CALIFORNIA Standards Preview

Standard Set 1. Physical Sciences

1. Electricity and magnetism are related effects that have many useful applications in everyday life. As a basis for understanding this concept:

1.b. *Students know* how to build a simple compass and use it to detect magnetic effects, including Earth's magnetic field.

1.c. *Students know* electric currents produce magnetic fields and know how to build a simple electromagnet.

1.d. *Students know* the role of electromagnets in the construction of electric motors, electric generators, and simple devices, such as doorbells and earphones.

1.e. *Students know* electrically charged objects attract or repel each other.

1.f. *Students know* that magnets have two poles (north and south) and that like poles repel each other while unlike poles attract each other.

1.g. *Students know* electrical energy can be converted to heat, light, and motion.

Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Main Idea and Details	• Captions • Call Outs • Diagrams • Glossary	Magnetism

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California Science Explorer

Physical Sciences

Magnetism and Its Uses

by Anne Cambal

Vocabulary

electromagnet
generator
magnetism
magnetic field
magnetic poles

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3 Tony Randazzo; 7 Peter Bollinger.

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Magnetism *and* Its Uses

by Anne Cambal

PEARSON
Scott Foresman

Magnetic Fields

The objects shown on these two pages are made from different materials. They work in different ways. But each one is either a magnet or has a magnet inside it. Magnets attract iron, steel, and some other metals through their magnetism. **Magnetism** is a force that acts on moving electric charge and on magnetic materials that are near a magnet.

The moving electric charge in fans and flashlights produces magnetism.

The magnets that we use every day, such as the refrigerator magnets that we use to post things, are usually pretty small. They contain a small amount of magnetism. But other magnets, such as the ones that keep maglev trains running, are much larger. "Maglev" stands for *magnetic levitation*. The magnetic force created by the electric current running through maglev train tracks lifts the entire train off the tracks. Magnets create pushing and pulling forces to move the train along the track.

Magnetism makes a compass needle (left) point in different directions. It makes a maglev train (below) run.

How Magnetic Fields Work

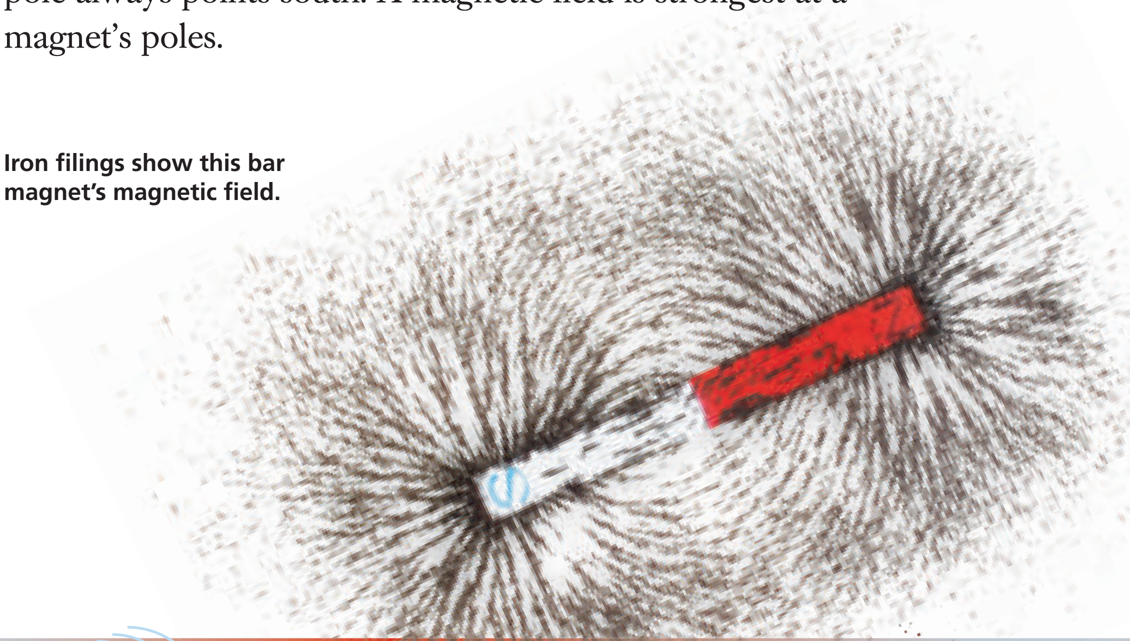
A magnet's magnetic field can cause objects to move closer to or farther away, without actually touching the magnet. A **magnetic field** is the space around a magnet in which magnetic forces operate. A magnet's magnetic field surrounds it in all directions.

You cannot see a magnetic field. But you can use iron filings to outline it. If you place iron filings near a bar magnet, they will line up to recreate the magnetic field. They show the lines of force that surround a magnet.

A Magnet's Poles

Notice that the filings in the picture are gathered near the ends of the magnet. They have been attracted to the magnet's **magnetic poles.** Magnetic poles are the two ends of a magnet. One pole always points north, while the other pole always points south. A magnetic field is strongest at a magnet's poles.

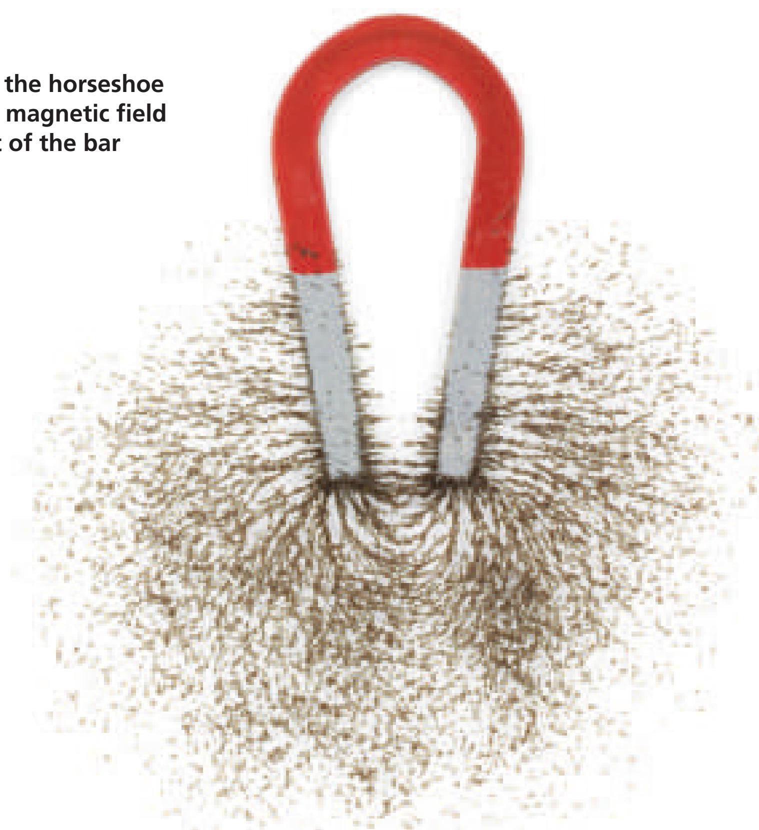
Iron filings show this bar magnet's magnetic field.



Different Magnets' Magnetic Fields

Look at the picture at the bottom of the page. It shows a horseshoe magnet. Its shape is totally different from the shape of the bar magnet on page 4. It is also shaped differently from donut-shaped magnets. Magnets' different shapes cause their magnetic fields to be shaped differently. But there are patterns to all magnets' magnetic fields. Each magnet's magnetic field has curved lines of force spreading out from each pole. The lines run from pole to pole. At each magnet's pole the lines of force are closest together and the magnetic field is strongest.

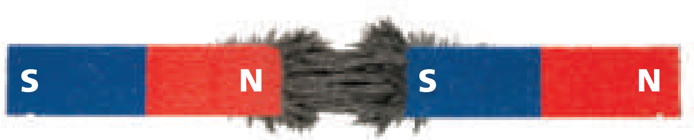
Compare the horseshoe magnet's magnetic field with that of the bar magnet.



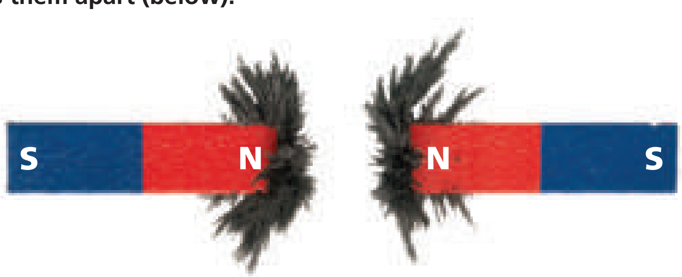
The Behavior of Magnetic Fields

A magnet's like and unlike poles are similar to like and unlike electric charges in the rules they follow. Just as unlike electric charges attract, so do unlike magnetic poles. And like magnetic poles repel, just as like electric charges do.

The picture shows two magnets that are repelling each other. The magnets' north poles are trying to push away from each other. But what would happen if one magnet's north pole were placed next to the other magnet's south pole? The magnets would try to pull together. You can scatter iron filings around magnets that are attracting and repelling each other. The filings will show how magnetic fields change shape based on attraction and repulsion.



Attraction pulls iron filings together (above). Repulsion pushes them apart (below).



What happens with broken magnets?

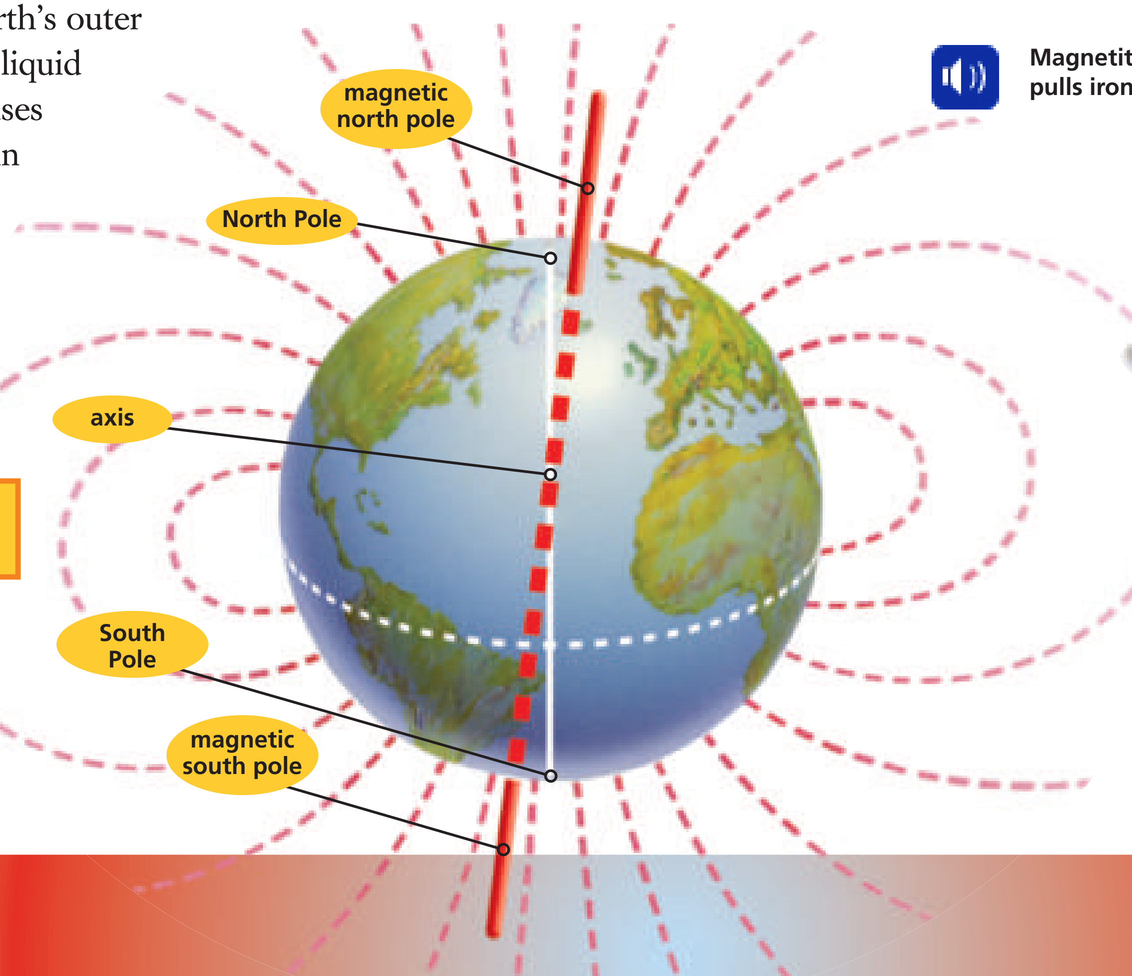
Suppose you took a magnet and broke it in two. What do you think would happen? If you predicted that there would be two new magnets, you are right! But there is more to it. Each new magnet would have a north pole and south pole. You cannot have a magnet with only one pole. It must have an opposite pole. So magnetic poles always come in pairs.

Pieces of a broken magnet may look different. But they still work like all other magnets.

Magnetic Effects

Compass needles are a type of magnet. A compass needle always swings so that one end points north and the other points south. Many ancient sailors used compasses to navigate. When Christopher Columbus crossed the Atlantic Ocean over 500 years ago, he used a compass. William Gilbert, working about 400 years ago, proposed that the Earth was like a magnet. He believed that it was surrounded by a huge magnetic field.

Today's scientists believe Gilbert was right. But how can they be sure? They cannot, since they cannot see inside Earth. But they suspect that Earth's outer core is made of very hot liquid iron. Earth's rotation causes electric currents to flow in the iron. This creates a magnetic field.



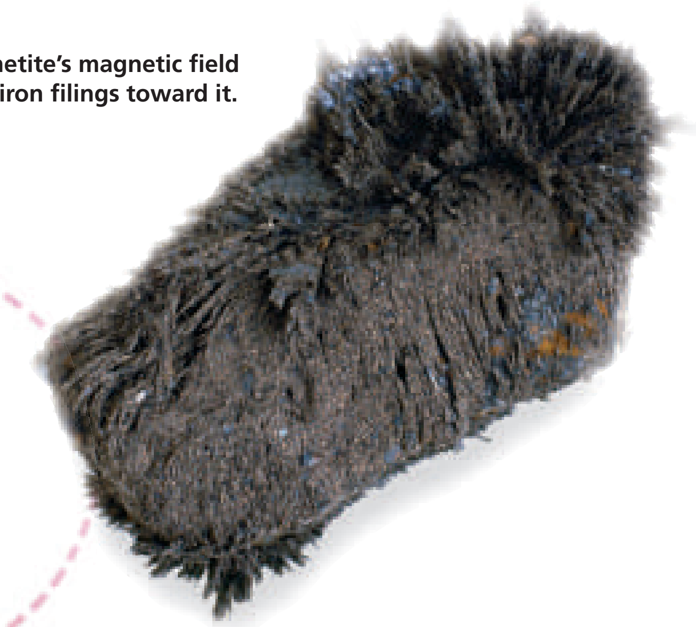
Earth's magnetic field and related features

Magnetic Minerals and Poles

For thousands of years, people have noticed that certain rocks and minerals have magnetic properties. Magnetite, also known as lodestone, is highly magnetic. Sailors would use lodestones as a kind of early compass.

Magnets have magnetic poles. Earth's magnetic poles are different from its geographic poles. The geographic poles are on Earth's axis, the invisible line around which Earth spins. But the north magnetic pole is almost 1,000 kilometers from the geographic North Pole, in Canada. The south magnetic pole is found in the ocean near Antarctica.

Magnetite's magnetic field pulls iron filings toward it.



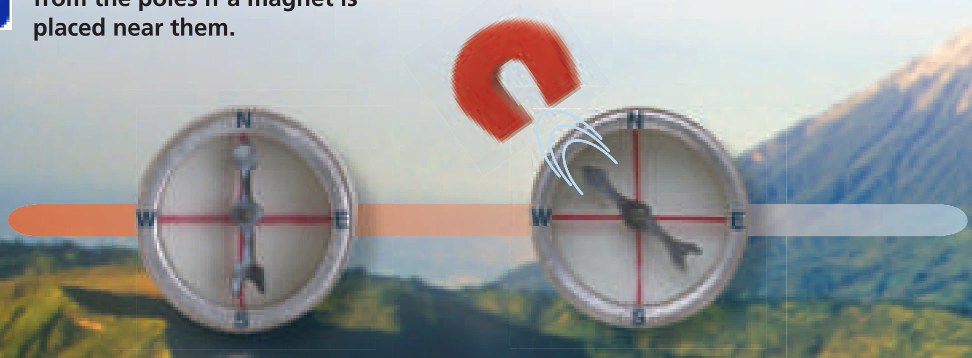
How Compasses Work

A compass' needle is magnetized. It is set within the compass so that it can turn in a complete circle. No matter where you travel with a compass, one end of the needle will always point toward Earth's north magnetic pole.

But why does the compass needle do this? It is attracted to Earth's magnetic field. Look at the picture on pages 8 and 9. Our planet's magnetic field is shown by lines that run north and south between the magnetic poles. The compass needle lines up with Earth's magnetic field.

As you know, magnetite is highly magnetic. It is so magnetic that it can affect a compass needle. What happens if you walk by a piece of magnetite while holding a compass? The magnetite's magnetic field causes the compass needle to swing toward it! After you walk past the magnetite, the needle will swing back toward the north magnetic pole.

Compass needles swing away from the poles if a magnet is placed near them.



Studying Earth's Magnetic Field

Compasses are good at showing us Earth's magnetic field. But any magnet, not just a compass, can be used to detect it. Take a simple magnet and tie it to a string. Then hold the string in your hand so that the magnet hangs in the air. After a few seconds, the magnet's poles will swing so that the north pole is pointing north and the south pole is pointing south.

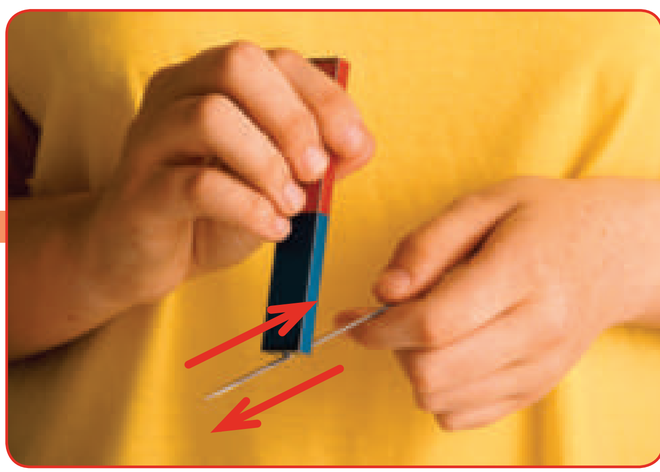
You can check your hanging magnet against a compass to find out which pole is which. Place the compass far enough away from the magnet so they do not affect each other. The magnet's north pole points the same way as the north pole of the compass needle. You can then label the poles of your hanging magnet.

Making Your Own Compass

All you need to make your own compass are a few simple objects. First, find a needle, bowl of water, piece of cork or sponge, and magnet. Then rub the needle on the magnet. Make sure that you rub it quickly and in the same direction every time. This gives the needle a magnetic field.

Next, place the needle on the cork or sponge. Put the cork or sponge in the bowl of water, with the needle. Make sure the needle is floating above the water and that the water is still. The needle, like a compass, will point north and south once it lines up with Earth's magnetic field. Like with your hanging magnet, place a regular compass a safe distance away from the needle. Then you can figure out which end of the needle is the north pole and which is the south pole.

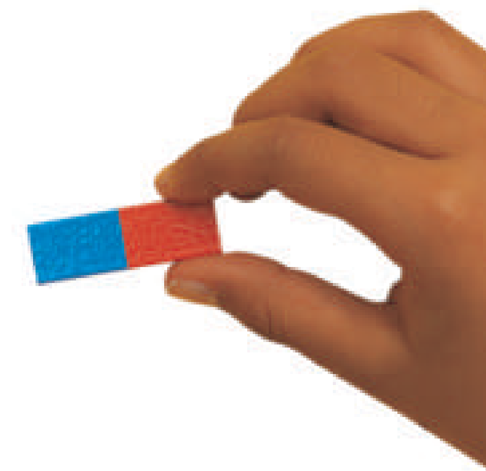
Rubbing a needle on a magnet will give the needle a magnetic field.

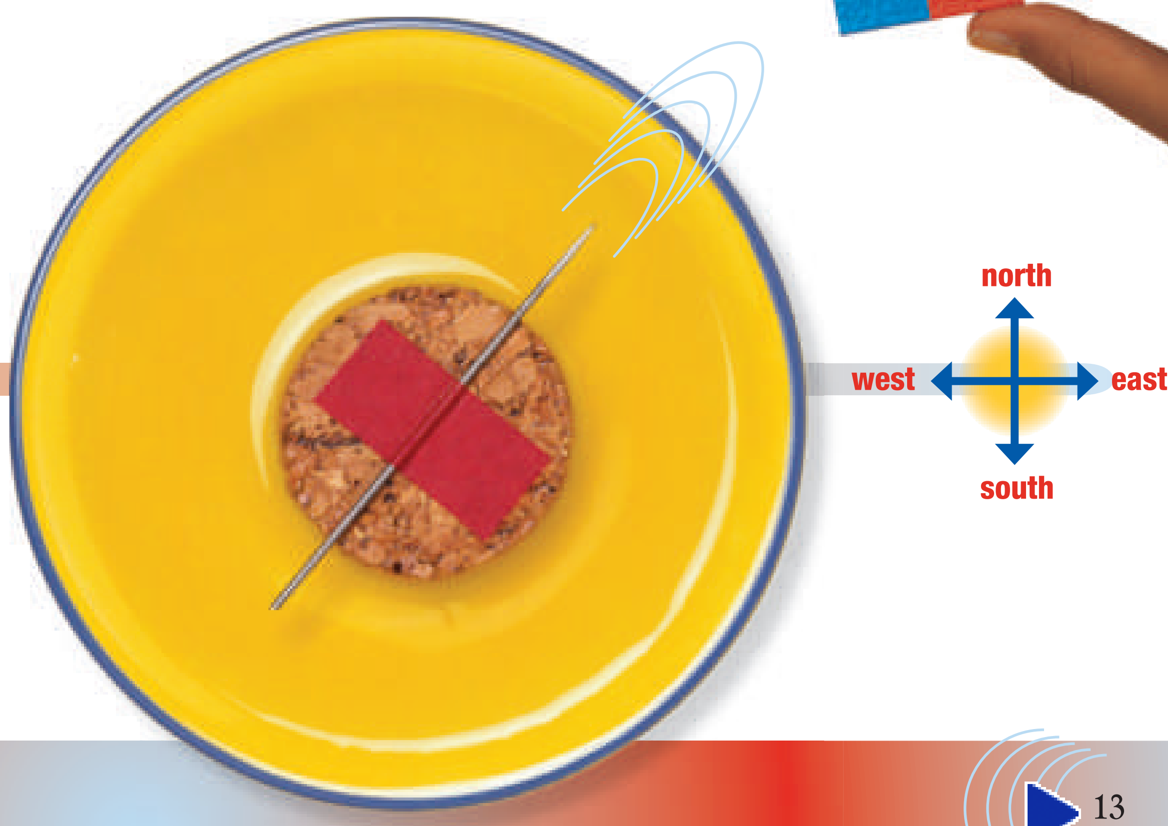


Using Your Compass

Your compass needle is now made. But you still have to mark the bowl of water as if it were a compass. Write *north*, *south*, *east*, and *west* on the edges of the bowl. Make sure the words are equally spaced around the bowl. Then turn the bowl until the needle is pointing at where you wrote *north*. You now have a working compass! Your new compass would be difficult to use in the woods. But it works just the same as a regular one.

Homemade compasses work like all other compasses. Their needles are attracted to nearby magnets.





Electric Currents and Magnetic Fields

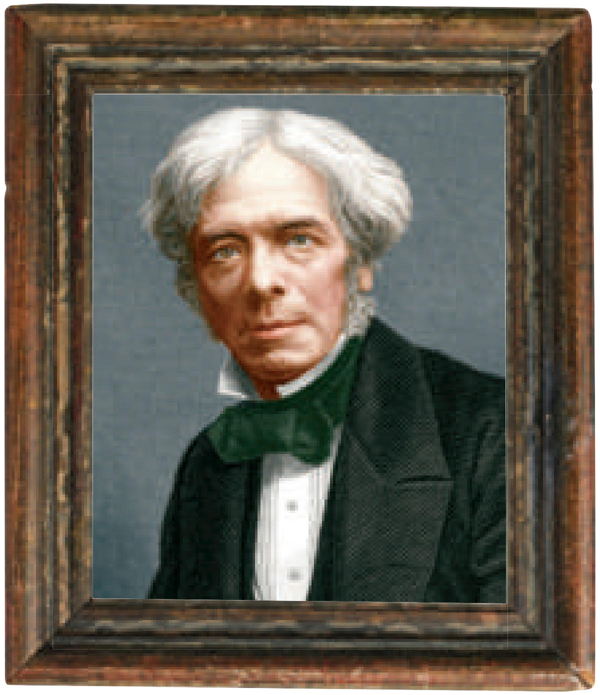
Hans Christian Oersted was a Danish scientist. In 1820, while running electric current through a wire, he saw something interesting. Each time he turned on the current, the needle on a nearby compass moved. What Oersted had discovered was that a magnetic field is made by a flowing electric current. Oersted had demonstrated the relationship between magnetism and electricity.

Hans Christian Oersted

Michael Faraday was a British scientist who built on Oersted's work. In 1831, he saw that electric current could be made by moving a magnet inside a wire coil. Faraday had invented the dynamo, a device which makes electricity by using a moving magnet.

You can see how a magnet makes electricity by watching a meter that measures electric current. The meter needs to be attached to a magnet that is inside a coil. If the magnet is not moved across the coil, electric current will not flow. The meter will read zero.

Suppose the magnet is moved back and forth across the coil. Electricity will flow through the wire to the attached meter. The needle on the meter will move past zero.



Michael Faraday

What is an electromagnet?

Each coil of wire within a dynamo makes up an electromagnet. An **electromagnet** is a coil of wire with many loops through which an electric current passes. As the current flows through an electromagnet, it creates a magnetic field.

If you place a magnetic bar inside of the coil of wire, the electromagnet's magnetic field will become stronger. You can also add more coils, or wrap the coils closer to each other. Each of these changes will make the electromagnet's magnetic field stronger. You can also strengthen the electric current that runs through it. This can be done by using more batteries. A stronger electric current will make a stronger magnetic field.

The Magnetic Resonance Imaging (MRI) machine uses magnetic fields to make images of the human body.

Electromagnets All Around Us

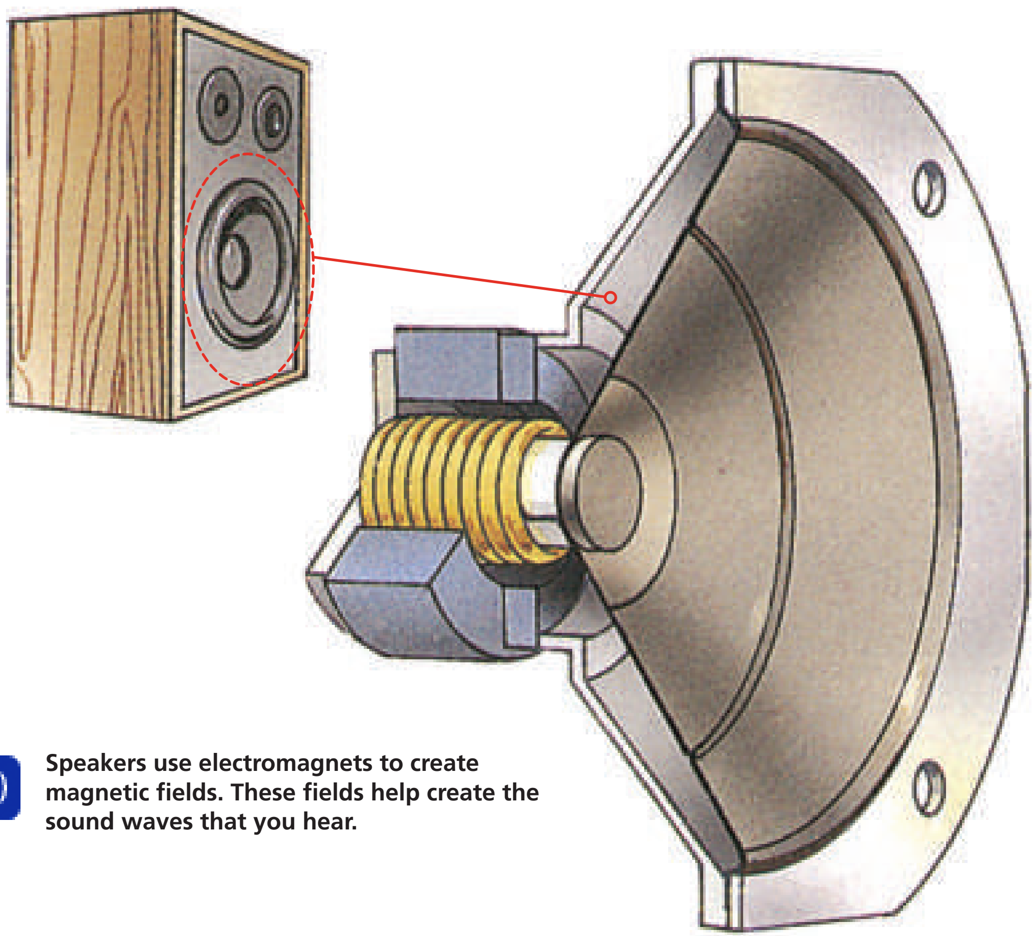
We use electromagnets every day without realizing it. For example, every time you turn on a computer, you are using an electromagnet. Its electromagnet is very different from the kind you just read about. Computer electromagnets are found inside computer hard drives.

The electromagnet that you read about on page 16 is the simplest kind. Today, there are many more types of electromagnets. They are different sizes and shapes. They have different purposes. But electromagnets work only when an electric current flows through them. Then they create their magnetic field.

Laptop computers contain hard drives that use electromagnets.

Electromagnets in Machines That Make Sound

The speakers for a sound system use electromagnets. These electromagnets create changing magnetic fields. The magnetic fields change as the current changes. The changes to the current cause motion in the speakers. This motion, also known as vibrations, makes the sound waves you hear.



Speakers use electromagnets to create magnetic fields. These fields help create the sound waves that you hear.

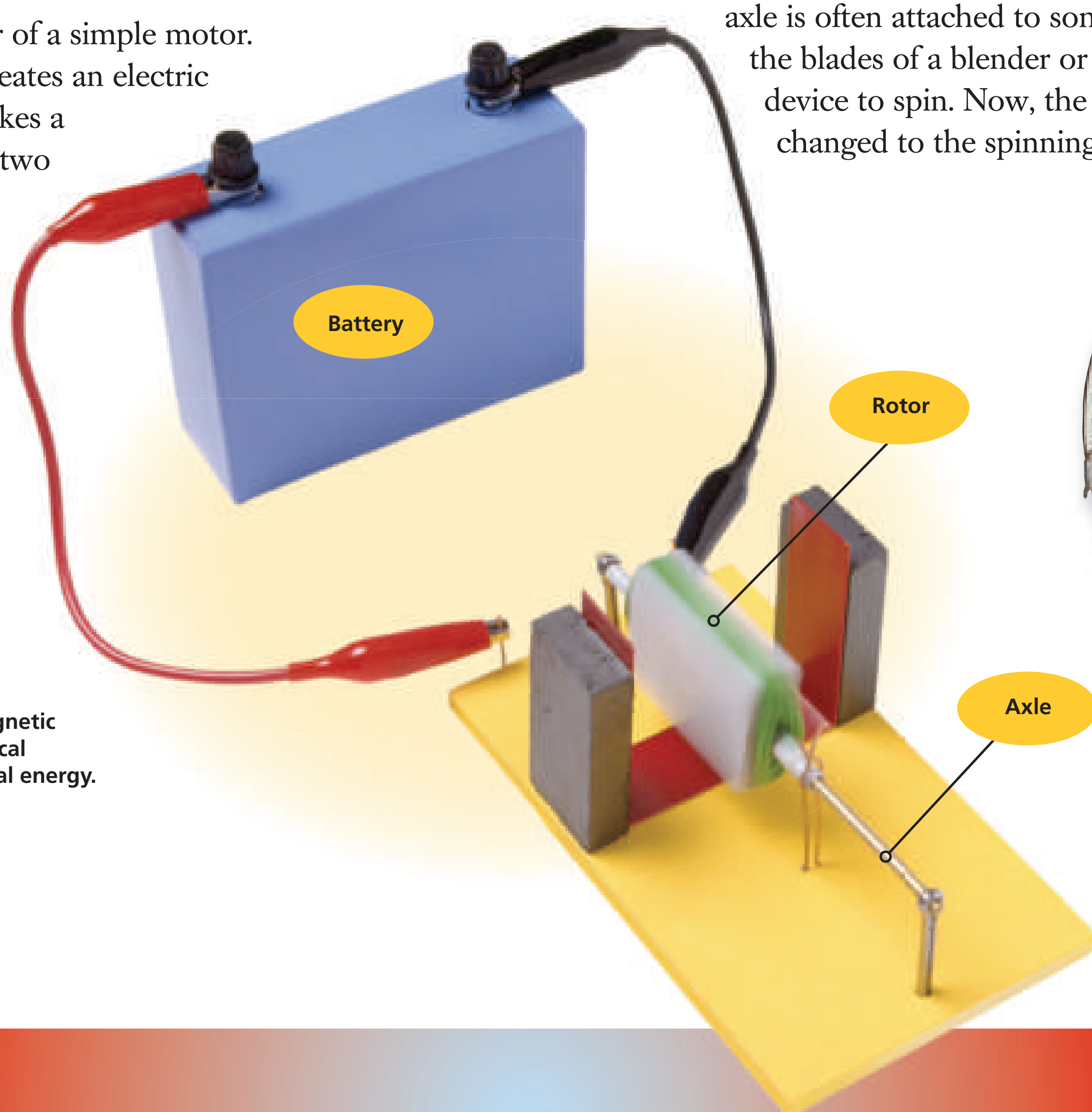
Earphones are another kind of sound system. Each set of earphones contains a metal disc. The disc is located in front of an electromagnet. As with speakers, the magnetic field of the earphones changes as the electric current flowing through them changes. The changes in the earphones' magnetism cause the metal disc to vibrate. The vibrations cause the sound waves that you listen to.

Earphones and speakers work in much the same way. Both use electromagnets.

Electrical Energy into Mechanical Energy

Along with speaker systems and earphones, we use many devices that spin. These devices use motors to change electrical energy into mechanical energy. The energy involved in motion is *mechanical energy*.

A *rotor* is found at the center of a simple motor. A battery inside of the motor creates an electric current. The electric current makes a magnetic field in the rotor. The two poles of the rotor's magnetic field repel and attract the poles of the magnets that are inside the motor. This makes the rotor turn.



This motor uses a magnetic field to change electrical energy into mechanical energy.

Making Motion

Once the rotor spins halfway, a *commutator* takes over. It reverses the direction of the current. This keeps the rotor turning in the same direction, instead of changing directions halfway.

As the rotor spins, it turns something called the axle. The axle is often attached to something that spins, such as the blades of a blender or fan. The axle causes the device to spin. Now, the motion of the motor has changed to the spinning motion of the device.

Generators and Electricity

You now know how a motor changes electrical energy into mechanical energy. But can machines change mechanical energy into electrical energy? Yes! A **generator** is a machine that turns coils of wire around powerful magnets, changing motion into electrical energy.

Generators give us the electricity we need to run our cities. When water flows through a dam, it provides the motion needed to run the dam's generator. Wind turning the blades of a wind turbine also helps create electricity.

Hoover Dam's generators (right) use magnets to change the motion of water into electrical energy.

Wind farms are made up of rows and rows of turbines. A *turbine* is turned by moving wind or water.

There are wind farms in different parts of California. One of the biggest is east of Los Angeles, near Palm Springs. Another large one is near Altamont Pass, outside of San Francisco. The blades of wind turbines can be 60 meters long! California has over 13,000 wind turbines. Together they are capable of producing enough electricity to light San Francisco.

Wind flowing through this mountain pass gets captured by wind turbines.

Glossary

electromagnet a coil of wire through which electric current passes, creating a magnetic field

generator a machine that uses moving magnets to produce electrical energy

magnetic field the space around a magnet in which magnetic forces operate

magnetic poles the two ends of a magnet, called the north magnetic pole and the south magnetic pole

magnetism a force that acts on either a moving electric charge or a magnetic material that is near a magnet

What did you learn?

1. What does "maglev" stand for?
2. What happens to a magnet that has been broken in two?
3. What did Hans Christian Oersted discover?
4. **Writing** in Science Write a couple of sentences about Earth's outer core and how it is related to Earth's magnetism. Then revise what you have written by adding information about Earth's magnetic poles.
5. **Main Idea and Details** Go back and reread page 23. What is its main idea? What details support this idea?