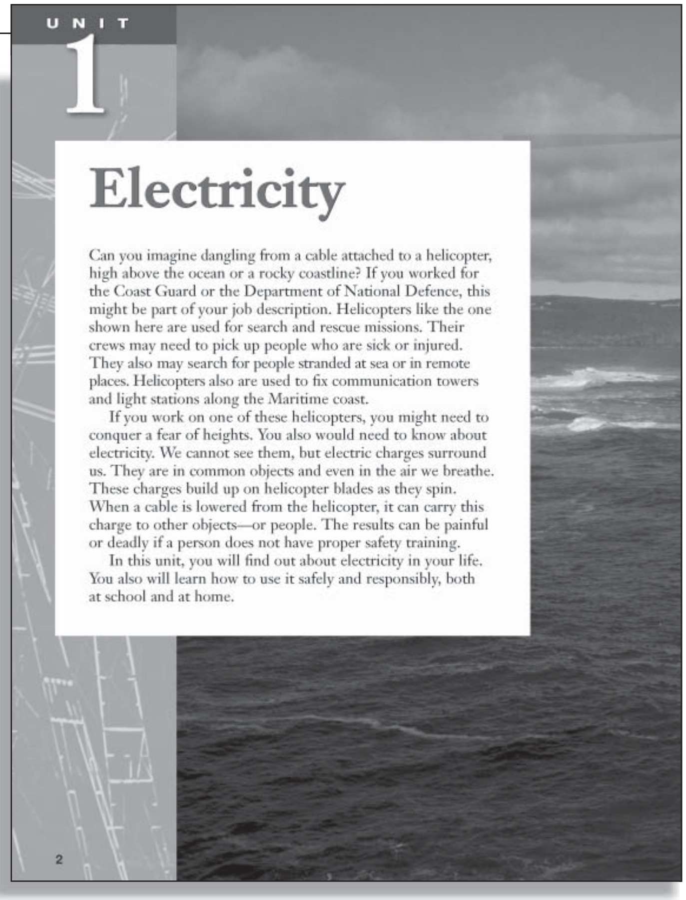
USING THE UNIT 1 OPENER

TEACHING STRATEGIES

- Each student should have a science logbook with enough space on each page for both writing and drawing pictures. Before beginning the unit, ask “What does the word ‘electricity’ mean to you?” Allow time for thinking, writing, and drawing. Have the students share their ideas and then proceed.
- **Begin the Lesson**—Examine the photograph as a group and ask the students where electricity may be at work in the picture. Encourage them to describe devices that may rely on or be affected by electricity both inside and outside of the helicopter.
- **During Reading**—Read the passage silently or as a group and ask the students to reflect on the relationships between helicopters and electricity. Ask students to think about how the blades might become charged and how to prevent the charge from injuring someone. What types of safety precautions must the pilot and crew consider before attempting a rescue?
- **After Reading**—Have students discuss the meaning of the term “electricity” as a class or small group. How is electricity produced? What can electricity be used for? What different types of electricity are there? Ask students to discuss where electricity is used in their day-to-day lives and how it helps them choose methods of completing certain tasks.


UNIT 1

Electricity

Can you imagine dangling from a cable attached to a helicopter, high above the ocean or a rocky coastline? If you worked for the Coast Guard or the Department of National Defence, this might be part of your job description. Helicopters like the one shown here are used for search and rescue missions. Their crews may need to pick up people who are sick or injured. They also may search for people stranded at sea or in remote places. Helicopters also are used to fix communication towers and light stations along the Maritime coast.

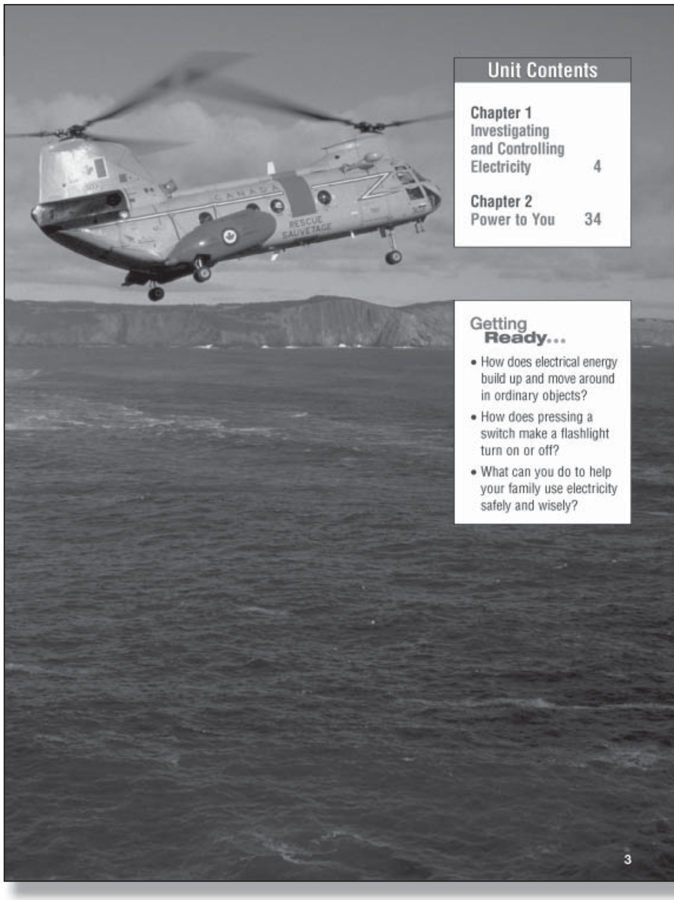
If you work on one of these helicopters, you might need to conquer a fear of heights. You also would need to know about electricity. We cannot see them, but electric charges surround us. They are in common objects and even in the air we breathe. These charges build up on helicopter blades as they spin. When a cable is lowered from the helicopter, it can carry this charge to other objects—or people. The results can be painful or deadly if a person does not have proper safety training.

In this unit, you will find out about electricity in your life. You also will learn how to use it safely and responsibly, both at school and at home.

2

ATTENTION Grabber to Introduce Unit 1

- Ask students what will happen if you hold a comb near a stream of water from a faucet. Hold it near the stream, and then note that there is no change. Then ask what will happen if you give the comb several firm wipes with a paper towel and hold it near the stream. Invite students’ ideas about reasons why the stream of water bends towards the comb.
- Obtain a small cork. Tie approximately 30 cm of string around the cork and suspend it from a stand so that it hangs freely. Vigorously rub a comb or plastic spoon with some paper towel and hold it near the cork. Keep the comb in place, allowing it to come in contact with the cork. Invite students’ ideas for reasons why the cork is first attracted to the comb, then repelled by it. Wrap the cork in metal foil and repeat the demonstration. Invite students to explain the new results.
- Obtain a simple electroscope from a high school or junior high lab. Demonstrate the motion of the foils in an electroscope when a charged object is brought near it.
- The Power Corporation has a program called the Electric House that is available for all grade six classes in Nova Scotia. It introduces safety issues related to electricity, including what to do in an unsafe situation. The program is free of charge and presented by retired employees. This can be used before or after electrical safety issues are explored.



Getting Ready Answers

- **How does electricity build up and move around in ordinary objects?** Electricity builds up and moves around as either static or current electricity. In the case of static electricity, charges build up on a type of material (an insulator) that does not allow the charges to move. Charges of static electricity can be transferred from one insulator to another by friction, but they do not flow through the insulator. In current electricity, charges flow through another type of material (a conductor). Charges cannot build up on a conductor.
- **How does pressing a switch make a flashlight go on or off?** A switch is a device that creates a pathway for the flow of current electricity. When a switch is closed, charges can move from the negative side of a battery through the switch and the light bulb to the positive side of the battery, creating light as they flow through the filament. When the switch is open, the pathway is blocked and electricity cannot flow. In this case, the light is off.
- **What can you do to help your family use electricity safely and wisely?** Students should be encouraged to discuss their own ideas of electrical safety. Issues that may arise could be about high-voltage lines and outlets, water and electricity, and/or lightning. After reading the unit, students will know of the need for grounding and the safety issues associated with short circuits. Wise use of electricity should include discussions about conservation, clean power, and the cost of electricity. Students should be encouraged to identify ways to save electricity around home, such as use of compact fluorescent bulbs and electricity meters, and turning off electric devices when not in use.
- **Further question: How is electrical power generated in Nova Scotia?** Students may be familiar with coal-fired power, natural-gas power plants, and wind turbines. They may not be familiar with the use of hydroelectric (Wreck Cove), wood biomass (Pictou), and tidal (Bay of Fundy) energy before reading the unit. They may note that some private homes and businesses use solar power.

Connecting to the World Outside the School

- Ask students to brainstorm a list of industries from across the province that rely on electricity to operate. This should be a long list. Follow up by having students brainstorm a list of industries across the province that do not rely on electricity. This will likely be a short list.

Cross-Curricular Connections

The electricity unit provides many opportunities to connect with other disciplines. In mathematics, the data management strand, as well as graphing and measurement outcomes are easy to integrate with science in a meaningful way. Students can use their math skills with everyday data.

When studying, preparing, and reporting the investigations for this unit, science provides an opportunity to fulfill language arts outcomes such as reading, writing, and communication that relate specifically to everyday life in a meaningful way.

Stewardship and environment are interconnected in all subjects, and this electricity unit gives the opportunity for teachers to plan to meet multiple outcomes in an effective way. The Outcome Cards provided by the Department of Education are an excellent resource for this planning.

Promoting Positive Attitudes

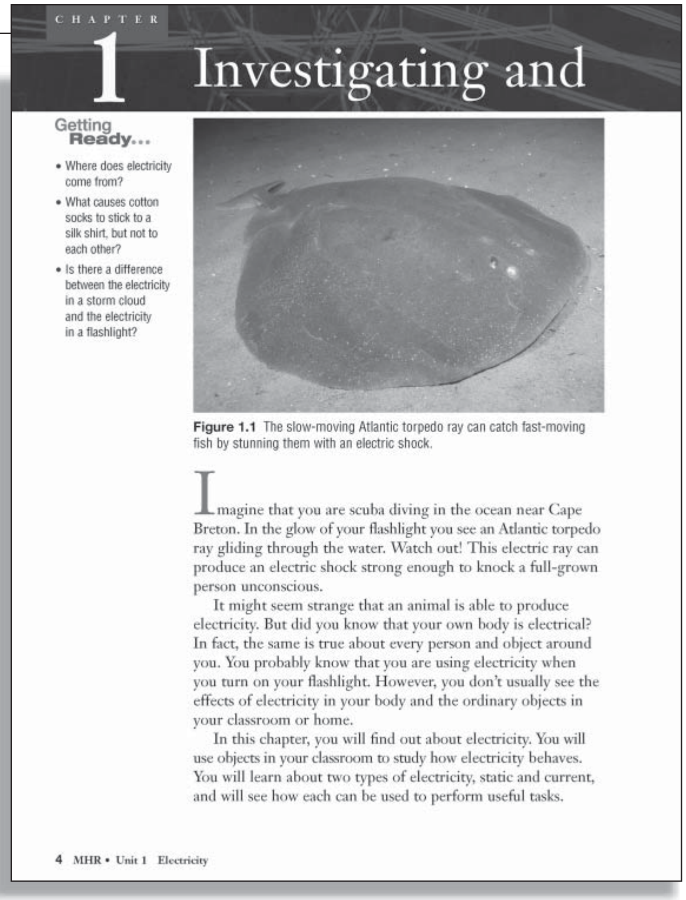
- Discuss the difference between being afraid of electricity and being confident (and safe) around electricity. Have students explain the difference between fear and caution.
- Discuss the rising concerns about the use of energy in all forms and its relationship to climate change. Engage students in a critical discussion in which both the benefits and the detrimental effects of power generation are discussed.
- Have students answer a “What Can You Do To …” question in regards to electricity and the environment. Have students focus on realistic changes that can be made in both the short and long term.

USING THE CHAPTER 1 OPENER

TEACHING STRATEGIES

- **Begin the Lesson**—Have students read the *What You Will Learn*, *Why It Is Important*, and *Skills You Will Use* sections. Discuss the points as a class.
- Science Logbook: Have students begin their logbooks by answering questions to determine their knowledge about electricity. Students can write, draw, or share their thoughts through discussion. Possible questions include the following:
  - What is electricity?
  - Can you describe what electricity does?
  - How is electricity generated (created)?
  - How is electricity used in your home?

  Have students share their thoughts in small groups. As each new section is explored, have students ask new questions and record their responses in their logbooks. These will be revisited upon completion of the chapter. Use Learning Skills Rubric 2 Science Logbook to assess the logbooks.
- Students who are unfamiliar with science logbooks could be encouraged to use a strategy for reading and analyzing non-fiction text from Tony Stead's *Reality Checks*. Using the heading "What do I think I know about electricity?", students can use subheadings of "Information I Was Able to Confirm," "Misconceptions (differences between the facts in the text and my thinking)," "New Information," and "Wonderings (questions that I had during and after reading)" to classify the information.
- **During Reading**—Ask students to create their own definitions of key terms. Distribute BLM 1.1 Key Terms for students to use as a reference throughout the chapter. Alternatively, students could use a graphic organizer for learning new vocabulary in context.
- **After Reading**—Discuss Figure 1.1 with students. Ask students how they think the Atlantic torpedo ray might generate electricity. What other organisms use electricity to protect themselves or stun their prey? Students may be aware that electric eels give off electric shocks. Students will be interested to learn that the organs responsible for producing electricity in an electric eel take up 80 percent of its body. The organs are composed of special electric cells that are able to give off both low-voltage and high-voltage shocks. The latter can be powerful enough to harm a human being.
  – Provide students with a small pile of Styrofoam™ peanuts and have them transfer these into a small beaker. After 2 minutes, discuss reasons why the task was more difficult than expected, referring to the role of static electricity.



CHAPTER 1 Investigating and

Getting Ready...

- Where does electricity come from?
- What causes cotton socks to stick to a silk shirt, but not to each other?
- Is there a difference between the electricity in a storm cloud and the electricity in a flashlight?

Figure 1.1 The slow-moving Atlantic torpedo ray can catch fast-moving fish by stunning them with an electric shock.

Imagine that you are scuba diving in the ocean near Cape Breton. In the glow of your flashlight you see an Atlantic torpedo ray gliding through the water. Watch out! This electric ray can produce an electric shock strong enough to knock a full-grown person unconscious.

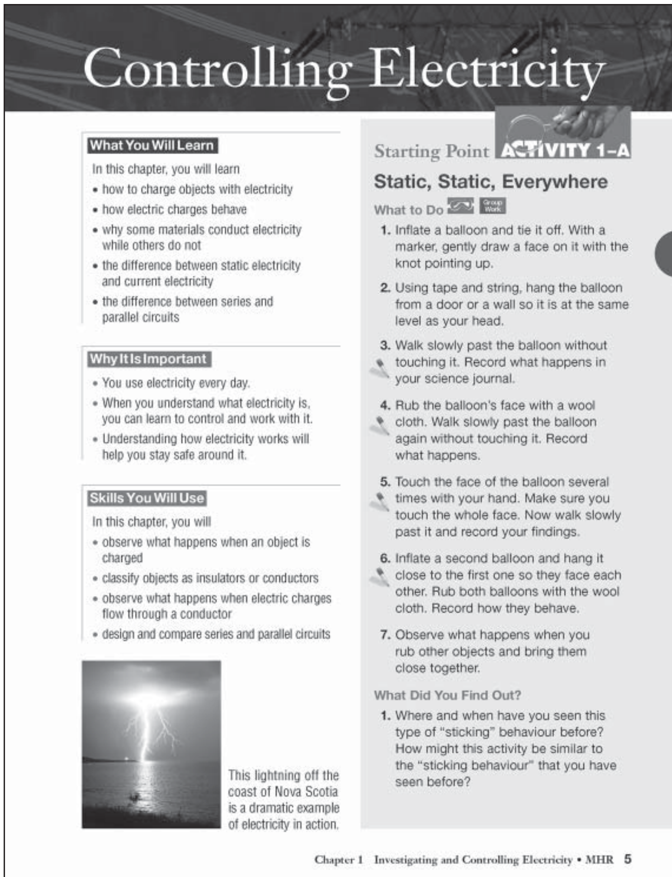
It might seem strange that an animal is able to produce electricity. But did you know that your own body is electrical? In fact, the same is true about every person and object around you. You probably know that you are using electricity when you turn on your flashlight. However, you don't usually see the effects of electricity in your body and the ordinary objects in your classroom or home.

In this chapter, you will find out about electricity. You will use objects in your classroom to study how electricity behaves. You will learn about two types of electricity, static and current, and will see how each can be used to perform useful tasks.

4 MHR • Unit 1 Electricity

Getting Ready Answers

- **Where does electricity come from?** All matter has two kinds of charges, which have been called positive and negative charges. The movement of these charges creates electricity. When there is an imbalance in the number of positive and negative charges in an object, an electrical charge is generated. (If students are unfamiliar with the term "matter," it can be defined as what makes up physical things, taking up space and having mass.)
- **What causes cotton socks to stick to a silk shirt but not to each other?** Opposite charges attract. When a silk shirt and cotton socks tumble together in a dryer, there is a charge transfer. The shirt and socks become oppositely charged and stick together. However, the cotton socks repel each other because any charges they obtain from rubbing the silk are identical.
- **Is there a difference between the electricity in a storm cloud and the electricity in a flashlight?** Yes and no. Both types of electricity are generated by charges. However, the electricity in a storm cloud is static electricity that is generated when water droplets and ice particles rub together. The clouds become charged and remain so until the charges are discharged to the ground as lightning. The electricity in a flashlight is current electricity. Charges move through an object, rather than stay in one place. In the flashlight, charges created by chemicals in the batteries flow through a circuit to light a bulb.



Controlling Electricity

What You Will Learn

In this chapter, you will learn
- how to charge objects with electricity
- how electric charges behave
- why some materials conduct electricity while others do not
- the difference between static electricity and current electricity
- the difference between series and parallel circuits

Why It Is Important

- You use electricity every day.
- When you understand what electricity is, you can learn to control and work with it.
- Understanding how electricity works will help you stay safe around it.

Skills You Will Use

In this chapter, you will
- observe what happens when an object is charged
- classify objects as insulators or conductors
- observe what happens when electric charges flow through a conductor
- design and compare series and parallel circuits

This lightning off the coast of Nova Scotia is a dramatic example of electricity in action.

Starting Point ACTIVITY 1-A

Static, Static, Everywhere

What to Do

1. Inflate a balloon and tie it off. With a marker, gently draw a face on it with the knot pointing up.
2. Using tape and string, hang the balloon from a door or a wall so it is at the same level as your head.
3. Walk slowly past the balloon without touching it. Record what happens in your science journal.
4. Rub the balloon's face with a wool cloth. Walk slowly past the balloon again without touching it. Record what happens.
5. Touch the face of the balloon several times with your hand. Make sure you touch the whole face. Now walk slowly past it and record your findings.
6. Inflate a second balloon and hang it close to the first one so they face each other. Rub both balloons with the wool cloth. Record how they behave.
7. Observe what happens when you rub other objects and bring them close together.

What Did You Find Out?

1. Where and when have you seen this type of "sticking" behaviour before? How might this activity be similar to the "sticking behaviour" that you have seen before?

Chapter 1 Investigating and Controlling Electricity • MHR 5

STARTING POINT ACTIVITY 1-A STATIC, STATIC, EVERYWHERE

Purpose

- Students will use balloons to investigate and describe the creation and behaviour of static charges.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
3 days before	– Obtain a class set of materials.

MATERIALS	
Per group:	
– string	– markers
– tape	– 2 balloons
– 1 wool cloth	
– other lightweight objects that can be hung, such as plastic containers or Styrofoam™ cups	

Suggested Time

- 20 min

Safety Precautions

- Students should wear eye protection to prevent injuries from bursting balloons. Students who have extreme sound or tactile sensitivities should be provided with gloves and ear protection.
- Ensure that the area used to hang the balloons is safe and free of clutter. No individual (student or adult) should stand on furniture to hang balloons. Support stands may also be used to hang the balloons.

HINTS & HELPS

- Humid air allows for the transfer of electric charge. Avoid humid, rainy days when completing this activity.
- Avoid doing the activity in a carpeted area.
- Hang lightweight objects, such as plastic containers or Styrofoam™ cups, to test other objects in step 7.
- Students may become charged during the activity. They can ground themselves by touching a metal object, such as a tap. This should be done before students ground the balloon by touching it with their hands.

Implementing the Activity

- Optional start: Before describing the activity, distribute the materials and encourage students to "play around" with them and report on what happens.
- Describe the activity before beginning. Have students predict what they think will happen.
- Try this activity with other fabrics if time permits.

Adaptations

- Provide students who wish to explore the nature of charge creation with BLM 1.2 Exploring Charge.
- Students who have trouble conceptualizing charge transfer should be encouraged to examine the surface of the wool (pieces come off easily) and the surface of the balloon (nothing is given off when rubbed). An analogy can be drawn to explain that wool loses charges easily while the balloon does not.

Activity Wrap-Up

- Ask students how their knowledge of the behaviour of charged objects changed after the activity.
- Have students draw a picture explaining what might be happening on the surface of the balloons as they are rubbed with wool.

What Did You Find Out? Answer

1. Students may mention the following "sticking" behaviours: clothes sticking together when they come out of a clothes dryer, a balloon sticking to a wall, Styrofoam™ packing materials sticking to the body, or hair sticking to a comb or sweater. The sticking behaviour is caused by static electricity.

SECTION 1.1 STATIC ELECTRICITY

What Students Do in Section 1.1

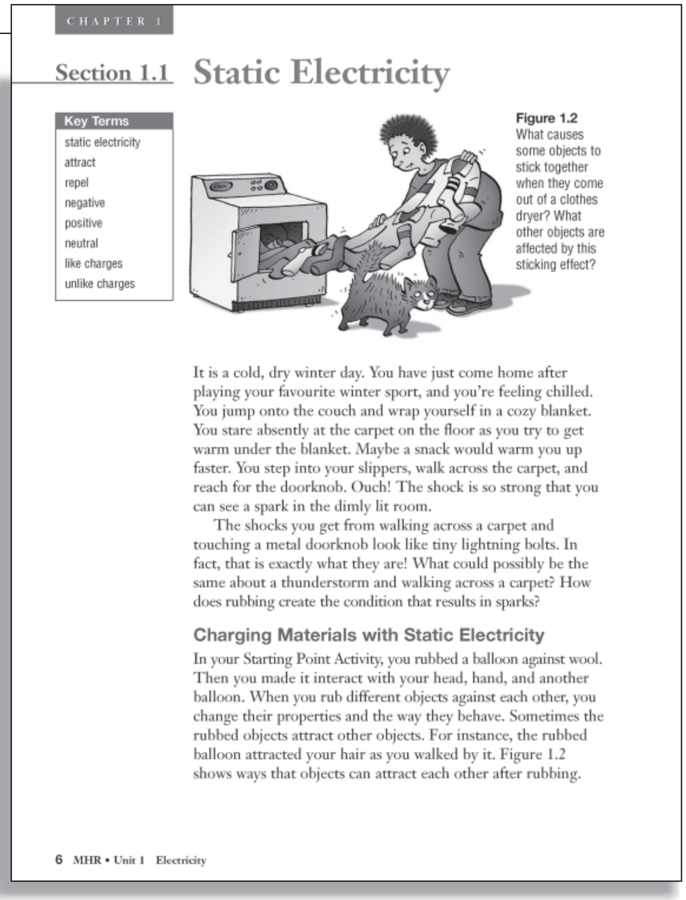
- develop knowledge of attraction, repulsion, and static electricity based on their observations of charged objects
- investigate methods of creating charge using various materials
- learn that objects become charged as a result of an imbalance in the number of positive and negative charges in an object, caused by friction
- describe the interaction between charged objects and neutral objects
- describe the creation and discharge of lightning and investigate a number of myths about its behaviour

BACKGROUND INFORMATION

- All matter is made up of tiny particles called atoms. Atoms have electric charges, which come in two forms that scientists have called positive and negative charges. As materials rub together, one surface gives up negative charges and is left with an overall positive charge. The other surface receives negative charges and will have an overall negative charge. Both of these surfaces are charged with static electricity.
- The charges transferred as a result of friction are always negative. Negative charges are easily transferred because they are small, light components of atoms that are loosely bound to the atom.
- Some materials, such as silk, are more likely to lose negative charges and become positively charged, while others, such as cotton, are more likely to gain negative charges and become negatively charged.

TEACHING STRATEGIES

- **Begin the Lesson**—Ask students to open their logbooks and record their answers to the question, "What do I know about static electricity?" Have them review their answers and record any questions they still have about static electricity once they have read the section. Students can share their answers as a class.
- **During Reading**—Refer to Figure 1.2 to discuss what the picture might have in common with a carpet shock or lightning.
- **After Reading**—Discuss what factors could affect the strength of a shock. Ask for some reasons why lightning is much more dangerous than a carpet shock.



CHAPTER 1

Section 1.1 Static Electricity

Key Terms
static electricity
attract
repel
negative
positive
neutral
like charges
unlike charges

Figure 1.2 What causes some objects to stick together when they come out of a clothes dryer? What other objects are affected by this sticking effect?

It is a cold, dry winter day. You have just come home after playing your favourite winter sport, and you're feeling chilled. You jump onto the couch and wrap yourself in a cozy blanket. You stare absently at the carpet on the floor as you try to get warm under the blanket. Maybe a snack would warm you up faster. You step into your slippers, walk across the carpet, and reach for the doorknob. Ouch! The shock is so strong that you can see a spark in the dimly lit room.

The shocks you get from walking across a carpet and touching a metal doorknob look like tiny lightning bolts. In fact, that is exactly what they are! What could possibly be the same about a thunderstorm and walking across a carpet? How does rubbing create the condition that results in sparks?

Charging Materials with Static Electricity

In your Starting Point Activity, you rubbed a balloon against wool. Then you made it interact with your head, hand, and another balloon. When you rub different objects against each other, you change their properties and the way they behave. Sometimes the rubbed objects attract other objects. For instance, the rubbed balloon attracted your hair as you walked by it. Figure 1.2 shows ways that objects can attract each other after rubbing.

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Common Misconceptions

- Students may think that they must touch a doorknob or metal object in order to get a shock. The extra charge built up on a person actually jumps through the air from the hand to the metal object before contact is made. This is the same way that lightning jumps from a cloud to the ground.

Figure 1.2

Clothes stick together when they come out of the dryer because they develop opposing charges as a result of rubbing together. Other objects affected by static electricity include hair that clings to a brush or sweater and Styrofoam™ peanuts that stick to a hand.

Scientists use the word "charged" to talk about objects that attract or repel other objects. Some objects become charged when they are rubbed with other objects. The charges on a rubbed object are electrical. The build-up of charges is referred to as **static electricity** because the charges are on the surface of an object. (*Static* means "not moving.")

Describing How Charged Objects Behave

Think again about what you observed in your Starting Point Activity. When you rubbed the balloon with wool cloth, you charged it with static electricity. After you charged the balloon, you saw that it behaved in certain ways.

- When you moved toward the balloon, the balloon moved toward you. Charged objects can **attract** (pull on) other objects. Figure 1.3 shows an example of attracting.
- When you put the charged balloon near a second charged balloon, the two charged balloons moved away from each other. Charged objects also can **repel** (push away) other objects. Figure 1.4 shows an example of repelling.

Is there a pattern to the way that objects behave when they are charged? When can you see objects repel? When can you see objects attract? You will explore more about how charged objects behave in Investigation 1-B on the next page.

READING Check: What are two ways that charged objects can behave?

Figure 1.3 The charged comb is attracting bits of paper. Where have you seen an effect like this before? What do you think might cause it to happen?

Figure 1.4 This machine creates a strong static electric charge on its dome. Each strand of hair on this student's head repels each of the other strands when she touches the charged dome.

CHARGING MATERIALS WITH STATIC ELECTRICITY

BACKGROUND INFORMATION

- An object's surface appearance may give a clue as to whether it is going to gain or lose negative charges when rubbed with another material. Smooth surfaces, such as glass rods or balloons, generally accept negative charges, while loose surfaces, such as wool and fur, lose negative charges.
- When negative charges are transferred onto a surface, such as a balloon, they stay in this location. This lack of movement is the reason why the charges are described as static. They only move by another transfer of electrons to or from another object.

TEACHING STRATEGIES

- **Begin the Lesson**—Ask students to describe any experiences they have had with static electricity. Have they ever received a static shock? Ask them to describe the shock and how they received it.
- The experience of charge is more important than the students knowing the type of charge (whether the charge is positive or negative). The key point for students to learn is that objects can have a charge.

Common Misconceptions

- Students may think that an object, such as a balloon, becomes charged over its entire surface. The charge is actually located only at the point of contact where the two surfaces were rubbed together. To show that the charge is static on the balloon, rub one side of a balloon on your hair and try to stick the opposite side to the wall. It will not stick, while the rubbed side will. This will also help demonstrate that static charges do not move.

DESCRIBING HOW CHARGED OBJECTS BEHAVE

BACKGROUND INFORMATION

- The machine shown in Figure 1.4 is a Van de Graaff generator. A Van de Graaff generator uses a moving belt to create a static charge on its hollow metal dome. These generators were originally designed in 1929 to generate high voltages and are now popular in science centres, where they are used for dramatic demonstrations like the one in Figure 1.4. Modern Van de Graaff generators can generate up to 5 megavolts of electricity and are used to sterilize food and for nuclear-physics experiments. They are also used in X-ray technology.

TEACHING STRATEGIES

- **Begin the Lesson**—Begin with a quick review of Starting Point Activity 1-A Static, Static, Everywhere and ask students to describe their knowledge of attraction and repulsion.
- **During Reading**—Examine Figures 1.3 and 1.4 and have students describe how the pictures show attraction and repulsion.
- **After Reading**—If possible, arrange a visit to a Van de Graaff generator so students can experience the effect shown in Figure 1.4. There is one at the Discovery Centre in Halifax.

READING Check: Charged objects can attract or repel each other.

Figure 1.3

1. This effect was seen in the balloons in Starting Point Activity 1-A Static, Static, Everywhere and in the socks coming out of the dryer in Figure 1.2. Students may also describe their hair sticking to a sweater or a balloon sticking to a wall.
2. The paper and comb have opposing static charges and are attracted to each other.

CONDUCT AN INVESTIGATION 1-B GET READY, GET SET, CHARGE!

Purpose

- Students will discover what types of objects can become electrically charged and how charged objects behave when they are near one another or an uncharged object.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
3 days before	– Obtain or ask students to bring in materials for each group.
1 day before	– Photocopy BLM 1.3 Get Ready, Get Set, Charge! or have students prepare the tables required to complete the investigation.

MATERIALS	
Per group:	
– 2 plastic spoons	– 2 glass rods
– 1 piece of wool cloth	– 1 piece of silk
– paper punches or confetti	

Suggested Time

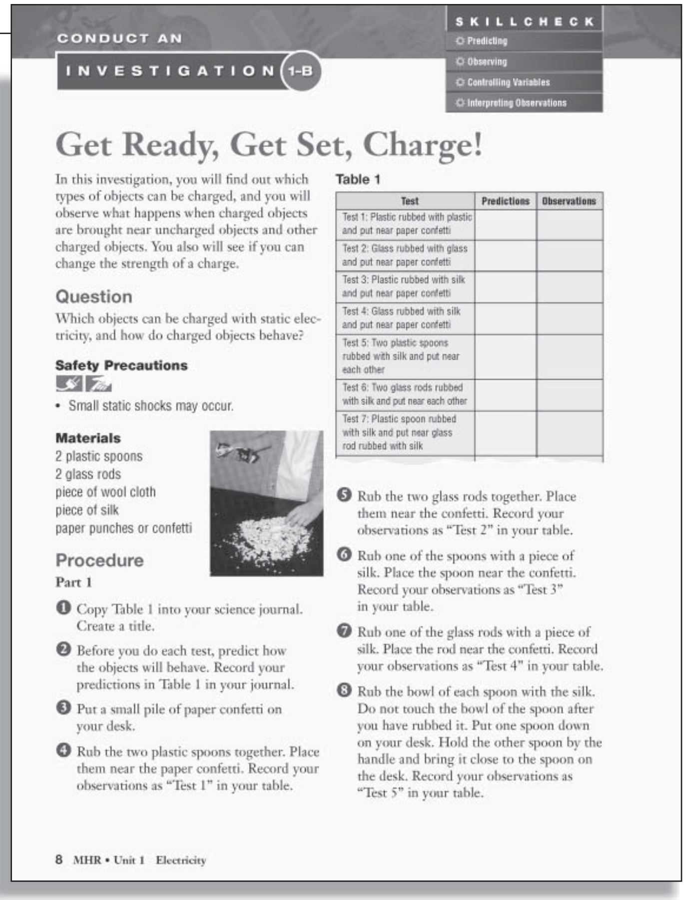
- Part 1: 20 min
- Part 2: 10 min
- Wrap-Up: 10 min

Safety Precautions

- Advise students of the fragile nature of glass rods, which can break or splinter, causing cuts to students' hands. This part of the investigation may be completed as a demonstration if safety is a concern.

HINTS & HELPS

- If possible, complete the investigation on a dry day, as humidity will affect the investigation. Experiments such as this work well when warm, dry air created by indoor heating fills the classroom
- Suggest that students try a number of different rub counts in Part 2 beyond the 10 rubs and 30 rubs that are suggested.


CONDUCT AN INVESTIGATION 1-B

SKILLCHECK
- Predicting
- Observing
- Controlling Variables
- Interpreting Observations

Get Ready, Get Set, Charge!

In this investigation, you will find out which types of objects can be charged, and you will observe what happens when charged objects are brought near uncharged objects and other charged objects. You also will see if you can change the strength of a charge.

Question

Which objects can be charged with static electricity, and how do charged objects behave?

Safety Precautions

- Small static shocks may occur.

Materials

2 plastic spoons
2 glass rods
piece of wool cloth
piece of silk
paper punches or confetti

Procedure

Part 1

1. Copy Table 1 into your science journal. Create a title.
2. Before you do each test, predict how the objects will behave. Record your predictions in Table 1 in your journal.
3. Put a small pile of paper confetti on your desk.
4. Rub the two plastic spoons together. Place them near the paper confetti. Record your observations as "Test 1" in your table.

Table 1

Test	Predictions	Observations
Test 1: Plastic rubbed with plastic and put near paper confetti		
Test 2: Glass rubbed with glass and put near paper confetti		
Test 3: Plastic rubbed with silk and put near paper confetti		
Test 4: Glass rubbed with silk and put near paper confetti		
Test 5: Two plastic spoons rubbed with silk and put near each other		
Test 6: Two glass rods rubbed with silk and put near each other		
Test 7: Plastic spoon rubbed with silk and put near glass rod rubbed with silk		

5. Rub the two glass rods together. Place them near the confetti. Record your observations as "Test 2" in your table.
6. Rub one of the spoons with a piece of silk. Place the spoon near the confetti. Record your observations as "Test 3" in your table.
7. Rub one of the glass rods with a piece of silk. Place the rod near the confetti. Record your observations as "Test 4" in your table.
8. Rub the bowl of each spoon with the silk. Do not touch the bowl of the spoon after you have rubbed it. Put one spoon down on your desk. Hold the other spoon by the handle and bring it close to the spoon on the desk. Record your observations as "Test 5" in your table.

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Implementing the Investigation

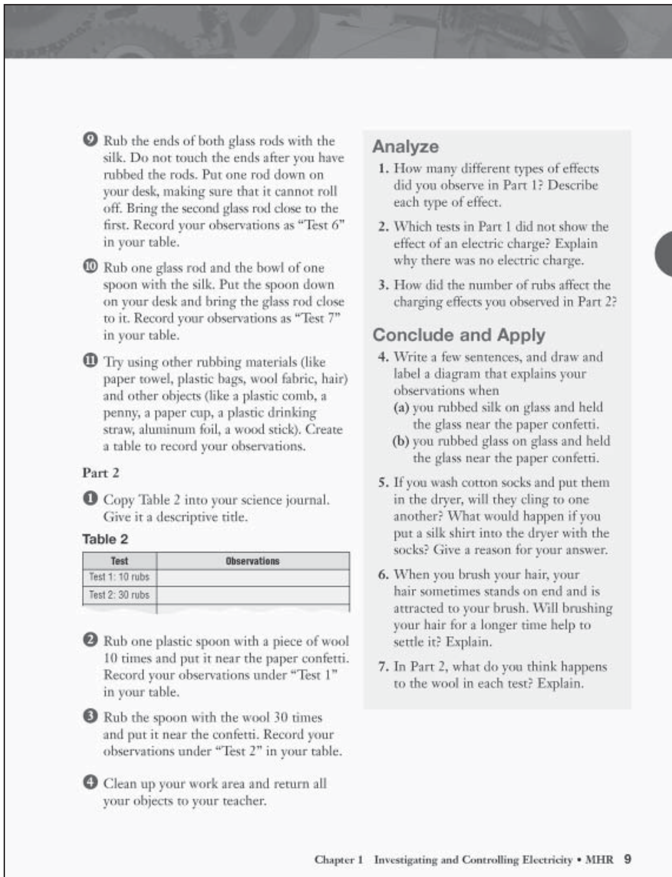
- Group size for this activity should be no more than two or three.
- Distribute BLM 1.3 Get Ready, Get Set, Charge! or have students prepare the tables required to complete the investigation.
- A support stand may be used for Procedure steps 8-10. If the charged object is suspended vertically with tape or string, it will be easier to move.
- If students are having difficulties with the confetti sticking to their hands or other objects, they may need to ground themselves by touching a water tap or other large metal object.
- Encourage students to go beyond the instructions and try this activity with other materials or objects.

Investigation Wrap-Up

- Upon completion of the investigation, a group discussion of observations may be completed to arrive at a general conclusion.
- After student reports have been evaluated and returned to students, discuss and review the Analyze and Conclude and Apply sections.

Assessment Option

- Use Science Skills Checklist 14, Scientific Drawing to assess student work in this activity.



9. Rub the ends of both glass rods with the silk. Do not touch the ends after you have rubbed the rods. Put one rod down on your desk, making sure that it cannot roll off. Bring the second glass rod close to the first. Record your observations as "Test 6" in your table.
10. Rub one glass rod and the bowl of one spoon with the silk. Put the spoon down on your desk and bring the glass rod close to it. Record your observations as "Test 7" in your table.
11. Try using other rubbing materials (like paper towel, plastic bags, wool fabric, hair) and other objects (like a plastic comb, a penny, a paper cup, a plastic drinking straw, aluminum foil, a wood stick). Create a table to record your observations.

Part 2

1. Copy Table 2 into your science journal. Give it a descriptive title.

Table 2

Test	Observations
Test 1: 10 rubs	
Test 2: 30 rubs	

2. Rub one plastic spoon with a piece of wool 10 times and put it near the paper confetti. Record your observations under "Test 1" in your table.
3. Rub the spoon with the wool 30 times and put it near the confetti. Record your observations under "Test 2" in your table.
4. Clean up your work area and return all your objects to your teacher.

Analyze

1. How many different types of effects did you observe in Part 1? Describe each type of effect.
2. Which tests in Part 1 did not show the effect of an electric charge? Explain why there was no electric charge.
3. How did the number of rubs affect the charging effects you observed in Part 2?

Conclude and Apply

4. Write a few sentences, and draw and label a diagram that explains your observations when
   (a) you rubbed silk on glass and held the glass near the paper confetti.
   (b) you rubbed glass on glass and held the glass near the paper confetti.
5. If you wash cotton socks and put them in the dryer, will they cling to one another? What would happen if you put a silk shirt into the dryer with the socks? Give a reason for your answer.
6. When you brush your hair, your hair sometimes stands on end and is attracted to your brush. Will brushing your hair for a longer time help to settle it? Explain.
7. In Part 2, what do you think happens to the wool in each test? Explain.

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Analyze Answers

1. Three different types of effects are observed:
   (a) No reaction occurs when identical substances are rubbed together.
   (b) Attraction occurs when an object (spoon or rod) rubbed with silk is brought near an uncharged object (confetti).
   (c) Repulsion occurs when two objects rubbed with silk are brought near one another.
2. Tests 1 and 2 of Part 1 showed no effects of charge. Both objects are the same. They have an equal tendency to gain or give off charges, thus no charge imbalance is created.
3. The more the object was rubbed, the greater the force of attraction or repulsion.

Conclude and Apply Answers

4. (a) The confetti was attracted to the rod. It sprung up and stuck to the glass. Students' diagrams should show the confetti being attracted to the rod. Some students may show that charges are transferred from the silk to the rod, and that the rod and confetti are oppositely charged.
   (b) The confetti experienced neither attraction nor repulsion. It did not move. Students' diagrams should show that the confetti is not attracted to the rod. Students may also show that no charges are transferred between the glass rods.
5. Tests 1 and 2 in Part 1 showed that no attraction or repulsion occurs when the same objects are rubbed together. The socks are the same material, so no charge would be generated when they rub together and they would not stick together. Tests 3 and 4 in Part 1 showed attraction results when an object is rubbed with silk. Thus the shirt and socks would stick together.
6. No, brushing your hair for a longer time will not help settle it. The tests in Part 2 showed that the more an object is rubbed, the more it attracts another object. Thus, the more times the brush rubs against your hair, the stronger the attraction becomes. Test 5 and 6 in Part 1 showed that the same objects rubbed with the same material experience repulsion. Thus, each strand of hair rubbed with the brush is repelled by the others and stands on end.
7. In Test 1 in Part 2, the wool develops an opposing charge to the spoon. In Test 2, the wool becomes even more oppositely charged as it has been rubbed more.

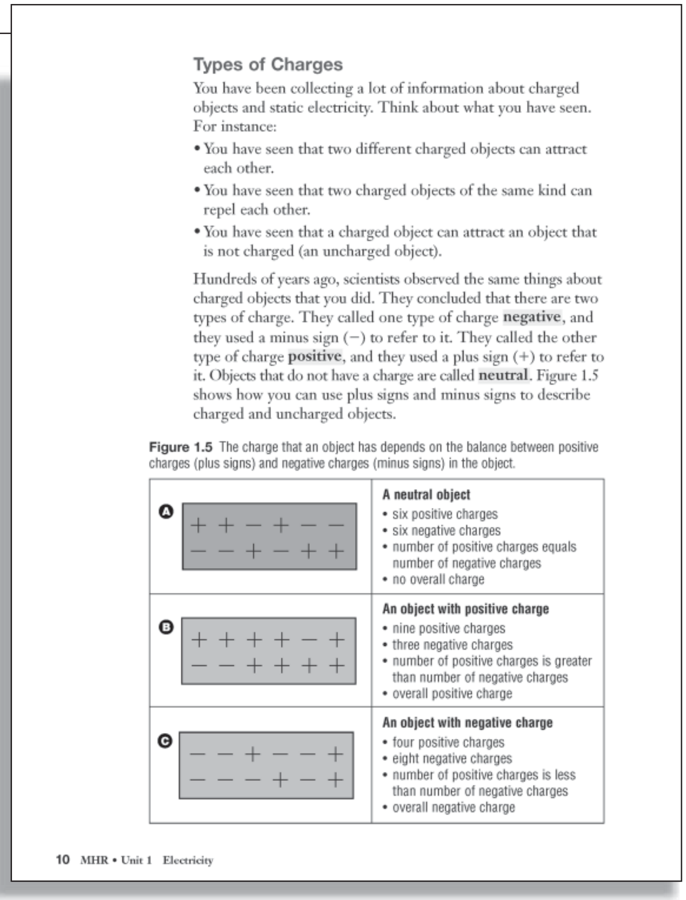
TYPES OF CHARGE/ HOW CHARGES INTERACT

BACKGROUND INFORMATION

- Objects become charged when charges are transferred between surfaces in contact with one another. When an object gains negative charges, it becomes negatively charged. When an object loses negative charges, it becomes positively charged. Gaining positive charges never creates positively charged objects; losing positive charges does not create negatively charged objects.

TEACHING STRATEGIES

- **Begin the Lesson**—There are a large number of new terms in this section. Before students begin reading, introduce the Key Terms in class. Discuss them and have students try to explain what they mean. Review those that require clarification. Encourage students to note the new terms and definitions in their science logbooks.
- **During Reading**—Use the figures in this section to help students explore key concepts. Figure 1.5 should be used to add a visual aspect to the information. Students may have a hard time grasping the invisible aspect of charge. Examine Figure 1.6 with students and answer the questions in the caption via classroom discussion.
- **After Reading**—Review the discoveries of Conduct an Investigation 1-B Get Ready, Get Set, Charge! and relate them to the concepts of positive, neutral, and negative charge. Have students update their key terms list, adding their own descriptions of positive charge, negative charge, neutral charge, as well as like and unlike charges.
- Use the following kinesthetic activity to investigate the effects of different types of charges. Give each student a card with a positive sign (+), a negative sign (–), or a neutral sign (o) on it. Form students into pairs, without looking at their cards. Have them stand facing each other with about 1 m between them. Next, have the students reveal their cards and move according to attraction or repulsion that occurs between the two charges. If they are repelled by one another, they should move towards someone with a charge they would be attracted to.
- Distribute BLM 1.4 What's the Charge? to help students review the concept of positive and negative charges.



Types of Charges

You have been collecting a lot of information about charged objects and static electricity. Think about what you have seen. For instance:

- You have seen that two different charged objects can attract each other.
- You have seen that two charged objects of the same kind can repel each other.
- You have seen that a charged object can attract an object that is not charged (an uncharged object).

Hundreds of years ago, scientists observed the same things about charged objects that you did. They concluded that there are two types of charge. They called one type of charge **negative**, and they used a minus sign (−) to refer to it. They called the other type of charge **positive**, and they used a plus sign (+) to refer to it. Objects that do not have a charge are called **neutral**. Figure 1.5 shows how you can use plus signs and minus signs to describe charged and uncharged objects.

Figure 1.5 The charge that an object has depends on the balance between positive charges (plus signs) and negative charges (minus signs) in the object.

A	+ + − + − − − − + − + +	**A neutral object** • six positive charges • six negative charges • number of positive charges equals number of negative charges • no overall charge
B	+ + + + − + − − + + + +	**An object with positive charge** • nine positive charges • three negative charges • number of positive charges is greater than number of negative charges • overall positive charge
C	− − + − − + − − − + − +	**An object with negative charge** • four positive charges • eight negative charges • number of positive charges is less than number of negative charges • overall negative charge

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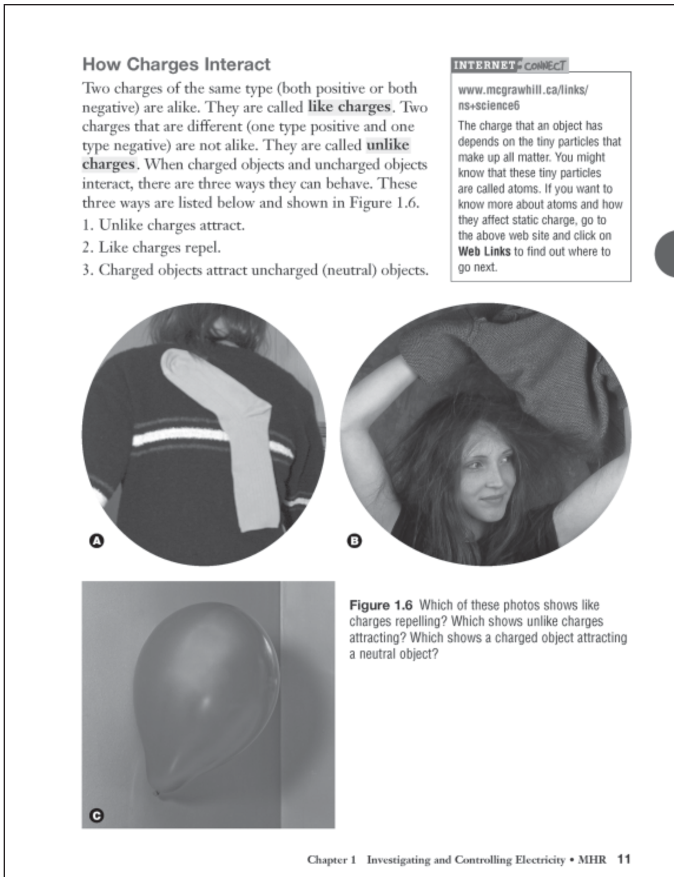

How Charges Interact

Two charges of the same type (both positive or both negative) are alike. They are called **like charges**. Two charges that are different (one type positive and one type negative) are not alike. They are called **unlike charges**. When charged objects and uncharged objects interact, there are three ways they can behave. These three ways are listed below and shown in Figure 1.6.

1. Unlike charges attract.
2. Like charges repel.
3. Charged objects attract uncharged (neutral) objects.

INTERNET CONNECT

www.mcgrawhill.ca/links/ns+science6

The charge that an object has depends on the tiny particles that make up all matter. You might know that these tiny particles are called atoms. If you want to know more about atoms and how they affect static charge, go to the above web site and click on **Web Links** to find out where to go next.

A B C

Figure 1.6 Which of these photos shows like charges repelling? Which shows unlike charges attracting? Which shows a charged object attracting a neutral object?

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Figure 1.6

1. Picture B shows like charges repelling. Charges are transferred between the hair and the sweater. The strands of hair now have like charges and therefore repel one another.
2. Picture A shows opposite charges attracting. One article of clothing has transferred charges to the other. The resulting unlike charges attract.
3. Picture C shows a charged object attracting a neutral object. The balloon sticks to the wall because it has been rubbed with a material that transfers charge, like a wool cloth or someone's hair. As a result, it has become charged. When brought towards the neutral wall, like charges in the wall are repelled from the balloon, leaving an oppositely charged area to which the balloon is attracted.

Common Misconceptions

- Neutral objects often confuse students in that they are attracted to both positive and negative objects. The attraction and repulsion seen in neutral objects occurs because the charges within a neutral object can move internally, creating charged areas that result in the attraction of opposite charges. A link to a model of this can be found at www.mcgrawhill.ca/links/ns+science6.

INTERNET CONNECT

- Students who wish to learn more about atoms and how they affect static charge can also be provided with BLM 1.2 Exploring Charge if it was not used earlier.

THE DANGER OF LIGHTNING

BACKGROUND INFORMATION

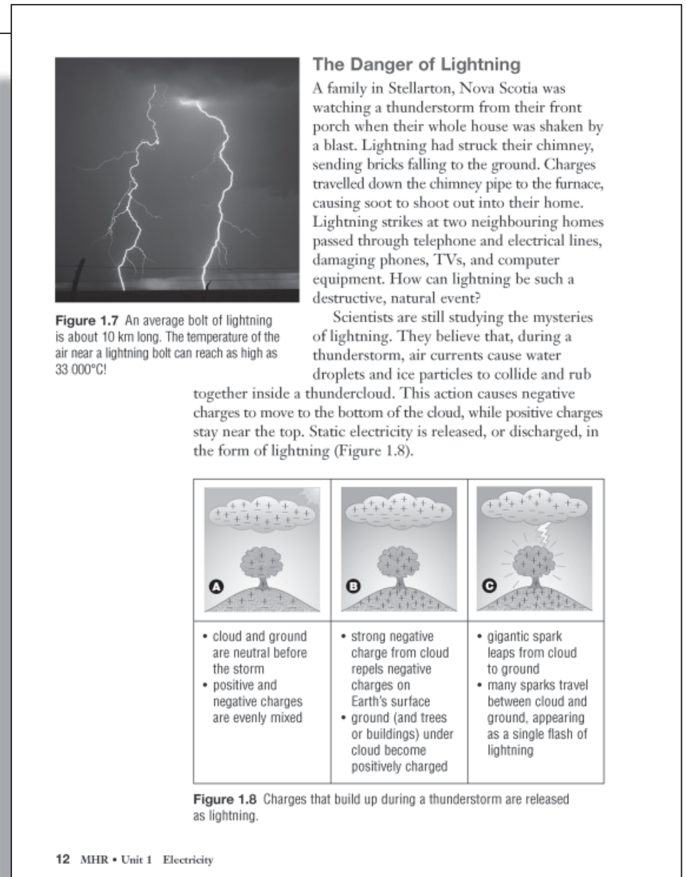
- A typical storm cloud has extremely large numbers of charges separated by distances as large as 5 km. The negative charges are discharged from the cloud to the ground in approximately 30 microseconds.
- Lightning strikes the ground about 100 times each second on Earth.
- The temperature of the average bolt of lightning is hotter than the Sun. At this temperature, the air is heated and expands so rapidly that it makes the sound we recognize as thunder.
- The chance of being struck by lightning in your lifetime is 1 in 3000, which is more likely than getting a hole-in-one (1 in 5000). With proper medical treatment, most people survive being struck by lightning.

TEACHING STRATEGIES

- **Begin the Lesson**—Ask students to use their science logbooks to record their answers to the question "What do I know about lightning?" Have them review their answers and record any remaining questions they have about lightning after they have read the section. Later, students can share these questions as a class.
- **During Reading**—Refer to Figure 1.8 to help explain the process of lightning creation.
- **After Reading**—Revisit the idea of a doorknob shock from the start of the section and compare one type of spark (shock) to another type of spark (lightning).
- *ICT Option:* Photographs of lightning are often awe-inspiring and help to create a sense of wonder. The Internet has many sites with excellent pictures of lightning. Links can be found at www.mcgrawhill.ca/links/ns+science6.

Common Misconceptions

- Most people believe that lightning strikes always travel from cloud to Earth. This statement is not entirely true. As the charges stream towards Earth, they ionize (charge) the air, which provides a pathway for charges to move in the direction of the cloud. The return path is often much brighter than the downward flow.



The Danger of Lightning

A family in Stellarton, Nova Scotia was watching a thunderstorm from their front porch when their whole house was shaken by a blast. Lightning had struck their chimney, sending bricks falling to the ground. Charges travelled down the chimney pipe to the furnace, causing soot to shoot out into their home. Lightning strikes at two neighbouring homes passed through telephone and electrical lines, damaging phones, TVs, and computer equipment. How can lightning be such a destructive, natural event?

Scientists are still studying the mysteries of lightning. They believe that, during a thunderstorm, air currents cause water droplets and ice particles to collide and rub together inside a thundercloud. This action causes negative charges to move to the bottom of the cloud, while positive charges stay near the top. Static electricity is released, or discharged, in the form of lightning (Figure 1.8).

Figure 1.7 An average bolt of lightning is about 10 km long. The temperature of the air near a lightning bolt can reach as high as 33 000°C!

A	B	C
• cloud and ground are neutral before the storm • positive and negative charges are evenly mixed	• strong negative charge from cloud repels negative charges on Earth's surface • ground (and trees or buildings) under cloud become positively charged	• gigantic spark leaps from cloud to ground • many sparks travel between cloud and ground, appearing as a single flash of lightning

Figure 1.8 Charges that build up during a thunderstorm are released as lightning.

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AT HOME ACTIVITY 1-C HOW SHOCKING!

Purpose

- Students will survey their family and friends to develop a list of commonly held beliefs about lightning. Then they will research beliefs about lightning using library resources or the Internet to determine if the beliefs are valid.

Advance Preparation

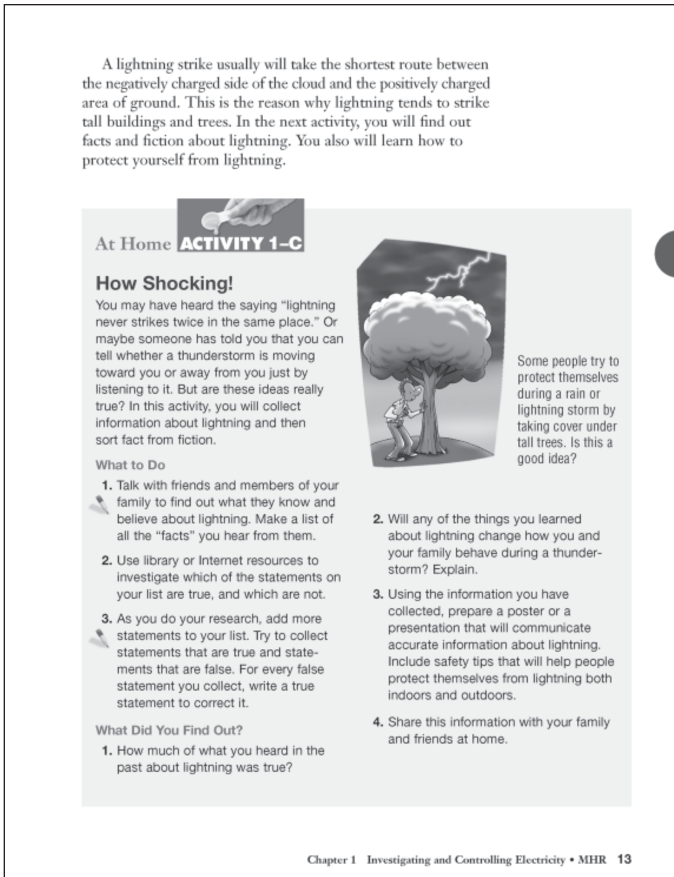
WHEN TO BEGIN	WHAT TO DO
1 week before	– Identify some age-appropriate books and web sites the students may use to research beliefs about lightning.
1 day before	– Have students list and begin to collect lightning beliefs.

Suggested Time

- 2 h including research at home

HINTS & HELPS

- Review the appropriate use of Internet and library facilities and the effective use of search engines with students.
- Some students may need some examples, such as not swimming during a thunderstorm, to get them started.



A lightning strike usually will take the shortest route between the negatively charged side of the cloud and the positively charged area of ground. This is the reason why lightning tends to strike tall buildings and trees. In the next activity, you will find out facts and fiction about lightning. You also will learn how to protect yourself from lightning.

At Home ACTIVITY 1–C

How Shocking!

You may have heard the saying "lightning never strikes twice in the same place." Or maybe someone has told you that you can tell whether a thunderstorm is moving toward you or away from you just by listening to it. But are these ideas really true? In this activity, you will collect information about lightning and then sort fact from fiction.

Some people try to protect themselves during a rain or lightning storm by taking cover under tall trees. Is this a good idea?

What to Do

1. Talk with friends and members of your family to find out what they know and believe about lightning. Make a list of all the "facts" you hear from them.
2. Use library or Internet resources to investigate which of the statements on your list are true, and which are not.
3. As you do your research, add more statements to your list. Try to collect statements that are true and statements that are false. For every false statement you collect, write a true statement to correct it.

What Did You Find Out?

1. How much of what you heard in the past about lightning was true?
2. Will any of the things you learned about lightning change how you and your family behave during a thunderstorm? Explain.
3. Using the information you have collected, prepare a poster or a presentation that will communicate accurate information about lightning. Include safety tips that will help people protect themselves from lightning both indoors and outdoors.
4. Share this information with your family and friends at home.

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Implementing the Activity

- Advise students of the appropriate method(s) of presenting the results of their research. All statements verifying or contradicting the beliefs collected should be written in sentence form.

Adaptations

- Establish a small collection of beliefs for students who may have difficulty collecting them. These should include some lower-level ideas as well as some more complex ones.
- Obtain some level-specific texts for students who need assistance with reading scientific material.

Activity Wrap-Up

- Have students prepare and share their discoveries through the use of photographs, sketches, role-playing, or other activities.
- Some students may wish to write poetry or a rap song about lightning. Encourage them to include feelings and senses as they describe the phenomenon.

Assessment Options

- Adapt Learning Skills Checklist 1, Investigating an Issue to assess student work in this activity.
- Use Learning Skills Checklist 5, Poster, or other applicable checklist to assess student presentations.

What Did You Find Out? Answers

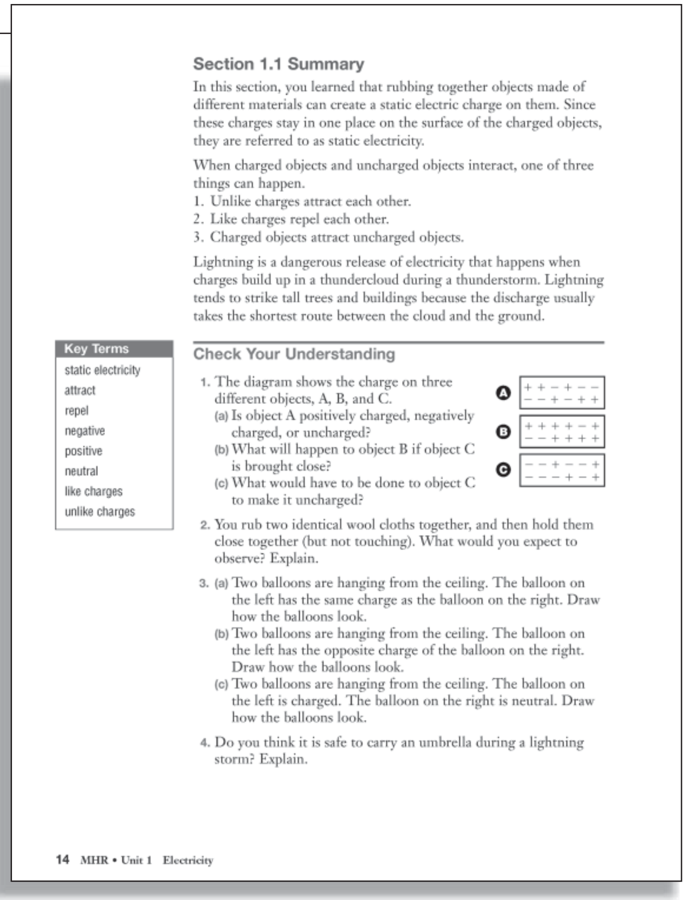
1. Accept all reasonable answers. Students may be divided into small groups to share their research and report as a group back to the class.
2. Accept all reasonable answers. Answers should describe how their behaviours would (or would not) change and give reasons why.
3. Develop a rubric or use Learning Skills Checklist 5, Poster to assess students' posters or presentations.

SECTION 1.1 SUMMARY

Read the section summary together as a class.

✓ ASSESSMENT OPTIONS FOR SECTION 1.1

- Assign some or all of the Check Your Understanding questions on page 14 as a quiz to review the section.
- Collect and review science logbooks, using Learning Skills Rubric 2, Science Logbook as a guide to evaluation.
- Review checklists and rubrics used throughout this section.



Section 1.1 Summary

In this section, you learned that rubbing together objects made of different materials can create a static electric charge on them. Since these charges stay in one place on the surface of the charged objects, they are referred to as static electricity.

When charged objects and uncharged objects interact, one of three things can happen.
1. Unlike charges attract each other.
2. Like charges repel each other.
3. Charged objects attract uncharged objects.

Lightning is a dangerous release of electricity that happens when charges build up in a thundercloud during a thunderstorm. Lightning tends to strike tall trees and buildings because the discharge usually takes the shortest route between the cloud and the ground.

Key Terms
static electricity
attract
repel
negative
positive
neutral
like charges
unlike charges

Check Your Understanding

1. The diagram shows the charge on three different objects, A, B, and C.
   (a) Is object A positively charged, negatively charged, or uncharged?
   (b) What will happen to object B if object C is brought close?
   (c) What would have to be done to object C to make it uncharged?

A: + + − + − − / − − + − + +
B: + + + + − + / − − + + + +
C: − − + − − + / − − − + − +

2. You rub two identical wool cloths together, and then hold them close together (but not touching). What would you expect to observe? Explain.
3. (a) Two balloons are hanging from the ceiling. The balloon on the left has the same charge as the balloon on the right. Draw how the balloons look.
   (b) Two balloons are hanging from the ceiling. The balloon on the left has the opposite charge of the balloon on the right. Draw how the balloons look.
   (c) Two balloons are hanging from the ceiling. The balloon on the left is charged. The balloon on the right is neutral. Draw how the balloons look.
4. Do you think it is safe to carry an umbrella during a lightning storm? Explain.

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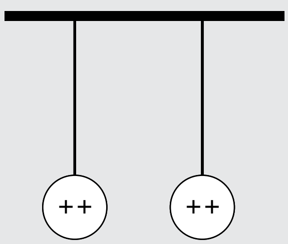
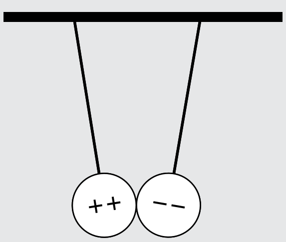
Check Your Understanding Answers

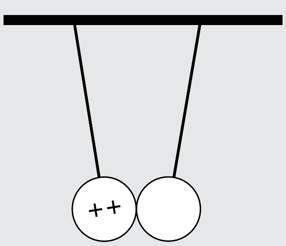
1. (a) Object A is uncharged because it has an equal number of positive and negative charges.
   (b) Object B has an overall positive charge, and object C has an overall negative charge. Thus, if they are brought close together, they will be attracted to each other.
   (c) The object has to be grounded.
2. There would be no attraction or repulsion between the cloths as they are identical. Thus, no charge exchange will take place when they rub together.
3. (a)



(b)



(c)



4. It is not safe. Lightning takes the shortest path to the ground, so holding an umbrella above your head shortens the path between the cloud and the ground. If the lightning strikes the umbrella, it will pass through the person holding it.

SECTION 1.2 MAKING CONNECTIONS

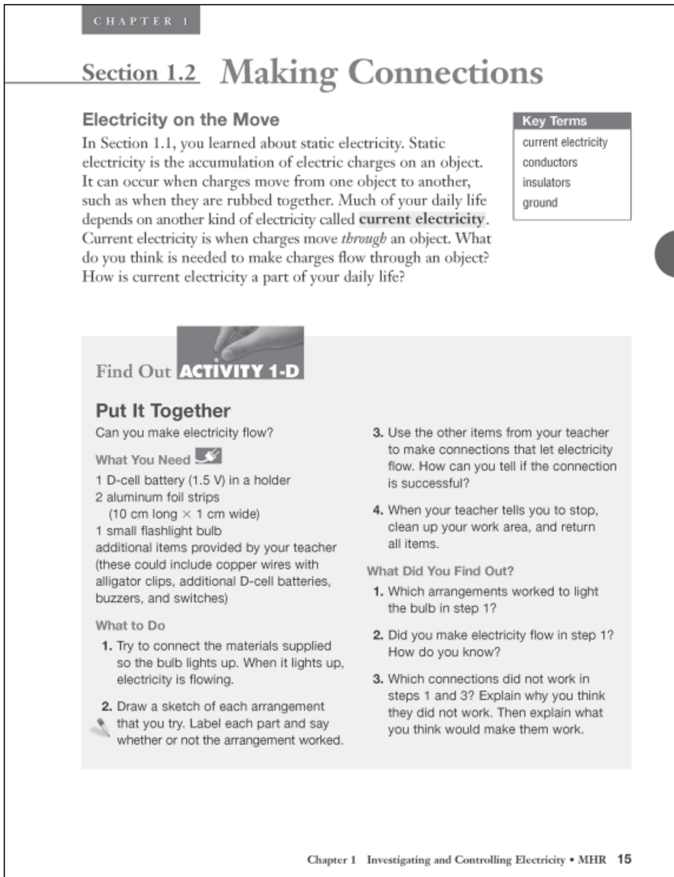
What Students Do in Section 1.2

- discover that electrical charges can flow through a conductive material
- explain how and give reasons why charged objects are often grounded
- construct simple electrical circuits

ELECTRICITY ON THE MOVE

■ BACKGROUND INFORMATION

- Current electricity is created when charges flow through conducting material, such as a metal wire. Recall that charges are the small, lightweight components of an atom that are loosely bound to its nucleus. Charges easily gain mobility to generate a current.
- Current electricity flows from areas of negative charge (i.e., the negative terminal of a battery) to areas of positive charge (i.e., the positive terminal of a battery), as the negatively charged particles are attracted to areas of opposing charge. Many people in the general public often believe that current begins at the positive area of charge. This view was commonly held throughout history and positive current, although theoretically incorrect, is still described in some areas of physics and engineering.



CHAPTER 1

Section 1.2 Making Connections

Electricity on the Move

In Section 1.1, you learned about static electricity. Static electricity is the accumulation of electric charges on an object. It can occur when charges move from one object to another, such as when they are rubbed together. Much of your daily life depends on another kind of electricity called **current electricity**. Current electricity is when charges move *through* an object. What do you think is needed to make charges flow through an object? How is current electricity a part of your daily life?

Key Terms
current electricity
conductors
insulators
ground

Find Out ACTIVITY 1-D

Put It Together

Can you make electricity flow?

What You Need

1 D-cell battery (1.5 V) in a holder
2 aluminum foil strips (10 cm long × 1 cm wide)
1 small flashlight bulb
additional items provided by your teacher (these could include copper wires with alligator clips, additional D-cell batteries, buzzers, and switches)

What to Do

1. Try to connect the materials supplied so the bulb lights up. When it lights up, electricity is flowing.
2. Draw a sketch of each arrangement that you try. Label each part and say whether or not the arrangement worked.
3. Use the other items from your teacher to make connections that let electricity flow. How can you tell if the connection is successful?
4. When your teacher tells you to stop, clean up your work area, and return all items.

What Did You Find Out?

1. Which arrangements worked to light the bulb in step 1?
2. Did you make electricity flow in step 1? How do you know?
3. Which connections did not work in steps 1 and 3? Explain why you think they did not work. Then explain what you think would make them work.

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TEACHING STRATEGIES

- **Begin the Lesson**—Have students write in their logbooks to describe the term "current" in several contexts, such as wind, water, and electricity. Ask what these currents all have in common (flow) and what makes them different.
- **During Reading**—You may choose to explain the direction of electric current. Negative charges flow from the negative terminal of the battery towards the positive terminal. Have students examine a battery in small groups. Ask them to try to explain what the positive and negative signs on the battery refer to and give reasons why they are important.
- **After Reading**—Discuss the following questions as a class: What do you think is needed to make charges flow through an object? How is current electricity a part of your daily life?

FIND OUT ACTIVITY 1-D PUT IT TOGETHER

Purpose

- Students will investigate various arrangements of simple circuits and determine which arrangements can illuminate a small bulb with a D-cell battery.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
3 days before	– Collect a complete set of materials for each group in the class. – Allow students to bring in as much of this material as possible; this makes learning real and relevant. – Test all components to ensure that each group has a full set of operational equipment.
1 day before	– Photocopy BLM 1.5 Working Safely with Electric Circuits for the class.

MATERIALS
Per group: – 1 D-cell battery (1.5 V) in a holder – 2 aluminum-foil strips (10 cm long by 1 cm wide) – 1 small flashlight bulb – additional items (these could include copper wires with alligator clips, additional D-cell batteries, buzzers, and switches)

Suggested Time

- 30 min

Safety Precautions

- Check for corroded or leaky batteries.
- Be aware that conductors will become warm (or even hot) as electricity flows through them. Encourage students to leave their circuits connected only for a short period of time.
- Warn students not to connect the circuit unless the bulb is in place.
- Ensure that students do not connect several batteries in series.

HINTS & HELPS

- Using tape will make it easier to attach the aluminum-foil strips to the battery.
- Optional: Have a variety of lengths and widths of aluminum foil (e.g., 5 to 15 cm long and 2 to 5 cm wide) for the students to experiment with.
- Depending on the class, you may want to distribute the materials and challenge students to build something with them before you introduce the activity.

Implementing the Activity

- Distribute BLM 1.5 Working Safely with Electric Circuits and review the information with the students. Have students take a few minutes to answer the questions and review the answers with the class.
- Have students prepare a chart to record sketches and observations. Ask them to use one column to draw the arrangement and another column to describe the result.

(continued) ➜

Adaptations

- Rather than draw a diagram, some students may be better able to demonstrate the knowledge gained by arranging a set of cards and/or blocks with the circuit elements drawn on them.
- Students with dexterity issues should be provided with alligator clips.

Activity Wrap-Up

- Relate this activity to the structure and operation of a flashlight.

What Did You Find Out? Answers

1. To illuminate the bulb, one piece of foil must be connected from the negative terminal of the battery to one terminal of the bulb. The other piece of foil must be connected from the other terminal of the bulb to the positive terminal of the battery.
2. Yes, electricity was flowing in step 1. Students should indicate they knew this was the case because the bulb lit up and the foil became warm.
3. Connections that do not work use only one terminal of the light bulb or battery. They will not work because electricity needs to follow a path (circuit) from one terminal of the battery through the bulb to the other terminal of the battery in order to flow. The aluminum foil must touch both terminals of the battery and both terminals of the bulb.

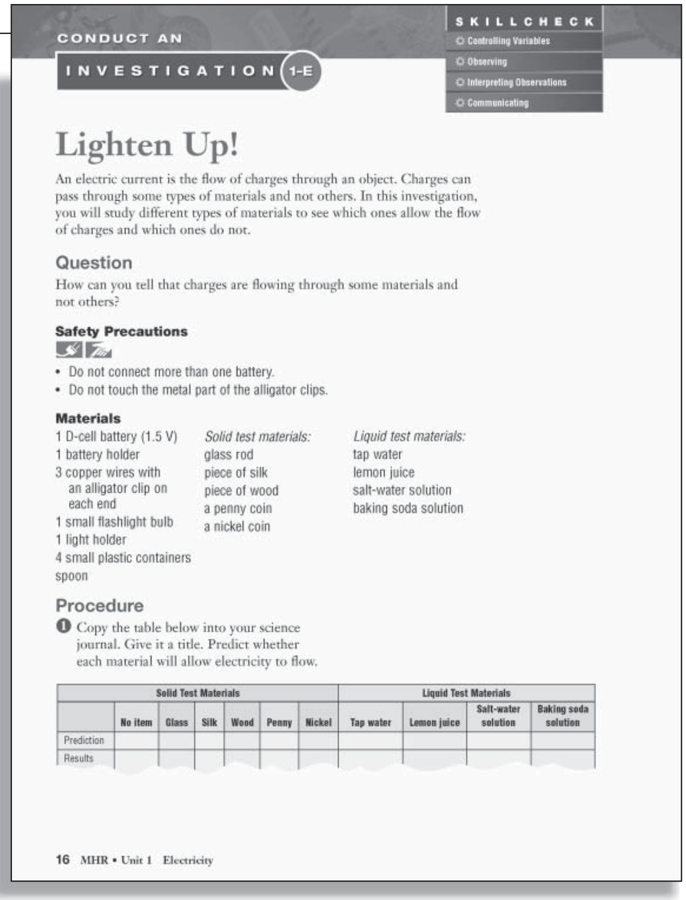
CONDUCT AN INVESTIGATION 1-E LIGHTEN UP!

Purpose

- Students will discover the types of materials that allow or prevent the flow of electric current.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
3 days before	– Prepare a complete set of materials for each group. – Allow students to bring in as much of this material as possible. In their collection of the material, students sometimes learn the use of the material in an indirect way. – Test all components to ensure that each group has a full set of operational equipment.
1 day before	– Photocopy the BLM 1.6 Lighten Up! or have each group prepare the table required to complete the investigation.



CONDUCT AN INVESTIGATION 1-E

SKILLCHECK
- Controlling Variables
- Observing
- Interpreting Observations
- Communicating

Lighten Up!

An electric current is the flow of charges through an object. Charges can pass through some types of materials and not others. In this investigation, you will study different types of materials to see which ones allow the flow of charges and which ones do not.

Question

How can you tell that charges are flowing through some materials and not others?

Safety Precautions

- Do not connect more than one battery.
- Do not touch the metal part of the alligator clips.

Materials

1 D-cell battery (1.5 V)
1 battery holder
3 copper wires with an alligator clip on each end
1 small flashlight bulb
1 light holder
4 small plastic containers
spoon

Solid test materials:
glass rod
piece of silk
piece of wood
a penny coin
a nickel coin

Liquid test materials:
tap water
lemon juice
salt-water solution
baking soda solution

Procedure

1. Copy the table below into your science journal. Give it a title. Predict whether each material will allow electricity to flow.

	Solid Test Materials						Liquid Test Materials			
	No item	Glass	Silk	Wood	Penny	Nickel	Tap water	Lemon juice	Salt-water solution	Baking soda solution
Prediction										
Results										

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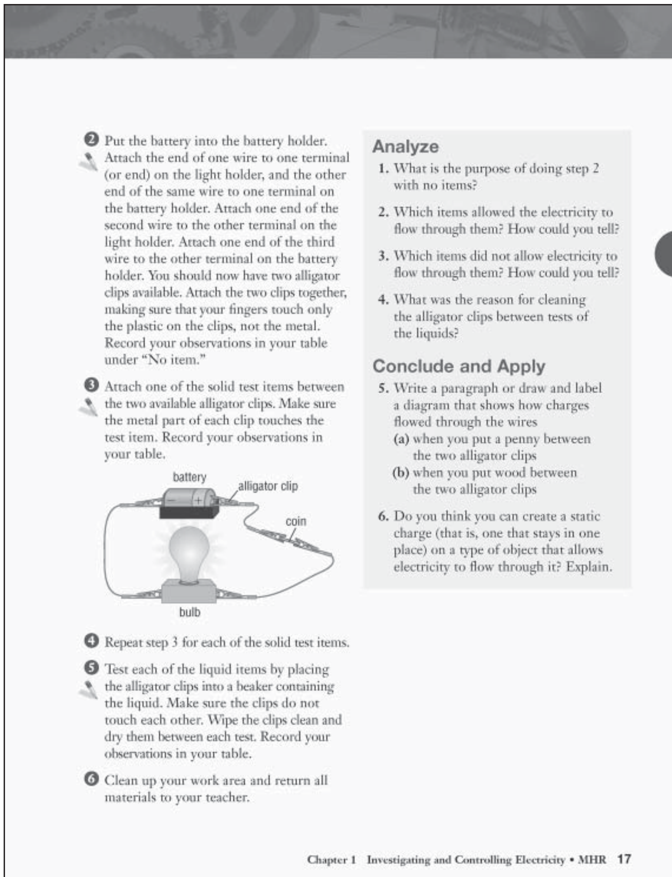
MATERIALS
Per group: – 1 D-cell battery (1.5 V); 1 battery holder; 3 copper wires with an alligator clip on each end; 1 small flashlight bulb; 1 light holder; 4 small plastic containers; 1 spoon – glass rod; piece of silk; piece of wood; a penny coin; a nickel coin; tap water; lemon juice; salt-water solution; baking-soda solution

Suggested Time

- 60 min

Safety Precautions

- Review safety rules for working with electricity with students. Advise students to be cautious using liquids around electricity.
- Students should not connect more than one battery to their circuit.
- Warn students not to touch the metal parts of the alligator clips.
- Remind students of the safety precautions for working with glass.



❷ Put the battery into the battery holder. Attach the end of one wire to one terminal (or end) on the light holder, and the other end of the same wire to one terminal on the battery holder. Attach one end of the second wire to the other terminal on the light holder. Attach one end of the third wire to the other terminal on the battery holder. You should now have two alligator clips available. Attach the two clips together, making sure that your fingers touch only the plastic on the clips, not the metal. Record your observations in your table under "No item."

❸ Attach one of the solid test items between the two available alligator clips. Make sure the metal part of each clip touches the test item. Record your observations in your table.

❹ Repeat step 3 for each of the solid test items.

❺ Test each of the liquid items by placing the alligator clips into a beaker containing the liquid. Make sure the clips do not touch each other. Wipe the clips clean and dry them between each test. Record your observations in your table.

❻ Clean up your work area and return all materials to your teacher.

Analyze

1. What is the purpose of doing step 2 with no items?
2. Which items allowed the electricity to flow through them? How could you tell?
3. Which items did not allow electricity to flow through them? How could you tell?
4. What was the reason for cleaning the alligator clips between tests of the liquids?

Conclude and Apply

5. Write a paragraph or draw and label a diagram that shows how charges flowed through the wires
   (a) when you put a penny between the two alligator clips
   (b) when you put wood between the two alligator clips
6. Do you think you can create a static charge (that is, one that stays in one place) on a type of object that allows electricity to flow through it? Explain.

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HINTS & HELPS

- Distribute BLM 1.6 Lighten Up! for students to use to record their data. Alternatively, have students copy the table from the student textbook into their notebooks on the day prior to performing the investigation. Ask them to give it a descriptive title. This will save time on the day of the investigation and will get students thinking about the investigation.
- Some of the samples (tap water, baking-soda solution) would be considered fair/poor conductors (not conductive enough to light a bulb). If you wish to show that they do conduct *some* current, use either an ammeter or a multi-meter (commonly available from hardware stores) or insert a cheap digital clock in the circuit, both of which require less current to operate.
- Consider setting up a few example devices on the teacher's demonstration desk to help students set up their own circuits.

Implementing the Investigation

- Groups for this activity should have no more than two or three members.
- Encourage students to keep their materials well organized.

Investigation Wrap-Up

- Note that in the Analyze answers, both tap water and the baking-soda solution are recorded as NOT allowing electricity to flow through them. This is not strictly correct, since they do form charged ions in solution and allow electricity to flow. However, the flow is not sufficient in this set-up to light the bulb, which is the criterion used by the student. (It may be important to remind students that while water was not the best conductor for the weaker current used here, it can easily conduct the electricity produced by lightning or devices that are plugged in.)
- As a follow-up to this investigation, ask students to give examples of situations in which it is desirable for materials to allow electricity to flow through them, and others in which it is not.
- After student reports have been evaluated and returned to the students, discuss and review the Analyze and Conclude and Apply sections.

Assessment Options

- Adapt Process Skills Rubric 14, Predicting to assess student work in this activity.

Analyze Answers

1. The purpose of completing step 2 with no items is to set up a control situation for comparison. This confirms that all components are working and provides a basis for comparison with other materials.
2. The items that allow electricity to flow through them were the penny, nickel, lemon juice, and salt-water solution. The evidence for this is that the bulb glowed (as it did in the control step), indicating that electricity was flowing through the circuit.
3. The glass, silk, wood, tap water, and baking-soda solution did not allow sufficient flow of electricity to light the light bulb.
4. The purpose of cleaning the alligator clips between tests of the liquids is to ensure that one liquid does not contaminate another liquid, leading to a false positive result.

Conclude and Apply Answers

5. (a) Charges flowed from one terminal of the battery along the wire. They passed through the penny, a second wire, the bulb, a third wire, and back to the other battery terminal. The bulb and penny may be in any order. Students may know that charges flow from the negative terminal of the battery, through the circuit, to the positive terminal.
   (b) The wood does not allow current electricity to flow through it. Thus, no charges travel through the wires.
6. No. Charges placed on an object that allows electricity to flow through it will flow away from the point of application due to the fact that like charges repel each other. So instead of staying in one place like a static charge, the charges spread through the material.

CONDUCTORS AND INSULATORS/ GROUNDING AN ELECTRIC CHARGE

BACKGROUND INFORMATION

- Different types of materials have different affinities for their negative charges. The negative charges of some materials easily leave the outer part of the atom, while other materials have a tighter hold on their negative charges. This hold on negative charges determines if a substance is a conductor or an insulator.
- Conductors do not allow the build-up of static electricity. This is due to the fact that conductors allow negative charges to move through them, preventing the build-up of charged areas.
- At certain temperatures, some metals become superconductors—materials that can conduct electricity without any resistance. A current will flow indefinitely in a closed circuit made from a superconductor. The first superconductor was discovered in 1911. At an extremely low temperature of –269 ºC, a Dutch physicist discovered that mercury conducted electricity with no resistance. Today, high-speed magnetic (maglev) trains "float" on superconductor electromagnets, keeping friction to a minimum. Similarly, electric generators made with super-conducting wires are extremely efficient.

READING Check
What is the difference between a conductor and an insulator?

Conductors and Insulators

Some materials let charges flow through them easily. These materials are called **conductors**. Metals such as copper are good conductors. An electric charge at one end of a metal object will spread over the whole object.

Other materials block the flow of charges. These materials are called **insulators**. Rubber and wool are both insulators. An electric charge on one part of an insulator is static. In other words, it will stay in one place. You can build static electricity only on objects that are insulators.

A In humid areas such as many parts of Nova Scotia, a static charge will flow away into the air instead of building up on the surface of an object.

B It is much easier to create static electricity on an object in drier areas of the East Coast or in the dry prairies of western Canada (shown above).

Figure 1.9 Humid air is a good conductor of electricity, while dry air is not.

Some materials let charges flow through them, but not very well. These materials are called *fair conductors*. Table 1.1 shows some examples of good conductors, fair conductors, and insulators.

Table 1.1 Conductors and Insulators

Good Conductors	Fair Conductors	Insulators
aluminum	carbon	cotton
copper	Earth	rubber
gold	human body	glass
iron	humid air	dry air
nickel	salt water	wool

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TEACHING STRATEGIES

- **Begin the Lesson**—In class discussion, see if students can define the terms conductor and insulator. Use student discoveries from Conduct an Investigation 1-E Lighten Up! to develop a list of materials that are conductors and insulators. Ask students to note in their logbooks where they have seen conductors and insulators.
- **During Reading**—Use the figures in this section to help students explore key concepts. Refer to Figure 1.9 and discuss reasons why the moist air would be a conductor. Referring to Figure 1.10 and Figure 1.11, have students develop a definition of grounding. Use the definition to describe situations in students' daily lives in which grounding is important.
- **After Reading**—Discuss the concept of grounding in greater depth. Discuss with students how Earth can ground everything from electrical devices to lightning without any noticeable effect. The fact Earth is so large and made up of so many particles means it is an excellent donor or receiver of electrical charge. Address the importance of grounding by explaining how the current in a loose wire in an electrical device could flow through a person if the device is not properly grounded.

Grounding an Electric Charge

"You're grounded!" Those words are not usually ones you want to hear. But when you are using electricity, being grounded can be very important. It can even save your life. To **ground** an object means to connect it through a conductor to the ground, or Earth. Grounding is a way to prevent electric charges from building up on an object, or to get rid of electric charges. Extra charges can flow into the ground so that the object is uncharged again. As shown in Figure 1.10, Earth is so large that it can accept or give up charges without any noticeable change in its overall charge.

Grounding works for big charges like lightning, but it also works for smaller charges. Remember that you can charge an insulator such as a balloon by rubbing it with wool. If you touch the balloon with your hand, you ground the static charge. Figure 1.11 shows another example of grounding for smaller charges.

Figure 1.10 Earth can absorb even big electric charges, the same way the ocean absorbs a cup of water. The overall effect is so small it cannot be measured.

READING Check

How does grounding help keep people safe?

Figure 1.11 Static electric charges can damage sensitive electric equipment like computers. The arrow points to a special ground wire often worn by computer technicians to get rid of static electricity.

READING Check Page 18: A conductor is a material that allows charges to flow through it easily. An insulator is a material that blocks the flow of charges.

Page 19: Grounding, or connecting an object through a conductor to Earth, allows excess charges to flow to Earth, or charges to flow from Earth to where there is a deficit. This neutralizes the charge on the object, preventing electrical charges from building up in that object. If these charges cannot be grounded, they may flow into another conductor, such as a person touching the object.

Common Misconceptions

- Some students may believe that all conductors conduct current equally well and all insulators block current equally well. Describe the concept of good, fair, and poor conductors. Use Table 1.1 Conductors and Insulators to provide examples.
- Some students may believe that when the ground absorbs large amounts of electricity due to lightning or grounding, it becomes permanently charged. Inform them that the excess charge dissipates through the material that holds it.

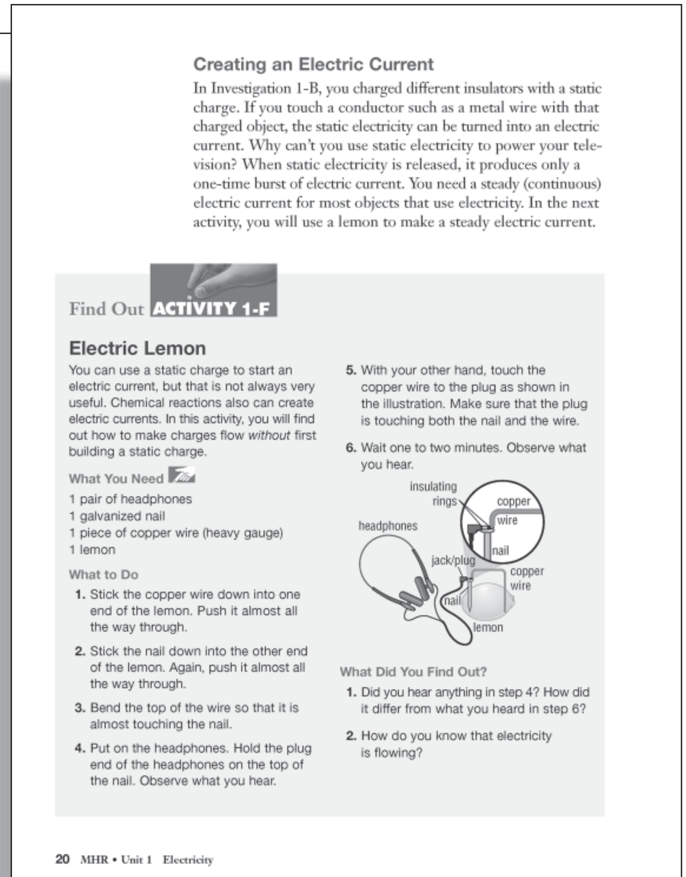
CREATING AN ELECTRIC CURRENT

BACKGROUND INFORMATION

- Lemon batteries produce an electric current via chemical reactions that occur between the lemon juice and the two different metals—the galvanized nail and the copper wire—inserted in the fruit. These electrochemical reactions ionize the citric acid in the lemon, providing a path for the flow of negative charges between the two metals. Lemon batteries can be linked in series. About 500 lemon cells in series can power a small flash-light. Potatoes, oranges, and other acidic fruits can also be used to create batteries.

TEACHING STRATEGIES

- **During Reading**—Discuss as a group the reasons that static electricity is not a useful source of electric current to power our homes and schools.



Creating an Electric Current

In Investigation 1-B, you charged different insulators with a static charge. If you touch a conductor such as a metal wire with that charged object, the static electricity can be turned into an electric current. Why can't you use static electricity to power your television? When static electricity is released, it produces only a one-time burst of electric current. You need a steady (continuous) electric current for most objects that use electricity. In the next activity, you will use a lemon to make a steady electric current.

Find Out ACTIVITY 1-F

Electric Lemon

You can use a static charge to start an electric current, but that is not always very useful. Chemical reactions also can create electric currents. In this activity, you will find out how to make charges flow *without* first building a static charge.

What You Need

1 pair of headphones
1 galvanized nail
1 piece of copper wire (heavy gauge)
1 lemon

What to Do

1. Stick the copper wire down into one end of the lemon. Push it almost all the way through.
2. Stick the nail down into the other end of the lemon. Again, push it almost all the way through.
3. Bend the top of the wire so that it is almost touching the nail.
4. Put on the headphones. Hold the plug end of the headphones on the top of the nail. Observe what you hear.
5. With your other hand, touch the copper wire to the plug as shown in the illustration. Make sure that the plug is touching both the nail and the wire.
6. Wait one to two minutes. Observe what you hear.

What Did You Find Out?

1. Did you hear anything in step 4? How did it differ from what you heard in step 6?
2. How do you know that electricity is flowing?

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FIND OUT ACTIVITY 1-F ELECTRIC LEMON

Purpose

- Students will discover that the chemical reactions between metals and a lemon can create electric current.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
3 days before	– Gather a class set of headphones and other materials. – Test all headphones to ensure that they work.

MATERIALS
Per group: – 1 pair of headphones – 1 galvanized nail – 1 piece of copper wire (heavy gauge) – 1 lemon

Suggested Time

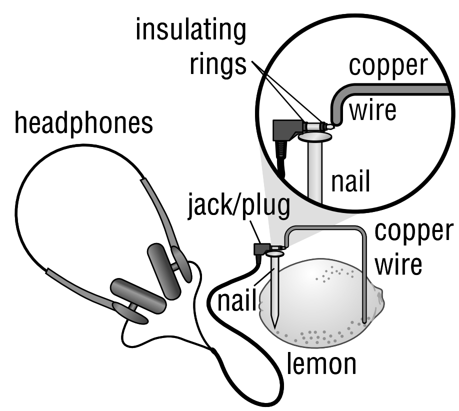
- 20 min

Safety Precautions

- Caution students about handling sharp objects such as nails and copper wire.
- Advise students to rinse their hands if they get lemon juice on them. Remind them not to touch their eyes if they have lemon juice on their hands.

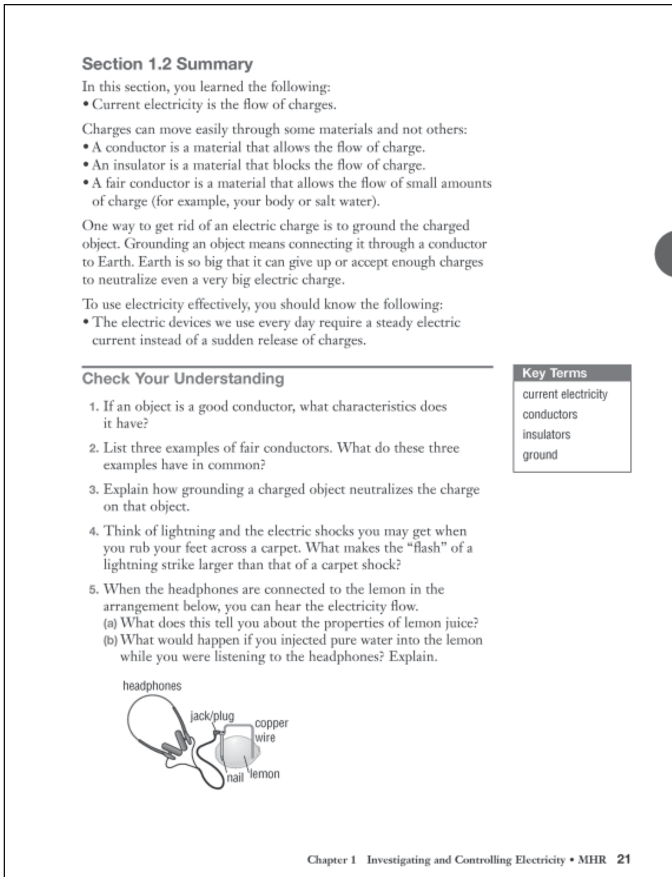
HINTS & HELPS

- **NOTE:** The diagram on page 20 in the student textbook could be interpreted as showing *both* parts of the headphone jack touching the nail. This would short out the headphones, and they will not detect the flow of negative charges. In addition, headphones will almost certainly be stereo with three metal parts to the jack. The basis of the set-up is that the *middle* metal part has to contact one "terminal" (the nail or wire) *alone* and the *end* metal part must contact the other "terminal" *alone* (see diagram below).



It may also be more convenient to use alligator clips, rather than try to bend the wire to get closer to the nail.

- LEDs or small digital clocks may be used in place of headphones.



Section 1.2 Summary

In this section, you learned the following:
- Current electricity is the flow of charges.

Charges can move easily through some materials and not others:
- A conductor is a material that allows the flow of charge.
- An insulator is a material that blocks the flow of charge.
- A fair conductor is a material that allows the flow of small amounts of charge (for example, your body or salt water).

One way to get rid of an electric charge is to ground the charged object. Grounding an object means connecting it through a conductor to Earth. Earth is so big that it can give up or accept enough charges to neutralize even a very big electric charge.

To use electricity effectively, you should know the following:
- The electric devices we use every day require a steady electric current instead of a sudden release of charges.

Check Your Understanding

1. If an object is a good conductor, what characteristics does it have?
2. List three examples of fair conductors. What do these three examples have in common?
3. Explain how grounding a charged object neutralizes the charge on that object.
4. Think of lightning and the electric shocks you may get when you rub your feet across a carpet. What makes the "flash" of a lightning strike larger than that of a carpet shock?
5. When the headphones are connected to the lemon in the arrangement below, you can hear the electricity flow.
   (a) What does this tell you about the properties of lemon juice?
   (b) What would happen if you injected pure water into the lemon while you were listening to the headphones? Explain.

Key Terms
current electricity
conductors
insulators
ground

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Implementing the Activity
- Ask the class to remain quiet so that the sounds can be heard in the headphones.
- Remind students that it may take a minute or two for the sound to be heard, so they should be patient.

Adaptations
- Some students could use oranges or potatoes to make a battery.
- There are "two-potato clocks" available from hobby and emporium stores. Some students could research how they work.
- An apparatus could be set up before class for students who have difficulty reading or compre-hending instructions.

Activity Wrap-Up
- Demonstrate how other devices such as a digital clock or small motor could be operated with things such as lemons, oranges, or potatoes.

Assessment Option
- Use Science Skills Checklist 15, Making Observations and Inferences to assess student work in this activity.

What Did You Find Out? Answers
1. Nothing is heard in step 4. A clear "click" is heard in step 6 when contact is made, followed by a low buzzing sound.
2. The buzzing sound indicates that electric current is flowing in step 6. The silence indicates that no current is flowing in step 4.

SECTION 1.2 SUMMARY

Read the section summary together and discuss questions that students still have related to the flow of electricity. Have the students update their science logbooks and key terms list. As a class, create a list of materials that are good conductors, fair conductors, and insulators.

✓ ASSESSMENT OPTIONS FOR SECTION 1.2
- Assign some or all of the Check Your Understanding questions on page 21 as a quiz to review the section.
- Collect and review science logbooks, using Learning Skills Rubric 2, Science Logbook as a guide to evaluation.
- Review checklists and rubrics used throughout this section.

Check Your Understanding Answers
1. Students may have two types of answers: "Good conductors are materials that are metallic," or "Good conductors are materials that allow charges to flow through them easily." Students should be encouraged to use the latter when describing conductors.
2. Students will likely list three of carbon, Earth, the human body, humid air, or salt-water. Materials that allow charges to flow through them, although not very well, are all fair conductors.
3. Grounding allows excess charges to flow to Earth, or charges to flow from Earth to where there is a deficit. This neutralizes the charge on the object.
4. The flash of light from a carpet shock is much smaller than that of lightning due to the fact that the number of charged particles that build up in a cloud is much, much greater than the number of charges that build up on someone walking across a carpet.
5. (a) The lemon juice is a conductor.
   (b) Injecting pure water into the lemon would dilute the lemon juice, which is the conductor. The flow of charges would decrease and the sound heard in the headphones would be quieter.

SECTION 1.3 ELECTRICAL CIRCUITS

What Students Do in Section 1.3

- build and sketch electric circuits
- identify the components of electric circuits
- distinguish between open and closed circuits and series and parallel circuits
- discover how changing an electrical pathway affects the overall action of an electric circuit
- describe the roles of loads, sources, switches, and conductors in electric circuits

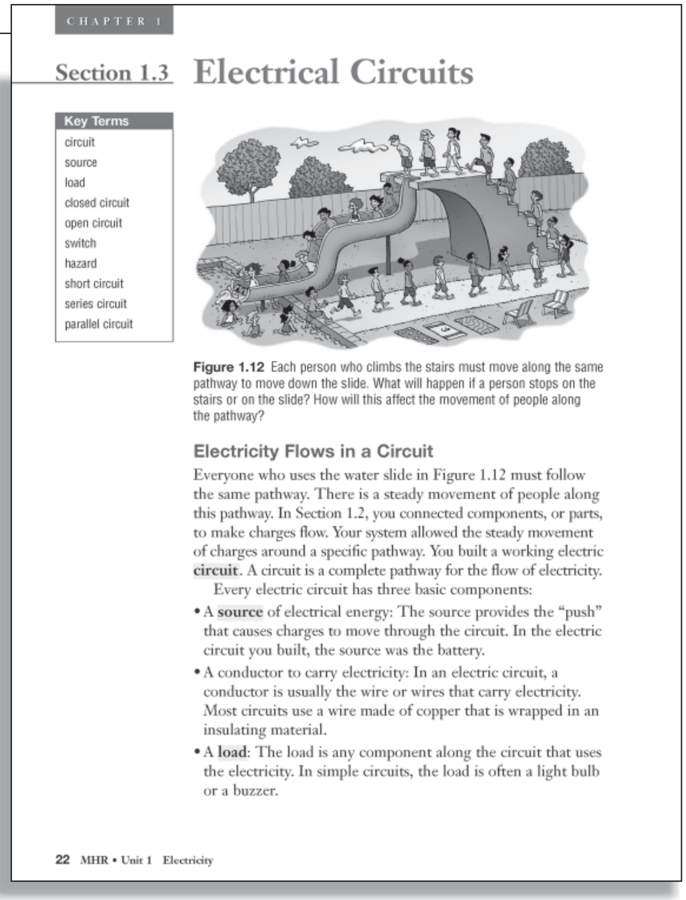
ELECTRICITY FLOWS IN A CIRCUIT/ CLOSED AND OPEN CIRCUITS

BACKGROUND INFORMATION

- The purpose of circuit breakers and fuses is to create open circuits and stop the flow of electricity if it becomes hazardous. For instance, if too many devices are plugged into one circuit, the high current demanded may overburden the wiring and cause overheating. A switch, on the other hand, creates an open circuit when convenient and practical.
- Loads are any devices that convert electrical energy into heat, light, sound, or mechanical energy. In the activities and investigations in the student book, the load is typically a bulb or buzzer. Loads do not remove charges from the current. Instead, they reduce the flow of charges and convert some of the energy of the charges into another form of energy.

TEACHING STRATEGIES

- **Begin the Lesson**—Use a diagram to illustrate the basic concepts of a simple circuit, namely source, conductor, and load.
- *ICT Option:* Students could draw their own diagrams with a simple graphics program on the computer or with an online simulation.
- **During Reading**—Referring to Figure 1.13 and its caption, discuss the difference between open and closed circuits. Discuss the use of a switch to control the flow of current in a circuit. Then refer to Figure 1.14 and its caption to explain the function of the parts of a switch.



CHAPTER 1

Section 1.3 Electrical Circuits

Key Terms
circuit
source
load
closed circuit
open circuit
switch
hazard
short circuit
series circuit
parallel circuit

Figure 1.12 Each person who climbs the stairs must move along the same pathway to move down the slide. What will happen if a person stops on the stairs or on the slide? How will this affect the movement of people along the pathway?

Electricity Flows in a Circuit

Everyone who uses the water slide in Figure 1.12 must follow the same pathway. There is a steady movement of people along this pathway. In Section 1.2, you connected components, or parts, to make charges flow. Your system allowed the steady movement of charges around a specific pathway. You built a working electric **circuit**. A circuit is a complete pathway for the flow of electricity.

Every electric circuit has three basic components:

- A **source** of electrical energy: The source provides the "push" that causes charges to move through the circuit. In the electric circuit you built, the source was the battery.
- A conductor to carry electricity: In an electric circuit, a conductor is usually the wire or wires that carry electricity. Most circuits use a wire made of copper that is wrapped in an insulating material.
- A **load**: The load is any component along the circuit that uses the electricity. In simple circuits, the load is often a light bulb or a buzzer.

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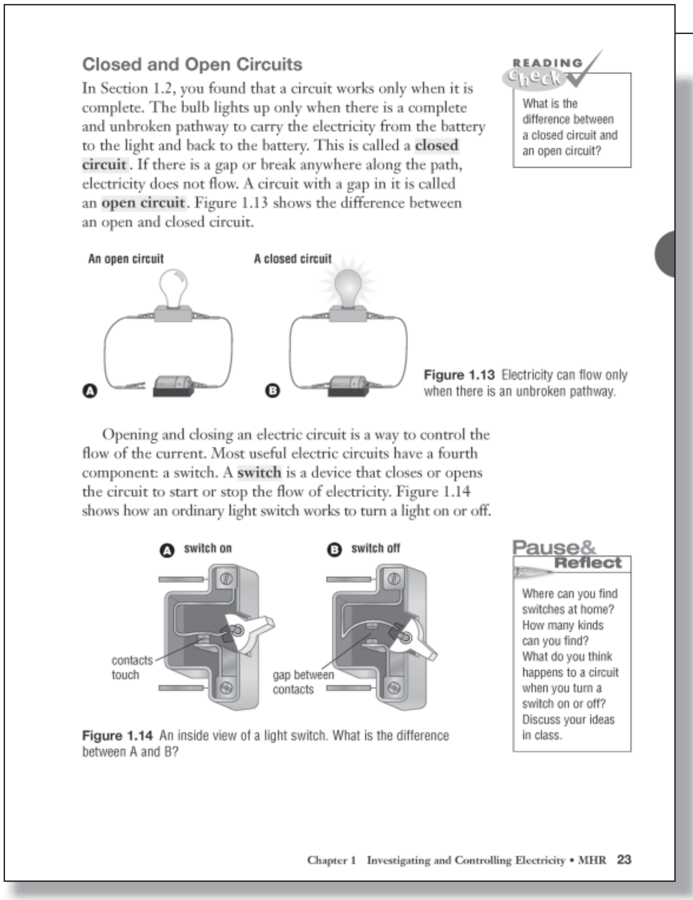
- **After Reading**—Have students develop an analogy for an electric circuit. As a class, brainstorm the characteristics of a circuit. For example, it is one-directional, requires a complete path, and has specific components. The analogy of a train line travelling from station to station with stations, crossings, switches, and engines works well.
- You could have fun with a kinesthetic activity in which students represent the parts of a circuit: the "source" is a student who gives out Styrofoam™ balls from a box, one at a time, to the next student in line; the "conductor" is a line of students passing the balls along; the "load" is a student who uses the electricity in some way such as by raising her arms and shouting before passing on the balls; and another line of "conductor" students continues to pass the balls back to a "return" student who drops them into the box for the "source" to retrieve. Ask the students to simulate open and closed circuits and observe the affect on current.



Closed and Open Circuits

In Section 1.2, you found that a circuit works only when it is complete. The bulb lights up only when there is a complete and unbroken pathway to carry the electricity from the battery to the light and back to the battery. This is called a **closed circuit**. If there is a gap or break anywhere along the path, electricity does not flow. A circuit with a gap in it is called an **open circuit**. Figure 1.13 shows the difference between an open and closed circuit.

READING Check

What is the difference between a closed circuit and an open circuit?

Figure 1.13 Electricity can flow only when there is an unbroken pathway.

Opening and closing an electric circuit is a way to control the flow of the current. Most useful electric circuits have a fourth component: a switch. A **switch** is a device that closes or opens the circuit to start or stop the flow of electricity. Figure 1.14 shows how an ordinary light switch works to turn a light on or off.

Figure 1.14 An inside view of a light switch. What is the difference between A and B?

Pause& Reflect

Where can you find switches at home? How many kinds can you find? What do you think happens to a circuit when you turn a switch on or off? Discuss your ideas in class.

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Common Misconceptions

- Loads are sometimes incorrectly thought of as objects that "drain" current. Advise students that loads reduce the *flow* of charges but do not remove charges from the current.

Figure 1.12

If a person stops on the stairs or the slide, the entire flow of people will stop. The resulting "break" in the current of the people stops every individual in the slide circuit.

READING Check A closed circuit is a complete and unbroken pathway that allows electricity to flow from the battery to the load and back to the battery. An open circuit is a circuit with a gap in it, so that the flow of electricity is blocked.

Figure 1.14

The difference between switch A and switch B is that the two metal contacts are not touching one another in switch B. Since air is an insulator, electricity cannot flow through switch B. Therefore, circuit B will not operate.

Pause& Reflect Some students may think that when you turn on the switch, charges travel from the switch to the light in order for the light to illuminate. In fact, opening the switch simply blocks the flow of charges and closing the switch allows the flow of charges to continue again. The charges do not return to the source.

SHORT CIRCUITS ARE DANGEROUS/ A SERIES CIRCUIT IS A SINGLE PATHWAY

BACKGROUND INFORMATION

- Electricity, like most things in the universe, takes the easiest route from point A to point B. A short circuit bypasses the intended route of electrical flow and can generate dangerous heat levels and sparking. In typical households, short circuits occur when an electrical device or panel is exposed to water or excess heat. Fuses or circuit breakers work to prevent damage that results from short circuits. When the current is too great, the fuse or circuit breaker will open. (Note that when this safety feature is not present, the result is often a fire.)

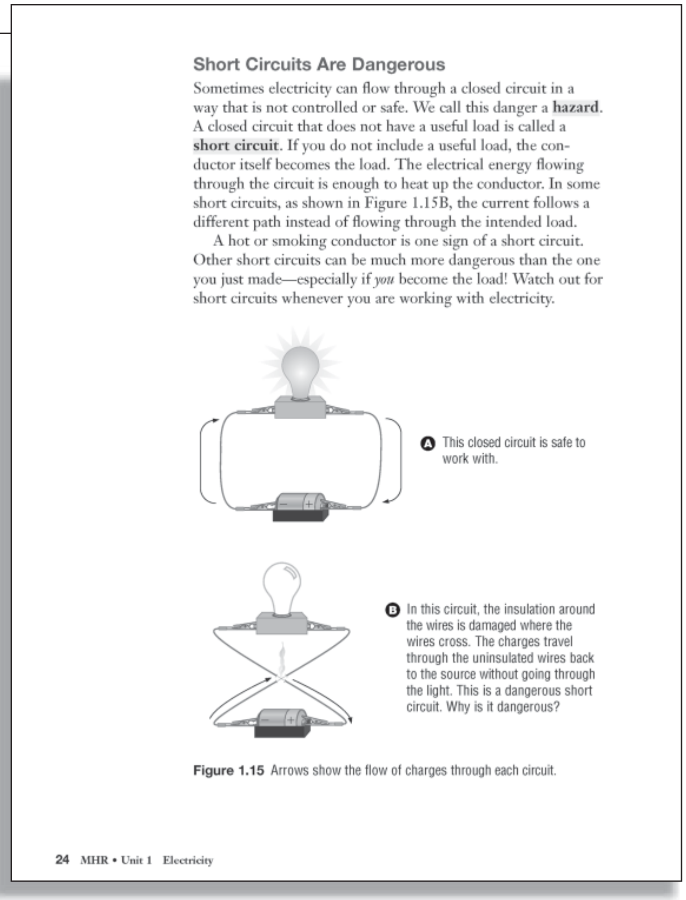
TEACHING STRATEGIES

- **During Reading**—Refer to the diagrams in Figure 1.15 to discuss the difference between a safe closed circuit (with load) and an unsafe closed circuit (with no load or with the load "shorted out"). Ask students how they could change the circuit in Figure 1.15A to represent a short circuit, by using one more connector. (Answer: Attach another copper wire with alligator clips from one side of the bulb to the other, thus "shorting it out.") Have students examine Figure 1.15B very closely to identify that not only do the wires have to cross, but also the insulation must be removed in order to create a short circuit.

Figure 1.15B

Short circuits are dangerous because they allow for an increased flow of electric current, which could create excess heat and sparks that could start a fire. They also provide an alternate pathway for electricity out of a circuit and into someone who comes in contact with the short.

Pause& Reflect No. If the insulation were not damaged, electricity would be blocked from flowing directly from one wire to the other. Thus, the circuit would not short out.



Short Circuits Are Dangerous

Sometimes electricity can flow through a closed circuit in a way that is not controlled or safe. We call this danger a **hazard**. A closed circuit that does not have a useful load is called a **short circuit**. If you do not include a useful load, the conductor itself becomes the load. The electrical energy flowing through the circuit is enough to heat up the conductor. In some short circuits, as shown in Figure 1.15B, the current follows a different path instead of flowing through the intended load.

A hot or smoking conductor is one sign of a short circuit. Other short circuits can be much more dangerous than the one you just made—especially if *you* become the load! Watch out for short circuits whenever you are working with electricity.

Figure 1.15 Arrows show the flow of charges through each circuit.

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FIND OUT ACTIVITY 1-G IT'S THE ONLY WAY TO GO

Purpose

- Students will discover through investigation that a flashlight is an example of a series circuit.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
1 week before	– Ask students to bring in simple flashlights that can be opened up and taken apart. Ask them to bring in both working and non-working flashlights with their names on them.
1 day before	– Sort flashlights into "working well" and "not working well" groups.

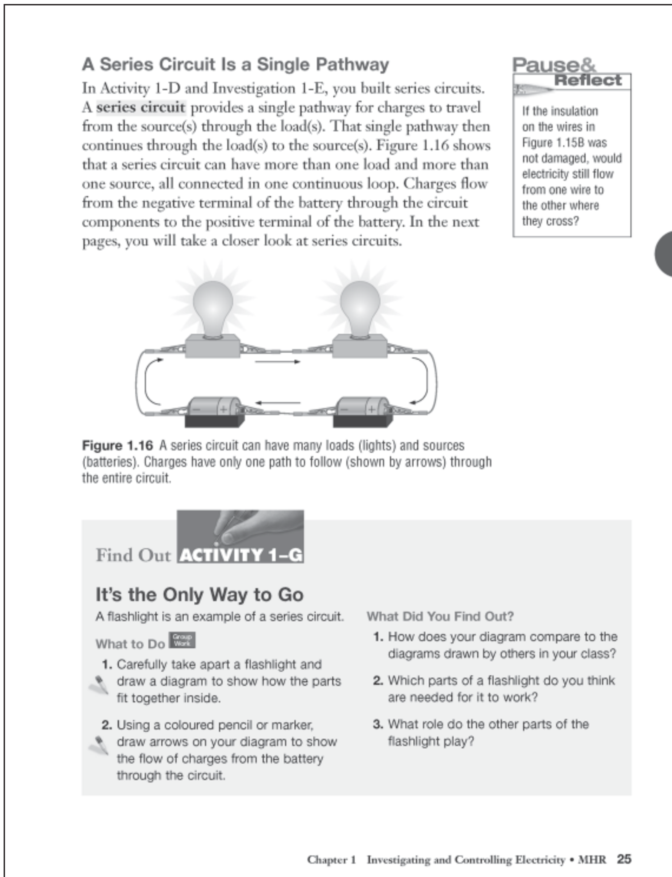
MATERIALS
Per group: – 1 flashlight with batteries – coloured pencils

Suggested Time

- 45 min

Safety Precautions

- Remind students to handle flashlight parts carefully and not to drop them on the floor.



A Series Circuit Is a Single Pathway

In Activity 1-D and Investigation 1-E, you built series circuits. A **series circuit** provides a single pathway for charges to travel from the source(s) through the load(s). That single pathway then continues through the load(s) to the source(s). Figure 1.16 shows that a series circuit can have more than one load and more than one source, all connected in one continuous loop. Charges flow from the negative terminal of the battery through the circuit components to the positive terminal of the battery. In the next pages, you will take a closer look at series circuits.

Pause& Reflect

If the insulation on the wires in Figure 1.15B was not damaged, would electricity still flow from one wire to the other where they cross?

Figure 1.16 A series circuit can have many loads (lights) and sources (batteries). Charges have only one path to follow (shown by arrows) through the entire circuit.

Find Out **ACTIVITY 1–G**

It's the Only Way to Go

A flashlight is an example of a series circuit.

What to Do (Group Work)

1. Carefully take apart a flashlight and draw a diagram to show how the parts fit together inside.
2. Using a coloured pencil or marker, draw arrows on your diagram to show the flow of charges from the battery through the circuit.

What Did You Find Out?

1. How does your diagram compare to the diagrams drawn by others in your class?
2. Which parts of a flashlight do you think are needed for it to work?
3. What role do the other parts of the flashlight play?

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HINTS & HELPS

- If there is a sufficient number of flashlights, give each group a working flashlight and a non-working flashlight. Ask them to suggest reasons why one works and the other does not.

Implementing the Activity

- Discuss the proper format for labelling and drawing the structures inside the flashlight and the pathway of current flow.

Adaptations

- Students could be encouraged to conduct a "fix-it" workshop in which those flashlights judged to work poorly, or not at all, could be assessed and repaired.
- Prepare a cutaway diagram of a flashlight for students to examine if required.

Activity Wrap-Up

- Have students display their labelled diagrams as wall posters.
- Relate a flashlight to a series circuit. Review the role of conductors and insulators.

Assessment Option

- Use Science Skills Checklist 14, Scientific Drawing to assess student work in this activity.

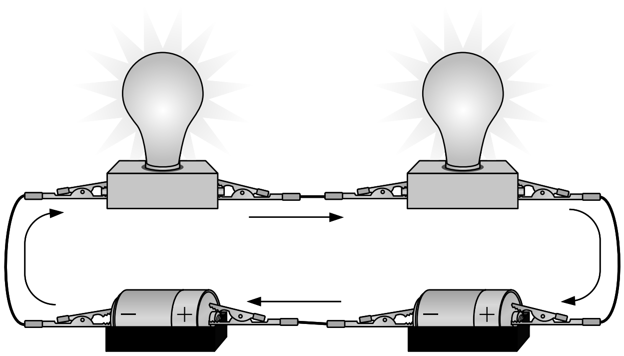
What Did You Find Out? Answers

1. All diagrams should have a battery, wires, bulb, and switch. As well, an identical pathway for current flow should be labelled.
2. The parts required for a flashlight to work are the bulb, conductor, switch, and battery.
3. The other parts of the flashlight are needed for support, containment, and insulation (particularly from moisture).

CONDUCT AN INVESTIGATION 1-H IN SERIES

Purpose

- Students will construct a series circuit and investigate its properties.



Advance Preparation

WHEN TO BEGIN	WHAT TO DO
3 days before	– Gather a class set of materials. Ask students to provide as much of this material as possible. – Test all components to ensure that each group has a full set of operational equipment.
1 day before	– Photocopy BLM 1.7 In Series or explain to students how to create observation charts to use during the investigation.

MATERIALS
Per group: – 2 D-cell batteries in holders (1.5 V) – 2 small flashlight bulbs in holders (3 V) – 4 copper wires with an alligator clip on each end – 1 switch

Suggested Time

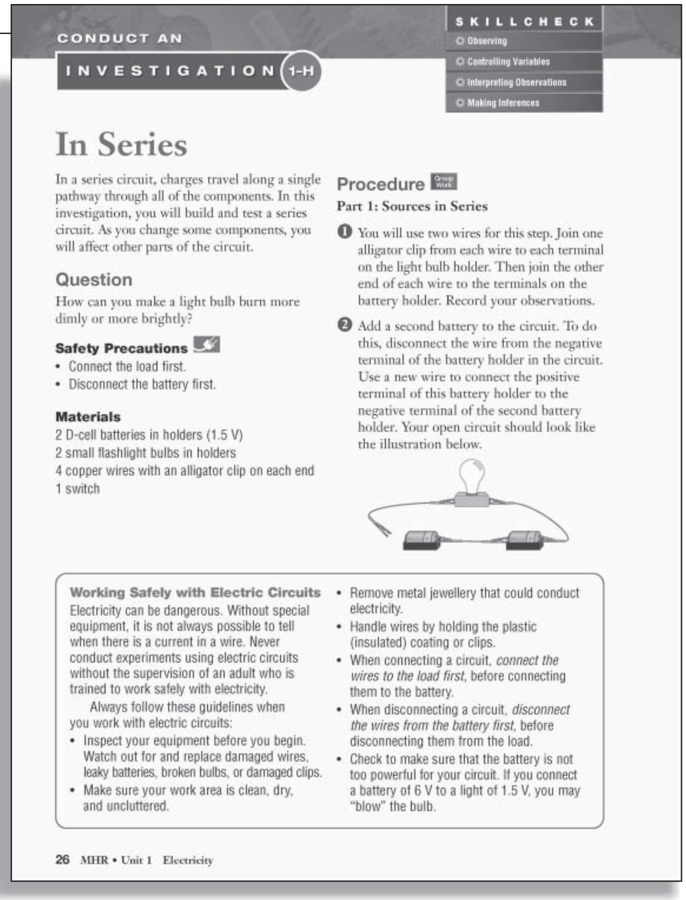
- Part 1: 15 min
- Part 2: 15 min
- Part 3: 20 min

Safety Precautions

- Remind students to connect the load first and disconnect the battery first when constructing circuits.
- Carefully review the student textbook box Working Safely with Electric Circuits on page 26. Discuss any questions or worries students have before beginning the hands-on investigation.

HINTS & HELPS

- Be prepared with extra bulbs, batteries, wires, and switches, as students may damage or blow components when creating circuits.
- Have a variety of bulbs that require different voltages to operate. These will allow students to discover that the effects of current do not only depend upon the source, but also on the load.



CONDUCT AN INVESTIGATION 1-H

SKILLCHECK
- Observing
- Controlling Variables
- Interpreting Observations
- Making Inferences

In Series

In a series circuit, charges travel along a single pathway through all of the components. In this investigation, you will build and test a series circuit. As you change some components, you will affect other parts of the circuit.

Question

How can you make a light bulb burn more dimly or more brightly?

Safety Precautions
- Connect the load first.
- Disconnect the battery first.

Materials

2 D-cell batteries in holders (1.5 V)
2 small flashlight bulbs in holders
4 copper wires with an alligator clip on each end
1 switch

Procedure Group Work

Part 1: Sources in Series

1. You will use two wires for this step. Join one alligator clip from each wire to each terminal on the light bulb holder. Then join the other end of each wire to the terminals on the battery holder. Record your observations.
2. Add a second battery to the circuit. To do this, disconnect the wire from the negative terminal of the battery holder in the circuit. Use a new wire to connect the positive terminal of this battery holder to the negative terminal of the second battery holder. Your open circuit should look like the illustration below.

Working Safely with Electric Circuits

Electricity can be dangerous. Without special equipment, it is not always possible to tell when there is a current in a wire. Never conduct experiments using electric circuits without the supervision of an adult who is trained to work safely with electricity.

Always follow these guidelines when you work with electric circuits:
- Inspect your equipment before you begin. Watch out for and replace damaged wires, leaky batteries, broken bulbs, or damaged clips.
- Make sure your work area is clean, dry, and uncluttered.
- Remove metal jewellery that could conduct electricity.
- Handle wires by holding the plastic (insulated) coating or clips.
- When connecting a circuit, *connect the wires to the load first*, before connecting them to the battery.
- When disconnecting a circuit, *disconnect the wires from the battery first*, before disconnecting them from the load.
- Check to make sure that the battery is not too powerful for your circuit. If you connect a battery of 6 V to a light of 1.5 V, you may "blow" the bulb.

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Implementing the Investigation

- It may be helpful to have a quiz based on the section Working Safely with Electric Circuits in advance of the actual class investigation.

Adaptations

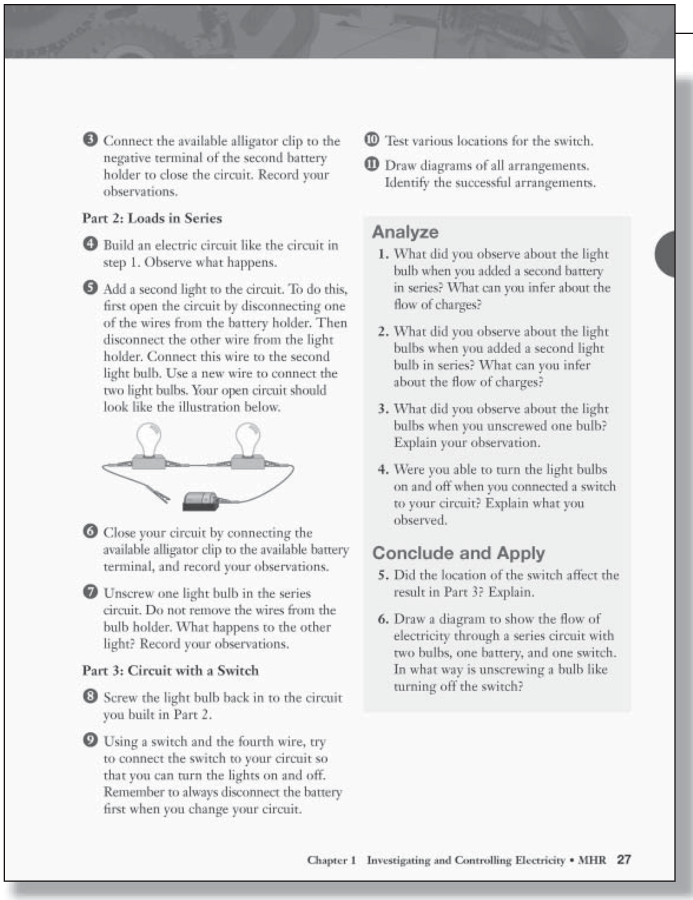
- Distribute BLM 1.7 In Series, for students to use to record their observations.
- Use preferential grouping when organizing students to allow all students, including those with fine motor or literacy difficulties, to fully participate in the investigation.
- Provide alternate loads for students. Have them investigate and describe the behaviour of these loads.

Investigation Wrap-Up

- Have students write a complete lab report, including diagrams, to report upon their discoveries in the investigation. Adapt and copy Science Skills Checklist 18, Lab Experiment/Activity Report for students to use as a guideline for their report.

Assessment Option

- Use Science Skills Rubric 19, Conduct an Investigation to assess student work in this activity.



3 Connect the available alligator clip to the negative terminal of the second battery holder to close the circuit. Record your observations.

Part 2: Loads in Series

4 Build an electric circuit like the circuit in step 1. Observe what happens.

5 Add a second light to the circuit. To do this, first open the circuit by disconnecting one of the wires from the battery holder. Then disconnect the other wire from the light holder. Connect this wire to the second light bulb. Use a new wire to connect the two light bulbs. Your open circuit should look like the illustration below.

6 Close your circuit by connecting the available alligator clip to the available battery terminal, and record your observations.

7 Unscrew one light bulb in the series circuit. Do not remove the wires from the bulb holder. What happens to the other light? Record your observations.

Part 3: Circuit with a Switch

8 Screw the light bulb back in to the circuit you built in Part 2.

9 Using a switch and the fourth wire, try to connect the switch to your circuit so that you can turn the lights on and off. Remember to always disconnect the battery first when you change your circuit.

10 Test various locations for the switch.

11 Draw diagrams of all arrangements. Identify the successful arrangements.

Analyze

1. What did you observe about the light bulb when you added a second battery in series? What can you infer about the flow of charges?
2. What did you observe about the light bulbs when you added a second light bulb in series? What can you infer about the flow of charges?
3. What did you observe about the light bulbs when you unscrewed one bulb? Explain your observation.
4. Were you able to turn the light bulbs on and off when you connected a switch to your circuit? Explain what you observed.

Conclude and Apply

5. Did the location of the switch affect the result in Part 3? Explain.
6. Draw a diagram to show the flow of electricity through a series circuit with two bulbs, one battery, and one switch. In what way is unscrewing a bulb like turning off the switch?

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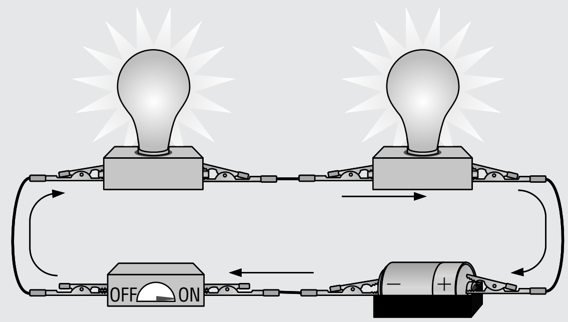
Analyze Answers

1. When a second battery was added in series, the bulb glowed more brightly. This suggests that adding a second battery increases the flow of charges in the circuit.
2. When a second bulb was added in series, both bulbs glowed more dimly. This suggests that adding more loads in series reduces the flow of charges.
3. When one bulb was unscrewed, the other bulb also went out. This suggests that removing one bulb opens the circuit and stops the flow of charges.
4. Yes, the switch could be used to turn the bulbs on and off. The switch could be used to open the circuit and stop the flow of charges, or to close the circuit and allow the flow of charges. (Note: The arrangement should work if students place the switch in series (i) between the two bulbs, or (ii) between either of the bulbs and the battery. The switch will not work if they create another loop and attach the switch outside of the series circuit (i.e., in parallel).)

Conclude and Apply Answers

5. No, the location of the switch did not affect the result (unless they placed it in parallel, as mentioned in the answer to question 4). No matter where the switch is placed in series, when open, it stops the flow of charges along the entire circuit.
6.

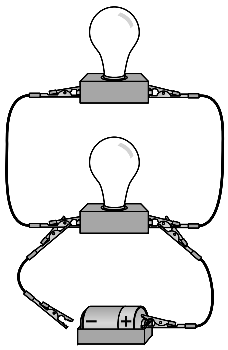


Unscrewing a bulb is like turning off the switch in that both actions create an open circuit by leaving a gap between the conductors.

PARALLEL CIRCUITS

BACKGROUND INFORMATION

- Household electrical systems consist of parallel circuits. The flow of current can be controlled by a separate switch (on each electrical device) or by a single switch (on an electric power bar).



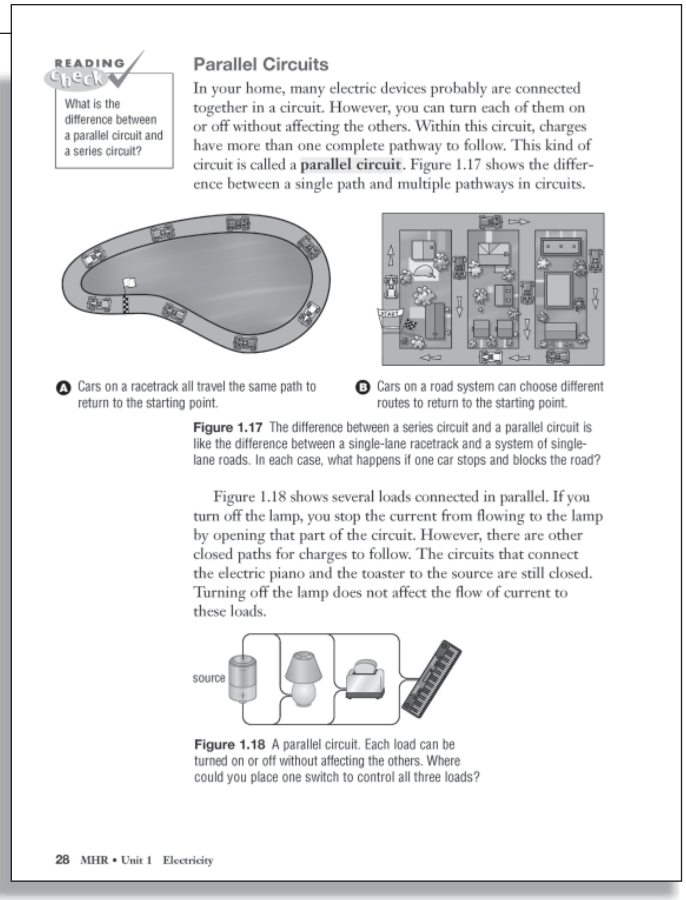
TEACHING STRATEGIES

- **During Reading**—Use the figures in the student textbook to help explain the concept of a parallel circuit. Refer to Figure 1.17 to explain how a parallel circuit differs from a series circuit. Refer to Figure 1.18 to discuss how a switch can control one, two, or three devices in parallel.
- **After Reading**—Use the analogy of a string of decorative lights to compare series and parallel circuits. Ask students what would happen if one of the lights burned out in a string of lights arranged in series. What would happen if the string were arranged in parallel?

READING Check In a series circuit, all charges flow through one pathway, while in a parallel circuit, they can take different pathways through the circuit.

Figure 1.17
If a car blocks the road in a series circuit (race track), all current stops. If a car blocks a pathway in a parallel circuit (road system), the current can still flow through other paths.

Figure 1.18
In order to operate all three devices with one switch, the switch must be placed between one terminal of the battery and all three loads.



READING Check
What is the difference between a parallel circuit and a series circuit?

Parallel Circuits

In your home, many electric devices probably are connected together in a circuit. However, you can turn each of them on or off without affecting the others. Within this circuit, charges have more than one complete pathway to follow. This kind of circuit is called a **parallel circuit**. Figure 1.17 shows the difference between a single path and multiple pathways in circuits.

A Cars on a racetrack all travel the same path to return to the starting point.

B Cars on a road system can choose different routes to return to the starting point.

Figure 1.17 The difference between a series circuit and a parallel circuit is like the difference between a single-lane racetrack and a system of single-lane roads. In each case, what happens if one car stops and blocks the road?

Figure 1.18 shows several loads connected in parallel. If you turn off the lamp, you stop the current from flowing to the lamp by opening that part of the circuit. However, there are other closed paths for charges to follow. The circuits that connect the electric piano and the toaster to the source are still closed. Turning off the lamp does not affect the flow of current to these loads.

source

Figure 1.18 A parallel circuit. Each load can be turned on or off without affecting the others. Where could you place one switch to control all three loads?

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AT HOME ACTIVITY 1-I CURRENT IN PARALLEL AND SERIES CIRCUITS

Purpose
- Students model current flow through series and parallel circuits.

Advance Preparation
None

Suggested Time
- 30 min

Safety Precautions
- Remind students that sharing straws and water could pass on bacteria and viruses that may cause a cold, flu, or other illness.
- Encourage students to use unbreakable glasses for all science investigations.

Implementing the Activity
- Discuss how the arrangements of straws are similar to series and parallel electric circuits.

Activity Wrap-Up
- Discuss student discoveries and relate conclusions to Figures 1.17 and 1.18.

Assessment Option
- Adapt Learning Skills Checklist 2, Developing Models to assess student work in this activity.

At Home **ACTIVITY 1-I**

Current in Parallel and Series Circuits

You can use water as a model for the rate of movement of charges (current) through a parallel and a series circuit.

What You Need

2 glasses (filled with water)
4 drinking straws
clear adhesive tape

What to Do

1. Put all four straws into one glass of water. Put the other end of all four straws into your mouth.
2. Draw the water up the straws with your mouth. Observe how much water enters your mouth.
3. Tape the four straws end to end and put one end into the second glass of water.
4. Draw the water up the four connected straws with your mouth. Try to draw with the same force and for the same amount of time as in step 2. Observe how much water enters your mouth.

What Did You Find Out?

1. (a) Which arrangement of straws (the first or the second) provided more than one path for water to flow?
   (b) Was this similar to a series circuit or a parallel circuit?
2. Which arrangement of straws allowed you to draw up more water into your mouth?
3. After drawing up the water once, what was the difference in the water level in the glass for each arrangement?
4. What does this model tell you about the flow of current in each type of circuit?

Current in a Parallel Circuit

Remember from Investigation 1-H that the current through a series circuit decreases as you add more loads to the circuit (the light bulbs got dimmer). In contrast, each time you add a new load to a parallel circuit, the total current through the system increases. In Activity 1-I, you used straws to model the flow of charges (current) through a parallel circuit and a series circuit. If you had added even more straws in parallel, more water would have been pulled up, and the glass of water would have been drained faster.

If a battery is your source, the battery will be drained more quickly as more loads are added in parallel. In your household electric system, as you add more loads, the total current can increase to a dangerous level.

READING Check

What happens to the total current flowing through a circuit as you add new loads in parallel?

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What Did You Find Out? Answers

1. (a) The first arrangement of straws provided more than one pathway for water to flow.
   (b) This was similar to a parallel circuit.
2. The first arrangement of straws allowed more water to be drawn into the mouth.
3. The water level was lower in the first arrangement of straws.
4. The model implies that the overall flow of current is greater in a parallel circuit than it is in a series circuit.

CURRENT IN A PARALLEL CIRCUIT

BACKGROUND INFORMATION

- The total current flowing through an individual circuit increases as new loads are added in parallel. If too many devices are connected in parallel to a single circuit or outlet, the current can reach dangerous levels, which will blow the fuse or trip the circuit breaker.

TEACHING STRATEGIES

- **After Reading**—Use a common household power bar with a circuit breaker to demonstrate parallel circuits and the effect of increased loads. Each of the parallel outlets can operate a separate device, but if too many devices are operating and the current reaches dangerous levels, the circuit breaker on the power bar will disconnect the pathway between the power bar and the wall outlet.

READING Check

As new loads are added in parallel, the total current drawn by the circuit increases.

CONDUCT AN INVESTIGATION 1-J ON PARALLEL TRACKS

Purpose
- Students will construct and test a parallel circuit and investigate the flow of charges through this circuit.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
3 days before	– Collect enough equipment for each group. (Ask students to bring in as much of this material as possible.) – Test all components to ensure that each group has a full set of operational equipment.
1 day before	– Photocopy BLM 1.8 On Parallel Tracks or have students prepare an observation table for the investigation.

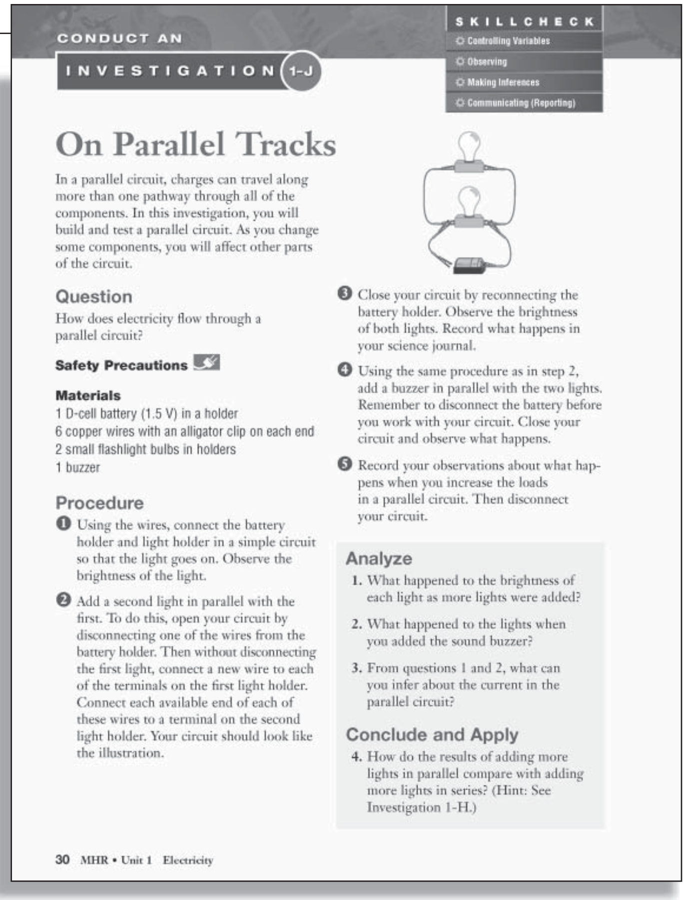
MATERIALS
Per group: – 1 D-cell battery (1.5 V) in a holder – 6 copper wires with an alligator clip on each end – 2 small flashlight bulbs (1.5 V) in holders – 1 buzzer (1.5 V) – old computer fans

Suggested Time
- 40 min

Safety Precautions
- Carefully review the student textbook box Working Safely with Electric Circuits on page 26. Discuss any questions or worries students have before beginning this hands-on investigation.

HINTS & HELPS
- Encourage students to keep their work area and circuits clean and uncluttered. Suggest that they do not overlap wires when creating electrical circuits.

Implementing the Investigation
- Distribute BLM 1.8 On Parallel Tracks to students before they begin the investigation.
- Some students may need guidance in the creation of their electrical circuits. Watch each group as carefully as possible to troubleshoot circuit difficulties.
- If time permits, encourage students to create circuits that are a combination of series and parallel circuits and describe their properties.


CONDUCT AN INVESTIGATION 1-J

SKILLCHECK
- Controlling Variables
- Observing
- Making Inferences
- Communicating (Reporting)

On Parallel Tracks

In a parallel circuit, charges can travel along more than one pathway through all of the components. In this investigation, you will build and test a parallel circuit. As you change some components, you will affect other parts of the circuit.

Question

How does electricity flow through a parallel circuit?

Safety Precautions

Materials

1 D-cell battery (1.5 V) in a holder
6 copper wires with an alligator clip on each end
2 small flashlight bulbs in holders
1 buzzer

Procedure

1. Using the wires, connect the battery holder and light holder in a simple circuit so that the light goes on. Observe the brightness of the light.
2. Add a second light in parallel with the first. To do this, open your circuit by disconnecting one of the wires from the battery holder. Then without disconnecting the first light, connect a new wire to each of the terminals on the first light holder. Connect each available end of each of these wires to a terminal on the second light holder. Your circuit should look like the illustration.
3. Close your circuit by reconnecting the battery holder. Observe the brightness of both lights. Record what happens in your science journal.
4. Using the same procedure as in step 2, add a buzzer in parallel with the two lights. Remember to disconnect the battery before you work with your circuit. Close your circuit and observe what happens.
5. Record your observations about what happens when you increase the loads in a parallel circuit. Then disconnect your circuit.

Analyze

1. What happened to the brightness of each light as more lights were added?
2. What happened to the lights when you added the sound buzzer?
3. From questions 1 and 2, what can you infer about the current in the parallel circuit?

Conclude and Apply

4. How do the results of adding more lights in parallel compare with adding more lights in series? (Hint: See Investigation 1-H.)

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Adaptations
- Circuits may be pre-assembled with open switches for students with motor difficulties.
- Encourage students with a strong grasp of the basics to add additional loads and/or batteries in series and parallel.
- *ICT Option:* Students may also model their circuits using computer modelling software.

Investigation Wrap-Up
- Relate students' discoveries in the investigation to decorative lights and reasons why newer models are connected in parallel rather than in series.

Assessment Option
- Use Science Skills Rubric 19, Conduct an Investigation to assess student work in this activity.

Sources Can Be Connected in Parallel

In Investigation 1-J, you found that you can add *bulbs* in a parallel circuit without changing the brightness of each bulb. The current increases as you increase the loads, but the "push" stays the same. In a parallel circuit, you can add or take away loads without affecting the strength of the current across other components of the circuit.

If you had added more *batteries* in parallel, you would have seen that the brightness of the light does not change in this situation either. The strength of the current in the circuit does not increase when you add batteries in parallel. Although the lights are not any brighter, the batteries will *last* longer because there are more of them. Figure 1.19 shows how the amount of "push" exerted by batteries is affected when they are wired in series and in parallel. (The amount of "push" is measured in units called volts.)

READING Check

Does the current in a circuit change as you add identical batteries in parallel?

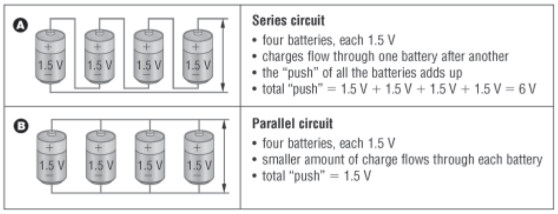

Figure 1.19 More than one battery is usually used in a device. Batteries can be grouped together either in series to produce a stronger "push" of charges, or in parallel to provide the "push" of charges for a longer time.

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Analyze Answers

1. As more lights were added in parallel, there was no change in the brightness of each light.
2. There was no resulting change in the brightness of the lights when the buzzer was added in parallel.
3. The current in each pathway is unchanged as more devices are added. This suggests that the total current increases as more devices are added in parallel to the circuit.

Conclude and Apply Answers

4. Adding more lights in parallel creates more pathways for electric current, thus increasing the total current flow. Adding more lights in series puts more "obstacles" in the single pathway of current flow, thus decreasing total current.

SOURCES CAN BE CONNECTED IN PARALLEL

BACKGROUND INFORMATION

- The "push" or "pull" a current receives is determined by the voltage of the source. Sources with higher voltage provide more push or pull. When a number of sources are connected in series, the total voltage, and the push or pull experienced, adds up. When the sources are connected in parallel, the overall push or pull does not change. The voltage remains the same as it would for one individual source.

TEACHING STRATEGIES

- **During Reading**—Use Figure 1.19 to help explain the difference between batteries connected in series and in parallel.
- **After Reading**—Use the following kinetic activity to illustrate how the push or pull experienced by the current changes (or does not change) when several sources are set up in a circuit. Arrange four desks where they can be pushed across the classroom. Ask four students to push one of the desks across the room together. Then ask each of the students to push one of the desks across the room on their own. In which case did a single desk receive more push? Ask students which scenario represented four sources or batteries being added in series and which represented the same number added in parallel.

Common Misconceptions

- Some students will think that more batteries automatically give more "push" or voltage. Remind students that when batteries are connected in parallel, the voltage across the circuit does not increase. When batteries are connected in series, however, the voltage across the circuit does increase (see Figure 1.19).

READING Check No, the current in a circuit remains the same as more identical batteries are added in parallel.

SECTION 1.3 SUMMARY

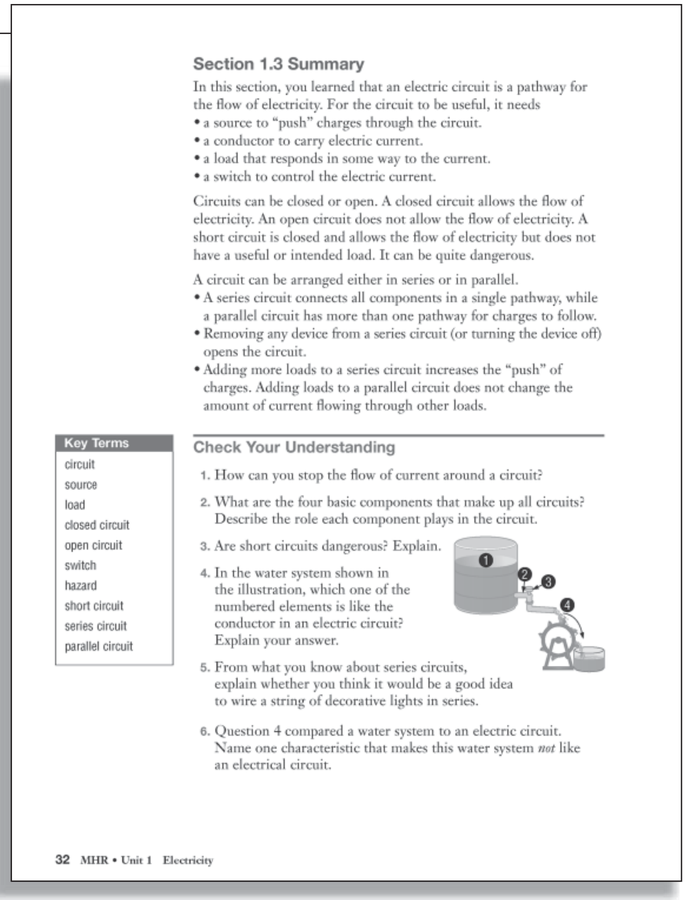
Review the section summary as a class and have students update their science logbooks and key terms list. Have students share some of their definitions of the key terms with the class and compare different interpretations of the same words. Have students create a short quiz that addresses the topics introduced in Section 1.3. Students can exchange quizzes with a partner and try to answer the questions.

✓ ASSESSMENT OPTIONS FOR SECTION 1.3

- Assign some or all of the Check Your Understanding questions on page 32 as a quiz to review the section.
- Collect and review science logbooks, using Learning Skills Rubric 2, Science Logbook as a guide to evaluation.
- Review checklists and rubrics used throughout this section.

Check Your Understanding Answers

1. You can stop the flow of current around a circuit by removing any of the objects along the electrical pathway (source, load, or conductor) or by opening a switch.
2. The four basic components of all electric circuits are:
   (a) sources: electrical energy that provides charges that move through a circuit, as well as the push and pull that moves them along
   (b) loads: any components along a circuit that convert electrical energy into heat, light, sound, or mechanical energy
   (c) conductors: materials that conduct electricity along a pathway; in an electrical circuit, the conductors are usually wires
   (d) switches: devices that can be opened to stop the flow of current or closed to allow the flow of current
3. Short circuits are dangerous because they allow for an increased flow of electric current, which could create excess heat and sparks that could start a fire. They also provide an alternate pathway for electricity out of a circuit and into someone who comes in contact with the short.
4. Number 2 is like the conductor of an electric current. It does not change the flow of electric current but provides a pathway for the current.



Section 1.3 Summary

In this section, you learned that an electric circuit is a pathway for the flow of electricity. For the circuit to be useful, it needs
- a source to "push" charges through the circuit.
- a conductor to carry electric current.
- a load that responds in some way to the current.
- a switch to control the electric current.

Circuits can be closed or open. A closed circuit allows the flow of electricity. An open circuit does not allow the flow of electricity. A short circuit is closed and allows the flow of electricity but does not have a useful or intended load. It can be quite dangerous.

A circuit can be arranged either in series or in parallel.
- A series circuit connects all components in a single pathway, while a parallel circuit has more than one pathway for charges to follow.
- Removing any device from a series circuit (or turning the device off) opens the circuit.
- Adding more loads to a series circuit increases the "push" of charges. Adding loads to a parallel circuit does not change the amount of current flowing through other loads.

Key Terms
circuit
source
load
closed circuit
open circuit
switch
hazard
short circuit
series circuit
parallel circuit

Check Your Understanding

1. How can you stop the flow of current around a circuit?
2. What are the four basic components that make up all circuits? Describe the role each component plays in the circuit.
3. Are short circuits dangerous? Explain.
4. In the water system shown in the illustration, which one of the numbered elements is like the conductor in an electric circuit? Explain your answer.
5. From what you know about series circuits, explain whether you think it would be a good idea to wire a string of decorative lights in series.
6. Question 4 compared a water system to an electric circuit. Name one characteristic that makes this water system *not* like an electrical circuit.

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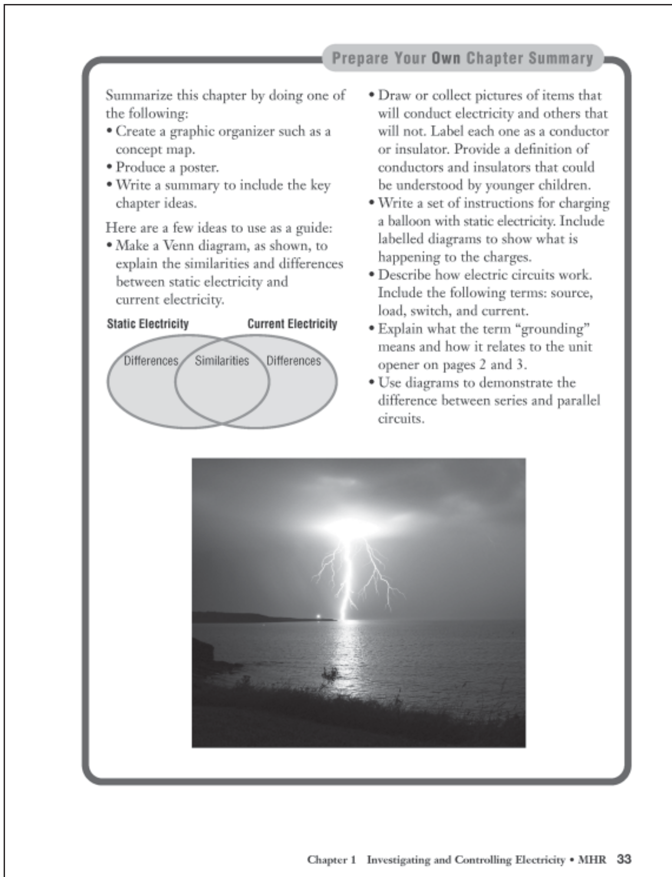
5. Decorative lights should not be strung in series because if one light in the circuit burns out, all other lights will go out. This will make it difficult to determine which light has burned out.
6. The water system is different from an electric circuit because the water does not pass from the load (water wheel) back into the source.



Prepare Your Own Chapter Summary

Summarize this chapter by doing one of the following:
- Create a graphic organizer such as a concept map.
- Produce a poster.
- Write a summary to include the key chapter ideas.

Here are a few ideas to use as a guide:
- Make a Venn diagram, as shown, to explain the similarities and differences between static electricity and current electricity.

- Draw or collect pictures of items that will conduct electricity and others that will not. Label each one as a conductor or insulator. Provide a definition of conductors and insulators that could be understood by younger children.
- Write a set of instructions for charging a balloon with static electricity. Include labelled diagrams to show what is happening to the charges.
- Describe how electric circuits work. Include the following terms: source, load, switch, and current.
- Explain what the term "grounding" means and how it relates to the unit opener on pages 2 and 3.
- Use diagrams to demonstrate the difference between series and parallel circuits.

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Prepare Your Own Chapter Summary

Student summaries should incorporate the following main ideas:

- Electric charge is a result of a separation or imbalance of charges in an object. An object is positively charged if it has more positive charges than negative charges. An object is negatively charged if it has more negative charges than positive charges. An object is neutral or has no charge if it has an equal number of positive and negative charges.
- Static electricity is created when an object becomes charged as a result of friction generated from rubbing against another object. The area to or from which the charges have been transferred holds a fixed (static) charge.
- Charged objects interact with one another. Positively charged objects attract negatively charged objects and neutral objects. They repel other positively charged objects. Negatively charged objects attract positively charged objects and neutral objects. They repel other negatively charged objects.
- The build-up of static electricity in clouds causes lightning. Lightning sparks consist of negative charges that are attracted to positive charges in the ground and travel the shortest path to them.
- Electric current is created when charges flow through conductors. Conductors are materials that allow the flow of charges. Insulators are materials that block the flow of charges.
- Grounding is the removal of charge from a charged object by transferring charges to or from the ground through a conductor.
- Electric circuits can harness electrical energy. All electric circuits have a source of electricity, a conductor along which charges flow, and a load to use the electrical energy. Most have a switch to control the flow of electricity.
- A short circuit is a situation in which charges find an alternate, easier path to flow through a circuit. This can create dangerous heat or sparking conditions.
- A series circuit is a circuit that provides only one pathway for the flow of electric current. A parallel circuit is a circuit that provides more than one pathway for the flow of electric current.
- The more loads that are added to a circuit in series, the weaker the current. The more loads that are added to a circuit in parallel, the greater the current.
- When more sources are added in series to a circuit, the voltage (push or pull) increases. When more sources are added in parallel to a circuit, the voltage remains unchanged.

Assessment Options

- Review students' definition of key terms in their own words.
- Use applicable checklist or rubric, e.g., Learning Skills Checklist 7, Concept Map, to assess students' chapter summaries.
- Use BLM 1.9, Drawing Circuits to assess students' knowledge of different kinds of circuits.
- Hold interviews with individual students to review their science logbooks, portfolios, and any questions they may have about the material.