place in water solutions, and most organisms use water to transport materials through their bodies. For example, many animals have blood that is mostly water and moves materials. Plants use water to move minerals and sugars between the roots and leaves.

Applying Math

Solve an Equation

CALCULATE THE IMPORTANCE OF WATER All life on Earth depends on water for survival. Water is the most vital part of humans and other animals. It is required for all of the chemical processes that keep us alive. At least 60 percent of an adult human body consists of water. If an adult man weighs 90 kg, how many kilograms of water does his body contain?

Solution

- | | |
|--|---|
| 1 <i>This is what you know:</i> | <ul style="list-style-type: none">● adult human body = 60% water● man = 90 kg |
| 2 <i>This is what you need to find:</i> | How many kilograms of water does the adult man have? |
| 3 <i>This is the procedure you need to use:</i> | <ul style="list-style-type: none">● Set up the ratio: $60/100 = x/90$.● Solve the equation for x: $(60 \times 90)/100$.● The adult man has 54 kg of water. |
| 4 <i>Check your answer:</i> | Divide your answer by 90, then multiply by 100. You should get 60%. |

Practice Problems

1. A human body at birth consists of 78 percent water. This gradually decreases to 60 percent in an adult. Assume a baby weighed 3.2 kg at birth and grew into an adult weighing 95 kg. Calculate the approximate number of kilograms of water the human gained.
2. Assume an adult woman weighs 65 kg and an adult man weighs 90 kg. Calculate how much more water, in kilograms, the man has compared to the woman.



For more practice, visit
[green.mssscience.com/
math_practice](http://green.mssscience.com/math_practice)



Characteristics of Water The atoms of a water molecule are arranged in such a way that the molecule has areas with different charges. Water molecules are like magnets. The negative part of a water molecule is attracted to the positive part of another water molecule just like the north pole of a magnet is attracted to the south pole of another magnet. This attraction, or force, between water molecules is why a film forms on the surface of water. The film is strong enough to support small insects because the forces between water molecules are stronger than the force of gravity on the insect.

When heat is added to any substance, its molecules begin to move faster. Because water molecules are so strongly attracted to each other, the temperature of water changes slowly. The large percentage of water in living things acts like an insulator. The water in a cell helps keep its temperature constant, which allows life-sustaining chemical reactions to take place.

You've seen ice floating on water. When water freezes, ice crystals form. In the crystals, each water molecule is spaced at a certain distance from all the others. Because this distance is greater in frozen water than in liquid water, ice floats on water. Bodies of water freeze from the top down. The floating ice provides insulation from extremely cold temperatures and allows living things to survive in the cold water under the ice.

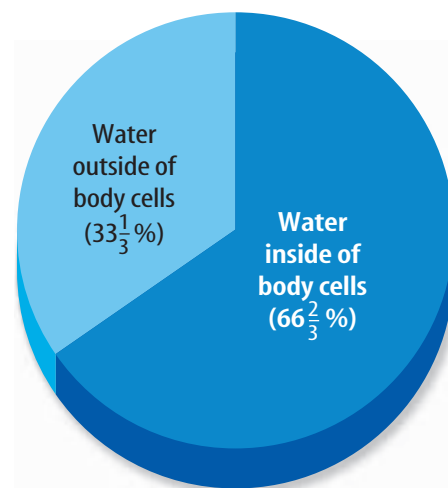


Figure 5 About two-thirds of your body's water is located within your body's cells. Water helps maintain the cells' shapes and sizes. One-third of your body's water is outside of your body's cells.

section 1 review

Summary

The Nature of Matter

- Atoms are made up of protons, neutrons, and electrons.
- Elements are made up of only one kind of atom.
- Compounds are made up of two or more elements.

Mixtures

- Solutions are made of two or more substances and are mixed evenly, whereas substances in suspension eventually will sink to the bottom.

Organic Compounds

- All living things contain organic compounds.

Inorganic Compounds

- Water is one of the most important inorganic compounds for living things.

Self Check

1. **Compare and contrast** atoms and molecules.
2. **Describe** the differences between an organic and an inorganic compound. Given an example of each type of compound.
3. **List** the four types of organic compounds found in all living things.
4. **Infer** why life as we know it depends on water.
5. **Think Critically** If you mix salt, sand, and sugar with water in a small jar, will the resulting mixture be a suspension, a solution, or both?

Applying Skills

6. **Interpret** Carefully observe **Figure 1** and determine how many protons, neutrons, and electrons an atom of oxygen has.



Moving Cellular Materials

as you read

What You'll Learn

- **Describe** the function of a selectively permeable membrane.
- **Explain** how the processes of diffusion and osmosis move molecules in living cells.
- **Explain** how passive transport and active transport differ.

Why It's Important

Cell membranes control the substances that enter and leave the cells in your body.



Review Vocabulary

cytoplasm: constantly moving gel-like mixture inside the cell membrane that contains hereditary material and is the location of most of a cell's life process

New Vocabulary

- | | |
|---------------------|--------------------|
| ● passive transport | ● active transport |
| ● diffusion | ● endocytosis |
| ● equilibrium | ● exocytosis |
| ● osmosis | |

Passive Transport

“Close that window. Do you want to let in all the bugs and leaves?” How do you prevent unwanted things from coming through the window? As seen in **Figure 6**, a window screen provides the protection needed to keep unwanted things outside. It also allows some things to pass into or out of the room like air, unpleasant odors, or smoke.

Cells take in food, oxygen, and other substances from their environments. They also release waste materials into their environments. A cell has a membrane around it that works for a cell like a window screen does for a room. A cell's membrane is selectively permeable (PUR mee uh bul). It allows some things to enter or leave the cell while keeping other things outside or inside the cell. The window screen also is selectively permeable based on the size of its openings.

Things can move through a cell membrane in several ways. Which way things move depends on the size of the molecules or particles, the path taken through the membrane, and whether or not energy is used. The movement of substances through the cell membrane without the input of energy is called **passive transport**. Three types of passive transport can occur. The type depends on what is moving through the cell membrane.

Figure 6 A cell membrane, like a screen, will let some things through more easily than others. Air gets through a screen, but insects are kept out.

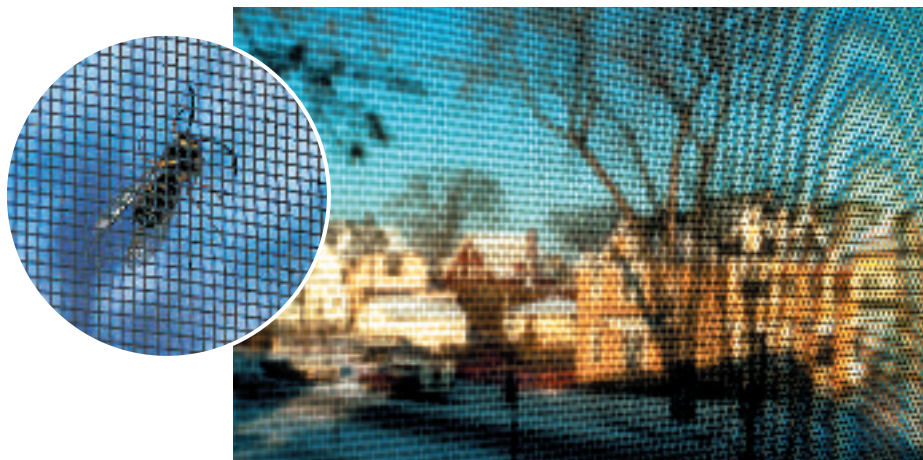
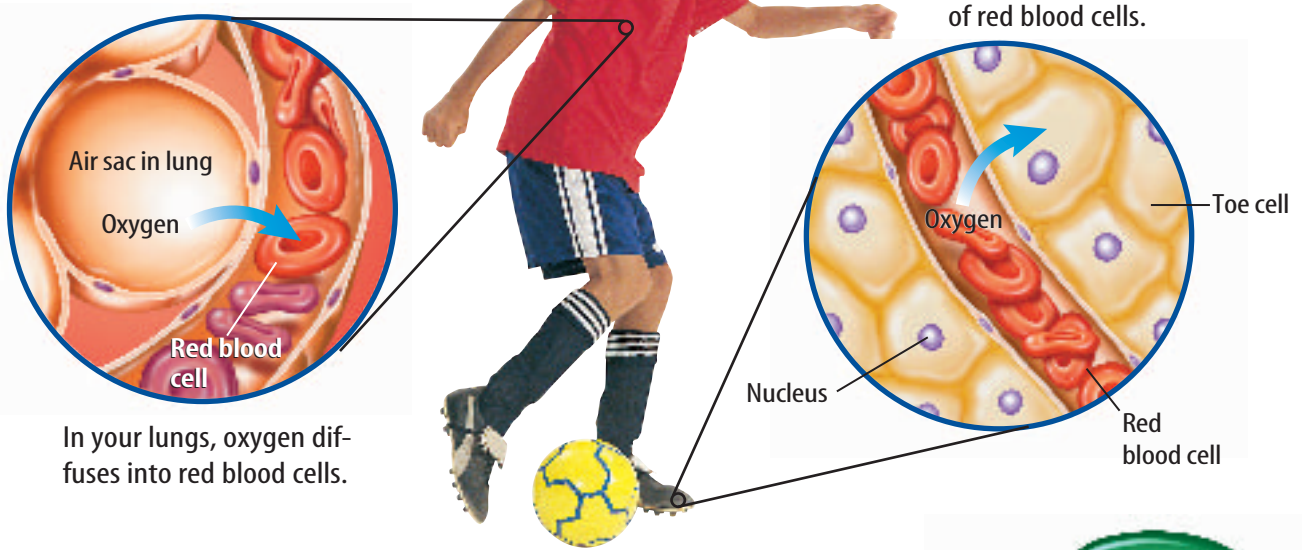




Figure 7 Like all other cells in your body, cells in your toes need oxygen.

Describe What is diffusion?



Diffusion Molecules in solids, liquids, and gases move constantly and randomly. You might smell perfume when you sit near or as you walk past someone who is wearing it. This is because perfume molecules randomly move throughout the air. This random movement of molecules from an area where there is relatively more of them into an area where there is relatively fewer of them is called **diffusion**. Diffusion is one type of cellular passive transport. Molecules of a substance will continue to move from one area into another until the relative number of these molecules is equal in the two areas. When this occurs, **equilibrium** is reached and diffusion stops. After equilibrium occurs, it is maintained because molecules continue to move.

Reading Check What is equilibrium?

Every cell in your body uses oxygen. When you breathe, how does oxygen get from your lungs to cells in your big toe? Oxygen is carried throughout your body in your blood by the red blood cells. When your blood is pumped from your heart to your lungs, your red blood cells do not contain much oxygen. However, your lungs have more oxygen molecules than your red blood cells do, so the oxygen molecules diffuse into your red blood cells from your lungs, as shown in **Figure 7**. When the blood reaches your big toe, there are more oxygen molecules in your red blood cells than in your big toe cells. The oxygen diffuses from your red blood cells and into your big toe cells, as shown also in **Figure 7**.

Mini LAB

Observing Diffusion

Procedure

1. Use two clean glasses of equal size. Label one *Hot*, then fill it until half full with **very warm water**. Label the other *Cold*, then fill it until half full with **cold water**. **WARNING: Do not use boiling hot water.**
2. Add one drop of **food coloring** to each glass. Carefully release the drop just at the water's surface to avoid splashing the water.
3. Observe the water in the glasses. Record your observations immediately and again after 15 min.

Analysis

1. Describe what happens when food coloring is added to each glass.
2. How does temperature affect the rate of diffusion?





Osmosis—The Diffusion of Water Remember that water makes up a large part of living matter. Cells contain water and are surrounded by water. Water molecules move by diffusion into and out of cells. The diffusion of water through a cell membrane is called **osmosis**.

If cells weren't surrounded by water that contains few dissolved substances, water inside of cells would diffuse out of them. This is why water left the carrot cells in this chapter's Launch Lab. Because there were relatively fewer water molecules in the salt solution around the carrot cells than in the carrot cells, water moved out of the cells and into the salt solution.

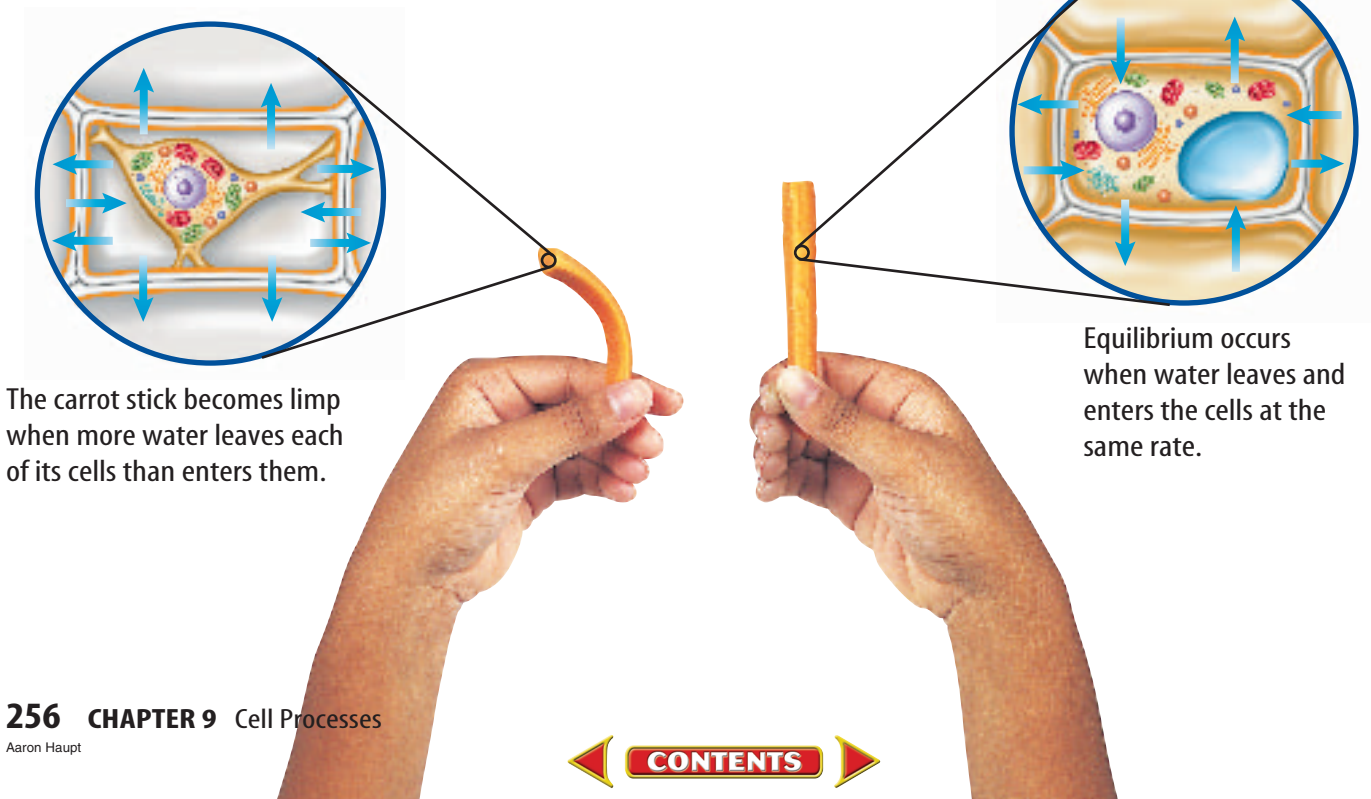
Losing water from a plant cell causes its cell membrane to come away from its cell wall, as shown on the left in **Figure 8**. This reduces pressure against its cell wall, and a plant cell becomes limp. If the carrot sticks were taken out of salt water and put in pure water, the water around the cells would move into them and they would fill with water. Their cell membranes would press against their cell walls, as shown on the right in **Figure 8**, pressure would increase, and the cells would become firm. That is why the carrot sticks would be crisp again.

 **Reading Check** *Why do carrots in salt water become limp?*

Osmosis also takes place in animal cells. If animal cells were placed in pure water, they too would swell up. However, animal cells are different from plant cells. Just like an overfilled water balloon, animal cells will burst if too much water enters the cell.

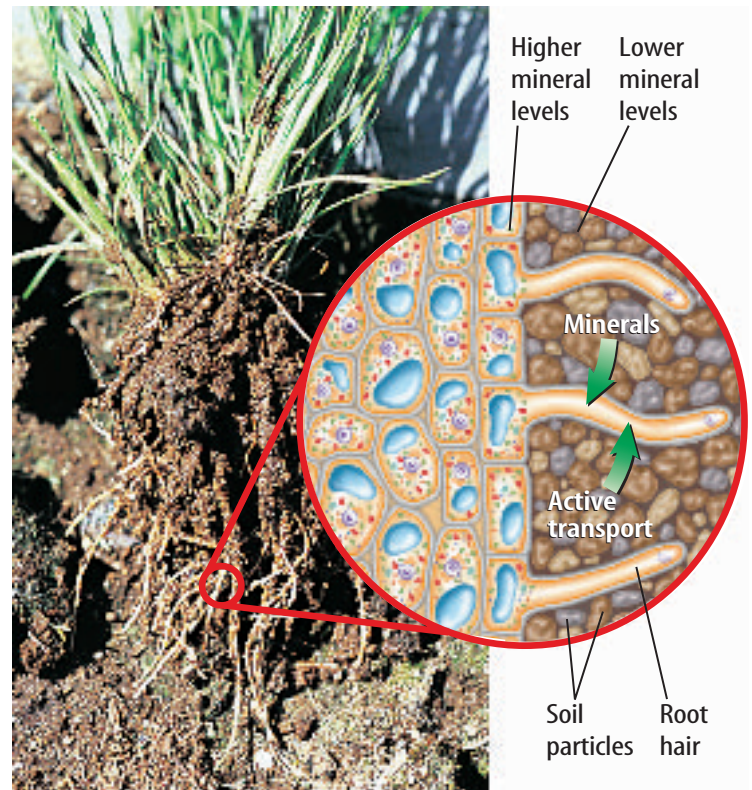
Figure 8 Cells respond to differences between the amount of water inside and outside the cell.

Define *What is osmosis?*





Facilitated Diffusion Cells take in many substances. Some substances pass easily through the cell membrane by diffusion. Other substances, such as glucose molecules, are so large that they can enter the cell only with the help of molecules in the cell membrane called transport proteins. This process, a type of passive transport, is known as facilitated diffusion. Have you ever used the drive through at a fast-food restaurant to get your meal? The transport proteins in the cell membrane are like the drive-through window at the restaurant. The window lets you get food out of the restaurant and put money into the restaurant. Similarly, transport proteins are used to move substances into and out of the cell.



Active Transport

Imagine that a football game is over and you leave the stadium. As soon as you get outside of the stadium, you remember that you left your jacket on your seat. Now you have to move against the crowd coming out of the stadium to get back in to get your jacket. Which required more energy—leaving the stadium with the crowd or going back to get your jacket? Something similar to this happens in cells.

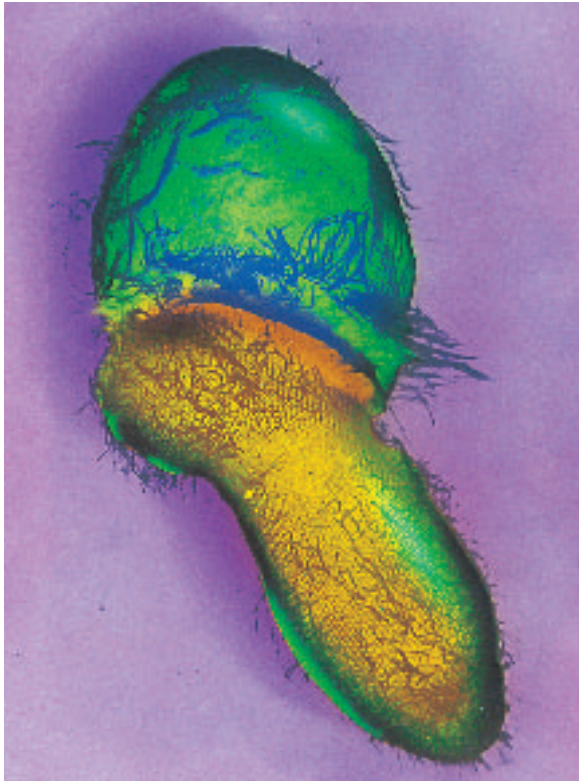
Sometimes, a substance is needed inside a cell even though the amount of that substance inside the cell is already greater than the amount outside the cell. For example, root cells require minerals from the soil. The roots of the plant in **Figure 9** already might contain more of those mineral molecules than the surrounding soil does. The tendency is for mineral molecules to move out of the root by diffusion or facilitated diffusion. But they need to move back across the cell membrane and into the cell just like you had to move back into the stadium. When an input of energy is required to move materials through a cell membrane, **active transport** takes place.

Active transport involves transport proteins, just as facilitated diffusion does. In active transport, a transport protein binds with the needed particle and cellular energy is used to move it through the cell membrane. When the particle is released, the transport protein can move another needed particle through the membrane.

Figure 9 Some root cells have extensions called root hairs that may be 5 mm to 8 mm long. Minerals are taken in by active transport through the cell membranes of root hairs.



Transport Proteins Your health depends on transport proteins. Sometimes transport proteins are missing or do not function correctly. What would happen if proteins that transport cholesterol across membranes were missing? Cholesterol is an important lipid used by your cells. Write your ideas in your Science Journal.



Color-enhanced TEM Magnification: 1,400×

Figure 10 One-celled organisms like this egg-shaped one can take in other one-celled organisms using endocytosis.

Endocytosis and Exocytosis

Some molecules and particles are too large to move by diffusion or to use the cell membrane's transport proteins. Large protein molecules and bacteria, for example, can enter a cell when they are surrounded by the cell membrane. The cell membrane folds in on itself, enclosing the item in a sphere called a vesicle. Vesicles are transport and storage structures in a cell's cytoplasm. The sphere pinches off, and the resulting vesicle enters the cytoplasm. A similar thing happens when you poke your finger into a partially inflated balloon. Your finger is surrounded by the balloon in much the same way that the protein molecule is surrounded by the cell membrane. This process of taking substances into a cell by surrounding it with the cell membrane is called **endocytosis** (en duh si TOH sus). Some one-celled organisms, as shown in **Figure 10**, take in food this way.

The contents of a vesicle can be released by a cell using the process called **exocytosis** (ek soh si TOH sus). Exocytosis occurs in the opposite way that endocytosis does. A vesicle's membrane fuses with a cell's membrane, and the vesicle's contents are released. Cells in your stomach use this process to release chemicals that help digest food. The ways that materials can enter or leave a cell are summarized in **Figure 11**.

section 2 review

Summary

Passive Transport

- Cells take in substances and release waste through their cell membranes.
- Facilitated diffusion and osmosis are types of passive transport.

Active Transport

- Transport proteins are involved in active transport.
- Transport proteins can be reused many times.

Endocytosis and Exocytosis

- Vesicles are formed when a cell takes in a substance by endocytosis.
- Contents of a vesicle are released to the outside of a cell by exocytosis.

Self Check

1. **Describe** how cell membranes are selectively permeable.
2. **Compare and contrast** the processes of osmosis and diffusion.
3. **Infer** why endocytosis and exocytosis are important processes to cells.
4. **Think Critically** Why are fresh fruits and vegetables sprinkled with water at produce markets?

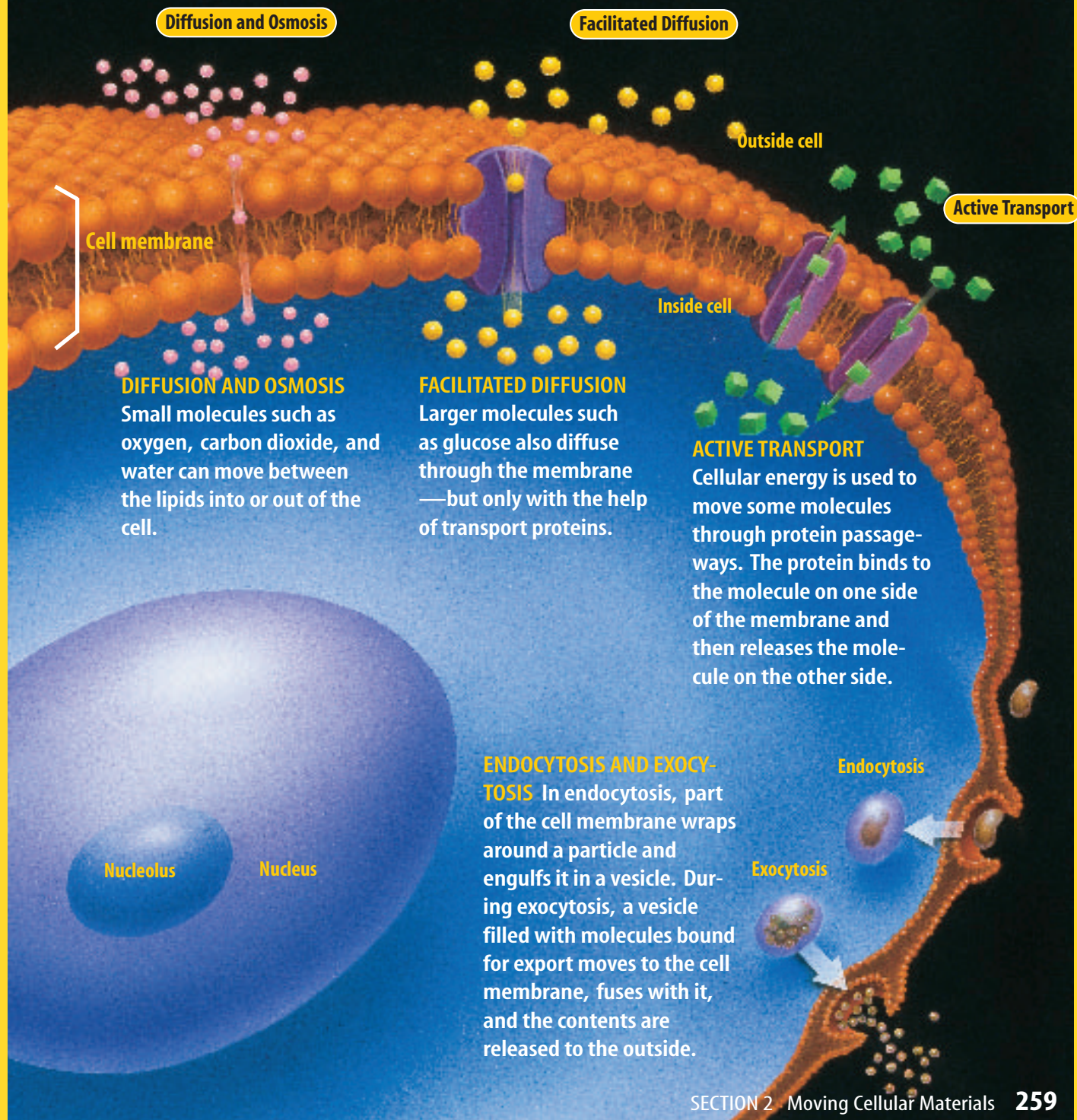
Applying Skills

5. **Communicate** Seawater is saltier than tap water. Explain why drinking large amounts of seawater would be dangerous for humans.



Figure 11

A flexible yet strong layer, the cell membrane is built of two layers of lipids (gold) pierced by protein “passageways” (purple). Molecules can enter or exit the cell by slipping between the lipids or through the protein passageways. Substances that cannot enter or exit the cell in these ways may be surrounded by the membrane and drawn into or expelled from the cell.



Observing Osmosis

It is difficult to observe osmosis in cells because most cells are so small. However, a few cells can be seen without the aid of a microscope. Try this lab to observe osmosis.

Real-World Question

How does osmosis occur in an egg cell?

Materials

unshelled egg* distilled water (250 mL)
balance light corn syrup (250 mL)
spoon 500-mL container

*an egg whose shell has been dissolved by vinegar

Goals

- **Observe** osmosis in an egg cell.
- **Determine** what affects osmosis.

Safety Precautions



WARNING: Eggs may contain bacteria. Avoid touching your face.

Procedure

1. Copy the table below into your Science Journal and use it to record your data.

Egg Mass Data		
	Beginning Egg Mass	Egg Mass After Two Days
Distilled water	Do not write in this book.	
Corn syrup		

2. Obtain an unshelled egg from your teacher. Handle the egg gently. Use a balance to find the egg's mass and record it in the table.



3. Place the egg in the container and add enough distilled water to cover it.
4. **Observe** the egg after 30 min, one day, and two days. After each observation, record the egg's appearance in your Science Journal.
5. After day two, remove the egg with a spoon and allow it to drain. Find the egg's mass and record it in the table.
6. Empty the container, then put the egg back in. Now add enough corn syrup to cover it. Repeat steps 4 and 5.

Conclude and Apply

1. **Explain** the difference between what happened to the egg in water and in corn syrup.
2. **Calculate** the mass of water that moved into and out of the egg.
3. **Hypothesize** why you used an unshelled egg for this investigation.
4. **Infer** what part of the egg controlled water's movement into and out of the egg.

Communicating Your Data

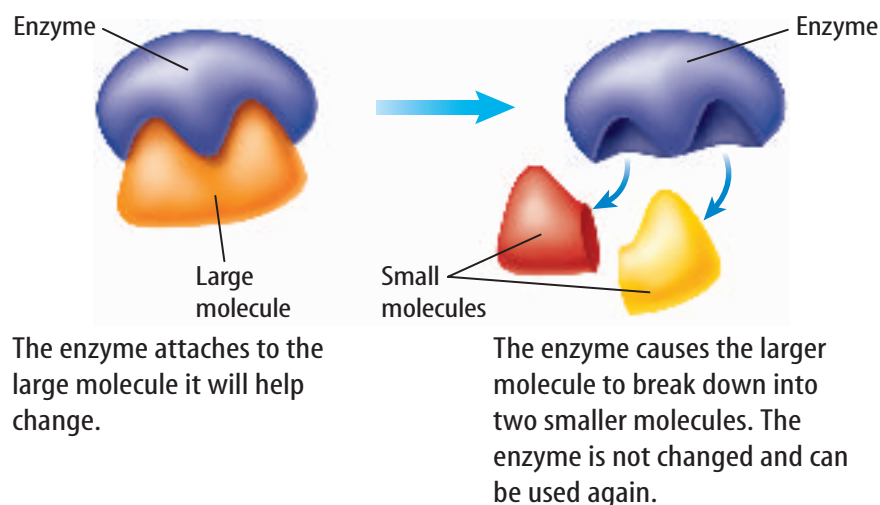
Compare your conclusions with those of other students in your class. **For more help, refer to the Science Skill Handbook.**

Energy for Life

Trapping and Using Energy

Think of all the energy that players use in a basketball game. Where does the energy come from? The simplest answer is “from the food they eat.” The chemical energy stored in food molecules is changed inside of cells into forms needed to perform all the activities necessary for life. In every cell, these changes involve chemical reactions. All of the activities of an organism involve chemical reactions in some way. The total of all chemical reactions in an organism is called **metabolism**.

The chemical reactions of metabolism need enzymes. What do enzymes do? Suppose you are hungry and decide to open a can of spaghetti. You use a can opener to open the can. Without a can opener, the spaghetti is unusable. The can of spaghetti changes because of the can opener, but the can opener does not change. The can opener can be used again later to open more cans of spaghetti. Enzymes in cells work something like can openers. The enzyme, like the can opener, causes a change, but the enzyme is not changed and can be used again, as shown in **Figure 12**. Unlike the can opener, which can only cause things to come apart, enzymes also can cause molecules to join. Without the right enzyme, a chemical reaction in a cell cannot take place. Each chemical reaction in a cell requires a specific enzyme.



as you read

What You'll Learn

- **List** the differences between producers and consumers.
- **Explain** how the processes of photosynthesis and respiration store and release energy.
- **Describe** how cells get energy from glucose through fermentation.

Why It's Important

Because of photosynthesis and respiration, you use the Sun's energy.



Review Vocabulary

mitochondrion: cell organelle that breaks down lipids and carbohydrates and releases energy

New Vocabulary

- metabolism
- photosynthesis
- respiration
- fermentation

Figure 12 Enzymes are needed for most chemical reactions that take place in cells.

Determine What is the sum of all chemical reactions in an organism called?

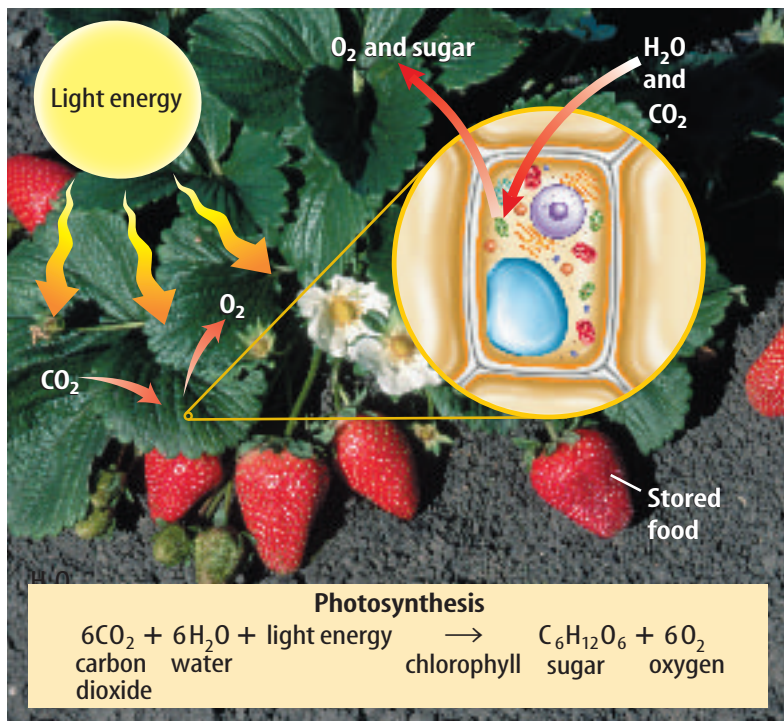


Figure 13 Plants use photosynthesis to make food.

Determine According to the chemical equation, what raw materials would the plant in the photo need for photosynthesis?

Photosynthesis Living things are divided into two groups—producers and consumers—based on how they obtain their food. Organisms that make their own food, such as plants, are called producers. Organisms that cannot make their own food are called consumers.

If you have ever walked barefoot across a sidewalk on a sunny summer day, you probably moved quickly because the sidewalk was hot. Sunlight energy was converted into thermal energy and heated the sidewalk. Plants and many other producers can convert light energy into another kind of energy—chemical energy. The process they use is called photosynthesis. During

photosynthesis, producers use light energy to make sugars, which can be used as food.

Producing Carbohydrates Producers that use photosynthesis are usually green because they contain a green pigment called chlorophyll (KLOR uh fihl). Chlorophyll and other pigments are used in photosynthesis to capture light energy. In plant cells, these pigments are found in chloroplasts.

The captured light energy powers chemical reactions that produce sugar and oxygen from the raw materials, carbon dioxide and water. For plants, the raw materials come from air and soil. Some of the captured light energy is stored in the chemical bonds that hold the sugar molecules together. **Figure 13** shows what happens during photosynthesis in a plant. Enzymes also are needed before these reactions can occur.

Storing Carbohydrates Plants make more sugar during photosynthesis than they need for survival. Excess sugar is changed and stored as starches or used to make other carbohydrates. Plants use these carbohydrates as food for growth, maintenance, and reproduction.

Why is photosynthesis important to consumers? Do you eat apples? Apple trees use photosynthesis to produce apples. Do you like cheese? Some cheese comes from milk, which is produced by cows that eat plants. Consumers take in food by eating producers or other consumers. No matter what you eat, photosynthesis was involved directly or indirectly in its production.



Respiration Imagine that you get up late for school. You dress quickly, then run three blocks to school. When you get to school, you feel hot and are breathing fast. Why? Your muscle cells use a lot of energy when you run. To get this energy, muscle cells break down food. Some of the energy from the food is used when you move and some of it becomes thermal energy, which is why you feel warm or hot. Most cells also need oxygen to break down food. You were breathing fast because your body was working to get oxygen to your muscles. Your muscle cells were using the oxygen for the process of respiration. During **respiration**, chemical reactions occur that break down food molecules into simpler substances and release their stored energy. Just as in photosynthesis, enzymes are needed for the chemical reactions of respiration.



Reading Check

What must happen to food molecules for respiration to take place?

Breaking Down Carbohydrates The food molecules most easily broken down by cells are carbohydrates. Respiration of carbohydrates begins in the cytoplasm of the cell. The carbohydrates are broken down into glucose molecules. Each glucose molecule is broken down further into two simpler molecules. As the glucose molecules are broken down, energy is released.

The two simpler molecules are broken down again. This breakdown occurs in the mitochondria of the cells of plants, animals, fungi, and many other organisms. This process uses oxygen, releases much more energy, and produces carbon dioxide and water as wastes. When you exhale, you breathe out carbon dioxide and some of the water.

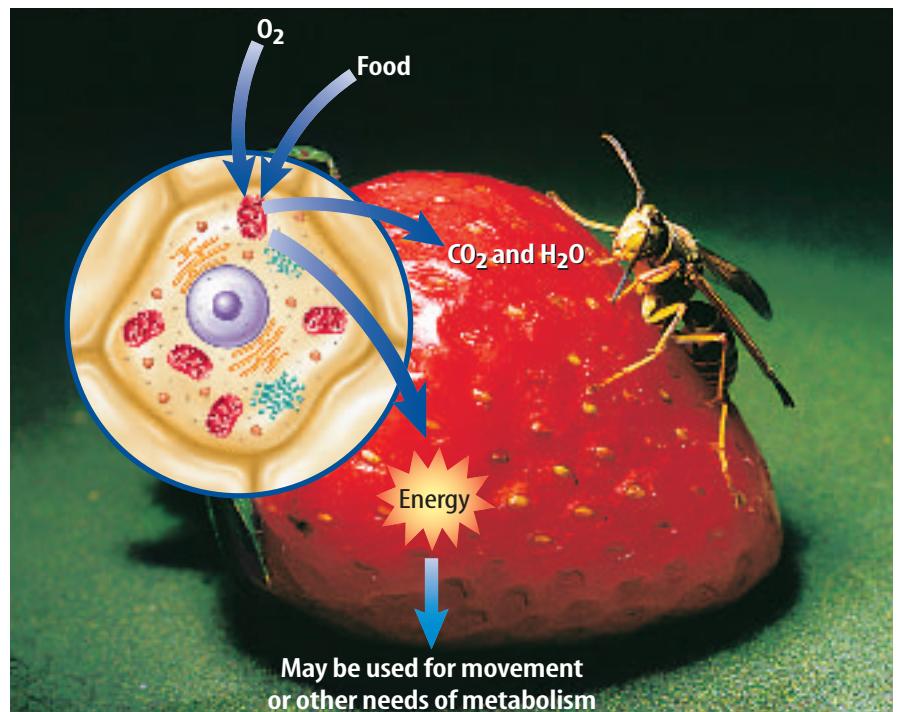
Respiration occurs in the cells of all living things. **Figure 14** shows how respiration occurs in one consumer. As you are reading this section of the chapter, millions of cells in your body are breaking down glucose, releasing energy, and producing carbon dioxide and water.



INTEGRATE Career

Microbiologist Dr. Harold Amos is a microbiologist who has studied cell processes in bacteria and mammals. He has a medical degree and a doctorate in bacteriology and immunology. He has also received many awards for his scientific work and his contributions to the careers of other scientists. Research microbiology careers, and write what you find in your Science Journal.

Figure 14 Producers and consumers carry on respiration that releases energy from foods.





Topic: Beneficial Microorganisms

Visit green.msscience.com for Web links to information about how microorganisms are used to produce many useful products.

Activity Find three other ways that microorganisms are beneficial.

Fermentation Remember imagining you were late and had to run to school? During your run, your muscle cells might not have received enough oxygen, even though you were breathing rapidly. When cells do not have enough oxygen for respiration, they use a process called **fermentation** to release some of the energy stored in glucose molecules.

Like respiration, fermentation begins in the cytoplasm. Again, as the glucose molecules are broken down, energy is released. But the simple molecules from the breakdown of glucose do not move into the mitochondria. Instead, more chemical reactions occur in the cytoplasm. These reactions release some energy and produce wastes. Depending on the type of cell, the wastes may be lactic acid or alcohol and carbon dioxide, as shown in **Figure 15**. Your muscle cells can use fermentation to change the simple molecules into lactic acid while releasing energy. The presence of lactic acid is why your muscle cells might feel stiff and sore after you run to school.



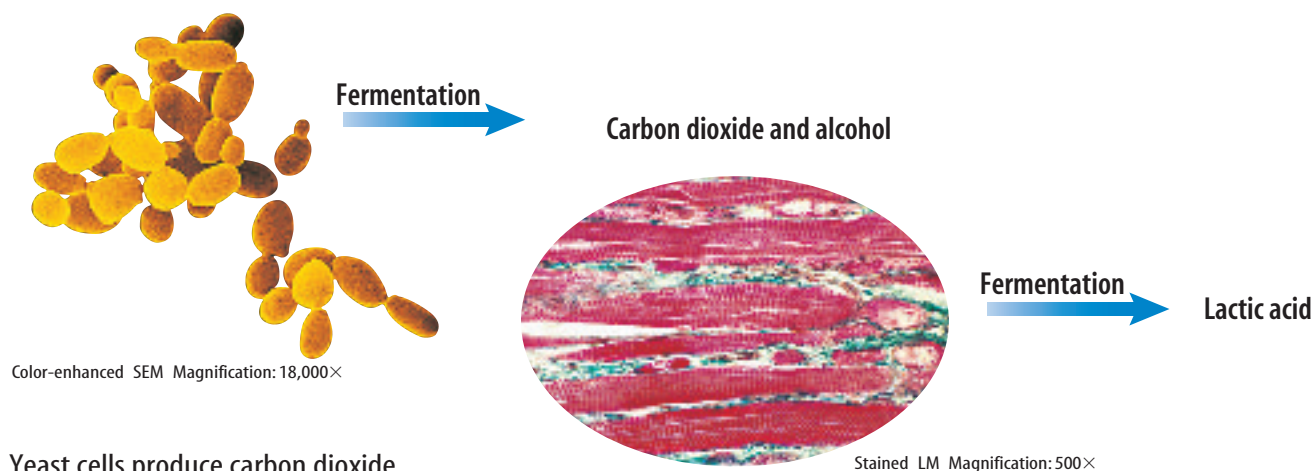
Reading Check

Where in a cell does fermentation take place?

Some microscopic organisms, such as bacteria, carry out fermentation and make lactic acid. Some of these organisms are used to produce yogurt and some cheeses. These organisms break down a sugar in milk and release energy. The lactic acid produced causes the milk to become more solid and gives these foods some of their flavor.

Have you ever used yeast to make bread? Yeasts are one-celled living organisms. Yeast cells use fermentation and break down sugar in bread dough. They produce alcohol and carbon dioxide as wastes. The carbon dioxide waste is a gas that makes bread dough rise before it is baked. The alcohol is lost as the bread bakes.

Figure 15 Organisms that use fermentation produce several different wastes.



Yeast cells produce carbon dioxide and alcohol as wastes when they undergo fermentation.

Your muscle cells produce lactic acid as a waste when they undergo fermentation.

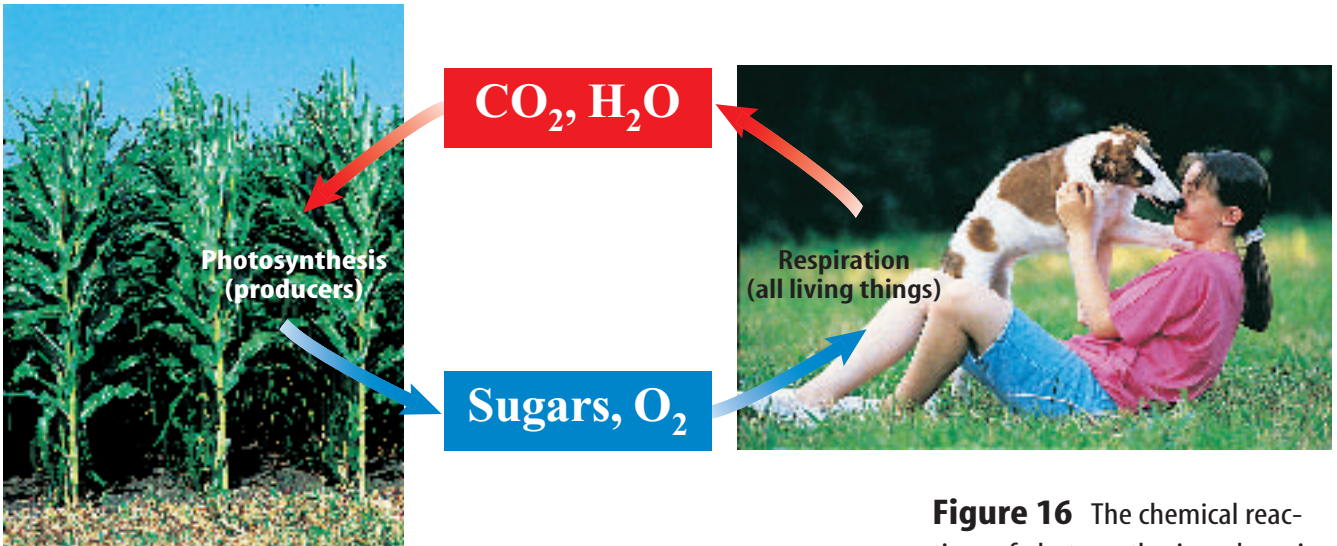


Figure 16 The chemical reactions of photosynthesis and respiration could not take place without each other.

Related Processes How are photosynthesis, respiration, and fermentation related? Some producers use photosynthesis to make food. All living things use respiration or fermentation to release energy stored in food. If you think carefully about what happens during photosynthesis and respiration, you will see that what is produced in one is used in the other, as shown in **Figure 16**. These two processes are almost the opposite of each other. Photosynthesis produces sugars and oxygen, and respiration uses these products. The carbon dioxide and water produced during respiration are used during photosynthesis. Most life would not be possible without these important chemical reactions.

section 3 review

Summary

Trapping and Using Energy

- Metabolism is the total of all chemical reactions in an organism.
- During photosynthesis, light energy is used to make sugars.
- Chlorophyll and other pigments capture light energy.
- Consumers take in energy by eating producers and other consumers.
- Living cells break down glucose and release energy. This is called respiration.
- Fermentation changes simple molecules and releases energy.
- Without photosynthesis and respiration, most life would not be possible.

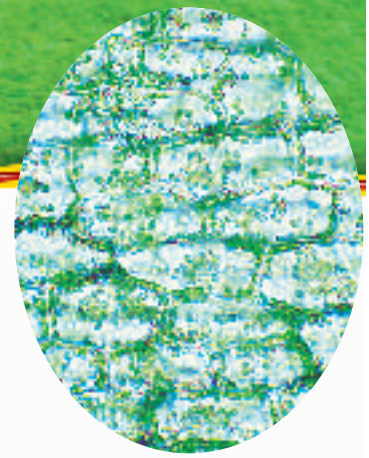
Self Check

1. **Explain** the difference between producers and consumers and give three examples of each.
2. **Infer** how the energy used by many living things on Earth can be traced back to sunlight.
3. **Compare and contrast** respiration and fermentation.
4. **Think Critically** How can some indoor plants help to improve the quality of air in a room?

Applying Math

5. **Solve** Refer to the chemical equation for photosynthesis. Calculate then compare the number of carbon, hydrogen, and oxygen atoms before and after photosynthesis.

Photosynthesis and Respiration



LM Magnification: 225×

Goals

- **Observe** green water plants in the light and dark.
- **Determine** whether plants carry on photosynthesis and respiration.

Materials

16-mm test tubes (3)
 150-mm test tubes with stoppers (4)
**small, clear-glass baby food jars with lids (4)*
 test-tube rack
 stirring rod
 scissors
 carbonated water (5 mL)
 bromthymol blue solution in dropper bottle
 aged tap water (20 mL)
**distilled water (20 mL)*
 sprigs of *Elodea* (2)
**other water plants*
**Alternate materials*

Safety Precautions



WARNING: Wear splash-proof safety goggles to protect eyes from hazardous chemicals.

Real-World Question

Every living cell carries on many chemical processes. Two important chemical processes are respiration and photosynthesis. All cells, including the ones in your body, carry on respiration. However, some plant cells can carry on both processes. In this experiment you will investigate when these processes occur in plant cells. How could you find out when plants were using these processes? Are the products of photosynthesis and respiration the same? When do plants carry on photosynthesis and respiration?

Procedure

1. In your Science Journal, copy and complete the test-tube data table as you perform this lab.

Test-Tube Data

Test Tube	Color at Start	Color After 30 Minutes
1		
2	Do not write in this book.	
3		
4		



Using Scientific Methods

2. Label each test tube using the numbers 1, 2, 3, and 4. Pour 5 mL of aged tap water into each test tube.
3. Add 10 drops of carbonated water to test tubes 1 and 2.
4. Add 10 drops of bromthymol blue to all of the test tubes. Bromthymol blue turns green to yellow in the presence of an acid.
5. Cut two 10-cm sprigs of *Elodea*. Place one sprig in test tube 1 and one sprig in test tube 3. Stopper all test tubes.
6. Place test tubes 1 and 2 in bright light. Place tubes 3 and 4 in the dark. Observe the test tubes for 30 min or until the color changes. Record the color of each of the four test tubes.

Analyze Your Data

1. **Identify** what is indicated by the color of the water in all four test tubes at the start of the activity.
2. **Infer** what process occurred in the test tube or tubes that changed color after 30 min.

Conclude and Apply

1. **Describe** the purpose of test tubes 2 and 4 in this experiment.
2. **Explain** whether or not the results of this experiment show that photosynthesis and respiration occur in plants.

Communicating Your Data

Choose one of the following activities to **communicate** your data. Prepare an oral presentation that explains how the experiment showed the differences between products of photosynthesis and respiration. Draw a cartoon strip to **explain** what you did in this experiment. Use each panel to show a different step. For more help, refer to the **Science Skill Handbook**.



from “Tulip”

by Penny Harter

I watched its first green push
through bare dirt, where the builders
had dropped boards, shingles,
plaster—
killing everything.

I could not recall what grew there,
what returned each spring,
but the leaves looked tulip,
and one morning it arrived,
a scarlet slash against the aluminum siding.

Mornings, on the way to my car,
I bow to the still bell
of its closed petals; evenings,
it greets me, light ringing
at the end of my driveway.

Sometimes I kneel
to stare into the yellow throat . . .
It opens and closes my days.
It has made me weak with love . . .



Understanding Literature

Personification Using human traits or emotions to describe an idea, animal, or inanimate object is called personification. When the poet writes that the tulip has a “yellow throat,” she uses personification. Where else does the poet use personification?

Respond to the Reading

1. Why do you suppose the tulip survived the builders’ abuse?
2. What is the yellow throat that the narrator is staring into?
3. **Linking Science and Writing** Keep a gardener’s journal of a plant for a month, describing weekly the plant’s condition, size, health, color, and other physical qualities.



Because most chemical reactions in plants take place in water, plants must have water in order to grow. The water carries nutrients and minerals from the soil into the plant. The process of active transport allows needed nutrients to enter the roots. The cell membranes of root cells contain proteins that bind with the needed nutrients. Cellular energy is used to move these nutrients through the cell membrane.

Reviewing Main Ideas

Section 1 Chemistry of Life

1. Matter is anything that has mass and takes up space.
2. Energy in matter is in the chemical bonds that hold matter together.
3. All organic compounds contain the elements hydrogen and carbon. The organic compounds in living things are carbohydrates, lipids, proteins, and nucleic acids.
4. Organic and inorganic compounds are important to living things.

Section 2 Moving Cellular Materials

1. The selectively permeable cell membrane controls which molecules can pass into and out of the cell.
2. In diffusion, molecules move from areas where there are relatively more of them to areas where there are relatively fewer of them.

3. Osmosis is the diffusion of water through a cell membrane.
4. Cells use energy to move molecules by active transport but do not use energy for passive transport.
5. Cells move large particles through cell membranes by endocytosis and exocytosis.

Section 3 Energy for Life

1. Photosynthesis is the process by which some producers change light energy into chemical energy.
2. Respiration that uses oxygen releases the energy in food molecules and produces waste carbon dioxide and water.
3. Some one-celled organisms and cells that lack oxygen use fermentation to release small amounts of energy from glucose. Wastes such as alcohol, carbon dioxide, and lactic acid are produced.

Visualizing Main Ideas

Copy and complete the following table on energy processes.

Energy Processes			
	Photosynthesis	Respiration	Fermentation
Energy source		food (glucose)	food (glucose)
In plant and animal cells, occurs in			
Reactants are			
Products are			

Do not write in this book.



Using Vocabulary

active transport p.257	metabolism p.261
diffusion p.255	mixture p.249
endocytosis p.258	organic compound p.250
enzyme p.251	osmosis p.256
equilibrium p.255	passive transport p.254
exocytosis p.258	photosynthesis p.262
fermentation p.264	respiration p.263
inorganic compound p.251	

Use what you know about the vocabulary words to answer the following questions.

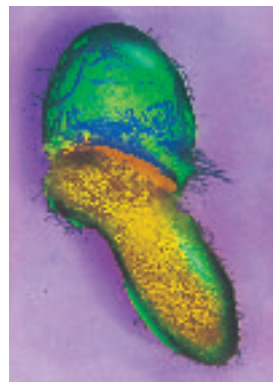
1. What is the diffusion of water called?
2. What type of protein regulates nearly all chemical reactions in cells?
3. How do large food particles enter an amoeba?
4. What type of compound is water?
5. What process is used by some producers to convert light energy into chemical energy?
6. What type of compounds always contain carbon and hydrogen?
7. What process uses oxygen to break down glucose?
8. What is the total of all chemical reactions in an organism called?

Checking Concepts

Choose the word or phrase that best answers the question.

9. What is it called when cells use energy to move molecules?
A) diffusion C) active transport
B) osmosis D) passive transport

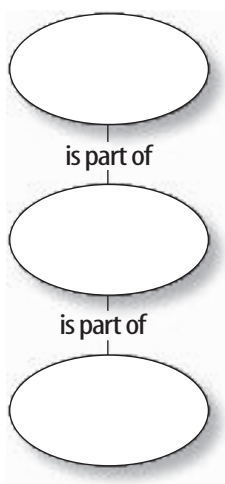
Use the photo below to answer question 10.



10. What cell process is occurring in the photo?
A) osmosis C) exocytosis
B) endocytosis D) diffusion
11. What occurs when the number of molecules of a substance is equal in two areas?
A) equilibrium C) fermentation
B) metabolism D) cellular respiration
12. Which of the following substances is an example of a carbohydrate?
A) enzymes C) waxes
B) sugars D) proteins
13. What is RNA an example of?
A) carbon dioxide C) lipid
B) water D) nucleic acid
14. What organic molecule stores the greatest amount of energy?
A) carbohydrate C) lipid
B) water D) nucleic acid
15. Which of these formulas is an example of an organic compound?
A) $C_6H_{12}O_6$ C) H_2O
B) NO_2 D) O_2
16. What are organisms that cannot make their own food called?
A) biodegradables C) consumers
B) producers D) enzymes

Thinking Critically

- 17. Concept Map** Copy and complete the events-chain concept map to sequence the following parts of matter from smallest to largest: *atom*, *electron*, and *compound*.



Use the table below to answer question 18.

Photosynthesis in Water Plants		
Beaker Number	Distance from Light (cm)	Bubbles per Minute
1	10	45
2	30	30
3	50	19
4	70	6
5	100	1

- 18. Interpret Data** Water plants were placed at different distances from a light source. Bubbles coming from the plants were counted to measure the rate of photosynthesis. What can you say about how the distance from the light affected the rate?
- 19. Infer** why, in snowy places, salt is used to melt ice on the roads. Explain what could happen to many roadside plants as a result.

- 20. Draw a conclusion** about why sugar dissolves faster in hot tea than in iced tea.
- 21. Predict** what would happen to the consumers in a lake if all the producers died.
- 22. Explain** how meat tenderizers affect meat.
- 23. Form a hypothesis** about what will happen to wilted celery when placed in a glass of plain water.

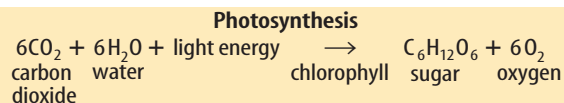
Performance Activities

- 24. Puzzle** Make a crossword puzzle with words describing ways substances are transported across cell membranes. Use the following words in your puzzle: *diffusion*, *osmosis*, *facilitated diffusion*, *active transport*, *endocytosis*, and *exocytosis*. Make sure your clues give good descriptions of each transport method.

Applying Math

- 25. Light and Photosynthesis** Using the data from question 18, make a line graph that shows the relationship between the rate of photosynthesis and the distance from light.
- 26. Importance of Water** Assume the brain is 70% water. If the average adult human brain weighs 1.4 kg, how many kilograms of water does it contain?

Use the equation below to answer question 27.



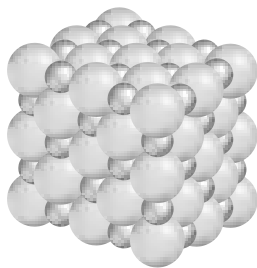
- 27. Photosynthesis** Refer to the chemical equation above. If 18 CO_2 molecules and 18 H_2O molecules are used with light energy to make sugar, how many sugar molecules will be produced? How many oxygen molecules will be produced?

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. An element cannot be broken down by chemical reactions and is made up of only one kind of
- A. electron. C. atom.
B. carbohydrate. D. molecule.

Use the illustration below to answer questions 2 and 3.



2. What kind of chemical compound do salt and water form?
- A. covalent
B. ionic
C. solution
D. lipid
3. Salt is very important in the human body. What kind of compound is salt?
- A. organic
B. carbohydrate
C. protein
D. inorganic
4. A cell that contains 40% water is placed in a solution that is 20% water. The cell and the solution will reach equilibrium when they both contain how much water?
- A. 30% C. 60%
B. 40% D. 20%
5. All chemical reactions in living things take place in what kind of a solution?
- A. protein C. gas
B. water D. solid

6. The sum of all the chemical reactions in an organism is
- A. respiration. C. fermentation.
B. metabolism. D. endocytosis.
7. What is needed for all chemical reactions in cells?
- A. enzymes C. DNA
B. lipids D. cell membrane
8. The carbon dioxide that you exhale is a product of
- A. osmosis.
B. DNA synthesis.
C. photosynthesis.
D. respiration.
9. Matter cannot be held together or broken apart without
- A. gas.
B. liquid.
C. energy.
D. temperature.

Use the table below to answer question 10.

Cell Substances		
Organic Compound	Flexibility	Found in
Keratin	Not very flexible	Hair and skin of mammals
Collagen	Not very flexible	Skin, bones, and tendons of mammals
Chitin	Very rigid	Tough outer shell of insects and crabs
Cellulose	Very flexible	Plant cell walls

10. According to this information, which organic compound is the least flexible?
- A. keratin
B. collagen
C. chitin
D. cellulose

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

11. Explain the structure of an atom.
12. How does chewing food affect your body's ability to release the chemical energy of the food?
13. Ice fishing is a popular sport in the winter. What properties of water is this sport based on?
14. Explain where the starch in a potato comes from.
15. Does fermentation or respiration release more energy for an athlete's muscles? Which process would be responsible for making muscles sore?

Use the table below to answer question 16.

Classification of Compounds			
Compound	Organic	Inorganic	Type of organic compound
Salt			
Fat			
Skin			
DNA			
Sugar			
Water			
Potassium			

16. Copy and complete the table above. Identify each item as inorganic or organic. If the item is an organic compound further classify it as a protein, carbohydrate, lipid or nucleic acid.
17. Define selectively permeable and discuss why it is important for the cell membrane.
18. What is the source of energy for the photosynthesis reactions and where do they take place in a cell?

Part 3 Open Ended

Record your answers on a sheet of paper.

19. Give examples of each of the four types of organic molecules and why they are needed in a plant cell.
20. Trace the path of how oxygen molecules are produced in a plant cell to how they are used in human cells.
21. Describe four ways a large or small molecule can cross the cell membrane.
22. Discuss how water is bonded together and the unique properties that result from the bonds.

Use the illustration below to answer question 23.



23. Describe in detail what process is taking place in this diagram and its significance for a cell.
24. How do plants use carbon dioxide? Why would plants need oxygen?

Test-Taking Tip

Diagrams Study a diagram carefully, being sure to read all labels and captions.