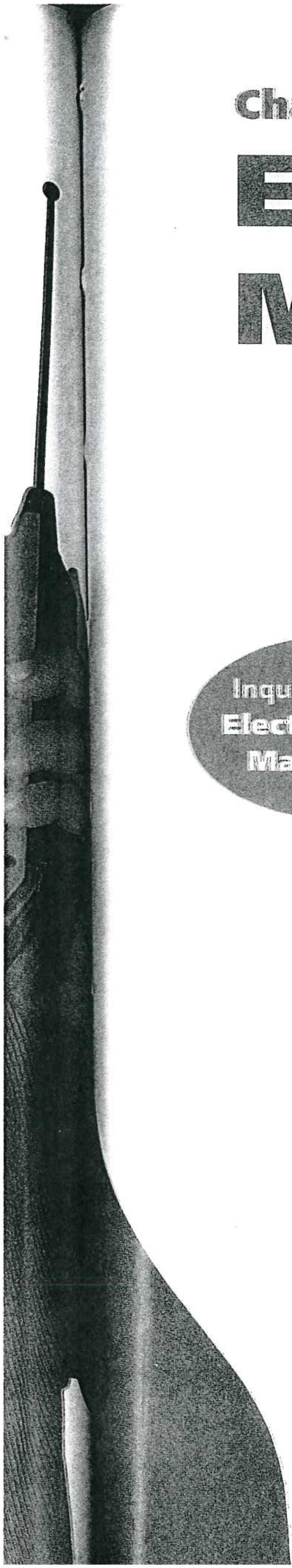


Chapter 3

Electricity and Magnetism

Inquiring about Electricity and Magnetism

Lesson 1
What Is an Electric Current?
- How do objects get an electric charge?
- How does electric current flow?

Lesson 2
How Do Electric Circuits Work?
- What are two types of circuits?
- How can electricity be used safely?

Lesson 3
What Is Magnetism?
- How do magnets act?
- How is the earth like a magnet?

Lesson 4
How Do Electricity and Magnetism Work Together?
- How can a magnet make electricity?
- How can electricity make a magnet?
- How are electromagnets useful?

Copy the chapter graphic organizer *onto your own paper. This organizer shows you what the whole chapter is all about. As you read the lessons and do the activities, look for answers to the questions and write them on your organizer.*

You will learn:

- how objects get an electric charge.
- how electric current flows.

Lesson 1

What Is an Electric Current?

ZAP! Your friend shuffles her feet and walks toward you across the rug. She touches you. **OUCH!** You get an electric shock. What caused this to happen?

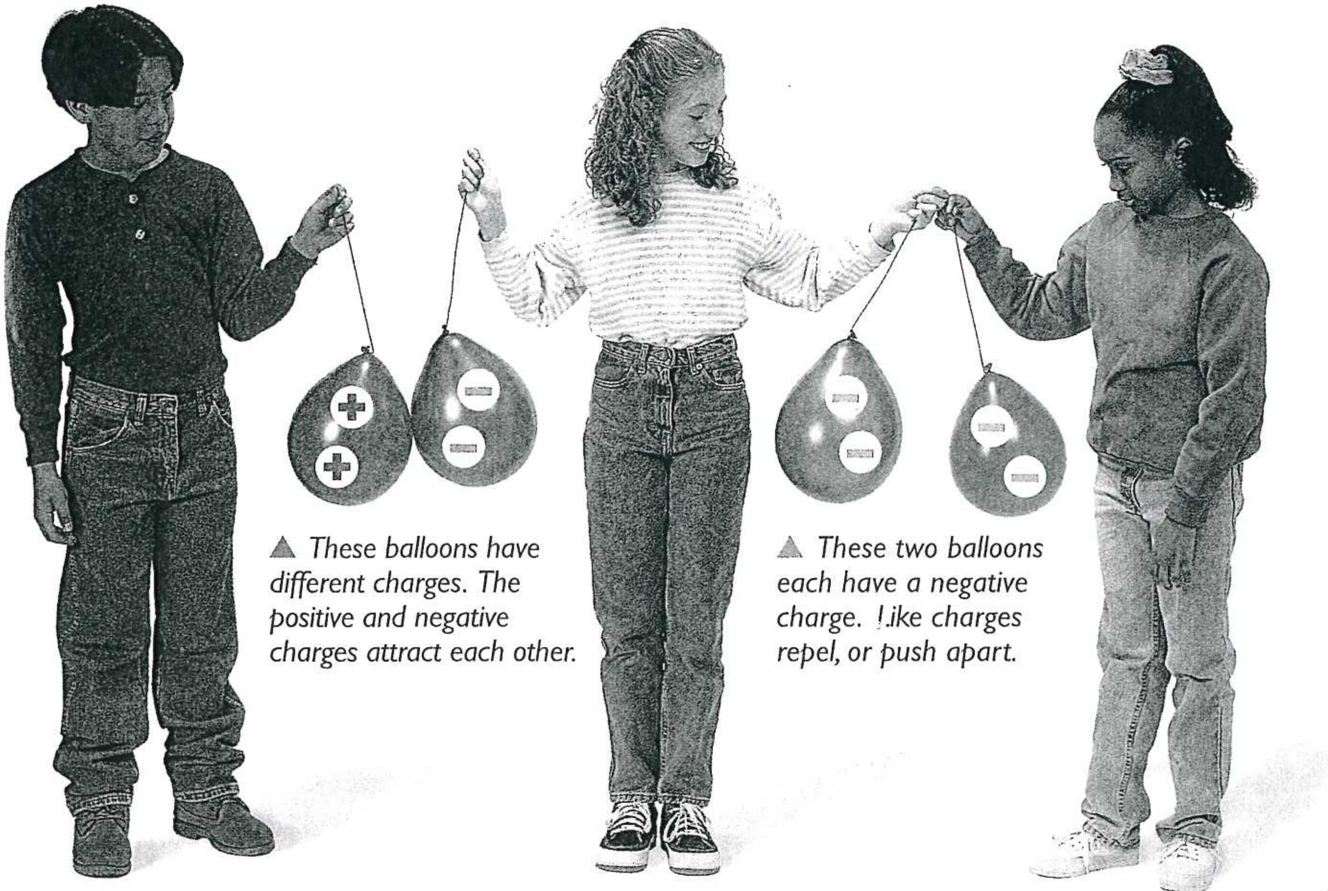
Electric Charge

If you rub two objects together, negative electric charges can move from one object to the other. Objects, such as balloons, people, and rugs, are all made up of matter. Matter is made up of tiny particles, and each of these particles is made of even smaller bits of matter. Some of the smaller bits have a negative (–) electric charge. Other bits have a positive (+) charge, and some have no charge.

Usually, objects have a balance of negative and positive charges. But this can change. Your friend rubbed the rug with her feet. The rubbing caused some bits of matter with negative charges to rub off from the rug onto her.

Before she rubbed the rug, your friend's body and clothing had an equal, or balanced, number of positive and negative charges. The more she rubbed her feet on the rug, the greater the number of negative charges she picked up.

When one person or object has more negative charges than positive charges, the extra negative charges move toward the positive charges in the other person or object. ▼



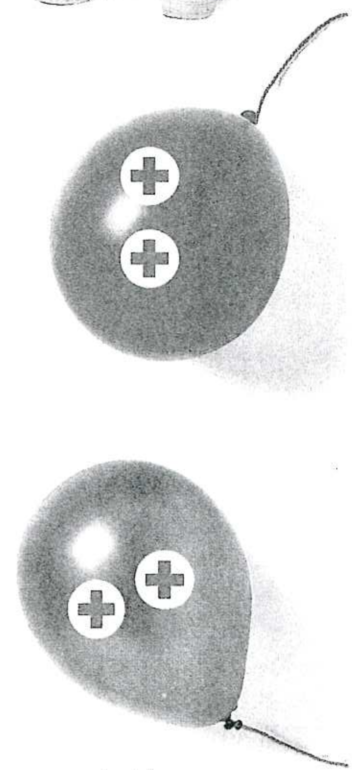
▲ These balloons have different charges. The positive and negative charges attract each other.

▲ These two balloons each have a negative charge. Like charges repel, or push apart.

Meanwhile, you sat there. Your body had a balanced number of negative and positive charges. Notice the different numbers of negative and positive charges on each child in the picture on page B64. When your friend reached toward you, the extra negative charges on her flowed toward the positive charges on you. Zap! You felt an electric shock. She felt the shock too.

What else can happen when an electric charge builds up in things? The electric charges in two objects can cause either a pulling or a pushing force. Look at the pictures on this page to see what happens when objects have like and different charges.

When two objects have different charges, they pull together. When two objects have the same charge, they repel each other, or push apart. If you rub two balloons on your sleeve, negative charges rub onto the balloons. If you hold them each up by a string, the like charges will push the balloons apart.



▲ *Suppose you held up these two balloons. Would their charges push them apart or pull them together? Explain why.*

Electric Current

Electric current is the flow of negative charges through matter. You make small electric charges when you drag your feet on the rug, touch someone, and cause a spark to jump. However, these charges only last a moment. To run a VCR, light bulb, or computer, you need an electric current that continues to flow. In the case of the spark, the charges flow through the air or the person or thing you touch. In the case of a VCR or a light bulb, the electric current flows through metal wires to these appliances.

At home, you plug machines into an outlet or turn on a switch. A strong electric current flows. This current travels to your house through wires from an electric power generator. A battery, such as the ones in the picture, can also provide an electric current to light a bulb or run a radio. However, electric current can only flow when it has a closed path, or a closed circuit, to flow through.

The diagram on the next page shows how electric current flows in a closed circuit. Trace the path of the electric current beginning at the battery.

Glossary

Glossary

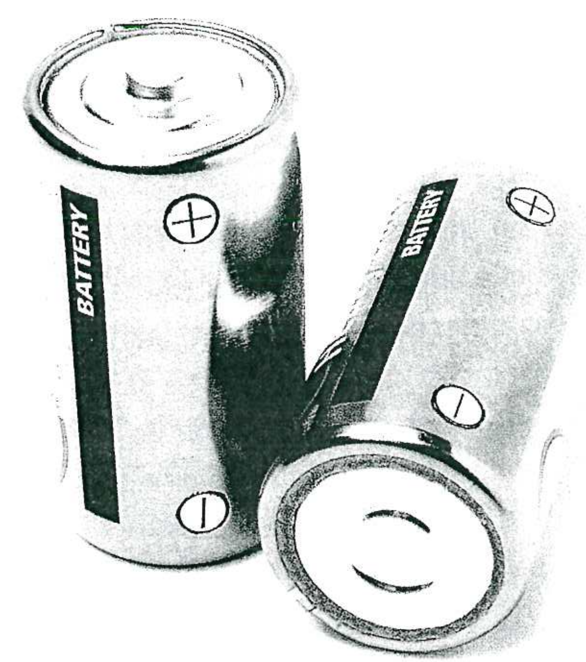
resistance
(ri zis′təns), a measure of how much a material opposes the flow of electric current and changes electric current into heat energy

conductor
(kən duk′tər), a material through which electric current passes easily

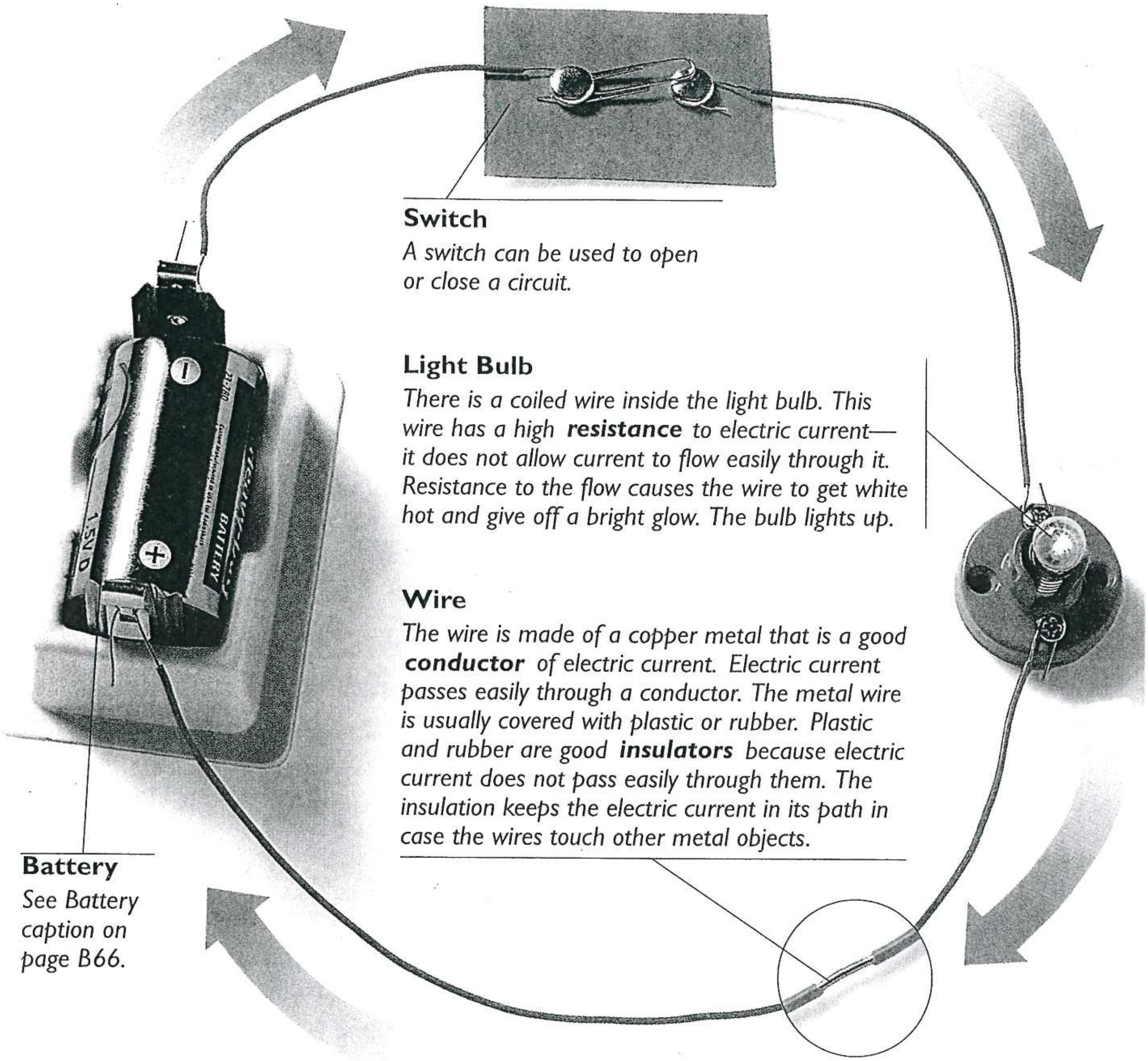
insulator
(in′sə lā′tər), a material through which electric current does not pass easily

Battery

Have you noticed the "+" and "–" marks on batteries? The "+" end of the battery has a positive charge. The "–" end has a negative electric charge. When the battery is in a closed circuit, the negative charges flow out from the negative end of the battery, through the wires, and back to the battery's positive end. Follow the path of the closed circuit on the next page. ▶



A Closed Circuit



Switch
A switch can be used to open or close a circuit.

Light Bulb
There is a coiled wire inside the light bulb. This wire has a high **resistance** *to electric current— it does not allow current to flow easily through it. Resistance to the flow causes the wire to get white hot and give off a bright glow. The bulb lights up.*

Wire
The wire is made of a copper metal that is a good **conductor** *of electric current. Electric current passes easily through a conductor. The metal wire is usually covered with plastic or rubber. Plastic and rubber are good* **insulators** *because electric current does not pass easily through them. The insulation keeps the electric current in its path in case the wires touch other metal objects.*

Battery
See Battery caption on page B66.

Lesson 1 Review

1. How does an object get an electric charge?
2. What happens to an electric current when a circuit is closed?
3. **Cause and Effect**
   What causes the bulb to light in a closed circuit?

What's the Big Idea?

You will learn:

- about two types of circuits.
- how electricity can be used safely.

Lesson 2

How Do Electric Circuits Work?

Light! Color! Sound! Flip a switch, and your computer comes alive. Because electric current flows through wires in circuits in your home or school, you can learn by computer or surf the internet. Visit the website at www.sfscience.com.

Electric Circuits

You know that electric current flows only through a closed circuit. As long as the path is unbroken, the current flows. To break a closed circuit, you turn off a switch or remove a part of the path. When electric current does not travel through a circuit, the circuit is open. Just think! Every time you turn off a light, you open a closed circuit.

Series Circuit

The bulbs and wires make one single path. Use your finger to trace the path of the current through the circuit.

A series circuit is one way to build a closed electric circuit. In a **series circuit,** several light bulbs or other appliances are connected in one path. Find the series circuit in the picture on page B68. Notice that there is only one possible path for the electric current to follow.

In a series circuit, all the parts must be "on" to complete the circuit. If even one light bulb is missing or burned out, the whole circuit won't work. If your classroom had a series circuit, the computer would shut off every time someone turned off the lights!

Another way to build a closed electric circuit is a parallel circuit. In a **parallel circuit,** each bulb has its own path. Find the parallel circuit in the picture.

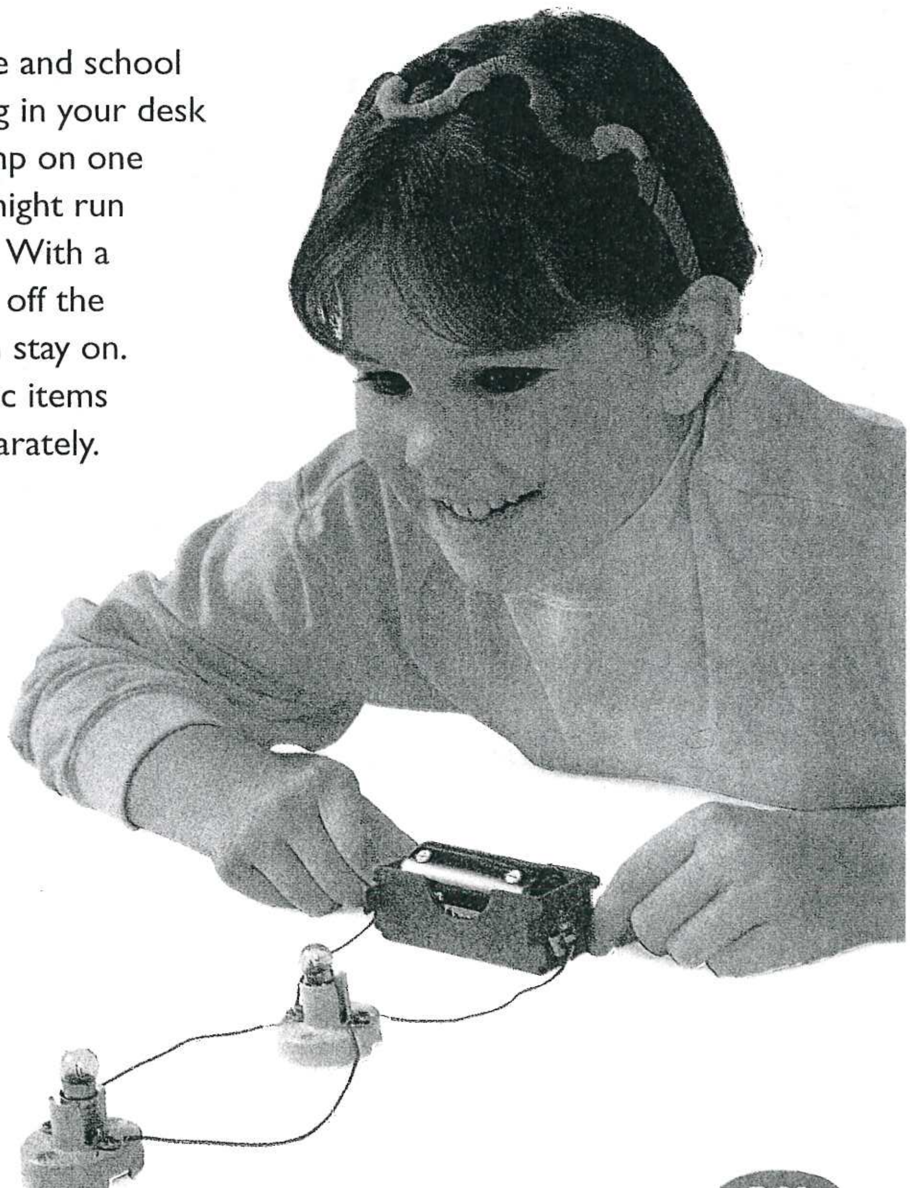
The circuits in your home and school are parallel circuits. You plug in your desk lamp. This puts the desk lamp on one parallel circuit. Your radio might run on the same parallel circuit. With a parallel circuit, you can turn off the desk lamp and the radio can stay on. Parallel circuits allow electric items to be turned on and off separately.

Glossary

Glossary

series circuit
(sir′ēz sėr′kit), a circuit that connects several objects one after another so that the current flows in a single path

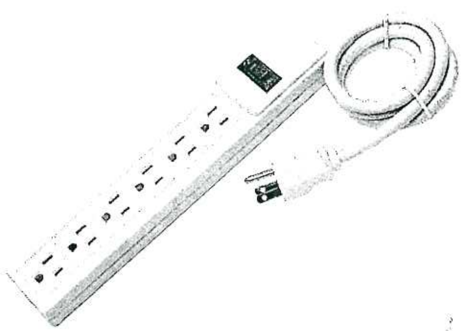
parallel circuit
(par′ə lel sėr′kit), a circuit that connects several objects in a way that the current for each object has its own path



Parallel Circuit ▶
If a bulb is burned out, the circuit is still closed. The current can still flow. Use your finger to trace two ways to make a closed circuit.

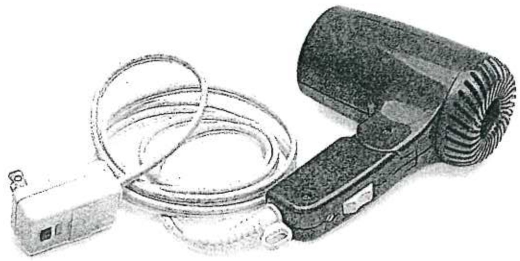
Using Electricity Safely

Electricity must always be used with great care. A strong electric current traveling into your body can be very dangerous. The shock can cause bad burns to your body, or even stop your heart! Electric current also produces heat and can start fires. To use electricity safely, follow the guidelines on these pages.



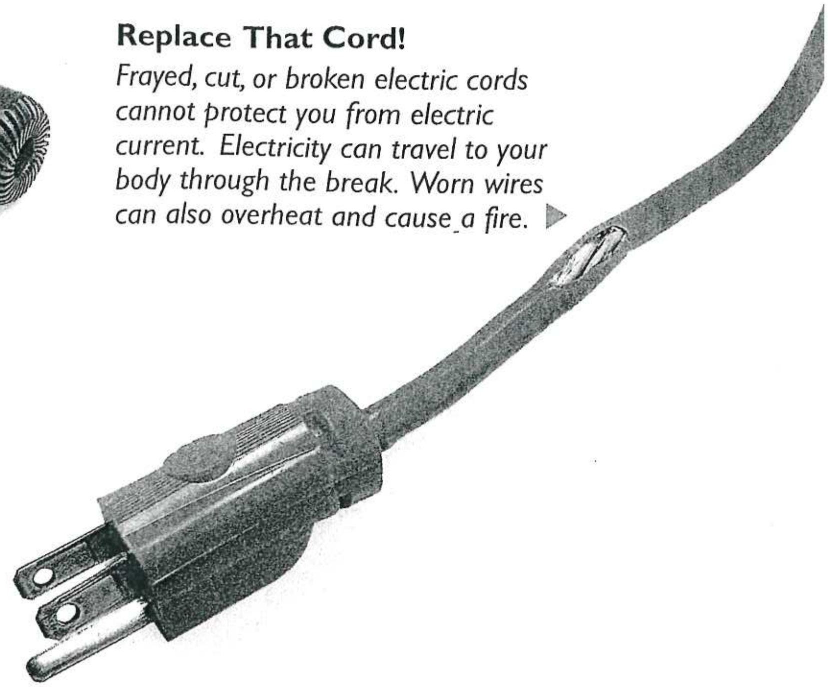
Unload That Outlet!

Don't plug too many appliances into one outlet. Too much current traveling through one circuit can cause an overload. The wires inside a wall can get too hot and start a fire. Using a special safety power strip can help prevent overloading a circuit.

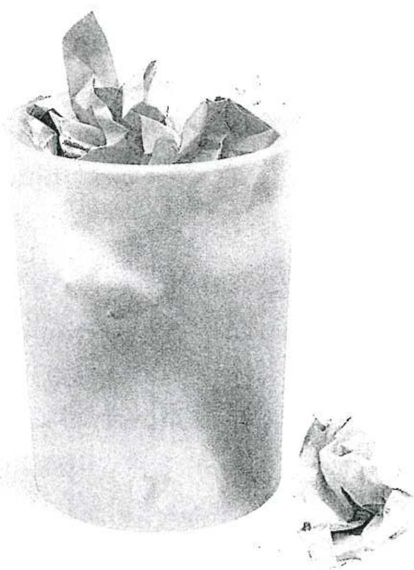


▲ **Unplug Those Appliances!**
Be sure to unplug your hair dryer or curling iron when you finish using it. It could cause a fire.

Replace That Cord!
Frayed, cut, or broken electric cords cannot protect you from electric current. Electricity can travel to your body through the break. Worn wires can also overheat and cause a fire. ▶



Move Those Papers!
Make sure that papers and other objects that can burn are moved away from an electric heater before it is turned on. Papers, curtains, and other objects that can burn might catch fire from the heater. ▶



▲ **Keep It Dry!**
Water conducts electricity. So can your body. Never touch electric appliances or cords when you are wet. Never use electric appliances around water. Make sure counters, sinks, and floors are dry.

Lesson 2 Review

1. How is a series circuit different from a parallel circuit?
2. Name three ways to use electricity safely.
3. **Cause and Effect**
   Write about how the unsafe use of electricity can cause harm.

What's the Big Idea?

You will learn:

- how magnets act.
- how the earth is like a magnet.

Lesson 3

What Is Magnetism?

You notice a note on the refrigerator door. Then you pull open the door. Guess what? You just found two magnets. One magnet holds the note on the metal door. Another magnet, hidden inside the door, holds the door closed.

How Magnets Act

A **magnet** is anything that will attract, or pull, iron, steel, and certain other metals to it. **Magnetism** is the pulling or pushing force that exists around a magnet. When you place a magnet near iron or steel, the two objects pull toward each other with a strong force. Because a refrigerator door is made partly of steel, a magnet will easily stick to it.

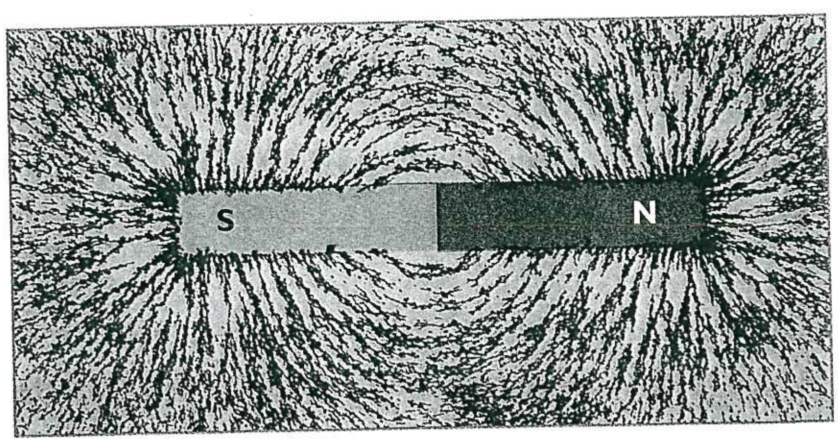
A **magnetic field** is the space around a magnet where magnetism acts. Magnetic force is invisible, but you can use tiny pieces of iron to see the magnetic field formed by magnetic force. Find the magnetic field in the picture below.

Glossary

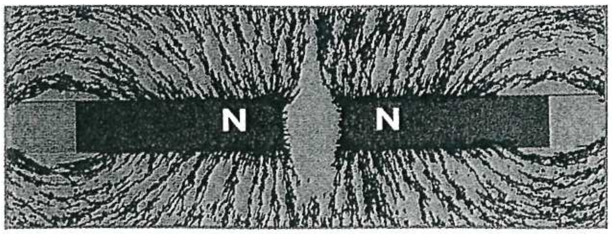
magnet (mag′nit), anything that pulls iron, steel, and certain other metals to it

magnetism (mag′nə tiz′əm), the force around a magnet

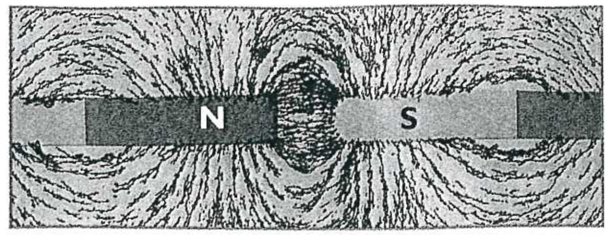
magnetic field (mag net′ik fēld), the space around a magnet where magnetism acts



The tiny pieces of iron line up along the lines of magnetic force. The iron pieces cluster around the poles, where the magnetic force is the greatest. ▶



▲ *Like poles push apart. Here the like ends of two magnets are near each other. The magnetic forces repel, or push away from, each other. The magnets push apart.*



▲ *Unlike poles pull together. Here the unlike ends of two magnets are near each other. The magnetic forces attract, or pull strongly together. The magnets may snap together.*

The magnets shown here have two ends called **poles.** If these magnets are allowed to swing freely, one pole, the north-seeking pole, points north. Sometimes it is marked N. The south-seeking pole points south. Sometimes it is marked S.

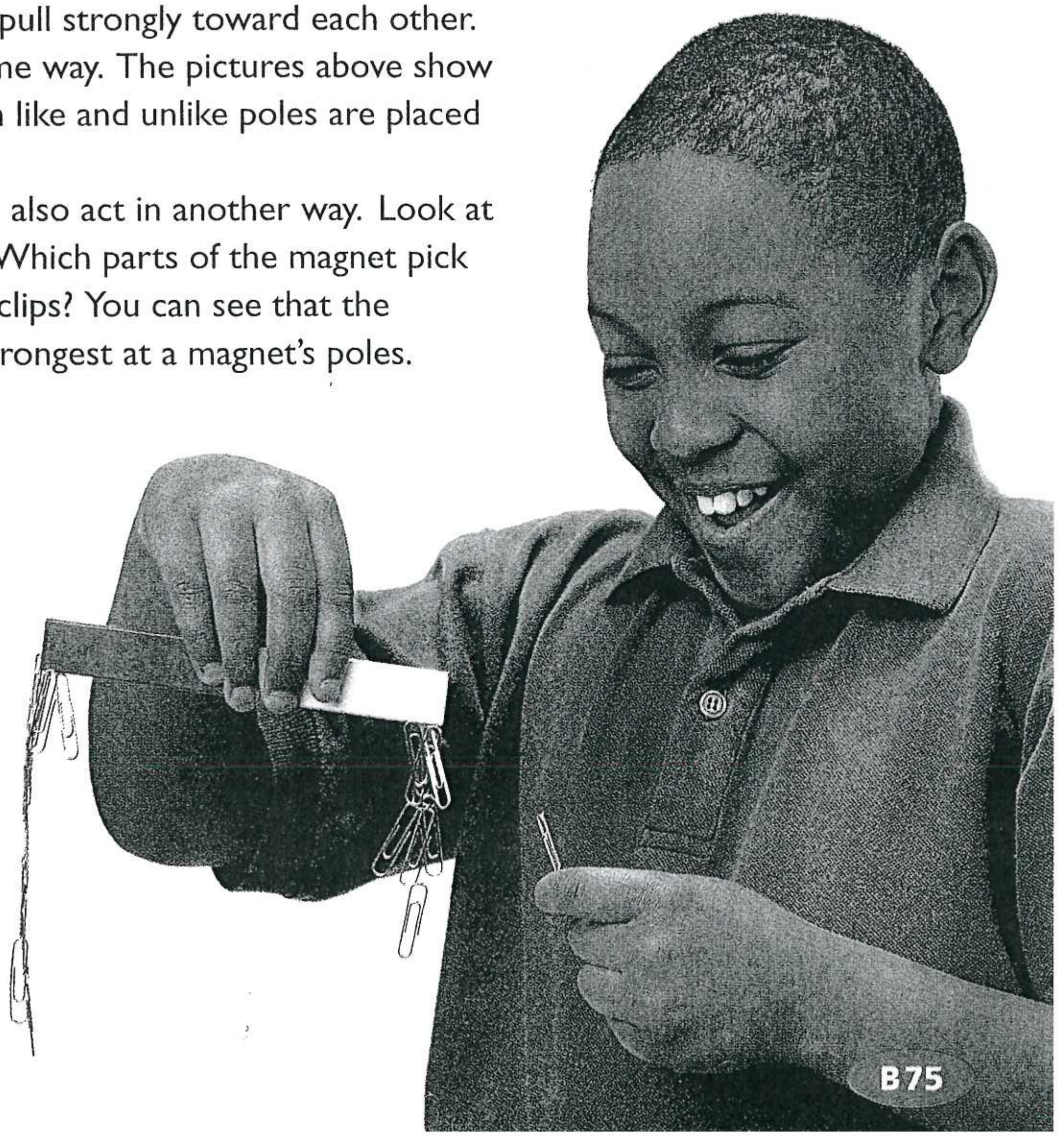
How else do a magnet's poles act? You know that like electric charges push away from each other and that unlike charges pull strongly toward each other. Magnets act the same way. The pictures above show what happens when like and unlike poles are placed near each other.

A magnet's poles also act in another way. Look at the picture below. Which parts of the magnet pick up the most paper clips? You can see that the magnetic force is strongest at a magnet's poles.

Glossary

pole (pōl), a place on a magnet where magnetism is strongest

Glossary



More paper clips stick to the ends, or poles, of the magnet. ▶

Glossary

compass (kum′pəs), a small magnet that can turn freely

▲ *The lodestone attracts the metal nails.*

The Earth: A Giant Magnet

In ancient times, people noticed certain rocks that pulled together or pushed apart. These rocks, such as the one in the picture, are called lodestones. The early Greeks had legends, or stories, about magnetic rocks. One story was about a shepherd. The legend claimed that the iron tacks in his sandals stuck to a rock when he stepped on it. Another legend claimed that a magnetic mountain could pull nails out of wooden ships.

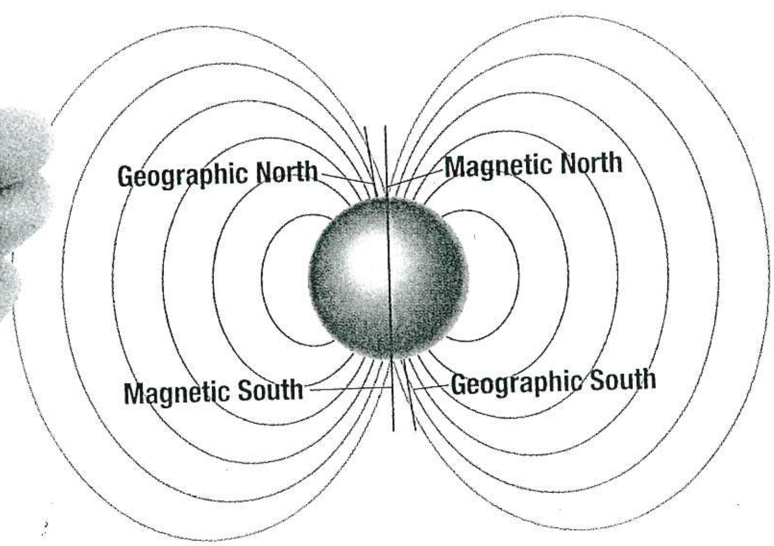
History of Science

The Chinese used lodestones thousands of years ago. They discovered that if a lodestone swings freely, one end points north. A Chinese general used this method to lead his army through heavy fog.

In about 1600, an English doctor named William Gilbert made a compass needle that acted the same toward the earth as it did toward a lodestone. This showed that the earth itself is a magnet. Now scientists know that the earth, like all magnets, has a south magnetic pole, a north magnetic pole, and a magnetic field.

Notice the compass in the picture. A **compass** is a small magnet that can turn freely. Its north-seeking pole points toward north. Today people use a compass to find directions.

The earth's north magnetic pole is about 1,600 kilometers from its north geographic pole. The compass is pointing toward the north magnetic pole. ▼



Earth Science

If you live in the far northern parts of the United States or Canada, you can sometimes see the northern lights. The lights, as shown in the picture, are caused by the earth's magnetic field. You remember how bits of iron are pulled and pushed into a pattern around a magnet's poles. Charged particles from the sun are pulled and pushed into patterns in the sky near the earth's magnetic poles. The particles react with gases in the air, making the brightly colored lights.

▲ *The northern lights, seen near the earth's magnetic north pole, are also called the* aurora borealis. *Lights seen near the earth's magnetic south pole are called the southern lights, or* aurora australis.

Lesson 3 Review

1. What is magnetism?
2. How is the earth's magnetism useful?
3. **Cause and Effect**
   What causes the northern and southern lights to occur?

You will learn:

- how a magnet can make electricity.
- how electricity can make a magnet.
- how electromagnets are useful.

Lesson 4

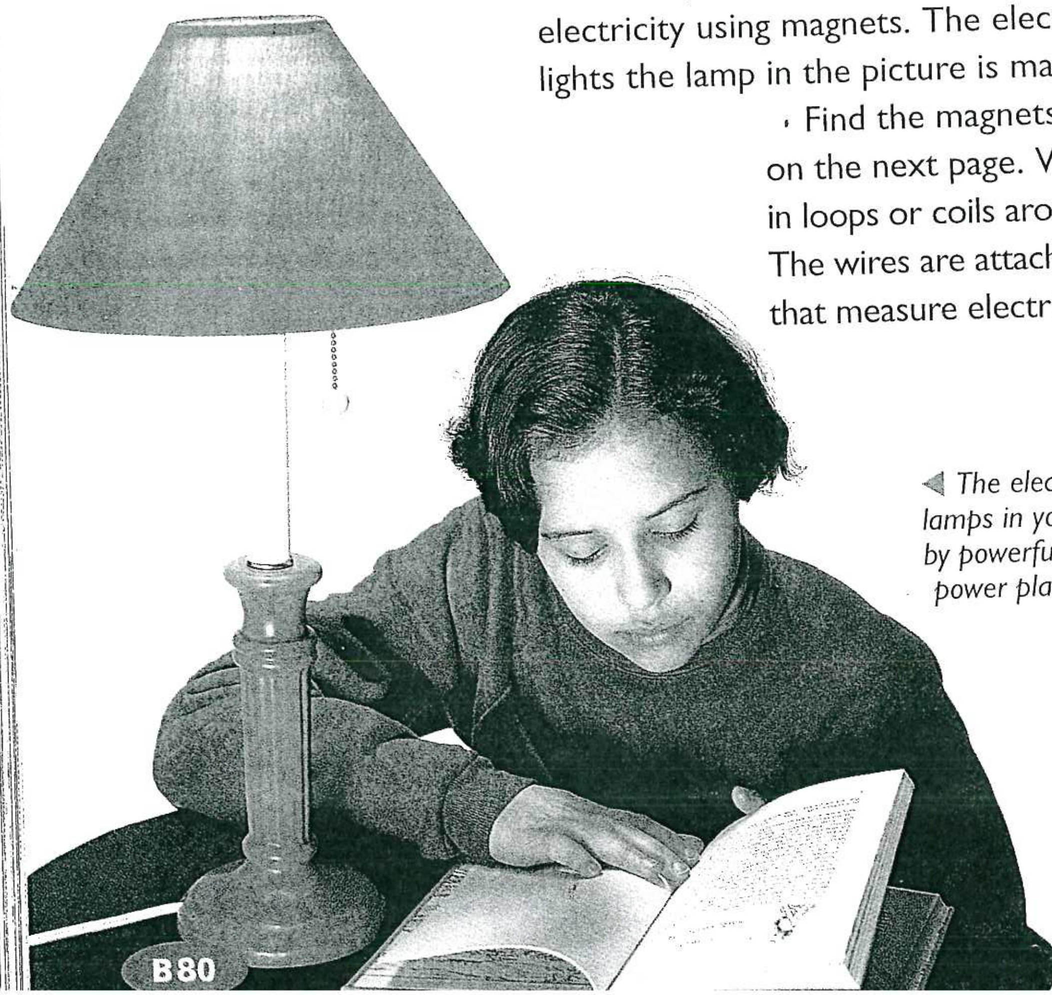
How Do Electricity and Magnetism Work Together?

Brrring! A telephone rings. Beeeeep! An alarm clock beeps. Ding-Dong! A doorbell chimes. All of these things work because electricity and magnetism work together.

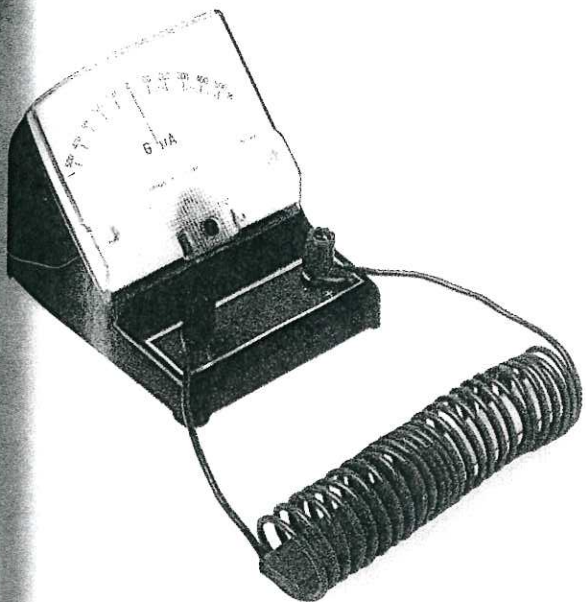
Electricity from Magnets

Magnets and electricity are closely linked. You already know that they act in some similar ways. However, you may not know that you can make electricity using magnets. The electric current that lights the lamp in the picture is made from a magnet.

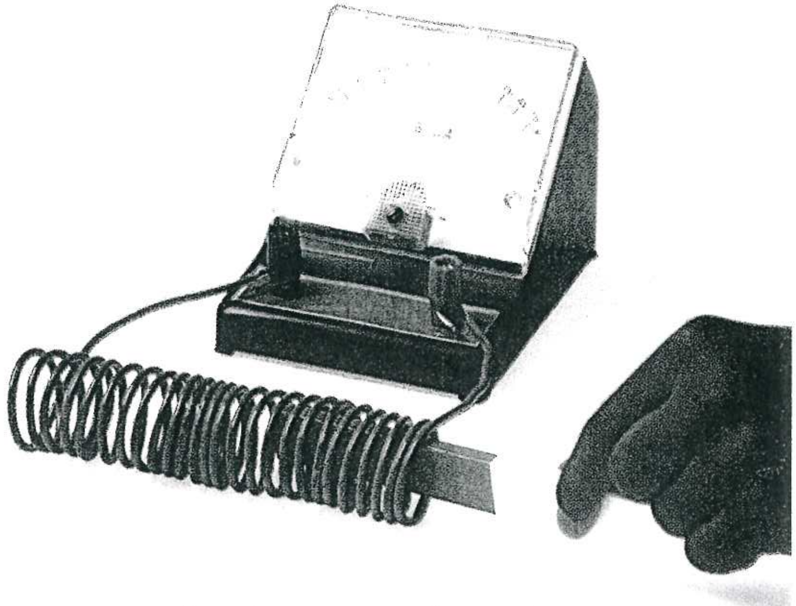
Find the magnets in the pictures on the next page. Wires are wound in loops or coils around the magnets. The wires are attached to meters that measure electric current.



The electricity used to light lamps in your home is made by powerful magnets in a power plant.



▲ *When no electric current flows, the pointer points straight up, at 0.*



▲ *The pointer moves or jumps when electric current flows. As a student moves the magnet back and forth inside the wire coil, the pointer moves. Electricity is flowing through the wire.*

The picture shows how electric current can be made, or generated, by moving a magnet through coils of wire. Electricity can be made from a magnet in several ways. You can slide a magnet back and forth inside a coiled wire or spin a magnet inside a coiled wire. You might also slide a coiled wire back and forth along a magnet or spin a coiled wire around a magnet.

The coiled wire and magnet make just a small model, but it shows how electricity is generated for your home. Most electric power is made by large machines called **generators.** Generators have huge magnets and huge coils of wire. Of course, they are too heavy to move or turn by hand. Some electric generators are powered by wind or rushing water. Others are powered by steam produced by nuclear power or by the burning of coal, gas, or oil.

Glossary

generator
(jen′ə rā′tər), a machine that uses an energy source and a magnet to make electricity

Glossary

electromagnet
(i lek′trō mag′nit), a magnet made when an electric current flows through a wire

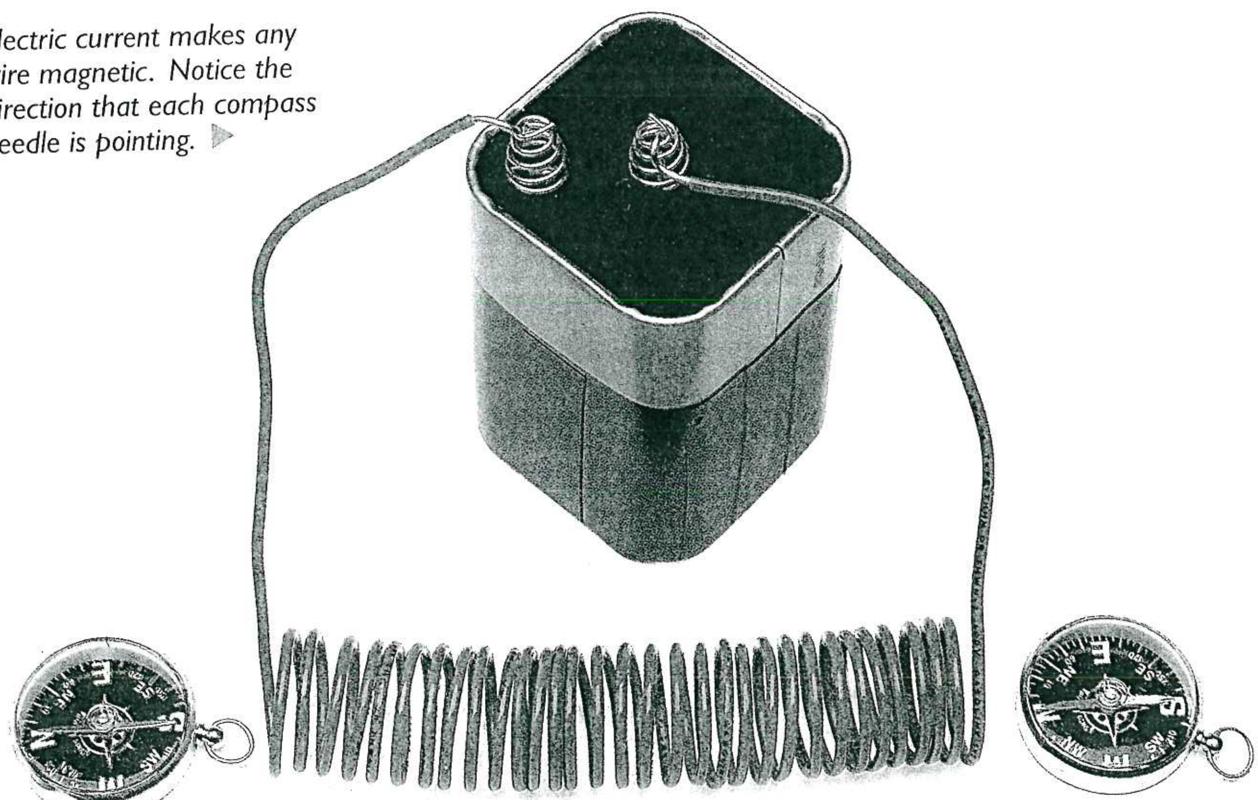
Magnets from Electricity

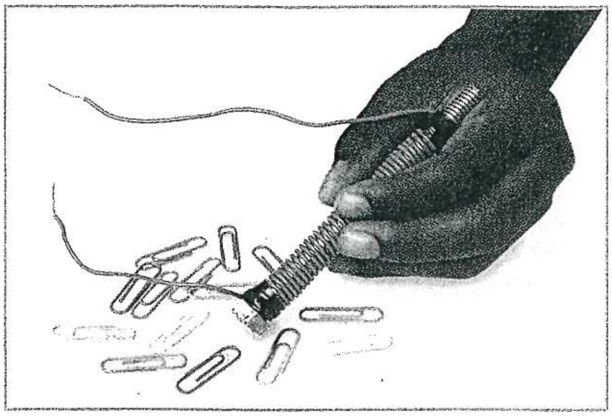
History of Science

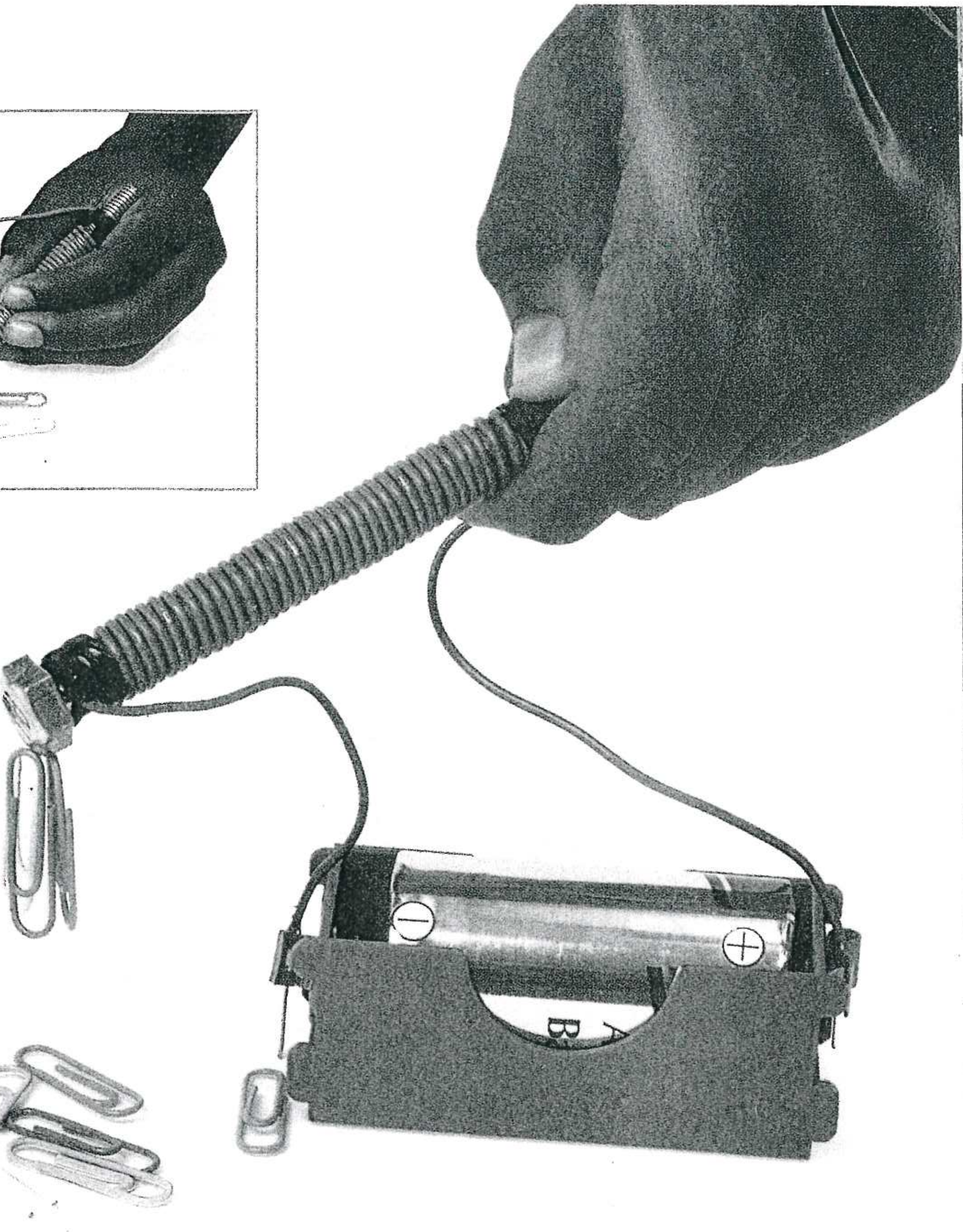
About 180 years ago, a scientist named Hans Christian Oersted was experimenting with electricity. Oersted connected some wire to a large battery so that electricity would flow through the wire. To his surprise, he noticed that when the electric current flowed through the wire something else happened. The needle on a nearby compass moved and pointed toward the wire. Oersted then realized that electricity and magnetism are linked. He concluded that electric current causes a wire to become magnetic.

An **electromagnet** is a temporary magnet made when electric current flows through a wire coil. The picture on this page shows one way to make an electromagnet. If you pass electricity through a coiled wire, the wire becomes magnetic. When the electric current stops flowing, the wire loses its magnetism.

Electric current makes any wire magnetic. Notice the direction that each compass needle is pointing.







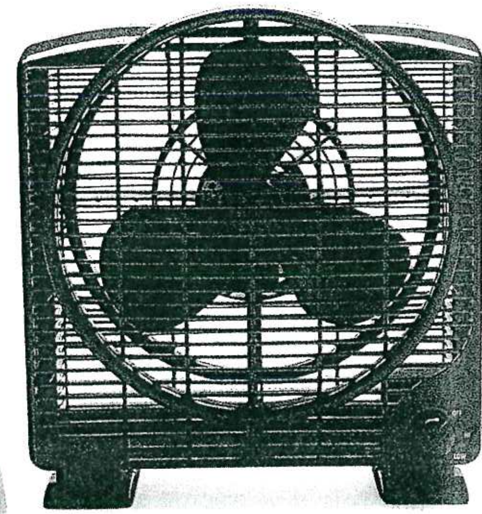
Now look at the picture above showing a wire wrapped around a bolt. This is another way to make an electromagnet. The wire is wrapped about 40 times around a bolt. When the ends of the wire are connected to a battery, electric current flows through the wire. The bolt and the coiled wire together make an electromagnet that is stronger than the electromagnet made with the coiled wire alone.

▲ *The magnetic field of the wire joins the magnetic field of the bolt. This makes an electromagnet strong enough to pick up paper clips.*

Many Uses for Electromagnets

▲ *The pushing of the doorbell closes an electric circuit. Then electric current flows through an electromagnet, and the doorbell rings.*

Electromagnets have many uses because they can be turned on and off by closing and opening an electric circuit. The appliances shown on this page all have electromagnets that make them work.



▲ *When the switch on a fan is turned on, electric current creates an electromagnet that runs the motor in the fan.*

▲ *When electricity flows through an electromagnet in a telephone, the telephone rings.*

Lesson [illegible] Review

1. How can a coil of wire and a magnet be used to make electricity?
2. How can electricity be used to make a magnet?
3. Why are electromagnets sometimes more useful than ordinary magnets?
4. **Cause and Effect**
   In your own words, write in the correct order the steps that describe how an electric fan runs.

Name ______________________ Date __________

Reviewing Main Ideas: True or False

Write **T** (True) or **F** (False) on the line before each sentence.

_____ **1.** All objects are made up of tiny bits of material that have electric charges.

_____ **2.** Most objects have positive charges.

_____ **3.** When two objects have the same charge, they attract each other.

_____ **4.** An electric charge may be either positive or negative.

_____ **5.** An electric current is a flow of negative charges.

_____ **6.** An electric circuit must have an opening for the electricity to enter through.

_____ **7.** A conductor is a substance that electric current easily passes through.

_____ **8.** A light bulb gives off light because the wire inside it is an insulator.

_____ **9.** Batteries and generators provide electric power.

Applying Strategies: Cause and Effect

Use complete sentences to answer question 10.

10. You rub two balloons on your sleeve. When you hold each balloon by a string, they move away from each other. Explain why this happens.

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Name ______________________ Date __________

Assessment
Chapter 3 Lesson 2

Reviewing Main Ideas: True or False

Write **T** (True) or **F** (False) on the line before each sentence.

_____ **1.** Electric current flows only through a closed circuit.

_____ **2.** When you turn on a light or other electric appliance, you close a circuit.

_____ **3.** In a series circuit, each light or appliance has its own path for electricity.

_____ **4.** Most circuits in your home and school are parallel circuits.

_____ **5.** Electricity can kill or seriously injure you.

_____ **6.** It is safe to use electricity around water, because water is an insulator.

_____ **7.** A frayed electrical cord cannot start a fire.

_____ **8.** You should always unplug a hair dryer or iron when it is not in use.

_____ **9.** A safety power strip is used to increase the amount of electricity flowing into your computer.

Applying Strategies: Cause and Effect

Use complete sentences to answer question 10.

10. Explain two ways that the unsafe use of electricity can cause harm.

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Name ______________________ Date __________

Assessment
Chapter 3 Lesson 3

Reviewing Main Ideas: Matching Words and Meanings

Match each term with its meaning. Write the letter of the term on the line.

_____ **1.** an object that pulls iron and steel toward it

_____ **2.** the force around a magnet

_____ **3.** the area around a magnet where magnetic forces can be felt

_____ **4.** that part of a magnet where magnetic forces are strongest

_____ **5.** to push away

_____ **6.** a magnetic rock

_____ **7.** a small magnet that can turn freely

_____ **8.** lights in the sky caused by Earth's magnetic field

_____ **9.** to pull toward

a. repel
b. magnetism
c. lodestone
d. northern lights
e. magnetic field
f. attract
g. magnet
h. compass
i. parallel circuits
j. poles

Applying Strategies: Cause and Effect

Use complete sentences to answer question 10.

10. Explain why a compass can be used to find direction.

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Name ______________________ Date __________

Assessment
Chapter 3 Lesson 4

Reviewing Main Ideas: True or False

Write **T** (True) or **F** (False) on the line before each sentence.

_____ **1.** Electric current can be generated with magnets.

_____ **2.** The magnets inside electric generators are usually small enough to be turned by hand.

_____ **3.** Magnetism and electricity are closely linked.

_____ **4.** An electromagnet is created when electric current flows through a compass needle.

_____ **5.** Hans Christian Oersted discovered electricity.

_____ **6.** An electromagnet made of a coiled wire and a metal bolt is stronger than one made with a wire alone.

_____ **7.** Electromagnets can be turned off by opening an electric circuit.

_____ **8.** Telephones use electromagnets.

_____ **9.** Electric current causes a coiled wire to become an electric bell.

Applying Strategies: Cause and Effect

Use complete sentences to answer question 10.

10. Explain how Hans Christian Oersted realized that electricity and magnetism are related.

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