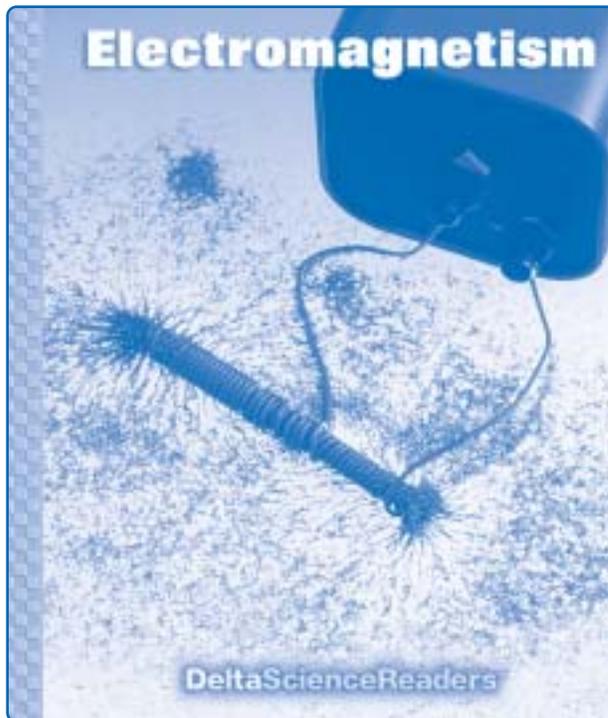


# Electromagnetism



*Delta Science Readers* are nonfiction student books that provide science background and support the experiences of hands-on activities. Every **Delta Science Reader** has three main sections: *Think About . . .*, *People in Science*, and *Did You Know?*

Be sure to preview the reader Overview Chart on page 4, the reader itself, and the teaching suggestions on the following pages. This information will help you determine how to plan your schedule for reader selections and activity sessions.

Reading for information is a key literacy skill. Use the following ideas as appropriate for your teaching style and the needs of your students. The After Reading section includes an assessment and writing links.

## OVERVIEW

In the Delta Science Reader *Electromagnetism*, students discover what electricity is and read about static electricity, current electricity, and electric circuits. They learn about magnets and magnetism and discover how electric current is used to make electromagnets. They also find out how generators produce electricity and how electric motors work. In a biographical sketch they are introduced to a famous scientist—Samuel Morse—and his invention of both a practical telegraph system and the signaling code that was named after him. Finally, students learn about the many uses of electromagnets.

### Students will

- ▶ learn the relationship between electricity and magnetism
- ▶ understand how generators and electric motors work
- ▶ discover the many uses of electromagnets
- ▶ examine nonfiction text elements such as table of contents, headings, and glossary
- ▶ interpret photographs and graphics to answer questions
- ▶ complete a KWL chart

## READING IN THE CONTENT AREA SKILLS

- Preview and set a purpose for reading
- Compare and contrast conductors and insulators
- Recognize cause and effect relationships related to electricity and magnets
- Identify main ideas and supporting details in text passages
- Explain the sequence of events in how a generator produces electricity
- Demonstrate critical thinking
- Interpret graphic devices
- Summarize text information

## NONFICTION TEXT ELEMENTS

*Electromagnetism* includes a table of contents, headings, photographs, captions, diagrams, boldfaced terms, and a glossary.

## CONTENT VOCABULARY

The following terms are introduced in context and defined in the glossary: *atom, conductor, current electricity, domain, electric charge, electric circuit, electric energy, electricity, electric motor, electromagnet, electron, energy, field lines, generator, insulator, magnet, magnetic field, magnetic poles, magnetism, mechanical energy, neutron, nucleus, parallel circuit, permanent magnet, proton, resistance, series circuit, static electricity, switch, temporary magnet.*

## BEFORE READING

### Build Background

Access students' prior knowledge of electromagnetism by displaying and discussing the cover. Ask, *What do you see in the photograph on the cover?* (a battery, a circuit, wire wrapped around a nail, iron filings showing magnetic field lines) Tell students that the setup shown is a simple

electromagnet, a device that uses electric current to produce a magnetic field.

Read the title aloud, and invite students to share what they know about the topic from their personal experiences and hands-on explorations in science. To stimulate discussion, ask questions such as these: *What do you think electromagnetism is? What uses do you think electromagnetism has? What kinds of things might use electromagnets?*

Begin a group KWL chart by recording facts students know about electromagnetism in the K column. You may want students to copy the KWL chart so they can maintain their own charts as they read.

<b>K</b> What I Know	<b>W</b> What I Want to Know	<b>L</b> What I Learned	<b>+</b> What I Want to Explore Further

### Preview the Book

Explain that when students preview nonfiction, they should look at the title, the table of contents, headings, boldfaced words, photographs, illustrations, charts, graphics, and captions.

Then preview the book with students. Call attention to the various nonfiction text elements and explain how they can help students understand and organize what they read. Ask questions such as these: *How do the headings help you predict what you will read about? What do you see in this picture? How do you think it will help you understand the text?* Explain that the words in boldface type are important words related to electromagnetism. Point out that these words are defined in the glossary. Choose one word and have students find its definition in the glossary.

Following the preview, ask, *What questions do you have about electromagnetism that you would like this book to answer?* Record students' responses in the W column of the KWL chart. Explain that they will complete the chart after they have finished reading.

### Preview the Vocabulary

You may wish to preview some of the vocabulary words before reading, rather than waiting to introduce them in the context of the book. Possibilities include creating a word wall, vocabulary cards, sentence strips, or a concept web.

For example, some of the terms are opposite in some way, such as *electron* (negatively charged particle) and *proton* (positively charged particle). Name a term and challenge students to find a term that is its opposite. Pairs include *permanent magnet–temporary magnet*, *conductor–insulator*, *electric motor–generator*.

### Set a Purpose

Discuss with students what they might expect to find out from the book, based on their preview. Encourage them to use the questions on the KWL chart to set an overall purpose for reading.

## GUIDE THE READING

Preview the book yourself to determine the amount of guidance you will need to give for each section. Depending on your schedule and the needs of your class, you may wish to consider the following options:

- **Whole Group Reading** Read the book aloud with a group or the whole class. Encourage students to ask questions and make comments. Pause as necessary to clarify and assess understanding.
- **Shared Reading** Have students work in pairs or small groups to read the book together. Ask students to pause after each text section. Clarify as needed and discuss any questions that arise or have been answered.

- **Independent Reading** Some students may be ready to read independently. Have them rejoin the class for discussion of the book. Check understanding by asking students to explain in their own words what they have read.

### Tips for Reading

- If you spread out the reading over several days, begin each session by reviewing the previous day's reading and previewing what will be read in the upcoming session.
- Begin each text section by reading or having a volunteer read aloud the heading. Have students examine any illustrations or graphics and read accompanying captions and labels. Discuss what students expect to learn, based on the heading, illustrations, and captions.
- Help students locate context clues to the meanings of words in boldface type. Remind them that these words are defined in the glossary. Provide help with words that may be difficult to pronounce.
- As appropriate, model reading strategies students may find helpful for nonfiction: adjust reading rate, ask questions, paraphrase, reread, visualize.

### Think About . . . (pages 2–13)

#### Pages 2–5 *What Is Electricity?*

- Before students read, invite them to share what they know about electricity. Then have them read the text in the first column on page 2 to confirm their ideas. Ask, *What is electricity?* (a form of energy) *What is the main idea—the most important point—about energy in the third paragraph?* (Energy can be changed from one form into another.) *Into what other forms of energy does a toaster change electrical energy?* (light energy and heat, or thermal, energy) *How does a telephone change energy?* (It changes the sound energy of a voice into electrical energy and then back into sound energy.)

- Have students study the diagram and finish reading the text on page 2. Ask, *What is the main idea of this paragraph?* (Electric energy results from the way electrons behave.) Then have students read the first two paragraphs on page 3. Ask them to summarize the information about the makeup of an atom. (An atom is made up of three main particles: electrons, which have a negative charge; protons, which have a positive charge; and neutrons, which have no charge. The *nucleus* is the center of the atom, made up of protons and neutrons and orbited by electrons.)
- Ask, *What causes charge to move from one object to another?* (Objects with unlike charges attract, so electrons will move from an object with a negative charge to an object with a positive charge.) *What are two kinds of electricity, and how are they different?* (Static electricity and current electricity are two kinds of electricity, or interaction of electric charges. Static electricity is the interaction of charges at rest, and current electricity is the interaction of charges in motion.)

### Page 3 *Static Electricity*

- Have students look at the photograph on page 3 and read the caption. Ask, *What is lightning?* (a giant discharge of static electricity) You may wish to ask students if they have ever heard about Benjamin Franklin’s famous experiment with lightning. If necessary, explain that in 1752 Franklin proved that lightning was actually static electricity by flying a silk kite during a thunderstorm. Using wet twine attached to a key, he was able to collect an electric charge from a cloud. Franklin coined many terms still used when referring to electricity, such as *positive*, *negative*, *battery*, and *conductor*. He also invented the lightning rod. These pointed iron rods attract lightning and conduct it safely into the ground, thus protecting buildings from fire, another of Franklin’s concerns.

### Page 4 *Current Electricity and Electric Circuits*

- Have students read the section on “Current Electricity” on page 4. Check understanding by asking, *What is current electricity?* (the flow of charge through material) *What is the difference between a conductor and an insulator?* (Electric current moves easily through a conductor; it does not flow well through an insulator.) *Which has greater resistance, a conductor or an insulator?* (an insulator)
- Before students continue reading, point out the term *Circuits* in the heading on the page. Explain: *The words circuit and circle are related. Just as a circle forms a closed path, so does a circuit.* Then have students read the remainder of pages 4 and 5 to learn about electric circuits.
- Have students trace the series and parallel circuits in the diagrams with their fingers to help them understand how the electric current flows in each. Ask, *What happens in a series circuit when you remove or turn off one light bulb? Why?* (None of the bulbs will light because the circuit is open and electric current cannot flow.) *What happens in a parallel circuit when you remove or turn off one light bulb? Why?* (The other bulbs will continue to light because only the path to that one bulb is open. The other paths remain closed, so electric current continues to flow.)

### Pages 6, 7 *What Is Magnetism?*

- Before students read pages 6 and 7, invite them to share their experiences with magnets. After they read, ask, *What is magnetism?* (the pull of a magnet on materials) *What kinds of materials does a magnet attract, or pull toward itself?* (the metals iron, cobalt, and nickel and other magnets)
- To check understanding, ask students to summarize the information on magnetic poles. (A magnet has two magnetic poles, places where the magnetism is strongest.)

The north-seeking pole always points north, and the south-seeking pole always points south. Unlike magnetic poles attract each other, and like poles repel.) As appropriate, tell students that the latter is called the Law of Magnetic Attraction. Ask, *How can you “see” a magnetic field if it is invisible?* (You can see its effect. Iron filings line up along the field lines and give a picture of the direction and strength of the magnetic field.)

- Ask, *How is Earth like a magnet?* (It has north and south magnetic poles and is surrounded by a magnetic field.) *How does a compass show direction?* (The magnetic needle of a compass points to Earth’s north magnetic pole.) You may wish to explain that Earth’s geographic North and South Poles and its magnetic north and south poles are not in the same places. Point out that even though Earth is spherical, it acts like a bar magnet.

### Further Facts

- William Gilbert (1544–1603), physician to Queen Elizabeth I of England, first proposed the idea in 1600 that Earth is a giant magnet. He also differentiated magnetism from static electricity and disproved the popular notion that garlic did not rob a compass of its magnetism. (However, until nearly 1700, sailors could be flogged for having garlic on their breath.)
- Earth’s magnetic field is blown out of shape by the solar wind—the stream of electrically charged particles that is emitted by the sun. On the side of Earth facing the sun, the magnetic field—called the magnetosphere—is compressed toward Earth. On the side facing away from the sun, the magnetosphere forms a long tail like that of a comet.
- A compass is useless at Earth’s magnetic poles because there the field lines point straight up and down.

- Geophysicists discovered that in the past, Earth’s magnetic field has reversed itself about every 200,000 years.
- After students read page 7, ask, *How can you make a magnet?* (place an iron or steel object in a strong magnetic field) *What effect does this have?* (It causes the magnetic fields of the material’s domains to line up with one another.) *Why are some magnets only temporary, while others are permanent?* (In some metals, the domains do not stay lined up when the magnetic force is removed, so the magnetism goes away. In other metals, the domains stay lined up, so the magnetism is permanent.)
- If necessary, provide help with the pronunciation of *magnetite* (MAG-nuh-tite).

### Pages 8, 9 Using Electric Current to Make Magnets

- Have students read the text on page 8 and look at the photograph and caption. Assess comprehension by having students summarize how an electromagnet works. (When an electric current flows through a wire wrapped around an iron or steel core, this creates a magnetic field. The iron or steel becomes a magnet. When the current is turned off, the magnetic field disappears, and the object is no longer a magnet.) Ask, *How can the magnetic field of an electromagnet be made stronger?* (wrap more loops of wire around the iron or steel object or increase the amount of current flowing through the wire)
- Have students read page 9. Ask, *What is the main idea on this page?* (An electromagnet is useful because it can be turned on and off.) *What details support this main idea?* (Electromagnets are used in many everyday devices, such as doorbells, telephones, and CD players.)
- Direct students’ attention to the photograph at the top of the page. Ask them to predict what will happen when the electromagnet is turned off. (The

metal will fall to the ground.) Ask, *How can an electromagnet be used to sort scrap metal?* (It will pick up only metal that is magnetic, such as iron and steel. It will not pick up nonmagnetic metals, such as aluminum and copper.)

- As students study the picture of the bell, read the caption aloud and have them follow the steps in the process of sounding the alarm. Ask, *What happens when the electric current is turned off?* (The magnetism of the electromagnet is turned off, and it will not attract the contact arm. The hammer will not strike the bell and so no alarm sounds.)
- If necessary, provide help with the pronunciation of *Oersted* (UR-sted).

### **Pages 10–12 Using Magnets to Make Electric Current**

- Remind students that on pages 8 and 9 they read how magnets can be made from electricity. Explain that now they will discover how electricity can be made from magnets. Then have them read page 10. Ask, *What happens when a magnet is moved through a coil of wire?* (It produces an electric current in the wire.) *What causes the electric current to flow?* (the change in the amount of magnetic field affecting the coil)

### **Pages 11, 12 Generators**

- Direct attention to the diagram on page 11 and explain that it shows how a machine called a generator produces electricity. Ask students to follow the steps as you read each numbered callout. Then have them read the text. Assess comprehension by asking students to describe the sequence of events that enable a generator to produce electricity. (Energy causes a wire coil to spin in a magnetic field. This causes an electric current to form in the coil. Electricity travels from the spinning loop to metal rings. The rings spin against brushes. The electricity travels to the brushes and from the

brushes to wires that carry the electricity away from the generator.) You may wish to remind students that to make electric current either the magnets or the wire coil must move. Moving a magnet near the coil creates a current in the wire. So does spinning the coil within a magnetic field.

- Have students read page 12. Ask, *What is the main idea about generators on this page?* (Generators change mechanical energy into electrical energy.) *What sources of mechanical energy are used to turn turbines in generators?* (steam, wind, and moving water)
- Direct students' attention to the generator diagram on page 11 again. Ask them to identify the source of the mechanical energy that will be changed into electrical energy. (someone or something turning the handle of the crank, in step 1)

### **Page 13 How Do Electric Motors Work?**

- Have students read the text on page 13, study the diagram, and read the caption. Ask, *How is an electric motor different from a generator?* (A generator changes mechanical energy into electrical energy. An electric motor changes electrical energy into motion, which is a kind of mechanical energy.) *What are the main parts of an electric motor?* (a permanent magnet, an electromagnet, and a device that changes the direction of the current flowing through the electromagnet) *Where does the electricity for an electric motor come from?* (a battery or household current)
- To assess comprehension, have students summarize how an electric motor works. (Current causes the electromagnet to spin so that the unlike poles of the electromagnet and the permanent magnet line up. The current then reverses, which reverses the electromagnet's poles. The like poles of the electromagnet and the permanent magnet are now lined up. They repel each other, so the electromagnet turns until the unlike poles line up. The

process is repeated, which keeps the coil spinning. The turning motion of the electromagnet is used to do work.)

### People in Science (page 14)

#### **Samuel F. B. Morse**

- Before students read, ask whether any of them has ever heard of Samuel Morse or Morse code. Encourage students to share any information they have. Then have them read page 14.
- After students read, ask, *What made Morse's version of the telegraph more practical than earlier versions?* (It used a single wire; earlier telegraphs used many wires.) *Why do you think the U.S. government was willing to give Morse money to build a telegraph line?* (Students may suggest that the government was interested in a faster method of communication to be able to spread political or business information.)
- You may wish to tell students that the original Morse code used spaces as well as dots and dashes to represent some letters, and dashes were of varying lengths. In 1851 a simpler and more exact version of the code was developed. Called International Morse Code, this system uses combinations of dots and dashes for all letters, and the dashes are constant in length.

#### **Further Facts**

- Morse's first career was as an artist. He went to England in 1811 to study art. After returning to the United States in 1815, he supported himself by painting portraits.
- A model of the telegraph that Morse constructed in 1837 is in the National Museum of American History of the Smithsonian Institution in Washington, D.C.
- The first formal message sent on the first intercity telegraph line in the world, from the U.S. Capitol building in Washington to

Baltimore in 1844, was "What Hath God Wrought!"

- International Morse Code is also used to communicate at sea using flashlamps. Ships send messages by turning bright lights off and on creating visual dots and dashes.
- The duration of one dash equals that of three dots.
- In the United States and Great Britain, railroads and landlines continued to use the original code until the 1960s.
- Digital communications by satellite has now replaced most radiotelegraphy for most military and commercial uses.

### Did You Know? (page 15)

#### **About the Uses of Electromagnets**

- Before reading, ask, *How many times a day do you think you use something that uses an electromagnet to work? What things do you use that contain electromagnets?* List responses on the board. Then have students read page 15 to discover the many uses of electromagnets.
- Ask, *What are probably the most important uses electromagnets have?* (in electric generators and electric motors) *What details support this main idea?* (Without generators to make electricity, we would not have electric lights, television, telephones, or anything else that runs on electricity. Electric motors run many things we use every day.)
- As appropriate, share with students how an MRI machine functions. Remind students that when an iron or steel object is placed in a magnetic field, the domains in the object line up in the same direction. The same thing happens to certain atoms inside the human body when it is placed in a magnetic field. An MRI machine is essentially a magnet shaped like a hollow cylinder. The patient is placed in the

cylinder. The magnetic field runs straight through the center of the cylinder, passing through the patient. After the magnet is turned on, radio waves are sent through the patient. The machine captures images that are revealed by the response of the body's atoms to the energy in the radio waves.

### Further Facts

- The first MRI performed on a human being took place on July 3, 1977. It took almost five hours to produce one image. MRIs today can take as little as 20 minutes.
- The magnets used in MRI scanners are so powerful that they have sucked metal oxygen tanks, IV poles, heart monitors, and patient stretchers—anything containing magnetic material—into the tube. Patients and technicians are carefully screened for metal objects before entering the scan room.

## AFTER READING

### Summarize

Complete the KWL chart you began with students before reading by asking them to share the answers to their questions. Call on volunteers to retell each text section. Then have students use the information in the KWL chart to write brief summary statements.

Discuss with students how using the KWL strategy helped them understand and appreciate the book. Encourage them to share any other reading strategies that helped them understand what they read. Direct attention to the fourth column in the chart and ask: *What questions do you still have about electromagnetism? What would you like to explore further?* Record students' responses. Then ask, *Where do you think you might be able to find this information?* (Students might mention an encyclopedia, science books, and the Internet.) Encourage students to conduct further research.

### Review/Assess

Use the questions that follow as the basis for a discussion of the book or for a written or oral assessment.

1. What is the connection between electricity and atoms? (Atoms are made up of three main particles: electrons and protons, which carry negative and positive electric charge, and neutrons, which carry no charge. Electricity is the interaction of electric charges.)
2. How does a switch in an electric circuit control the flow of current? (The switch opens or closes the circuit. When the circuit is open, the path is broken and current cannot flow. When the circuit is closed, the path is complete and current can flow.)
3. What feature of electromagnets makes them useful and why? (Their magnetism can be turned on and off. This is useful because devices that use electromagnets can be turned on and off.)
4. Name at least three everyday devices that use electric motors. (Responses may include fan, blender, car windshield wipers, electric saw, electric drill, dishwasher, and hair dryer.)

### Writing Links/Critical Thinking

Present the following as writing assignments.

1. Compare and contrast a series circuit and a parallel circuit. (In both types of circuit, current flows from a source through objects connected in the circuit. In a series circuit, the objects are in a single path. In a parallel circuit, each object has its own path.)
2. Samuel Morse not only invented a workable telegraph system, he also invented a code that could be used to send messages over the telegraph. How important do you think this second invention was? Why? (Students may recognize the fact that without a code in which to send messages, the telegraph itself would have been useless.)

**Science Journals:** You may wish to have students keep the writing activities related to the Delta Science Reader in their science journals.

### **References and Resources**

For trade book suggestions and Internet sites, see the References and Resources section of this teacher's guide.