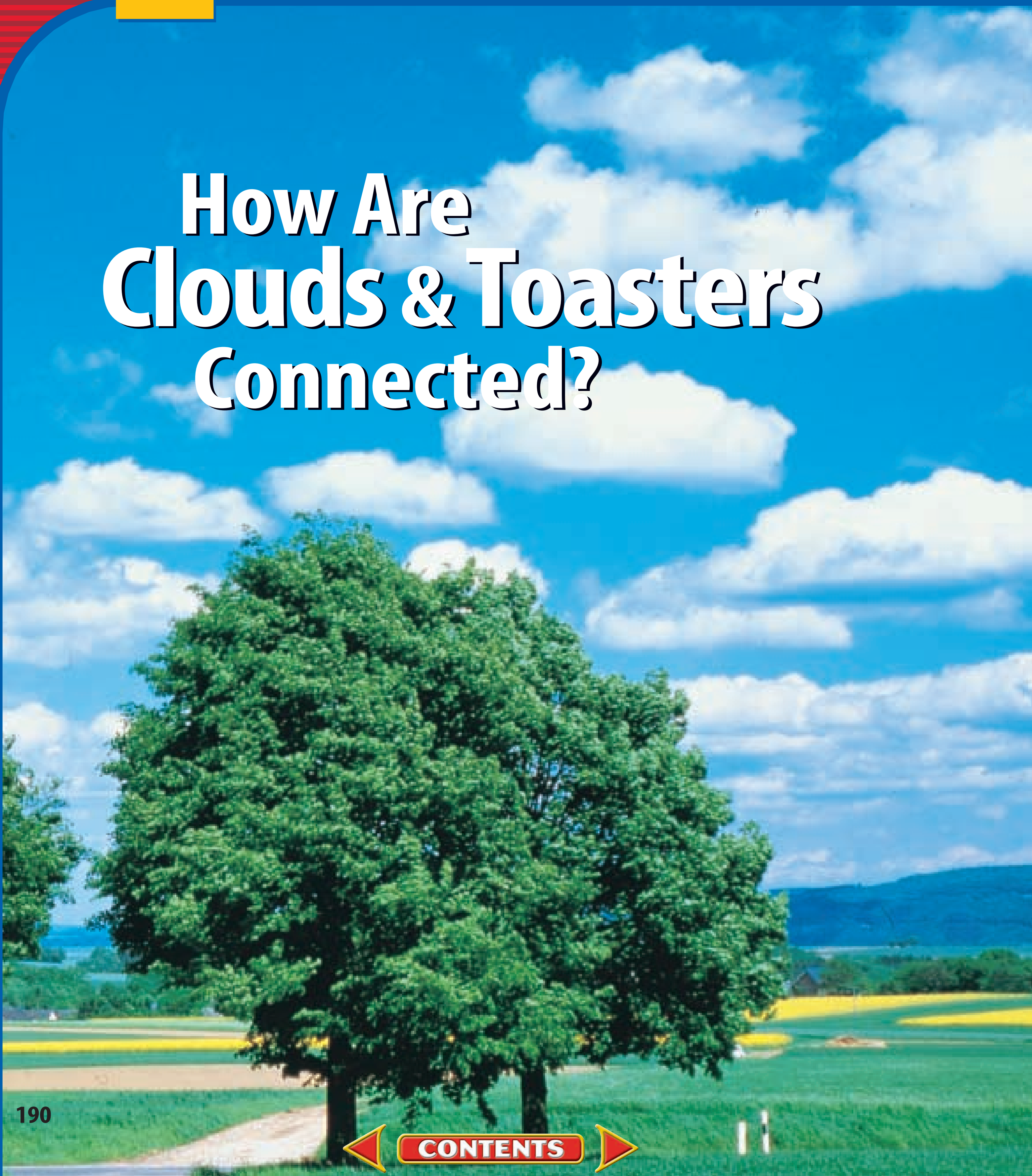
UNIT 2

Electricity and Energy Resources

How Are Clouds & Toasters Connected?



CONTENTS

NATIONAL GEOGRAPHIC

In the late 1800s, a mysterious form of radiation called X rays was discovered. One French physicist wondered whether uranium would give off X rays after being exposed to sunlight. He figured that if X rays were emitted, they would make a bright spot on a wrapped photographic plate. But the weather turned cloudy, so the physicist placed the uranium and the photographic plate together in a drawer. Later, on a hunch, he developed the plate and found that the uranium had made a bright spot anyway. The uranium was giving off some kind of radiation even without being exposed to sunlight! Scientists soon determined that the atoms of uranium are radioactive—that is, they give off particles and energy from their nuclei. In today's nuclear power plants, this energy is harnessed and converted into electricity. This electricity provides some of the power used in homes to operate everything from lamps to toasters.

SCIENCE CONNECTION

NUCLEAR ENERGY Does some of the electricity you use every day come from a nuclear power plant? Contact your local electric company to find out how much of the electricity produced in your area comes from nuclear, hydroelectric, and fossil-fuel-burning power plants. Make a graph of your research results. As a class, investigate and debate the advantages and disadvantages of using nuclear reactors to generate electricity.

CONTENTS

CHAPTER 7

Electricity

A city at night. Lights of every color and size reflect from windows and the river's glassy surface. What makes the lights so bright? Electricity. It not only provides us with light, but also heat, refrigeration, and power to run the countless electrical devices we use every day. Where does electricity come from? How does it get into our homes, schools, and offices? And how can you control it by flicking a switch or pushing a button? In this chapter, you will learn the answers to these questions.

What do you think?

Science Journal Look at the picture below with a classmate. Discuss what this might be or what is happening. Here's a hint: *What force might cause her hair to behave this way?* Write your answer or best guess in your Science Journal.

Explore Activity

Imagine life before electricity. CD players, refrigerators, dishwashers, TVs, and dozens of other things that make your life comfortable and enjoyable would be impossible without electricity. You wouldn't even have lightbulbs and would have to use candles or oil lamps to provide light at night. So how do these electrical devices work? Explore how electric lights work during this activity.

How many ways?

1. Obtain a battery, a flashlight bulb, and some wire.
2. Arrange the materials so that the lightbulb lights.
3. Record all the ways that you were able to light the bulb.
4. Record a few of the ways that didn't work.
5. Can you light the bulb using only one wire and one battery?

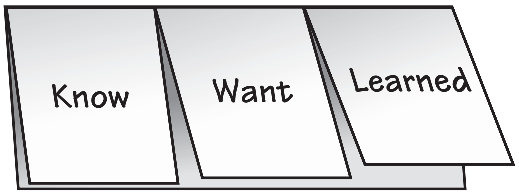
Observe

In your Science Journal, write a paragraph describing the requirements to light the bulb. Write out a procedure for lighting the bulb and have a classmate follow your procedure.

Before You Read

Foldables Reading & Study Skills

Making a Know-Want-Learn Study Fold **Make the following Foldable to help identify what you already know and what you want to know.**



1. Place a sheet of paper in front of you so the long side is at the top. Fold the paper in half from top to bottom.
2. Fold both sides in to divide the paper into thirds. Unfold the paper so three sections show.
3. Through the top thickness of paper, cut along each of the fold lines to the top fold, forming three tabs. Label the tabs *Know, Want,* and *Learned,* as shown.
4. Before you read the chapter, write what you know under the left tab and what you want to know under the middle tab.
5. As you read the chapter, add to or correct what you have written under the tabs.

CONTENTS

SECTION

1 Electric Charge

As You Read

What You'll Learn

- **Describe** the properties of static electricity.
- **Distinguish** between conductors and insulators.
- **Recognize** the presence of charge in an electroscope.

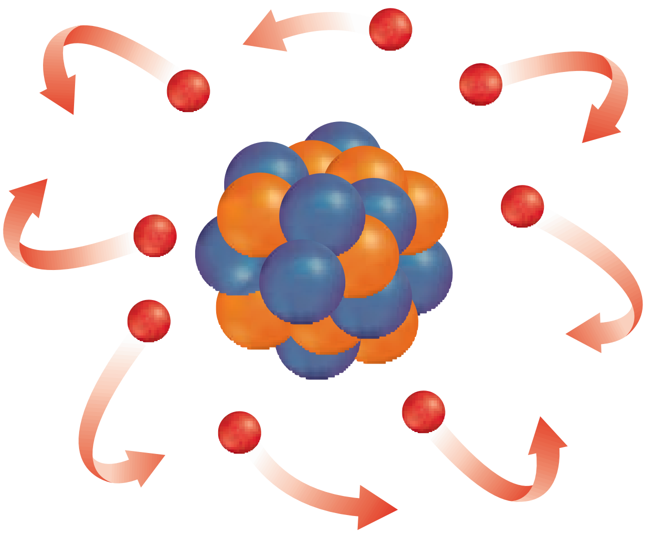
Vocabulary

static electricity
law of conservation of charge
conductor
insulator
charging by contact
charging by induction

Why It's Important

Static electricity can damage electrical equipment and be lethal to humans.

Figure 1
The center of an atom contains protons (orange) and neutrons (blue). Electrons (red) swarm around the atom's center.



Static Electricity

You know from experience that walking across a carpeted floor and touching something can often result in a shocking experience. What causes this startling and sometimes painful phenomenon?

Electric Charges When your shoes rub on the carpet, some of the atoms in the carpet are disturbed. Atoms contain particles called protons, neutrons, and electrons, as shown in **Figure 1.** Protons and electrons have a property called electric charge, and neutrons have no electric charge.

No one knows exactly what electric charge is, but there are two different types of electric charge. Protons have positive electric charge, and electrons have negative electric charge. The amount of positive charge on a proton is exactly equal to the amount of negative charge on an electron. An atom contains equal numbers of protons and electrons, so the positive and negative charges cancel out and an atom has no net electric charge. Objects such as shoes and carpets are made of atoms and usually have no net electric charge. Objects with no net charge are said to be neutral.

Building Up Charge Some atoms hold their electrons more tightly than other atoms. For example, atoms in your shoes hold their electrons more tightly than atoms in the carpet. As you walk on carpet, some electrons that are loosely held by the atoms in the carpet are transferred to your shoes. Your shoes gain electrons and then have more electrons than protons. Because your shoes have an excess of negative charge, your shoes are said to be negatively charged. The carpet loses electrons and has more protons than electrons. Because the carpet has an excess of positive charge, it is positively charged. This is an example of static electricity. **Static electricity** is the accumulation of excess electric charges on an object. Can you think of other examples of static electricity?

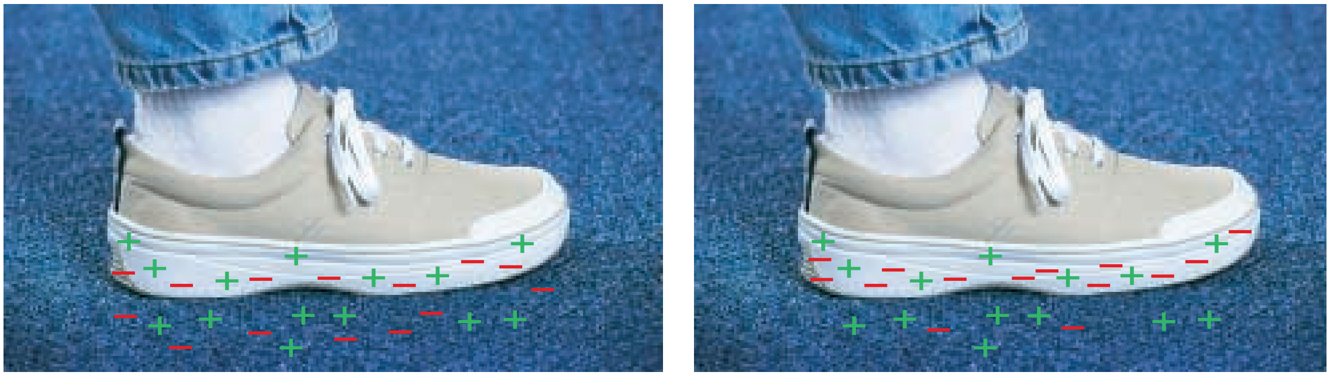


Figure 2
A Before the shoes scuff against the carpet, the shoes and the carpet have equal numbers of electrons and protons. This balance means the shoes and the carpet have no net charge. B Later, as electrons move from the carpet to the shoes, the shoes become negatively charged and the carpet becomes positively charged.

Conservation of Charge It is important to remember that when an object becomes charged, charge is neither created nor destroyed. Electrons simply have moved from one object to another. For example, before you rub your shoes against the carpet, your shoes and the carpet have equal numbers of electrons and protons. Your shoes and the carpet have no net charge and are electrically neutral, as shown in **Figure 2A.** After rubbing the carpet, your shoes gain electrons from the carpet and become negatively charged. The carpet, which now has more protons than electrons, is positively charged, as shown in **Figure 2B.** According to the **law of conservation of charge,** charge can be transferred from object to object, but it cannot be created or destroyed. In every case, when an object becomes charged, electric charges have moved.

Reading Check *How does an object acquire charge?*

Opposites Attract As shown in **Figure 3,** electrically charged objects obey two rules—opposite charges attract, and like charges repel. Have you noticed how clothes sometimes cling together when removed from the dryer? While the clothes tumble around, electrons are transferred from fabrics that hold their electrons loosely to those that hold their electrons tightly. Clothes that gain electrons become negatively charged and cling to clothes that have lost electrons and are positively charged. Clothes that are oppositely charged attract each other and stick together.

Figure 3
The only two kinds of electric charge are positive and negative. *How do charged objects interact with each other?*

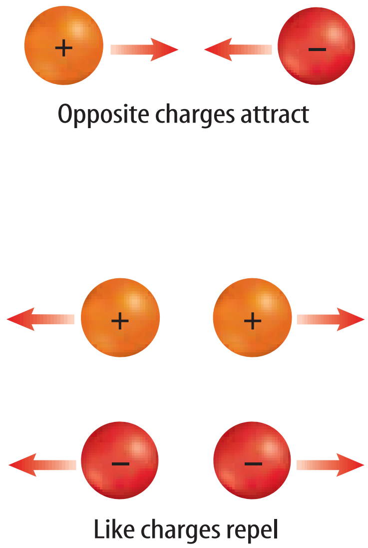
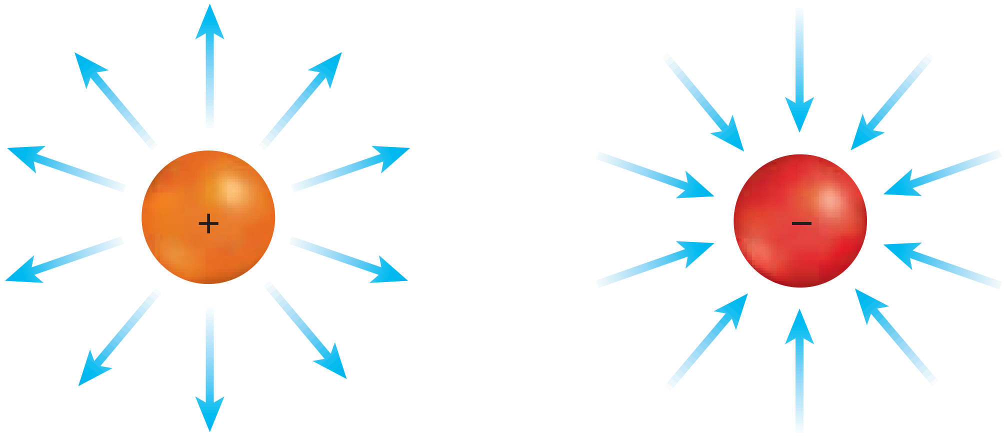


Figure 4
Surrounding every charge is an electric field. Through the electric field, a charge is able to push or pull on another charge.

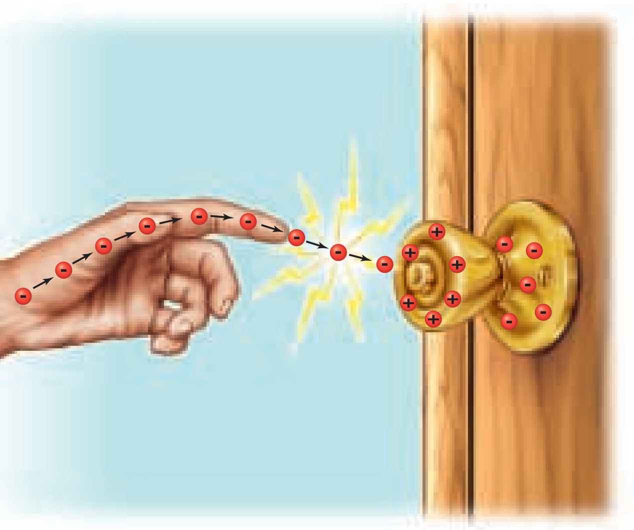


Force at a Distance You might have seen bits of tissue paper fly up and stick to a charged balloon. The balloon didn't even have to touch the bits of paper. The force of gravity behaves in the same way. A football in the air does not need to touch Earth for gravity to pull it downward. Likewise, the bits of paper do not need to touch the charged balloon for an electric force to act on them. If the balloon and the paper are not touching, what causes the paper to move?

An electric field surrounds every electric charge, as shown in **Figure 4.** The electric field exerts the force that causes other electric charges to move. Any charge that is placed in an electric field will be pushed or pulled by the field. Electric fields are represented by lines with arrows drawn away from positive charges and toward negative charges. The arrows show how the electric field would make a positive charge move.

Conductors and Insulators

Figure 5
As you walk across a carpeted floor, your body builds up a static charge. When you reach for a metal doorknob, the charges flow between your hand and the doorknob and you feel a shock.



If you reach for a metal doorknob after walking across a carpet, you could feel a shock and see a spark. The spark is caused by excess electrons moving from your hand to the doorknob. Excess electrons were transferred from the carpet to your shoes. How did excess electrons move from your shoes to your hand?

Conductors Look at **Figure 5.** An excess of electrons can move more easily through some materials, called **conductors,** than through others. Electrons on your shoes repel each other and some are pushed onto your skin. Because your skin is a conductor, the electrons spread out over your skin and onto your hand. The metal doorknob is also a conductor.

Metallic Conductors Metals are excellent conductors of electricity. The atoms in metals have electrons that are able to move easily through the material. For this reason, electric wires usually are made of metals, such as copper, which is one of the best conductors. Gold and silver wire are also excellent conductors of electricity but are much more expensive than copper.

Insulators Wires in cords attached to telephones and other household appliances are coated with some type of insulating material. An **insulator** is a material that doesn't allow electrons to move through it easily. Most plastics are insulators. Electrons are held strongly to atoms in insulating materials. The plastic coating around electric wires prevents a dangerous electrical shock when you touch the wire, as shown in **Figure 6.** In addition to plastic, other good insulators are wood, rubber, and glass.

Reading Check *What is an insulator?*

Transferring Electric Charge

Objects can become charged in several ways. Perhaps the most familiar situations are a static charge resulting from contact. For example, you probably have felt a charge on your own body after combing your hair on a dry day. You might have noticed socks being attracted to each other after they have been rubbed together in a clothes dryer. Rubbing two materials together can result in a transfer of electrons between the objects. Then one object is left with a positive charge and the other with an equal amount of negative charge. The process of transferring charge by touching or rubbing is called **charging by contact.**

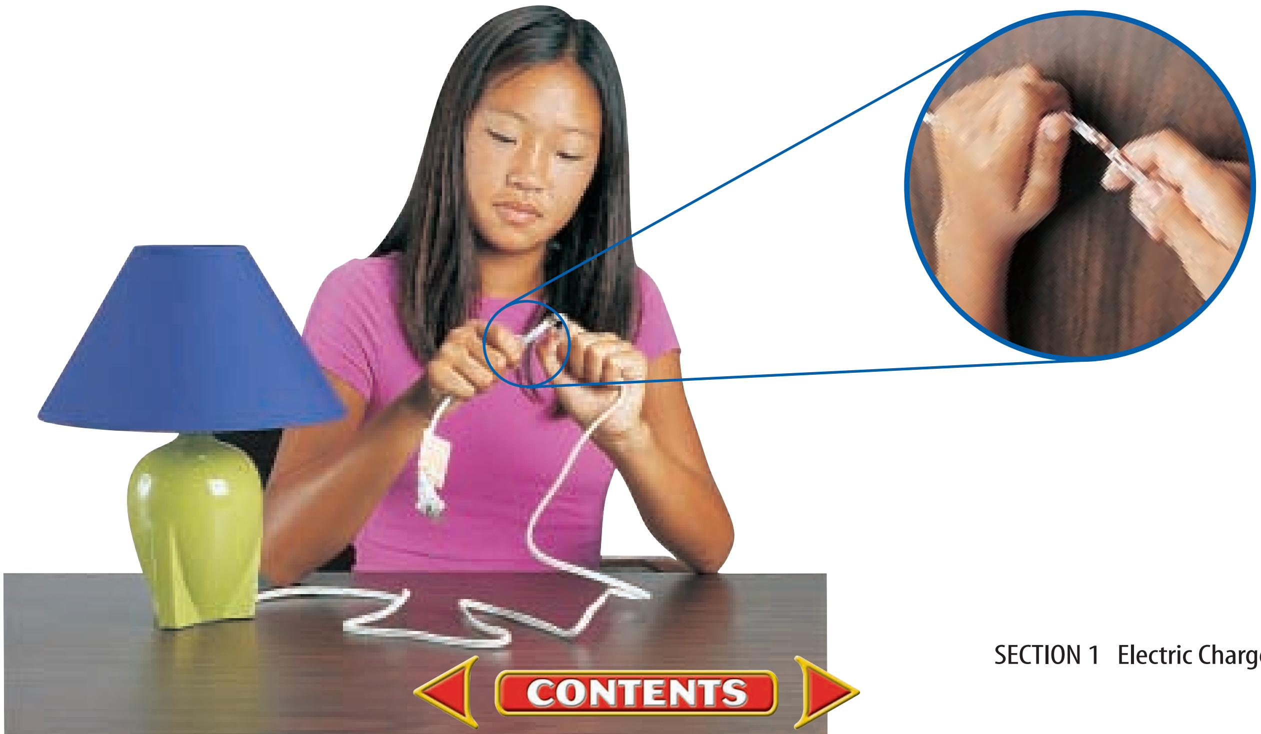


Figure 6
The plastic coating around wires is an insulator. A damaged electrical cord is hazardous when the conducting wire is exposed.

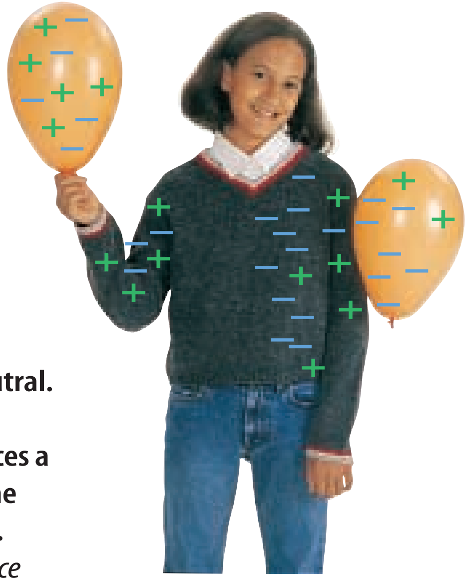


Figure 7
The balloon on the left is neutral. The balloon on the right is negatively charged. It produces a positively charged area on the sleeve by repelling electrons.
What is the direction of the force acting on the balloon?

Charging at a Distance

Because electrical forces act at a distance, charged objects brought near a neutral object will cause electrons to rearrange their positions on the neutral object. Suppose you charge a balloon by rubbing it with a cloth. If you bring the negatively charged balloon near your sleeve, the extra electrons on the balloon repel the electrons in the sleeve. The electrons near the sleeve's surface move away from the balloon, leaving a positively charged area on the surface of the sleeve, as shown in **Figure 7.** As a result, the negatively charged balloon attracts the positively charged area of the sleeve. The rearrangement of electrons on a neutral object caused by a nearby charged object is called **charging by induction.** The sweater was charged by induction. The balloon will now cling to the sweater, being held there by an electrical force.

Lightning Have you ever seen lightning strike Earth? Lightning is a large static discharge. A static discharge is a transfer of charge through the air between two objects because of a buildup of static electricity. A thundercloud is a mighty generator of static electricity. As air masses move and swirl in the cloud, areas of positive and negative charge build up. Eventually, enough charge builds up to cause a static discharge between the cloud and the ground. As the electric charges move through air, they collide with atoms and molecules. These collisions cause the atoms and molecules in air to emit light. You see this light as a spark, as shown in **Figure 8.**

Thunder Not only does lightning produce a brilliant flash of light, it also generates powerful sound waves. The electrical energy in a lightning bolt rips electrons off atoms in the atmosphere and produces great amounts of heat, warming the surrounding air to temperatures of about 25,000°C—several times hotter than the Sun's surface. The heat causes air in the bolt's path to expand rapidly, producing sound waves that you hear as thunder.

The sudden discharge of so much energy can be dangerous. It is estimated that Earth is struck by lightning more than 100 times every second. It can cause power outages, injury, loss of life, and fires.

CLICK HERE

SCIENCE Online

Collect Data Visit the Glencoe Science Web site at **science.glencoe.com** for an online update of lightning strikes each day. Communicate to your class what you learn.

CONTENTS

NATIONAL GEOGRAPHIC

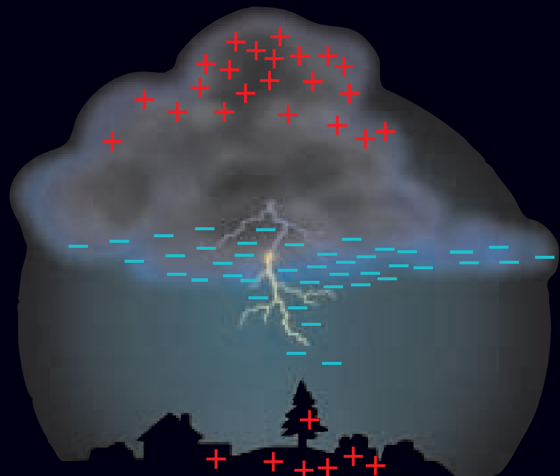
VISUALIZING LIGHTNING

Figure 8

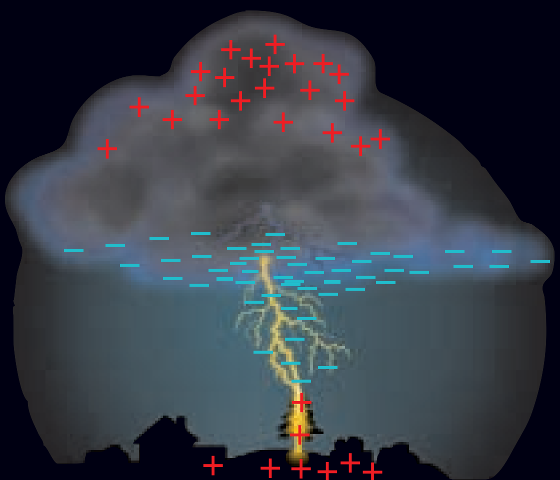
Storm clouds can form when humid, sun-warmed air rises to meet a colder air layer. As these air masses churn together, the stage is set for the explosive electrical display we call lightning. Lightning strikes when negative charges at the bottom of a storm cloud are attracted to positive charges on the ground.

A Convection currents in the storm cloud cause charge separation. The top of the cloud becomes positively charged, the bottom negatively charged.

B Negative charges on the bottom of the cloud induce a positive charge on the ground below the cloud by repelling negative charges in the ground.



C When the bottom of the cloud has accumulated enough negative charges, the attraction of the positive charges below causes electrons in the bottom of the cloud to move toward the ground.



D When the electrons get close to the ground, they attract positive charges that surge upward, completing the connection between cloud and ground. This is the spark you see as a lightning flash.

INTRA-CLOUD LIGHTNING can occur ten times more often in a storm than cloud-to-ground lightning and never strikes Earth.

Figure 9
A lightning rod directs the charge from a lightning bolt safely to the ground.

Grounding The sensitive electronics in a computer can be harmed by large static discharges. A discharge can occur any time that charge builds up in one area. Providing a path for charge to reach Earth prevents any charge from building up. Earth is a large, neutral object that is also a conductor of charge. Any object connected to Earth by a good conductor will transfer any excess electric charge. Connecting an object to Earth with a conductor is called grounding. For example, buildings often have a metal lightning rod that provides a conducting path from the highest point on the building to the ground to prevent damage by lightning, as shown in **Figure 9.**

Plumbing fixtures, such as metal faucets, sinks, and pipes, often provide a convenient ground connection. Look around. Do you see anything that might act as a path to the ground?

TRY AT HOME
Mini LAB

Investigating Charged Objects

Procedure

1. Fold over about 1 cm on the end of a **roll of tape** to make a handle. Tear off a strip of tape about 10 cm long.
2. Stick the strip on a clean, dry, smooth surface, such as a countertop. Make another identical strip and stick it directly on top of the first.
3. Pull both pieces off the counter together and pull them apart. Then bring the nonsticky sides of both tapes together. What happens?
4. Now stick the two strips of tape side by side on the smooth surface. Pull them off and bring the nonsticky sides near each other again.

Analysis

1. What happened when you first brought the pieces close together? Were they charged alike or opposite? What might have caused this?
2. What did you observe when you brought the pieces together the second time? How were they charged? What did you do differently that might have changed the behavior?

Detecting Electric Charge

The presence of electric charges can be detected by an electroscope. One kind of electroscope is made of two thin, metal leaves attached to a metal rod with a knob at the top. The leaves are allowed to swing freely from the metal rod. When the device is not charged, the leaves hang straight down, as shown in **Figure 10A.**

Suppose a negatively charged balloon touches the knob. Because the metal is a good conductor, electrons travel down the rod into the leaves. Both leaves become negatively charged as they gain electrons, as shown in **Figure 10B.** Because the leaves have similar charges, they repel each other.

If a glass rod is rubbed with silk, electrons are pulled from the atoms in the glass rod and build up on the silk. The glass rod becomes positively charged.

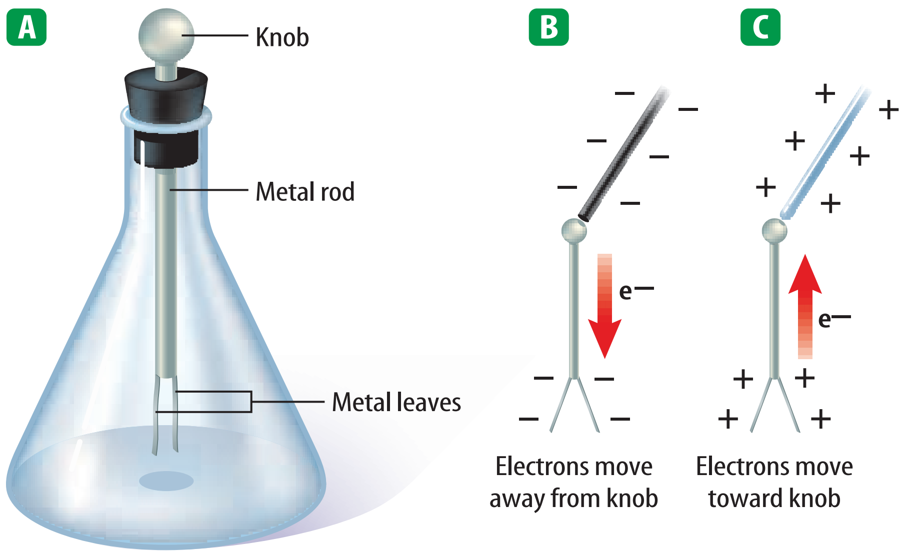


Figure 10
Notice the position of the leaves on the electroscope when they are A uncharged, B negatively charged, and C positively charged. *How can you tell whether an electroscope is positively or negatively charged?*

When the positively charged glass rod is brought into contact with the metal knob of an uncharged electroscope, electrons flow out of the metal leaves and onto the rod. The leaves repel each other because each leaf becomes positively charged as it loses electrons, as shown in **Figure 10C.**

Think of any other examples of static electricity that you have seen. Can you explain them in terms of like or opposite charges? How do objects become charged, and what happens when they discharge?

Section 1 Assessment

1. What is static electricity?
2. Distinguish between electrical conductors and insulators and give an example of each.
3. How is lightning produced?
4. How do like charges affect each other? Unlike charges? What could you use to detect the presence of electric charges?
5. **Think Critically** Assume you have already charged an electroscope with a positively charged glass rod. Hypothesize what would happen if you touched the knob again with another positively charged object.

Skill Builder Activities

6. **Drawing Conclusions** Suppose you observe that the individual hairs on your arm rise up when a balloon is placed near them. Using the concept of induction and the rules of static electricity, what could you conclude about the cause of this phenomenon? **For more help, refer to the Science Skill Handbook.**
7. **Communicating** Moist air is a better conductor than dry air. It is more difficult to observe events related to static electricity, such as clothes clinging or hair standing out, on humid days when the air is moist. In your Science Journal, explain how humidity affects static electricity. **For more help, refer to the Science Skill Handbook.**

SECTION 2

Electric Current

As You Read

What You'll Learn

- **Describe** how electric current is different from static electricity.
- **Explain** how a dry cell provides a source of voltage difference.
- **Describe** the relationship among voltage difference, resistance, and current.

Vocabulary

voltage difference
circuit
electric current
resistance
Ohm's law

Why It's Important

Without electric current, many devices would not exist, including telephones, personal computers, and lighting.

Charge on the Move

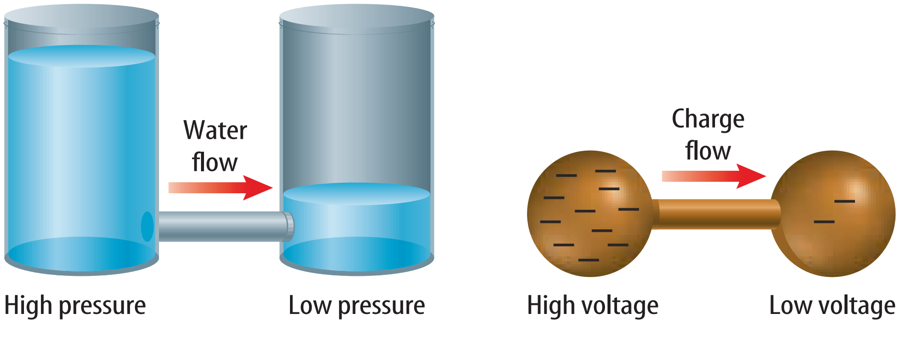
You just learned that if you touch a conductor after building up a negative charge on your body, electrons will move from you to the conductor. You also learned that charges flow easily through a conductor. Do you know why?

Electrical Pressure To understand this question, think about water. Why does water flow? To answer, you might develop a rule—water will flow from a place where the pressure is high to a place where the pressure is low, as in **Figure 11A.** Air also follows this rule, as wind always blows from a high-pressure region to a lower-pressure region. For water or air to flow, a pressure difference must exist. To explain why charges flow, a similar rule can be developed. Charges flow from high-voltage areas to low-voltage areas. Voltage is like an electrical pressure that pushes charge. Just as water or air must have a pressure difference to flow, a voltage difference must be present for electric charges to flow, as shown in **Figure 11B.** A **voltage difference** is the push that causes charges to move and is measured in volts (V).

Reading Check *What do electric charges need in order to flow?*

Look at **Figure 12A.** The water flows because the pump increases the pressure to push water through the loop. The turbine makes use of the flowing water to do work. The turbine might turn gears in a machine or connect to a generator to produce electricity.

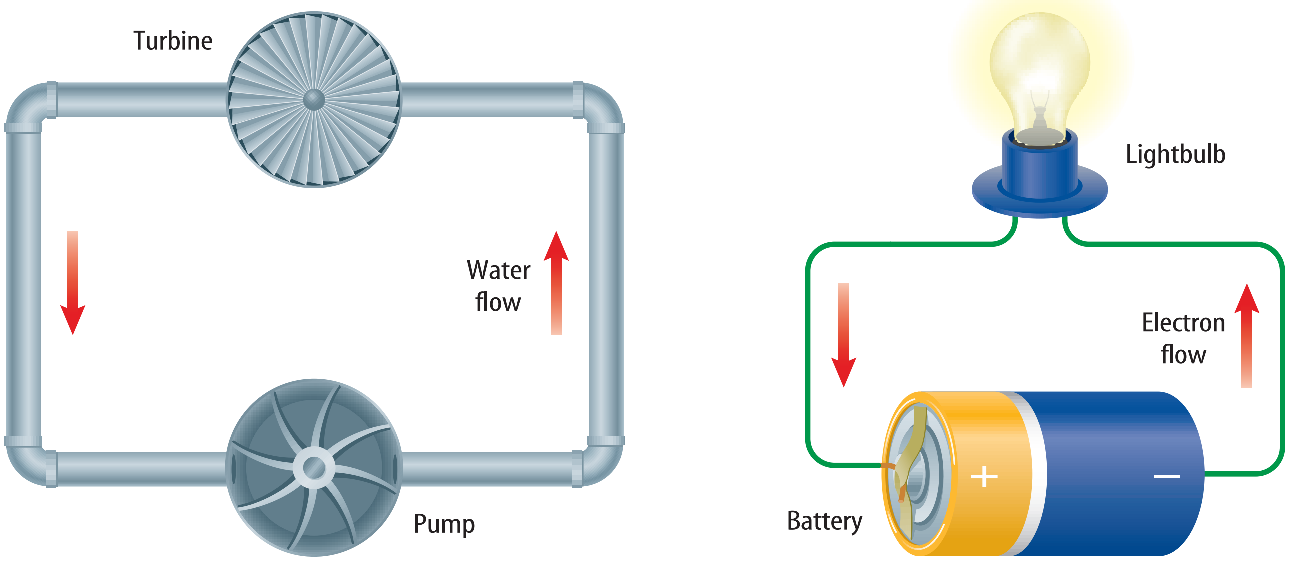
Figure 11
Water pressure and voltage are similar.



A A pressure difference causes water to flow.

B A voltage difference causes charge to flow.

Figure 12
There are some similarities between the flow of water in a pipe and the flow of electric current through a circuit.



A **Water flows only when the pipe makes a closed loop.**

B **Electric charge flows only when the wire makes a closed loop.**

Closed Circuits In **Figure 12A,** what would happen if the pipe broke? Rather quickly the water would stop flowing. For water to continue to flow, the pipe must always make a closed loop. The same is true for charges flowing in a wire. For charges to flow, the wire must always be connected in a closed loop, or circuit. A **circuit** is a closed, conducting path, as shown in **Figure 12B.**

The flow of charges through a wire or any conductor is called **electric current.** The electric current in a circuit is measured in amperes (A). Current is almost always the flow of electrons. Protons have charge, but they are locked deep within the center of atoms and do not move. Only the outer, loosely held electrons are free to move.

Batteries

In a static discharge, charges move from one place to another in a short period of time. In order to keep the current moving continuously through a circuit, a device must be present that maintains a voltage difference. One common source of a voltage difference is a battery. Portable radios and flashlights use the voltage difference provided by batteries for power. Batteries also are used to provide the energy needed to start a car. How do batteries cause an electric current to flow?

Mini LAB

Investigating Battery Addition

Procedure

1. Make a circuit by linking two **bulbs** and one **D-cell battery** in a loop. Observe the brightness of the bulbs.
2. Assemble a new circuit by linking two bulbs and two D-cell batteries in a loop. Observe the brightness of the bulbs.

Analysis

1. What is the voltage difference of each D cell? Add them together to find the total voltage difference for the circuit you tested in step 2.
2. Assuming that a brighter bulb indicates a greater current, what can you conclude about the relationship between the voltage difference and current?

Dry-Cell Batteries The individual batteries you are most familiar with are dry cells. Look at the dry cell shown in **Figure 13A.** The zinc container of the dry cell surrounds a moist chemical paste with a solid carbon rod suspended in the middle. Can you locate the positive and negative terminals of the dry cell in the diagram? A dry cell produces a voltage difference between the positive and negative terminals. What causes this voltage difference?

Chemistry INTEGRATION

When the two terminals of a standard D-cell battery are connected in a circuit, such as in a flashlight, a reaction involving zinc and several chemicals in the paste occurs. The carbon rod does not take part in the reaction. Instead, it serves as a conductor to transfer electrons. Electrons are transferred between some of the compounds in this chemical reaction. As a result, the carbon rod becomes positive, forming the positive (+) terminal. Electrons accumulate on the zinc, making it the negative (−) terminal.

The voltage difference between these two terminals causes current to flow through a closed circuit, such as when you turn on a portable CD player. You make a battery when you connect two or more cells together to produce a higher voltage difference. Can you think of a device in your home or school that requires more than one battery to operate?

Wet-Cell Batteries Another type of battery that is used commonly is the wet-cell battery. A wet cell, like the one shown in **Figure 13B,** contains two connected plates made of different metals or metallic compounds in a conducting solution.

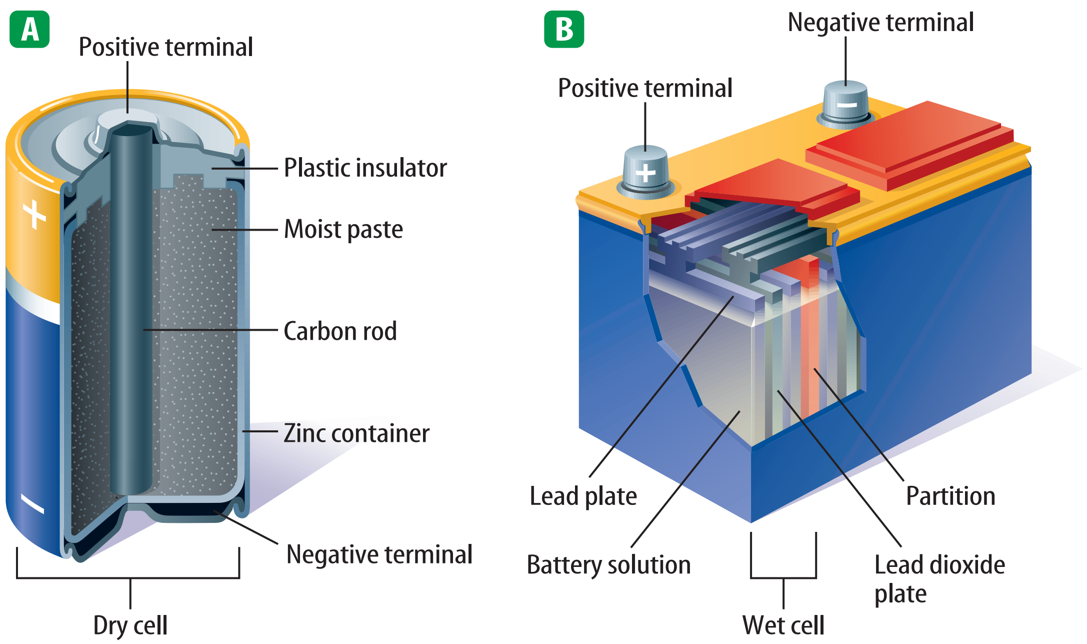


Figure 13
Batteries produce a voltage difference between the positive and negative terminals. A In this dry cell, chemical reactions in the moist paste transfer electrons to the zinc container. B In this wet cell, chemical reactions transfer electrons from the lead plates to the lead dioxide plates.

CONTENTS

Providing Voltage Most car batteries, also called lead-storage batteries, contain a series of six wet cells made up of lead and lead dioxide plates in a sulfuric acid solution. The chemical reaction in each cell provides a voltage difference of about 2 V, giving a total voltage difference of 12 V. As a car is driven, the alternator recharges the battery by sending current through the battery in the opposite direction to reverse the chemical reaction.

In addition to batteries, a voltage difference is provided at electrical outlets, such as a wall socket. Most types of household devices are designed to use the voltage difference supplied by a wall socket. In the United States, the voltage difference across the two holes in a wall socket is usually 120 V. Some wall sockets supply 240 V, which is required by electric ranges and clothes dryers.

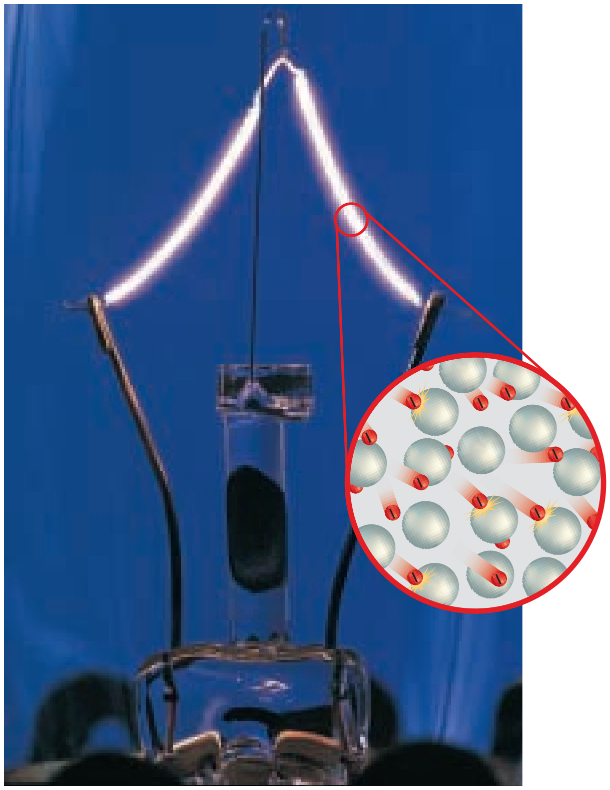


Figure 14
As electrons move through the filament in a lightbulb, they bump into metal atoms. Due to the collisions, the metal heats up and starts to glow.

Resistance

Flashlights use dry-cell batteries to provide the electric current that lights a lightbulb. What makes a lightbulb glow? Look at the lightbulb in **Figure 14.** Part of the circuit through the bulb contains a thin wire called a filament. As the electrons flow through the filament, they bump into the metal atoms that make up the filament. As these collisions occur, some of the electrical energy of the electrons is converted into thermal energy. Eventually, the metal filament becomes hot enough to glow, producing radiant energy that can light up a dark room.

Oppose the Flow Electric current loses energy as it moves through the filament because the filament resists the flow of electrons. **Resistance** is the tendency for a material to oppose the flow of electrons, changing electrical energy into thermal energy and light. With the exception of a few substances that become superconductors at low temperatures, all materials have some electrical resistance. Electrical conductors have much less resistance than insulators. Resistance is measured in ohms (Ω).

Copper is an excellent conductor and has low resistance to the flow of electrons. Copper is used in household wiring because little electrical energy is converted to thermal energy as current passes through the wires. In contrast, tungsten wire glows white-hot as current passes through it. Tungsten's high resistance to current makes it suitable for use as filaments in lightbulbs but not for carrying current through a house.

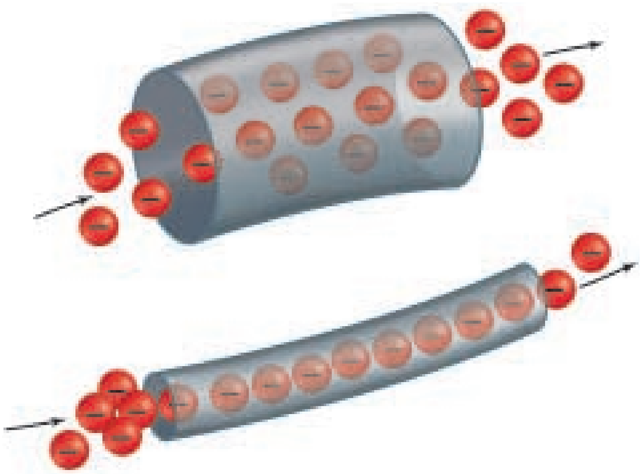


Figure 15
The resistance of a short, thick piece of wire is less than the resistance of a long, thin piece of wire.

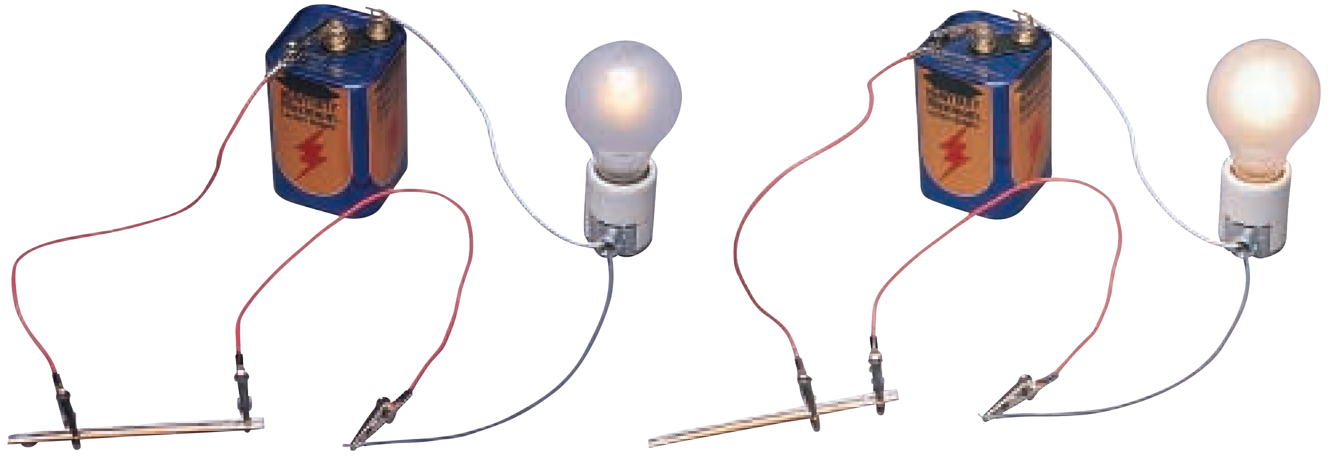
Resistance in Wires The size of a wire also affects its resistance. **Figure 15** illustrates how electrons move more efficiently through thick wires than thin wires. In wires of the same length and material, thinner wires have greater resistance to electron flow. Making a wire longer causes the resistance to increase because more collisions occur as electrons flow through the longer wire. In most conductors, the resistance also increases as the temperature increases.

Reading Check *Why might you want to use a material with high resistance?*

Control the Flow

So far, you have learned two ways that the flow of charges, or current, in a circuit can be changed. A voltage difference causes the charges to flow, and an electrical resistance restricts the movement of charges. To help visualize this, think of water flowing in a pipe. If you increase the water pressure, the water flows faster and the water current increases. On the other hand, if you place obstructions in the pipe, the water current decreases.

Figure 16
The amount of current flowing through a circuit is related to the amount of resistance in the circuit.



A **By changing the length of the graphite rod that the current must pass through, the resistance of the circuit can be changed. Recall that longer wires of a given material have higher resistances than shorter wires.** *How does changing the resistance affect the voltage difference of the circuit?*

B **Notice that here the current flows through a shorter section of the graphite rod. This decreases the total resistance of the circuit, while the voltage difference produced by the battery remains the same.** *How does the brightness of the bulb compare to the brightness of the bulb in the first photo?*

Ohm's Law For water flowing in a pipe, increasing the resistance causes the current to decrease, while increasing the pressure causes the current to increase. A similar relationship is true for electric current and is called Ohm's law.

$$\text{current} = \frac{\text{voltage difference}}{\text{resistance}}$$

$$I\,(\mathrm{A}) = \frac{V\,(\mathrm{V})}{R\,(\Omega)}$$

According to **Ohm's law,** the current in a circuit equals the voltage difference divided by the resistance. Consequently, as the resistance in a circuit increases, the current decreases. This relationship is shown in **Figure 16.** The graphite rod resists the flow of current in the circuit. As the length of the graphite rod increases, the resistance in the circuit increases, and the current through a lightbulb decreases. As a result, the bulb becomes less bright. On the other hand, from Ohm's law the current increases if the voltage difference increases.

By multiplying both sides of the above equation by the resistance, R, Ohm's law also can be written as follows.

$$V = IR$$

Health INTEGRATION

Harm from electricity is due to high current. Wet skin has a much lower resistance than dry skin. According to Ohm's law, low resistance means high current. Research the effects of high current on the human body.

Section 2 Assessment

1. How does a current traveling through a circuit differ from a static discharge?
2. Briefly describe how a carbon-zinc dry cell supplies electric current for your CD player.
3. Describe three factors that affect the resistance of a copper wire.
4. Compare and contrast the flow of water through a pipe and the flow of electrons through a wire.
5. **Think Critically** Calculate the voltage difference across a 25-Ω resistor if a 0.3-A current is flowing through it. What happens to the voltage difference if the current is doubled?

Skill Builder Activities

6. **Interpreting Data** Suppose you connect three copper wires of unequal length to a 1.5-V dry cell. The following currents flow in the wires: wire 1, 1.2 A; wire 2, 1.4 A; wire 3, 1.1 A. Use Ohm's law to calculate the resistance of each wire. Make a graph of current versus resistance. Describe the shape of the line on your graph. **For more help, refer to the Science Skill Handbook.**
7. **Using Fractions** Suppose you place a bulb with a resistance of 60 Ω in a circuit with a 12-V battery. What is the current through this circuit? How does the current change if you add one more bulb? Two more bulbs? **For more help, refer to the Math Skill Handbook.**

Activity

Identifying Conductors and Insulators

Have you ever had a flashlight that you couldn't seem to make work any longer? You replaced the batteries and put in a new bulb, yet the flashlight still wouldn't light. The most likely cause for such a broken flashlight is a break in the circuit. If you could find the break and then repair it, you could fix the flashlight.

What You'll Investigate

Compare the ability of different materials to conduct a current.

Materials

battery
flashlight bulb
bulb holder
insulated wire

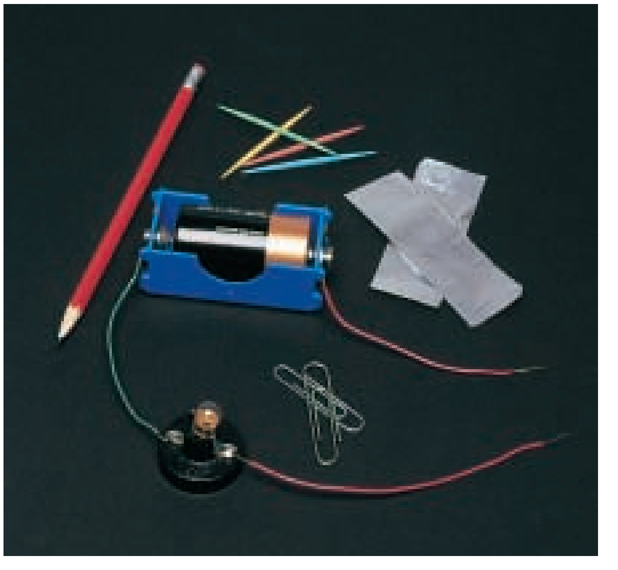
Goals

- **Identify** conductors and insulators.
- **Describe** the common characteristics of conductors and insulators.

Procedure

1. Set up an incomplete circuit as pictured in the photograph.
2. Touch the free bare ends of the wires to various objects around the room. Test at least 12 items.
3. In a table like the one below, record which materials make the lightbulb light and which don't.

Material Tested with Lightbulb Circuit	
Lightbulb Lights	**Lightbulb Stays Out**



Conclude and Apply

1. Is there a pattern to your data?
2. Do all or most of the materials that light the lightbulb have something in common?
3. Do all or most of the materials that don't light the lightbulb have something in common?
4. **Explain** why a material may allow the lightbulb to light and what will prevent the lightbulb from lighting.
5. **Predict** what other materials will allow the lightbulb to light and what will prevent the lightbulb from lighting.
6. **Classify** all the materials you have tested as conductors or insulators.

Communicating Your Data

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

SECTION 3 Electrical Energy

Electric Circuits

Look around. How many electrical devices such as lights, clocks, stereos, and televisions do you see that are plugged into wall outlets? These devices rely on a source of electrical energy and wires to complete an electric circuit. Circuits typically include a voltage source, a conductor such as a wire, and one or more devices that use the electrical energy to do work.

Consider, for example, a circuit that includes an electric hair dryer. The dryer must be plugged into a wall outlet to operate. A generator at a power plant produces a voltage difference across the outlet, causing charges to move when the circuit is complete. The dryer and the circuit in the house contain conducting wires to carry current. The hair dryer turns the electrical energy into thermal energy and mechanical energy. When you unplug the hair dryer or turn off its switch, you open the circuit and break the path of the current. To use electrical energy, a complete circuit must be made. Several kinds of circuits exist.

Series Circuits One kind of circuit is called a series circuit. In a **series circuit,** the current has only one loop to flow through, as shown in **Figure 17.** Series circuits are used in flashlights and some holiday lights.

Reading Check *How many loops are in a series circuit?*

As You Read

What You'll Learn

- **Describe** the difference between series and parallel circuits.
- **Recognize** the function of circuit breakers and fuses.
- **Explain and calculate** electrical power.

Vocabulary

series circuit
parallel circuit
electrical power
kilowatt-hour

Why It's Important

The convenience and safety of household electricity depend on how the electric circuits in your home are designed.

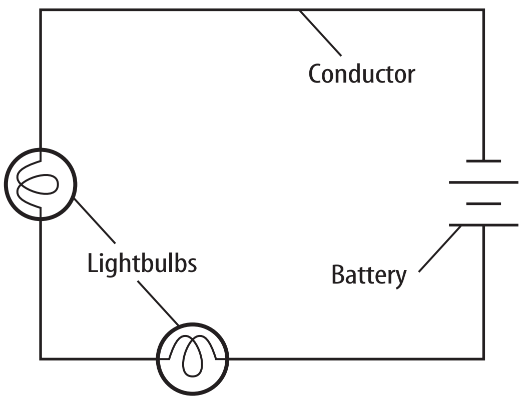


Figure 17
A series circuit provides only one path for the current to follow.
What happens to the brightness of each bulb as more bulbs are added?

Earth Science INTEGRATION

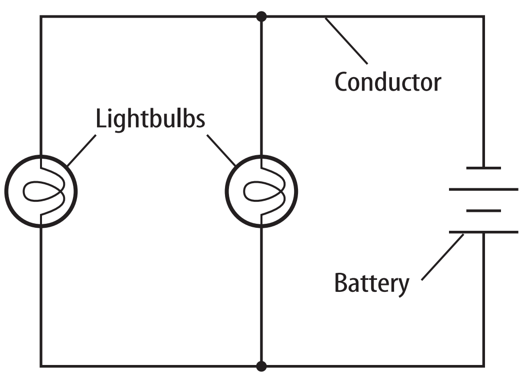
Rivers sometimes form different branches that separate and then rejoin, making an island. Write a paragraph describing which kind of circuit this is most like and why.

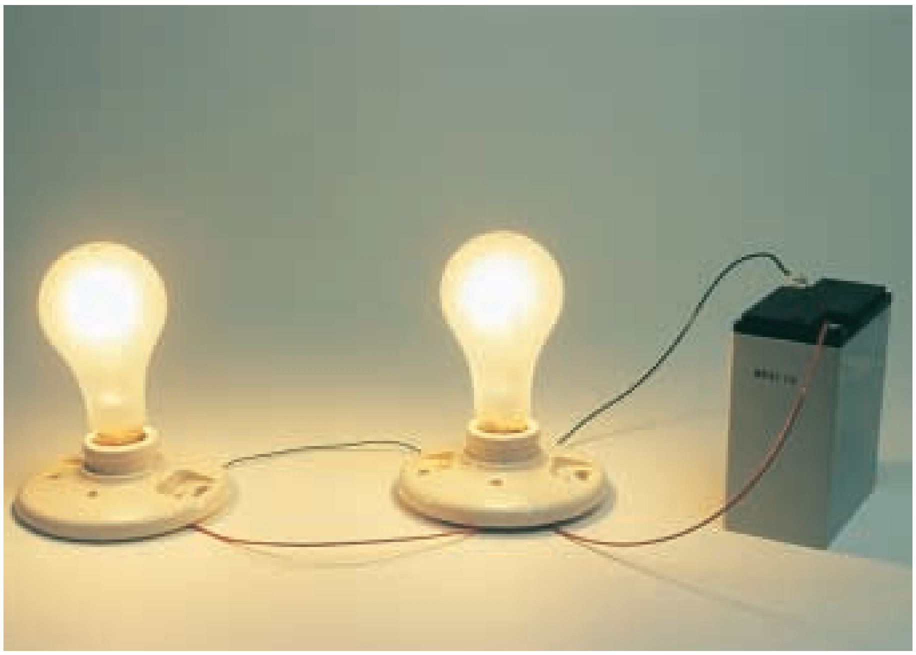
Open Circuit If you have ever decorated a window or a tree with a string of lights, you might have had the frustrating experience of trying to find one burned-out bulb. How can one faulty bulb cause the whole string to go out? Because the parts of a series circuit are wired one after another, the amount of current is the same through every part. When any part of a series circuit is disconnected, no current flows through the circuit. This is called an open circuit. The burned-out bulb causes an open circuit in the string of lights.

Parallel Circuits What would happen if your home were wired in a series circuit and you turned off one light? This would cause an open circuit, and all the other lights and appliances in your home would go out, too. This is why houses are wired with parallel circuits. **Parallel circuits** contain two or more branches for current to move through. Look at the parallel circuit in **Figure 18.** The current splits up to flow through the different branches. Because all branches connect the same two points of the circuit, the voltage difference is the same in each branch. Then, according to Ohm's law, more current flows through the branches that have lower resistance.

Parallel circuits have several advantages. When one branch of the circuit is opened, such as when you turn a light off, the current continues to flow through the other branches. Houses, automobiles, and most electrical systems use parallel wiring so individual parts can be turned off without affecting the entire circuit.

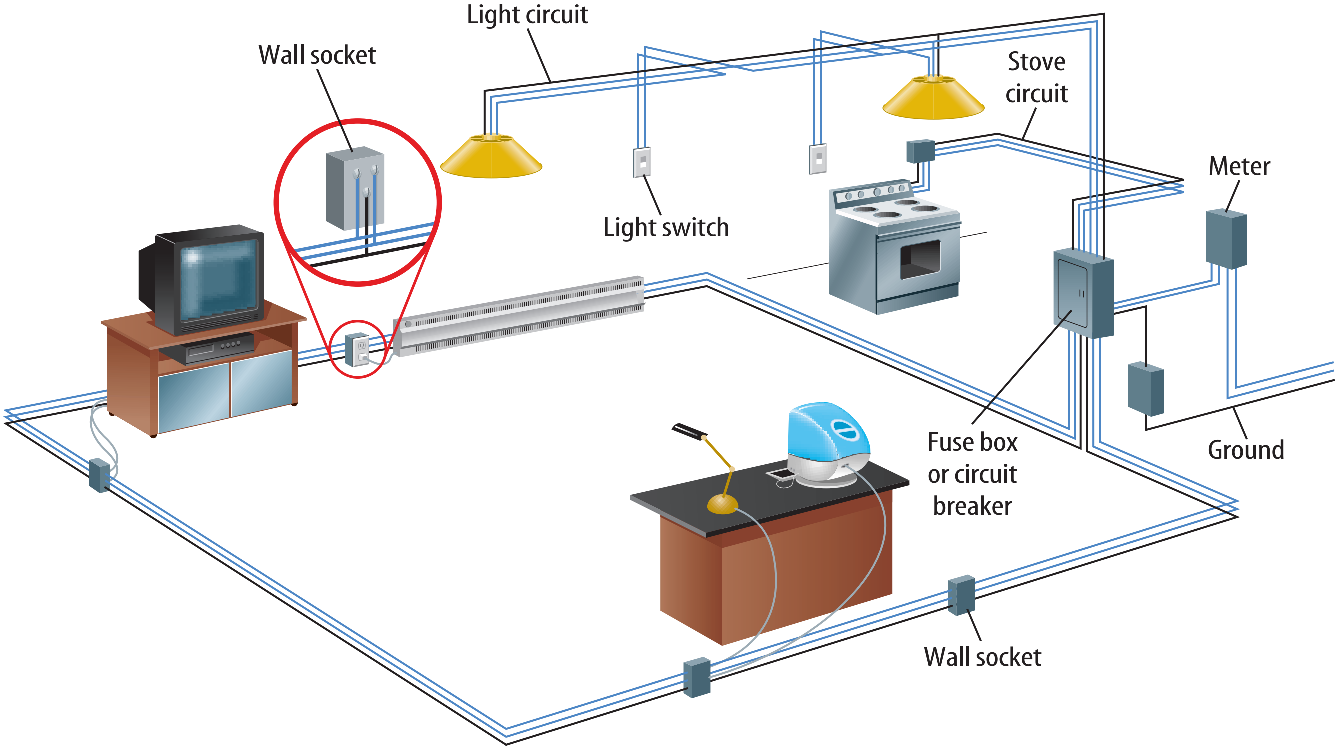
Figure 18
In parallel circuits, the current follows more than one path. *How will the voltage difference compare in each branch?*





CONTENTS

Figure 19
The wiring in a house must allow for the individual use of various appliances and fixtures.
What type of circuit is most common in household wiring?



Household Circuits

Count how many different things in your home require electrical energy. You don't see the wires because most of them are hidden behind the walls, ceilings, and floors. This wiring is made up mostly of a combination of parallel circuits connected in an organized and logical network. **Figure 19** shows how electrical energy enters a home and is distributed. Each branch receives the standard voltage difference from the electric company, which is 120 V in the United States. The main switch and circuit breaker or fuse box serve as an electrical headquarters for your home. Parallel circuits branch out from the breaker or fuse box to wall sockets, major appliances, and lights.

In a house, many appliances draw current from the same circuit. If more appliances are connected, more current will flow through the wires. As the amount of current increases, so does the amount of heating in the wires. If the wires get too hot, the insulation can melt and the bare wires can cause a fire. To protect against overheating of the wires, all household circuits contain either a fuse or a circuit breaker.

A B

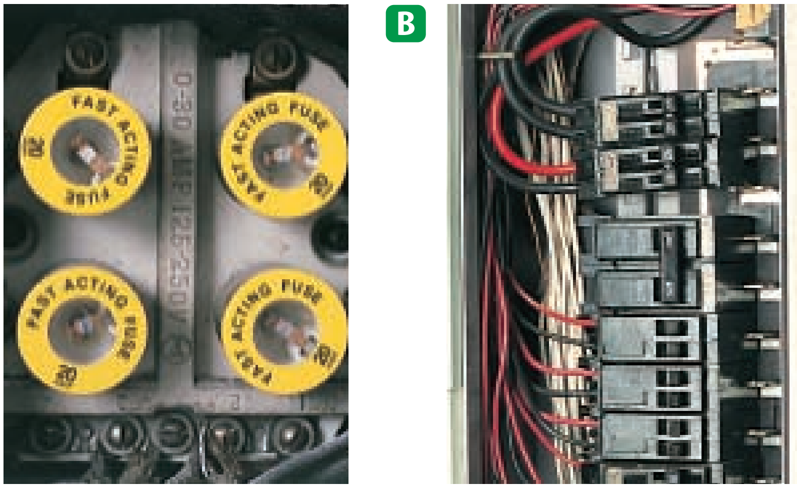


Figure 20
Two useful devices to prevent electric circuits from overheating are A fuses and B circuit breakers. *Which device, a fuse or a circuit breaker, seems more convenient to have in the home?*

Fuses When you hear that somebody has "blown a fuse," it means that the person has lost his or her temper. This expression comes from the function of an electrical fuse, **Figure 20A,** which contains a small piece of metal that melts if the current becomes too high. When it melts, it causes a break in the circuit, stopping the flow of current through the overloaded circuit. To fix this, you must replace the blown fuse with a new one. However, before you replace the blown fuse, you should turn off or unplug some of the appliances. Too many appliances in use at the same time is the most likely cause for the overheating of the circuit.

Circuit Breaker A circuit breaker, **Figure 20B,** is another guard against overheating a wire. A circuit breaker contains a piece of metal that bends when it gets hot. The bending causes a switch to flip and open the circuit, stopping the flow of current. Circuit breakers usually can be reset by moving the switch to its "on" position. Again, before you reset a circuit breaker, you should turn off or unplug some of the appliances from the overloaded circuit.

Reading Check *What is the purpose of fuses and circuit breakers in household circuits?*

Electrical Power

The reason that electricity is so important to your everyday life is that electrical energy is converted easily to other types of energy. For example, electrical energy is converted to mechanical energy as the blades of a fan rotate to cool you. Electrical energy is converted to light energy in lightbulbs. A hair dryer changes electrical energy into thermal energy. The rate at which electrical energy is converted to another form of energy is called **electrical power.**

The electrical power used by appliances varies. Appliances often are labeled with a power rating that describes how much power the appliance uses. Appliances that have electric heating elements, such as ovens and hair dryers, have a large power rating. Why might ovens and hair dryers require a high power rating?

CONTENTS

Calculating Power Appliances with high power ratings can be supplied with the electrical power they need by increasing the amount of charge flowing into the appliance or increasing the electrical pressure on the charge that is flowing already. The relationship among power, voltage, and current can be expressed as follows.

$$\text{power} = \text{current} \times \text{voltage difference}$$
$$P\,(\text{watts}) = I\,(\text{amperes}) \times V\,(\text{volts})$$

Electrical power is expressed in watts (W). For example, a hair dryer might draw 10 A of current at a voltage difference of 120 V. The power rating of the hair dryer is then 10 A times 120 V, or 1,200 W.

Power Rating Every electrical appliance comes with a label that shows how much power it uses. **Figure 21** shows the power-rating label for a typical hair dryer, and **Table 1** lists the power requirements of some appliances. Which appliance requires the most electrical power to operate? You can tell by looking at the number of watts listed for that appliance under the Power Rating column.

Figure 21
All appliances come with a power rating. *Why is a power rating important?*

Table 1 Power and Energy Used by Home Appliances

Appliance	Time of Usage (h/day)	Power Rating (W)	Energy Usage (kWh/day)
Hair dryer	0.25	1,000	0.25
Microwave oven	0.5	700	0.35
Stereo	2.5	109	0.27
Range (oven)	1	2,600	2.60
Refrigerator/freezer (15 ft^3, frostless)	10	615	6.15
Television (color)	3.25	200	0.65
Electric toothbrush	0.08	7	0.0006
100-W lightbulb	6	100	0.60
40-W fluorescent lightbulb	1	40	0.04

SCIENCE Online

Data Update For an online update about the current energy costs in different communities across the United States, visit the Glencoe Science Web site at **science.glencoe.com** and select the appropriate chapter.

CLICK HERE

Electrical Energy

Do you leave the light on or the stereo playing in your room when you aren't there? Consider that any electrical energy you use costs money. Furthermore, most electrical energy is produced from natural resources, such as oil and coal, which are in limited supply.

The amount of electrical energy you use depends on two things. One is the power required by appliances in your home, and the other is how long they are used. Many appliances with high power ratings, such as hair dryers, are used for such a short amount of time that the total amount of electrical energy they require in a given month is small. Appliances that run constantly, such as refrigerators, usually use more total energy. The last column of **Table 1** shows typical energy usage per day for various household appliances.

Math Skills Activity

Calculating Energy

Example Problem

You use your fan for 3 h each day. It has a power rating of 50 W. How much energy does it use in one day? Express your answer in kilowatt-hours.

Solution

1. *This is what you know:* time: $t = 3$ h; power: $P = 50$ W
2. *This is what you need to find:* energy: E
3. *This is the equation you need to use:* $E = P \times t$
4. *To calculate energy, the unit of power must be kW. So convert* P *from W to kW by dividing by 1,000:* $P = \dfrac{50 \text{ W}}{1{,}000 \text{ W/kW}} = 0.05 \text{ kW}$
5. *Substitute the known values:* $E = 0.05 \text{ kW} \times 3 \text{ h}$; $E = 0.15 \text{ kWh}$

Check your answer by solving the original equation, $E = P \times t$, *for* t. *Then substitute* E *and* P. *Do you calculate the same time that was given?*

Practice Problems

1. A 100-W lightbulb has a power rating of 100 W. How much energy in kWh is used when you leave it on for 5 h?
2. Find the power rating for a hair drier on **Table 1.** How much energy is used if you run it for 12 min (0.20 h)?

For more help, refer to the Math Skill Handbook.

Calculating Energy You can calculate the amount of energy an appliance uses in a day by multiplying the power required by the amount of time it uses that power.

$$\text{energy} = \text{power} \times \text{time}$$
$$E\,(\text{kWh}) = P\,(\text{kW}) \times t\,(\text{h})$$

Notice that to calculate energy, power is expressed in kilowatts. One kilowatt is 1,000 W. The unit of electrical energy is the **kilowatt-hour** (kWh). One kilowatt-hour is 1,000 W of power used for 1 h. The electric company charges you periodically for each kilowatt-hour you use. You can figure your electric bill by multiplying the energy used by the cost per kilowatt-hour. **Table 2** shows some sample costs of running electrical appliances. For example, to determine the cost of using a 100-W lightbulb for 20 h, the following calculation is made.

$$\text{cost} = 0.1 \text{ kW} \times 20 \text{ h} \times \$0.09/\text{kWh} = \$0.18$$

Table 2 Cost of Using Home Appliances

Appliance	Hair Dryer	Stereo	Color Television
Average power in watts	1,000	109	200
Hours used daily	0.25	2.5	2.5
Hours used monthly	7.5	75.0	75.0
Monthly watt-hours	7,500	8,175	15,000
kWh used monthly	7.5	8.175	15.000
Rate charge	$0.09	$0.09	$0.09
Monthly cost	$0.68	$0.74	$1.35

Section 3 Assessment

1. What is electrical power? What is electrical energy? How are the two related?
2. Compare and contrast fuses and circuit breakers. Which is easier to use? Why?
3. Do appliances with the highest power ratings always use the most energy per month? Use examples to explain why or why not.
4. How does a series circuit differ from a parallel circuit? Sketch an example of each.
5. **Think Critically** How much energy would be needed for brushing your teeth with an electric toothbrush daily for the month of May? How much would it cost at $0.09 kWh?

Skill Builder Activities

6. **Concept Mapping** Prepare a concept map that shows the steps that are followed in calculating the energy used in operating an electrical device with known voltage difference and current for a known amount of time. **For more help, refer to the Science Skill Handbook.**
7. **Using an Electronic Spreadsheet** On a spreadsheet, list the appliances your family uses daily, the estimated hours per day, and, from **Table 1**, the power usage. Multiply the power usage by the hours per day to find the electrical energy used daily for each appliance. Which appliance uses the most energy? **For more help, refer to the Technology Skill Handbook.**

Activity

Design Your Own Experiment

Comparing Series and Parallel Circuits

Imagine what a bedroom might be like if it were wired in series. For an alarm clock to keep time and wake you in the morning, your lights and anything else that uses electricity would have to be on. Fortunately, most outlets in homes are wired on separate branches of the main circuit. Can you design simple circuits that have specific behaviors and uses?

Recognize the Problem

How do the behaviors of series and parallel circuits compare?

Form a Hypothesis

Predict what will happen to the other bulbs when one bulb is unscrewed from a series circuit and from a parallel circuit. Also, write a hypothesis predicting in which circuit the lights shine the brightest.

Possible Materials

6-V dry-cell battery
small lights with sockets (3)
aluminum foil
paper clips
tape
scissors
paper

Goals

- **Design and construct** series and parallel circuits.
- **Compare and contrast** the behaviors of series and parallel circuits.

Safety Precautions

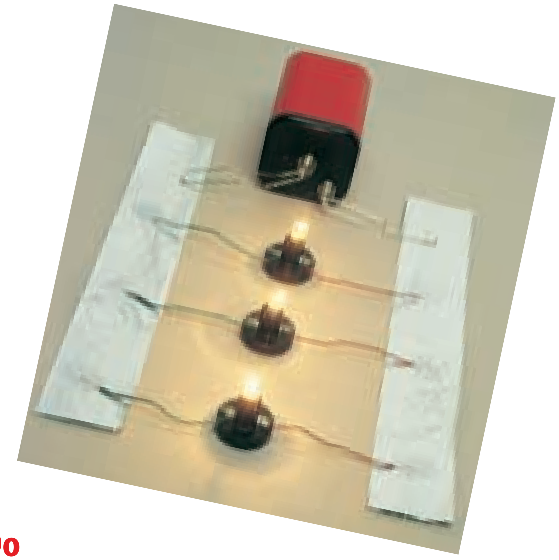
Some parts of circuits can become hot. Do not leave the battery connected or the circuit closed for more than a few seconds at a time. Never connect the positive and negative terminals of the dry-cell battery directly without including at least one bulb in the circuit.

CONTENTS

Test Your Hypothesis

Plan

1. As a group, agree upon and write the hypothesis statement.
2. Work together determining and writing the steps you will take to test your hypothesis. Include a list of the materials you will need.
3. How will your circuits be arranged? On a piece of paper, draw a large parallel circuit of three lights and the dry-cell battery as shown. On the other side, draw another circuit with the three bulbs arranged in series.
4. Make conducting wires by taping a 30-cm piece of transparent tape to a sheet of aluminum foil and folding the foil over twice to cover the tape. Cut these to any length that works in your design.



Do

1. Make sure your teacher approves your plan before you start.
2. Carry out the experiment. **WARNING:** *Leave the circuit on for only a few seconds at a time to avoid overheating.*
3. As you do the experiment, record your predictions and your observations in your Science Journal.

Analyze Your Data

1. **Predict** what will happen in the series circuit when a bulb is unscrewed at one end. What will happen in the parallel circuit?
2. **Compare** the brightness of the lights in the different circuits. Explain.
3. **Predict** what happens to the brightness of the bulbs in the series circuit if you complete it with two bulbs instead of three bulbs. Test it. How does this demonstrate Ohm's law?

Draw Conclusions

1. Did the results support your hypothesis? Explain by using your observations.
2. Where in the parallel circuit would you place a switch to control all three lights? Where would you place a switch to control only one light? Test it.

Communicating Your Data

Prepare a poster to highlight the differences between a parallel and a series circuit. Include possible practical applications of both types of circuits. **For more help, refer to the Science Skill Handbook.**

Science and Language Arts

The Invisible Man

by Ralph Ellison

Respond to the Reading

1. Sometimes you can figure out the meaning of words by their contexts. A word's context refers to the other words in a sentence or phrase that shed light on that word's meaning. Can you guess the meaning of the words *ectoplasm* and *epidermis* by their contexts?
2. What clues does the narrator give that he is not really invisible?
3. Why does the narrator believe he is in the "great American tradition of tinkers"?

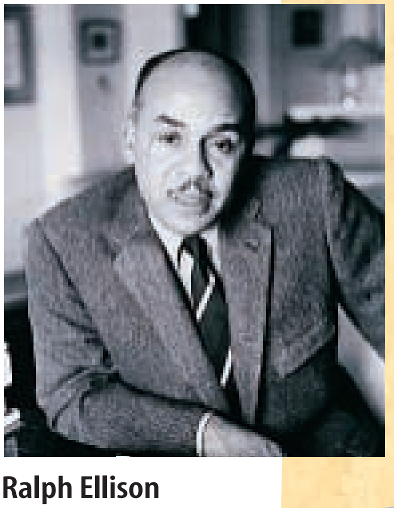
I am an invisible man. No, I am not a spook like those who haunted Edgar Allan Poe; nor am I one of your Hollywood-movie ectoplasms.[1] I am a man of substance, of flesh and bone, fiber and liquids—and I might even be said to possess a mind. I am invisible, understand, simply because people refuse to see me. . . . Nor is my invisibility exactly a matter of biochemical accident to my epidermis.[2] That invisibility to which I refer occurs because of a peculiar disposition of the eyes of those with whom I come in contact. A matter of the construction of their *inner* eyes . . .

. . . Now don't jump to the conclusion that because I call my home a "hole" it is damp and cold like a grave. . . . Mine is a warm hole.

My hole is warm and full of light. Yes, *full* of light. I doubt if there is a brighter spot in all New York than this hole of mine, and I do not exclude Broadway. . . . Perhaps you'll think it strange that an invisible man should need light, desire light, love light. Because maybe it is exactly because I *am invisible.* Light confirms my reality, gives birth to my form. . . . I myself, after existing some twenty years, did not become alive until I discovered my invisibility.

. . . In my hole in the basement there are exactly 1,369 lights. I've wired the entire ceiling, every inch of it. . . . Though invisible, I am in the great American tradition of tinkers. That makes me kin to Ford, Edison and Franklin.

[1]The outer layer of a part of the cell.
[2]The outer layer of skin.



Ralph Ellison

Understanding Literature

Prologue The passage you have just read is a prologue to a novel. A prologue is an introduction to a novel, play, or other work of literature. Often a prologue contains useful information about events to come in the story. In a prologue to a play, an actor addresses the audience directly and tells them what the play will be about or describes the setting of the play.

Foreshadowing is the use of clues by the author to prepare readers for events that will happen.

The prologue of *The Invisible Man,* likewise, sets the stage for the reader by foreshadowing two themes that will reoccur in the novel: invisibility and light.

Science Connection The narrator of *The Invisible Man* says that he has strung 1,369 lights in his basement room. How were this many bulbs wired together? If all the bulbs were all wired together in a series circuit, the electrical resistance in the circuit would be high. By Ohm's law, the current in the circuit would be low and the bulbs wouldn't glow. If all the bulbs were wired in a parallel circuit, so much current would flow in the circuit that the connecting wires would melt. For the bulbs to light, the narrator must have wired them in many independent circuits.

Linking Science and Writing

Prologue Write a prologue to a make-believe book describing Edison's invention of the light bulb. Recall that a prologue is not a summary of the book. The prologue can state general themes that the work of literature will address, or it can set the stage or describe the setting of the story. You might want to discuss what was happening in the world during Edison's time or foreshadow the character and personality traits that enabled him to be a great inventor.

Career Connection

Electrical Engineer

At the age of 10, **Hans Moravec** wired up a tin can man and started building animate things out of inanimate objects. Since 1980, he has been a Principal Research Scientist at the Robotics Institute of Carnegie Mellon University in Pittsburgh. He and his team have built several mobile robots—the latest one is being designed to "see" in three dimensions and to move in crowded spaces without going bump in the night. By 2010, he expects robots, with the improved computers of that time, to be doing many simple tasks.

CLICK HERE

SCIENCE*Online* To learn more about careers in electrical engineering, visit the Glencoe Science Web site at **science.glencoe.com**.

CONTENTS

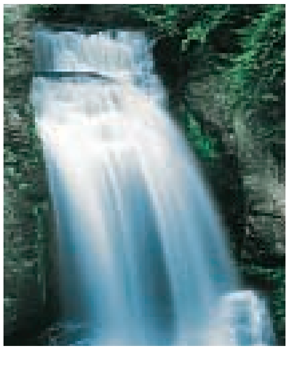
Chapter 7 Study Guide

Reviewing Main Ideas

Section 1 Electric Charge

1. There are two types of electric charge—positive charge and negative charge. Like charges repel and unlike charges attract. *Why are the towels clinging together?*
2. Electric charge is conserved. Charges cannot be created or destroyed.
3. An electrical conductor allows electrons to move through it easily. An electrical insulator doesn't allow electrons to move through it easily.
4. Objects can be charged by contact or by induction. Charging by induction occurs when a charged object is brought near an electrically neutral object.

Section 2 Electric Current



1. Charges flow through a conductor due to a voltage difference. *How is the flow of water similar to the flow of electric charge?*
2. Electric current is the movement of electric charges. A circuit is a closed conducting loop through which electric charges can move.
3. A battery establishes a voltage difference in a circuit by separating positive and negative charges.
4. In an electric circuit, increasing the voltage difference increases the current. Increasing the resistance decreases the current. These relations are known as Ohm's law.

Section 3 Electrical Energy

1. Current has only one path in a series circuit and more than one path in a parallel circuit.
2. Circuit breakers and fuses are safety devices that prevent excessive current from flowing in a circuit.
3. Electrical power is the rate at which electrical energy is used.
4. Utility companies sell electrical energy by the kilowatt-hour, which is 1,000 W of power used for 1 h. *How would your life change if electrical energy were no longer available?*

After You Read

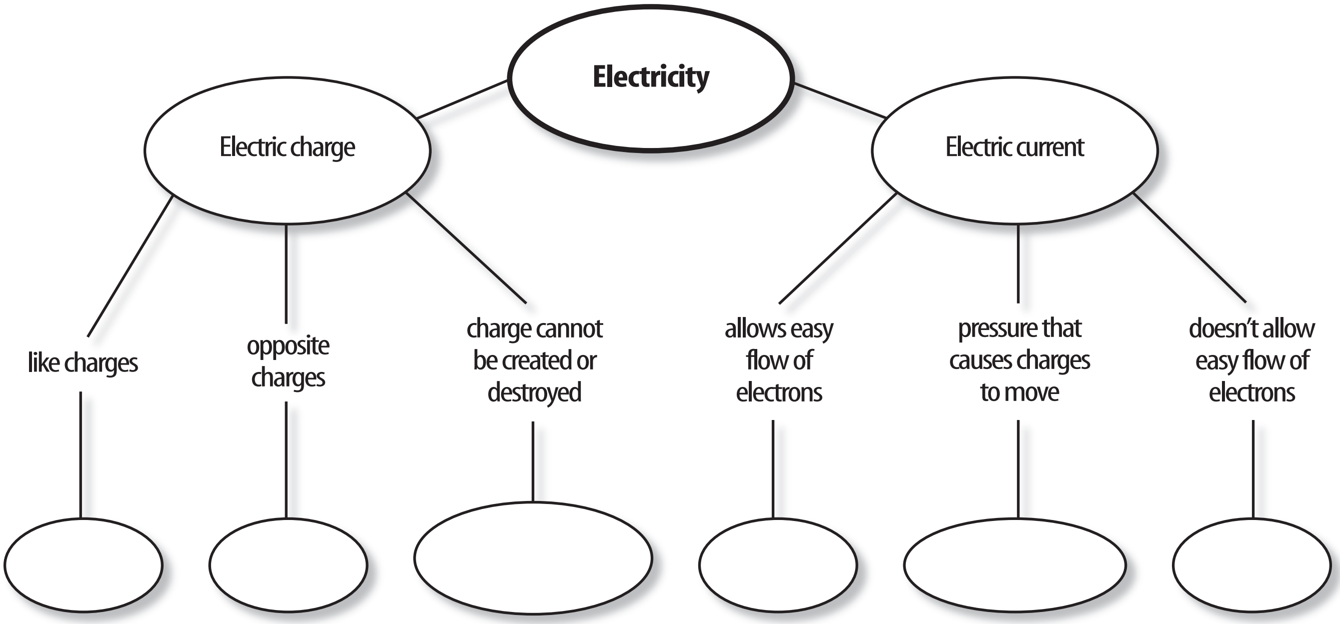
FOLDABLES Reading & Study Skills

Reflect on what you have learned about electricity in this chapter. Record your thoughts under the Learned tab of your Know-Want-Learn Study Fold.

Chapter 7 Study Guide

Visualizing Main Ideas

Use the following terms to complete the concept map: voltage difference, attract, conductor, repel, law of conservation of charge, insulator.



Vocabulary Review

Vocabulary Words

a. charging by contact
b. charging by induction
c. circuit
d. conductor
e. electric current
f. electrical power
g. insulator
h. kilowatt-hour
i. law of conservation of charge
j. Ohm's law
k. parallel circuit
l. resistance
m. series circuit
n. static electricity
o. voltage difference

Using Vocabulary

Distinguish between the terms in each of the following groups of words.

1. law of conservation of charge, Ohm's law
2. electric current, static electricity
3. voltage difference, electrical power
4. series circuit, parallel circuit
5. conductor, insulator
6. electrical power, kilowatt-hour
7. charging by contact, charging by induction
8. circuit, conductor
9. voltage difference, resistance
10. voltage difference, electric current

THE PRINCETON REVIEW **Study Tip**

Find a quiet place to study, whether you are at home or at school. Turn off the television or radio and give your full attention to your lessons.

Chapter 7 Assessment

Checking Concepts

Choose the word or phrase that best answers the question.

1. An object becomes positively charged when which of the following occurs?
   A) loses electrons **C)** gains electrons
   B) loses protons **D)** gains neutrons

2. How do two negative charges interact when they are brought close together?
   A) repel **C)** no interaction
   B) attract **D)** ground

3. What is a common source for a voltage difference?
   A) circuits **C)** wires
   B) batteries **D)** lightning

4. Which of the following is an insulator?
   A) copper **C)** wood
   B) silver **D)** salt water

5. What is the process of connecting an object to Earth with a conductor called?
   A) charging **C)** draining
   B) grounding **D)** induction

6. What is the SI unit used to measure the difference in voltage between two places?
   A) amperes **C)** ohms
   B) coulombs **D)** volts

7. What is the rate at which appliances consume energy?
   A) kilowatt-hour **C)** current
   B) resistance **D)** power

8. Resistance in wires causes electrical energy to be converted to what energy form?
   A) chemical energy **C)** thermal energy
   B) nuclear energy **D)** sound

9. Which of the following wires would tend to have the least amount of resistance?
   A) long **C)** hot
   B) fiberglass **D)** thick

10. What SI unit measures electrical energy?
    A) volts **C)** kilowatts
    B) newtons **D)** kilowatt-hours

Thinking Critically

11. How do lightning rods protect buildings from lightning?

12. Explain how an electroscope could be used to detect a negatively charged object.

13. A toy car with a resistance of 2 Ω is connected to a 3 V battery. How much current flows through the car?

14. The current flowing through an appliance connected to a 120-V source is 2 A. How many kilowatt-hours of electrical energy does the appliance use in 4 h?

15. You are asked to connect a stereo, a television, a VCR, and a lamp in a single, complete circuit. Would you connect these appliances in parallel or in series? How would you prevent an electrical fire? Draw a diagram of your circuit.

Developing Skills

16. **Making and Using Graphs** The resistance in a 1-cm length of copper wire at different temperatures is shown below. One microohm equals one millionth of an ohm. Construct a line graph for the data. Is copper a better conductor on a cold day or a hot day?

Copper Wire Resistance

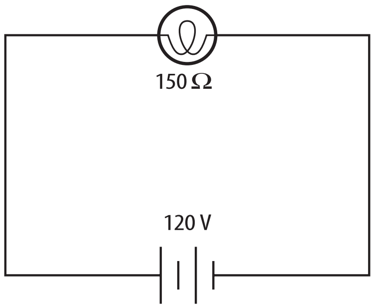
Resistance in Microohms	Temperature (°C)
2	50
3	200
5	475

Chapter 7 Assessment

17. Concept Mapping Make a network concept map sequencing the events that occur when an electroscope is brought near a positively charged object and a negatively charged object. Indicate which way electrons flow and the charge and responses of the leaves.

18. Identifying and Manipulating Variables and Controls Design an experiment to test the effect on current and voltage differences in a circuit when two identical batteries are connected in series. What is your hypothesis? What are the variables and control?

19. Interpreting Scientific Illustrations The diagram below shows a series circuit containing a lamp connected to a standard wall outlet. Using the information in the diagram, compute the current in the circuit shown.



Performance Assessment

20. Poster You probably have seen warnings about contacting overhead power lines. However, birds can perch safely on power lines. Find out how this is possible. Share the information you learn by making a poster for your classroom.

Technology

Go to the Glencoe Science Web site at **science.glencoe.com** or use the **Glencoe Science CD-ROM** for additional chapter assessment.

CLICK HERE

THE PRINCETON REVIEW Test Practice

The local electric company did a study of the power ratings of some common appliances. The results of this study are shown in the chart below.

Power Used by Common Appliances

Appliance	Power (watts)	Appliance	Power (watts)
Clock	3	Stove/oven	2,600
Microwave oven	1,450	Dishwasher	2,300
Clothes dryer	4,000	Refrigerator/ freezer	600
Radio	100	Hair dryer	1,000
Color TV	300	Toaster	700

Study the chart and answer the following questions.

1. According the chart, which appliance requires the least amount of power?

A) toaster
B) clock
C) radio
D) color television

2. According to this information, which appliance requires more than 3,000 W of power?

F) dishwasher
G) microwave oven
H) clothes drier
J) stove/oven