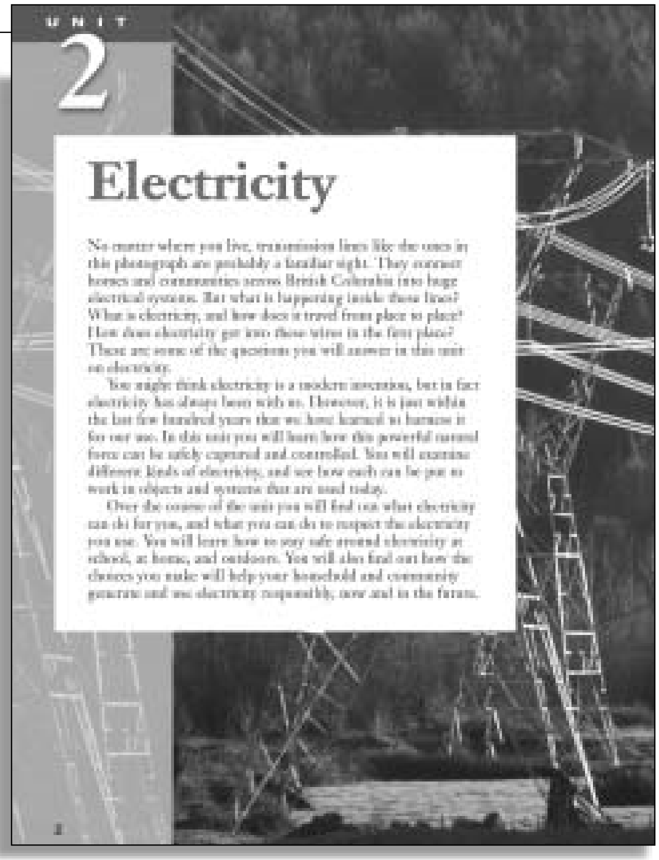
USING THE UNIT 2 OPENER

TEACHING STRATEGIES

- Ask students a series of true/false-type questions about electricity, and have them explain why they think or believe each is true or false. You can use BLM 4-1, Electrifying Facts and Fictions, as an overhead master, or distribute copies to small groups of students for discussion and later sharing with the whole class.
- Read the unit opener with students and have them, in small groups or as a class, share their ideas about the questions posed in the first paragraph. Now is a good time to have students flip through the pages of the unit and record their ideas, impressions, and questions about electricity.
- Use the "Getting Ready" questions to focus students' thinking about the science, technology, and societal implications of electricity.


UNIT 2

Electricity

No matter where you live, transmission lines like the ones in this photograph are probably a familiar sight. They connect homes and communities across British Columbia into huge electrical systems. But what is happening inside these lines? What is electricity, and how does it travel from place to place? How does electricity get into these wires in the first place? These are some of the questions you will answer in this unit on electricity.

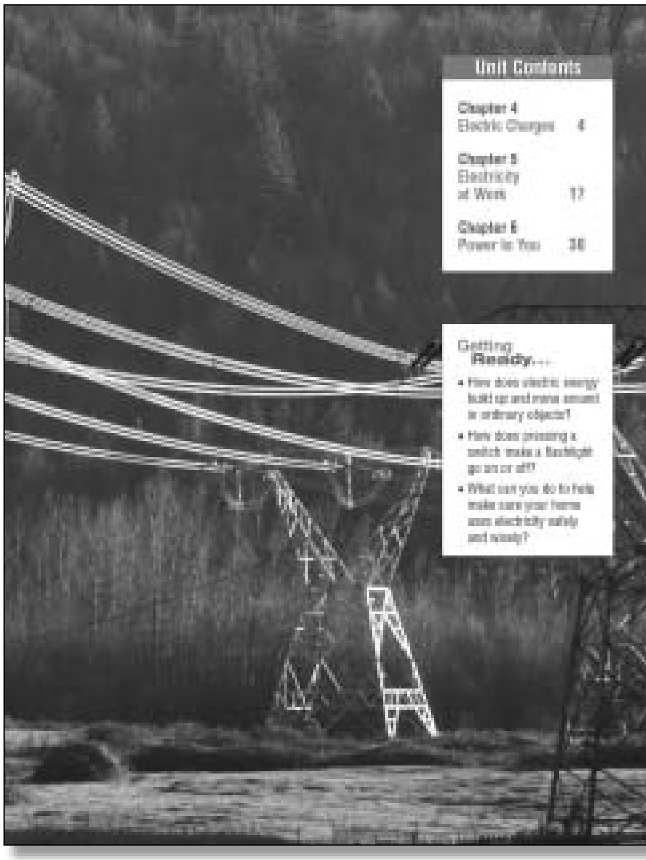
You might think electricity is a modern invention, but in fact electricity has always been with us. However, it is just within the last few hundred years that we have learned to harness it for our use. In this unit you will learn how this powerful natural force can be safely captured and controlled. You will examine different kinds of electricity, and see how each can be put to work in objects and systems that are used today.

Over the course of the unit you will find out what electricity can do for you, and what you can do to respect the electricity you use. You will learn how to stay safe around electricity at school, at home, and outdoors. You will also find out how the choices you make will help your household and community generate and use electricity responsibly, now and in the future.

2

ATTENTION Grabber to introduce Unit 2

- Display a variety of plug-in and battery-operated devices such as flashlight, a toaster, an electric toothbrush, a portable radio and/or CD player—but unplugged and without batteries. If at all possible, also have available a device that operates by mechanical action on a small generator (e.g., a bicycle lamp or a hand-cranked radio or flashlight). In addition, if possible, have a glow stick and/or a cold or hot pack—that is, items that light up or change temperature by chemical means. The idea is to invite and challenge students' notions and preconceptions about devices that use electricity and the sources of the energy for these devices. Students will have no trouble asserting why the battery-operated and plug-in devices don't work, because students' common relationship with electrical devices is to associate wall outlets and batteries with their operation. (But can students explain where the electricity "behind the wall" or in the batteries comes from?) Although many students might be familiar with bicycle generators, they likely will be hard-pressed to explain how or why the turning of the wheels makes the bulb light up. Familiarity with hand-cranked radios and flashlights is likely to be far less common, although students probably will link the turning (cranking) motion to that of a bicycle generator. The glow stick and hot/cold packs represent anomalies—light and temperature-change without electricity. (Later in the unit, students will learn that all forms of energy can be transformed into other forms, and they will use this understanding to help them appreciate the various means by which society generates the electricity on which so much of modern life depends.)
- Have several light objects—for example, some duck feathers, small pieces of newsprint, a cardboard toilet paper tube—on a desk or table in front of you. Without students knowing, charge a plastic ruler or glass rod with wool. (Rub vigorously to sustain the charge.) Bring the charged object near the cardboard tube and make it roll around the table (being careful not to let it touch the ruler or rod). Pause to recharge, and then attract the down and/or paper bits. Invite students' ideas about what is happening, and why.
- (Note: Practice this ahead of time.) Rub an elongated balloon vigorously with wool or on your hair, and then bring it in contact with an unlit compact fluorescent light bulb. The bulb (which contains a gas that fluoresces when electricity is applied to it) will light up briefly, or at least flicker. Ask students what they think is happening.



“Getting Ready” Answers

- **How does electric energy build up and move around in ordinary objects?** As students will discover in Chapter 4, static electric energy builds up in objects when negatively charged particles (electrons) are transferred from one object to another, either by direct contact or as a result of proximity. Once transferred, the electrons remain in place until they are discharged. Current electric energy is a stream of electrons moving in a conducting material such as a copper wire.
- **How does pressing a switch make a flashlight go on or off?** As students will discover in Chapter 5, pressing a switch opens and closes a circuit, either allowing (closed circuit) or restricting (open circuit) the movement of electrons through a wire.
- **What can you do to help make sure your home uses electricity safely and wisely?** As a result of their experiences in Chapters 4 and 5, students can appreciate the ways in which charges can build up on and move through different kinds of objects and materials; based on their understanding, students can approach and use electric devices wisely and respectfully. In addition, in Chapter 6, students will explore the ways in which different forms of energy are transformed to electric energy, and the economic and societal costs involved.

Supporting Diverse Student Needs

- Pair students with demonstrated strong reading skills with students whose reading skills are weaker to serve as a “reading buddy.”
- Scan through the numerous Supporting Diverse Student Needs sections throughout the chapters in this Teacher’s Resource unit to develop plans and strategies for providing differentiated instruction based on the aptitudes, skills, and needs of the individual students in your classroom.

Cross-Curricular Connections

- **Mathematics:** Chapter 5 provides students with opportunities to practice and apply basic computation skills.
- **Literacy:** Both within the chapters in this Teacher’s Resource and in the blackline masters that accompany them, there are suggestions and worksheets for using the science content to assist in developing reading, writing, numeracy, and comprehension skills.
- **Aboriginal Studies:** Contact your school district’s Aboriginal Education coordinator and/or your school’s Aboriginal support workers for assistance in securing local community support, information, and resources. They can help you make contacts with members of local bands and/or tribal councils and/or Aboriginal organizations (such as Friendship Centres) who may be willing to offer assistance to your students and class in learning about applications of electricity that are and could be meaningful to them.

USING THE CHAPTER 4 OPENER

TEACHING STRATEGIES

- Direct students' attention to the photograph. Read them the opening text as they examine the picture, and invite their responses to the questions posed.
- Use a KWL chart to set out students' responsibilities for their learning in the chapter.
- Encourage students to read the **What You Will Learn, Why It Is Important**, and **Skills You Will Use**. Remind students to return to these frequently throughout the chapter to add their own ideas or flesh out ones that are there.
- Use the "Getting Ready" questions to assess students' prior knowledge and interests, and to establish a baseline for assessing the development of their knowledge and skills.

"Getting Ready" Answers

- Students' answers will provide a baseline for determining their existing understanding of electricity and its sources. By the time they complete this chapter, students will understand that electricity results from the movement of electrons.
- Student might infer that there is something about the type of fabric (material) that makes some stick to other types, but not to the same type. They could also infer that the rubbing (tumbling) movement in a dryer is associated with the sticking effect. By the time they complete this chapter, students will understand that, in the dryer, different materials are rubbing together. When materials of different types (for example, wool and cotton) rub together, electrons from one (the wool) are transferred to the other (the cotton). As a result, the wool becomes more positively charged and the cotton becomes more negatively charged. Since opposite charges attract, the two materials stick together. When materials of the same type rub together, there is no transfer of electrons, so the materials do not stick together.
- Students might (rightly) distinguish between the strength or intensity of the electricity in a storm cloud compared to a flashlight. By the time they complete this chapter, students will understand that the electricity in a storm cloud, when it is discharged, produces a single burst of electric current, whereas the electricity in a flashlight involves a steady or continuous flow of current.


4 Electric Charges

STARTING POINT ACTIVITY 4-A BALLOON BUDDIES

Purpose

- Students experiment with charged balloons to begin thinking about the nature of electricity and electric charges.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
2 days before	• Gather apparatus and materials.
1 day before	• Test the activity and determine best placement for balloons.

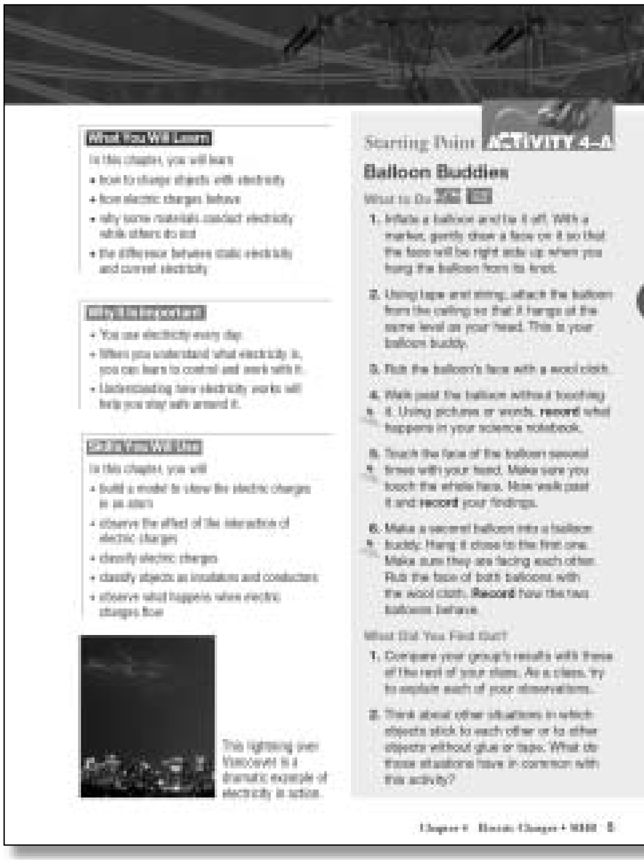
APPARATUS	MATERIALS
– indelible marking pens – pieces of wool fabric	– balloons – string – tape

Time Required

- 20 min

Safety Precautions

- Some students may have latex allergies. These students could be engaged as observers and recorders. Alternatively, cut overhead-master material (acetate) into strips and have the students use these instead of balloons.



Starting Point ACTIVITY 4-A

Balloon Buddies

What to Do

1. Inflate a balloon and tie it off. With a marker, gently draw a face on it so that the face will be right side up when you hang the balloon from its knot.
2. Using tape and string, attach the balloon from the ceiling so that it hangs at the same level as your head. This is your balloon buddy.
3. Rub the balloon's face with a wool cloth.
4. Walk past the balloon without touching it. Using pictures or words, **record** what happens in your science notebook.
5. Touch the face of the balloon several times with your hand. Make sure you touch the whole face. Now walk past it and **record** your findings.
6. Make a second balloon into a balloon buddy. Hang it close to the first one. Make sure they are facing each other. Rub the face of both balloons with the wool cloth. **Record** how the two balloons behave.

What Did You Find Out?

1. Compare your group's results with those of the rest of your class. As a class, try to explain each of your observations.
2. Think about other situations in which objects stick to each other or to other objects without glue or tape. What do these situations have in common with this activity?

This lightning over Vancouver is a dramatic example of electricity in action.

&

- If possible, obtain balloons that are easy for the students (or you) to blow up. Generally, round balloons are easier to inflate than sausage-shaped balloons.
- Be prepared to assist some students either in blowing up their balloons, tying them off, or tying string to them.
- If wool fabric is unavailable, nylon would be a good substitute.

Implementing the Activity

- If feasible, perform this activity on a day where the air is as dry or fairly dry. Otherwise, students will have to run the balloons more vigorously and longer.
- Place students in groups of 2; where possible, pair students in such a way that each complements the other. For example, one may be a stronger reader than the other, and one may have finer motor skills than the other.
- Advise students not to touch the balloons, with their hands or any part of their bodies, once the balloons have been rubbed.
- Students should move by and between the balloons slowly so that any motion caused by student-generated air currents is minimized.

Supporting Diverse Student Needs

- Kinesthetic and visual learners, as well as ESL students, may find the amount of instructional reading in this activity intimidating. One option is to invite other students to provide assistance. For example, students who enjoy or have an aptitude for drawing could reproduce the procedure in visual form—as a comic strip, for instance. Students who enjoy drama or sports could demonstrate the procedure, step by step, describing what is to happen at each step.

Promoting Positive Attitudes

- Making observations is an essential science process skill. Ask students what they do to observe something. As necessary, help students recall or recognize that they use their senses of sight, hearing, touch, and sometimes smell to obtain information about (i.e., observe) their surroundings.

What to Do Answers

5. The balloon will "follow" the students (i.e., be attracted to the students' bodies).
6. The two balloons move away from each other.

What Did You Find Out? Answers

1. Students likely had similar experiences and observations. Differences might result from the way students rubbed the balloons and the amount of rubbing they did. Collect students' ideas about what they observed and why. Likely responses will include reference to rubbing.
2. Students might suggest clothes sticking together from the dryer, tape sticking to itself or other nearby objects when being unrolled, paper sticking together or to their skin after they have walked across a carpet. Depending on examples they cite, students may notice rubbing as something all the events have in common. Some students may also suggest that these events happen more often during winter.

ASSESSING STUDENT LEARNING

ACTIVITY	CONCEPTS/OUTCOMES	ASSESSMENT OPTIONS
Starting Point Activity 4-A: Balloon Buddies, p. 5	– students demonstrate open-mindedness, accuracy, and precision in gathering information – students show curiosity and skepticism – students ask questions and formulate hypotheses	– discuss answers to What Did You Find Out? questions – use Assessment Checklist 1, Making Observations and Inferences

Section 4.2 Static Electricity

Figure 4.8 Do your socks go with your shirt—a little too well? Static electricity can make different fabrics stick together.

You pull a shirt out of the clean laundry basket and some other clothing is stuck to it. You drag your feet across the carpet and feel a shock when you reach for the doorknob. You brush your hair on a winter day and it sticks out from your head. You pull out an extra blanket on a winter night and sparks crackle. All of these are examples of **static electricity**. Static electricity is a buildup of positive and negative charges that have become separated from each other. The word "static" means "not moving." Static electricity is an electric charge that stays in one place on the surface of an object.

But what makes these charges build up? And why is static electricity noticeable sometimes, but not always? In this section you will explore the properties of static electricity.

Explaining Static Electricity

In Section 4.1 you saw that atoms can pick up electrons from other atoms. When this happens, both atoms become electrically charged. This picking up and losing—or transfer—of electrons takes place between the atoms of different objects or materials. If you rub two pieces of wool cloth together, they won't pick up electrons from each other. But if you rub a balloon and a wool cloth together, one will pick up electrons from the other. When you separate the objects, you have a static charge on each object.

SECTION 4.2 STATIC ELECTRICITY

What Students Do in Section 4.2

- learn to charge different materials and test the properties of charged and uncharged materials
- discover three rules for predicting what happens when charged objects and uncharged objects interact
- describe how lightning occurs and how to protect themselves during a thunderstorm

Prescribed Learning Outcomes

- evaluate various methods for producing small electrical charges

ICT OUTCOMES

- demonstrate Foundation skills including: entering, saving, modifying, and retrieving information; using appropriate keyboard techniques; demonstrating self-reliance when using information technology tools; using information technology tools responsibly
- demonstrate Process skills including: analyzing information using information technology tools and resources

SCIENCE BACKGROUND

- The word "electricity" is derived from the Greek word for amber, electron. The effect of rubbed amber on small bits of material eventually came to be known by scientists as the "amber effect." Combining the original Greek word for amber with the notion of there being an "effect" associated with this material led to the invention of the term "electriks," and then to the word "electricity."
- Electric charges exert a force on each other at a distance through an invisible field, which exists around every electric charge. The strength of an electric field increases as you get closer to a charge, and weaker as you move away from it.

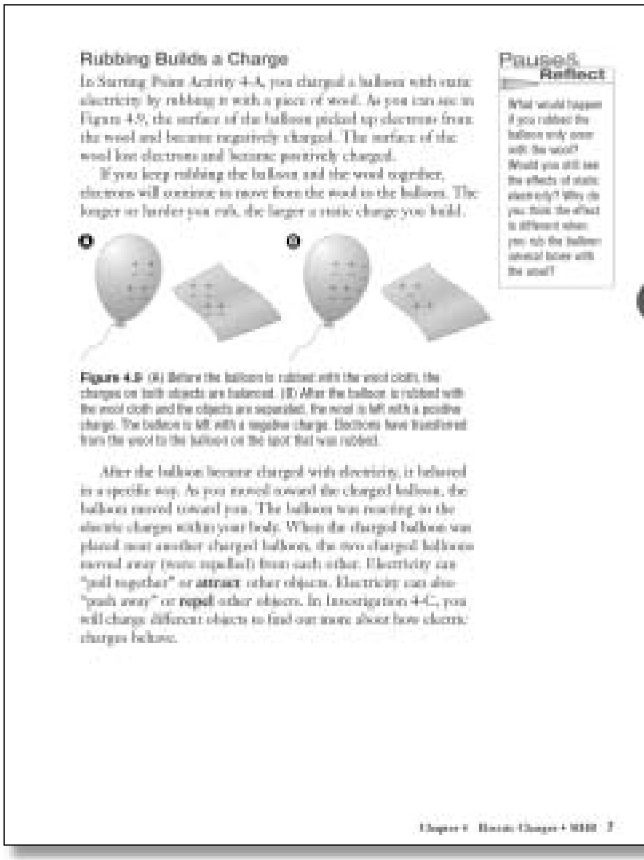
TEACHING STRATEGIES

- Poll the class to see how many students have experienced the effects described in the first paragraph of the student textbook. Invite other, similar experiences from students.
- Ask students to reflect on their experiences during the Starting Point Activity and to think about the additional examples noted in the first paragraph and those they have suggested from their personal experience. Encourage students to look for patterns or trends in all these experiences. For example, during what time of year do these experiences seem to happen most? (Winter.) What do they have in common? (In most cases, objects rubbing together or over other objects.)
- Review students' understanding of basic atomic structure from section 4.1. In particular, ensure that all students understand where electrons are located (i.e., around the nucleus—centre—of an atom), that electrons are negatively charged, and that the nucleus contains particles (protons) that are positively charged.

EXPLAINING STATIC ELECTRICITY/ RUBBING BUILDS A CHARGE

SCIENCE BACKGROUND

- **Types of charging:** Materials can gain charges in two ways. If materials are touched or rubbed together and then moved apart, charges can be transferred through a process called contact charging (or tribocharging). Another type of charging is called inductive charging (or charging by induction). Inductive charging occurs when an electric charge is transferred to an object. This occurs when the object is close to an electric field being given off by a charged object, or when the object is temporarily in contact with the ground in the presence of an electric field. No contact between charged objects is necessary for inductive charging.



Rubbing Builds a Charge

In Starting Point Activity 4-A, you charged a balloon with static electricity by rubbing it with a piece of wool. As you can see in Figure 4.9, the surface of the balloon picked up electrons from the wool and became negatively charged. The surface of the wool lost electrons and became positively charged.

If you keep rubbing the balloon and the wool together, electrons will continue to move from the wool to the balloon. The longer or harder you rub, the larger a static charge you build.

Figure 4.9 (A) Before the balloon is rubbed with the wool cloth, the charges on both objects are balanced. (B) After the balloon is rubbed with the wool cloth and the objects are separated, the wool is left with a positive charge. The balloon is left with a negative charge. Electrons have transferred from the wool to the balloon on the spot that was rubbed.

After the balloon became charged with electricity, it behaved in a specific way. As you moved toward the charged balloon, the balloon moved toward you. The balloon was reacting to the electric charges within your body. When the charged balloon was placed near another charged balloon, the two charged balloons moved away (were repelled) from each other. Electricity can "pull together" or **attract** other objects. Electricity can also "push away" or **repel** other objects. In Investigation 4-C, you will charge different objects to find out more about how electric charges behave.

Pause & Reflect

What would happen if you rubbed the balloon only once with the wool? Would you still see the effects of static electricity? Why do you think the effect is different when you rub the balloon several times with the wool?

- **Positive and negative charges:** Using the terms "positive" and "negative" to describe charges was largely an arbitrary decision. Benjamin Franklin was the first to use these terms to describe the electrical state of an object. In his view, what we now call a neutral object had the normal amount of electric charge. By adding charge, the object became positively charged. By removing charge, the object became negatively charged. Scientists later learned that the movement or redistribution of only electrons determines the charge on an object.
- The two types of charges, positive and negative, sometimes confuse students when they are told that a negative charge means there is an excess of electrons. Students often attribute the more usual meaning (i.e., "less than") to the word negative. There is no simple way to describe the difference between positive and negative charges except that a positive charge exhibits behaviour opposite to that of a negative charge when exposed to similar conditions.

■ TEACHING STRATEGIES

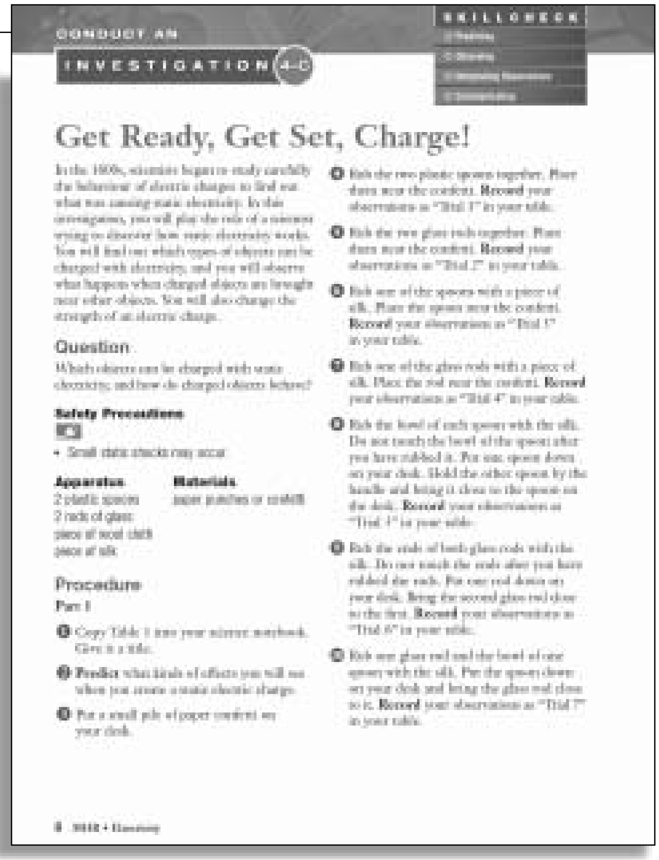
- Before they begin reading the explanation of static electricity in their books, direct students' attention to Figure 4.11. Ask them what they think is being shown, and to discuss their ideas. They should be able to recognize that two different materials are involved, and that there is a movement—a transfer—of electrons (negative charges) from one material to the other, resulting in a difference in the total number of positive and negative charges on each material. Refer to Supporting Diverse Student Needs below for an alternative to or augmentation of this strategy.
- As a whole class or in small groups, have students read through the text material about how static electricity develops when two objects are rubbed together. Ask students to refer to Figure 4.11 as they read the text, and use the illustration to help them understand what they are reading.

Ideas for Communicating (Literacy Links)

- The experience that many students have with text-based reading involves the reading of fiction books. Textbooks, because of their use of both words and visual material to communicate information, sometimes confuses students. They do not know where to look first, on which elements on the page to focus their attention, and how much "weight" to place on the different elements. The Teaching Strategies suggested above provide a valuable experience for students in learning how the use of one medium for communication, words, can be used to reinforce, augment, and/or complement the use of another medium for communication, visuals—and vice versa.

Supporting Diverse Student Needs

- Invite students to communicate their understanding of the information on pages 6 to 7 in a way that is most meaningful to them. Some students, for example, might like to draw their own diagram. Some might like to write a poem or short skit. Still others might like to use their whole bodies (with or without props) to model the transfer of electrons from wool to a balloon.
- Some students—particularly those who are more kinesthetic learners—may benefit from the use of manipulatives to help them visualize what happens when two objects become charged through rubbing. Provide students with a large jar lid or cardboard disk, a second smaller lid or disk, and a set of pennies. Place a piece of masking tape over the top of the pennies and use a felt-tip marker to write a positive sign on some and a negative sign on the others. Set the two lids or disks about 30 cm apart on a tabletop. Put, say, seven positive-coins in the centre of the large lid/disk and surround that lid with seven negative-coins. On the other lid/disk, place five positive-coins and surround it with five negative-coins. Tell students that the large lid/disk



represents (is a stand-in for) the charges on a balloon and the small one represents the charges on wool. Ask students to count the positive and negative charges for each lid/disk, so they can verify that the numbers of the different charges are equal for each; in other words, neither material has a charge; each material is electrically neutral.

Now supply students with a piece of wool and an inflated balloon to help concretize the analogy, and have students rub the wool on the balloon. Ask students to use their manipulatives to model what happens to the charges. If necessary, show the transfer of one negative charge from the wool to the balloon. Then have students count the charges on their models so they can see, as a result of the rubbing, that the wool now has an extra positive charge and the balloon now has an extra negative charge.

Pause& Reflect A balloon rubbed once with wool might display a slight static-electric effect, especially if the air conditions are quite dry. A balloon rubbed several times with wool will display a more significant static-electric effect, because more electrons are transferred.

DidYouKnow? Some students may need help understanding what amber is. Depending on where they live, many students will be familiar with the resin that seeps out of various types of coniferous trees. Their hands may have been sticky with it at one time or another, or they might have observed the hardened resin on the trunks or branches. Explain that tree resin usually hardens and eventually crumbles when it is exposed to air. If it is buried under layers of soil before that happens, the resin will change over time into a hard, gold-coloured, translucent material: amber. In British Columbia, amber has been found in the regions of Quesnel, the Peace River Canyon, and the Queen Charlotte Islands.

Connecting to the World Outside the School

- Show students the photograph of amber in their books, or (better) show them an actual sample if you can obtain one. Students might be interested to learn that people have been using this material for perhaps as long as 30 000 years. Although the Did You Know feature states that the "amber effect" of attraction was first reported over 2500 years ago, people almost certainly had observed it earlier—perhaps even in British Columbia, where amber is found in several locations. (See the Did You Know above for where.)

CONDUCT AN INVESTIGATION 4-C GET READY, GET SET, CHARGE!

Purpose

- Students determine, through observation and inference, which types of objects can be charged, and how charged and uncharged objects behave when they interact.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
1 or 2 days before	• Gather the apparatus and materials.

APPARATUS	MATERIALS
– 2 plastic spoons – 2 glass rods – piece of wool fabric – piece of silk fabric	– paper punches or confetti – paper towelling and water to moisten it (optional)

Time Required

- 40 min

HINTS&

- If glass rods are not available, you can use acetate strips (strips cut from overhead masters). If silk is not available, you could use nylon. If wool is not available, you can consider having students use their hair.
- Caution students that once they have rubbed the spoon or glass rod in each trial, they should not touch the object again until that trial is done. (Touching will remove-neutralize-the charge they have given the object. Students observed this in the Starting Point Activity, in step 5.)

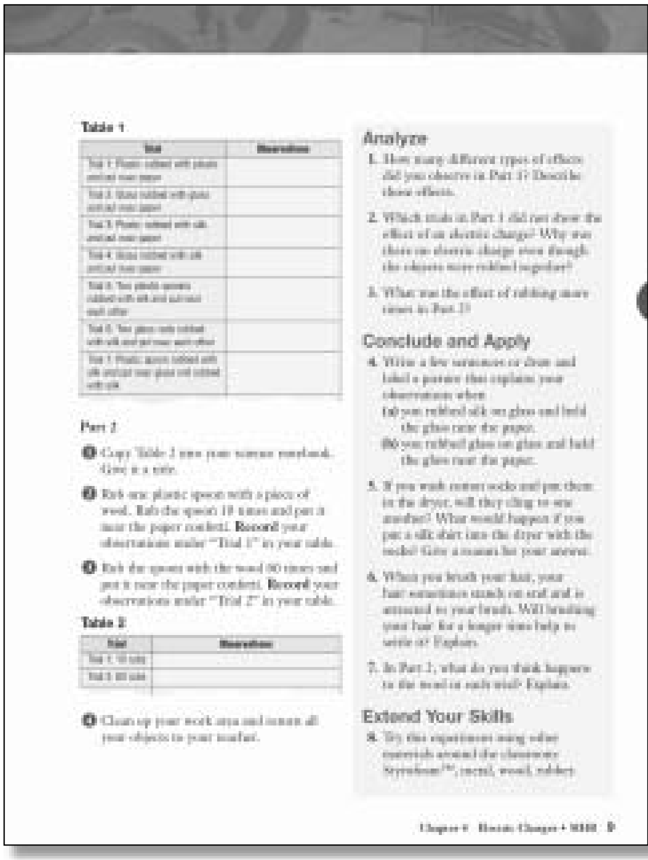


Table 1

Analyze

Conclude and Apply

Part 2

Table 2

Extend Your Skills

Implementing the Investigation

- Organize students into groups of 3 or 4, ensuring a suitable mix of skills and language levels.
- Prior to starting the Investigation, read over the entire procedure with the class while students are in the groups. At each appropriate step, have students in their groups make predictions about what they will observe, and their reasons for thinking so.
- Advise students that they should rub their spoons and glass rods with their hands or a damp piece of paper towelling after each trial has ended.

Supporting Diverse Needs

- The procedure for this Investigation is long, and could intimidate some students. Explain that some of the words in each procedure step are repetitions of certain actions. If students understand what to repeat in each trial, they could use Table 1 to help guide them instead. (Verify students' understanding of this modification before letting them proceed.)
- As an enrichment activity, some students could complete additional trials with additional objects and rubbing materials of their choice.

Analyze Answers

1. Three effects were observed: attraction, repulsion, and no change. In some cases, the charged objects pulled (attracted) the paper. In some cases, the charged objects pushed away (repelled) each other. In some cases, the paper was neither attracted to nor repelled by the charged objects.
2. Trial 1 and Trial 2 did not show the effect of an electric charge, because the two rubbed objects were made of the same material, so neither picks up electrons from the other.
3. Rubbing more times increased the strength and duration of the electric charge.

Conclude and Apply Answers

4. Students' written answers or drawings should indicate that electrons are being transferred from one material as it is rubbed on another, thus making it charged. The charged object is then able to pull on the paper.
5. The cotton socks should not cling to each other, because they are the same material. If a silk shirt were put into the dryer with the cotton socks, the socks would cling to the silk because rubbing two different materials leaves the materials charged.
6. Brushing longer will not settle the hair. In fact, it will increase the electric effects because more electrons are being transferred.
7. Students should recognize that the wool is being charged because electrons are being transferred as a result of rubbing. As a result, each material—the wool and the plastic—are charged. In Trial 1, the charge on both materials will be weaker and last a shorter length of time than in Trial 2.

Extend Your Skills Answer

8. Antistatic fabric softener works by coating the fabrics with a chemical that makes the fibres of the fabrics take on similar properties. The result is similar to rubbing two like fabrics together: no transfer of electrons, so no charge.

ASSESSING STUDENT LEARNING

ACTIVITY	CONCEPTS/OUTCOMES	ASSESSMENT OPTIONS
Conduct an Investigation 4-C: Get Ready, Get Set, Charge!, p. 9	– students evaluate various methods and materials for producing and testing electrical charges	– use Assessment Checklist 1, Making Observations and Inferences so that students can assess their own skill development – use Assessment Rubric 12, Using Tools, Equipment, and Materials


Pause& Reflect

Three Rules of Electricity

When scientists began to study static electricity, they did experiments as you did in Investigation 4-C. Through this research, scientists concluded that the behaviour of electric charges follows three basic rules.

1. Opposite Charges Attract

DidYouKnow?

Figure 4.10

2. Like Charges Repel

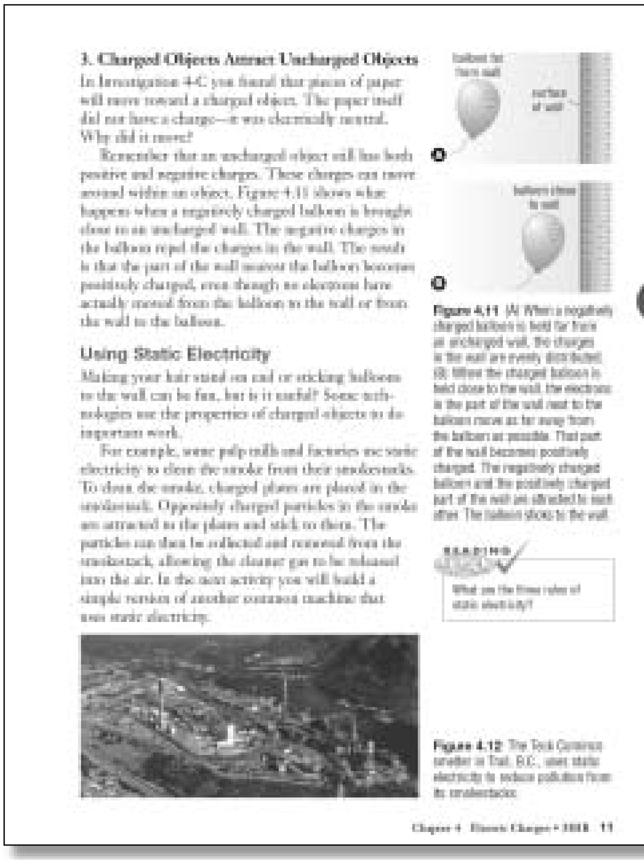
THREE RULES OF ELECTRICITY/ OPPOSITE CHARGES ATTRACT/LIKE CHARGES REPEL/A CHARGED OBJECT ATTRACTS AN UNCHARGED OBJECT

■ SCIENCE BACKGROUND

- **Conductors and insulators:** Metals are excellent conductors, mainly because of the nature of the metallic bonding that exists among atoms of the metal. In this type of bonding, the outer electrons of each metal atom are relatively free to associate with neighbouring atomic nuclei. Because these electrons are loosely held, they and the charge they carry can move within the conductor. Materials that are insulators, on the other hand, hold their electrons very tightly. Amber, glass, paper, plastic, rubber, wood, wool, cotton, and fur are examples of insulators.
- **Neutral objects and rules of static electricity:** When two neutral objects are rubbed together, they both become charged, suggesting that the charges must come from them. Since the objects are neutral, they must have the same number of both positive and negative charges to start with. What happens to these charges, then, to enable neutral objects to be attracted to positively or negatively charged objects? Charges in the molecules that make up insulators cannot move on or through the materials; however, they can rotate or stretch. If a charged object (e.g., glass) is brought up to a neutral object (e.g., paper), the positive charges in the glass attract the negative charges in the paper. Since these negative charges cannot move through the object, they pull to the ends of their molecules and distort all the molecules of the paper. As a result, one edge of the paper has an excess of negative charges and the opposite edge is slightly positive. Although the paper still has an equal number of positive and negative charges, they are rearranged.

■ TEACHING STRATEGIES

- Ensure that students have a reasonable grasp of the concepts of charge (positive and negative) and neutral objects. The following strategy can be used either to reinforce prior knowledge or further develop students' understanding. Ask students to think of the electron (negative charge) as contributing green charge and the proton (positive charge) as contributing red charge. Use an overhead projector and some green and red coloured sheets to demonstrate the behaviour of charge. If two equal-sized squares are used, you can show that when the red square is exactly overlapped by the green square, the object is neutral (i.e., no red or green shows; only black is seen). If a portion of the green square is cut away, then some of the red will show through, indicating that the object is now more red than green (i.e., positively charged) Similarly, if a portion of the red square is cut away, some of the green will show through; the object is now more green than red (i.e., negatively charged).
- Ask students what a rule is. (Likely responses will centre around something that is done a certain way, or an expectation of a certain type of behaviour.) Have students reflect on their experiences in Conduct an Investigation 4-C. Tell them that they observed three rules that describe what happens when charged and neutral objects come together. Ask students to infer what those three rules are, and to indicate where they observed those rules in play. (Students saw that opposite charges repel in Trials 5 and 6; they saw that like charges attract in Trial 7; they saw that charged objects attract neutral objects in Trials 3 and 4.)
- Now, as a class or in small groups, have students read and discuss the text on pages 10 to 11. Remind students to use the illustrations to help them understand the written text material.
- Assign BLM 4-4, What Will Happen Next?, to reinforce students' understanding of cause-and-effect interactions involving charged and neutral objects.



3. Charged Objects Attract Uncharged Objects

In Investigation 4-C you found that pieces of paper will move toward a charged object. The paper itself did not have a charge—it was electrically neutral. Why did it move?

Remember that an uncharged object still has both positive and negative charges. These charges can move around within an object. Figure 4.11 shows what happens when a negatively charged balloon is brought close to an uncharged wall. The negative charges in the balloon repel the charges in the wall. The result is that the part of the wall nearest the balloon becomes positively charged, even though no electrons have actually moved from the balloon to the wall or from the wall to the balloon.

Using Static Electricity

Making your hair stand on end or sticking balloons to the wall can be fun, but is it useful? Some technologies use the properties of charged objects to do important work.

For example, some pulp mills and factories use static electricity to clean the smoke from their smokestacks. To clean the smoke, charged plates are placed in the smokestack. Oppositely charged particles in the smoke are attracted to the plates and stick to them. The particles can then be collected and removed from the smokestack, allowing the cleaner gas to be released into the air. In the next activity you will build a simple version of another common machine that uses static electricity.

Figure 4.11 (A) When a negatively charged balloon is held far from an uncharged wall, the charges in the wall are evenly distributed. (B) When the charged balloon is held close to the wall, the electrons in the part of the wall next to the balloon move as far away from the balloon as possible. That part of the wall becomes positively charged. The negatively charged balloon and the positively charged part of the wall are attracted to each other. The balloon sticks to the wall.

READING Check

What are the three rules of static electricity?

Figure 4.12 The Teck Cominco smelter in Trail, B.C., uses static electricity to reduce pollution from its smokestacks.

Chapter 4 Electric Charges • MHR 11

Supporting Diverse Student Needs

- Kinesthetic learners may especially benefit by role-playing different materials (neutral, positively charged, and negatively charged), approaching one another, and displaying the appropriate effect. For example, a "neutral student" would be attracted to an approaching charged student; a "positive student" would be repelled by another "positive student." Be sure a large room or hallway is available for students to do this.

DidYouKnow? The list in this feature is sometimes called the electrostatic series. It provides a means for predicting the charge that results when you rub two materials together. For example, according to the list, rubbing glass with wool transfers electrons from the glass to the wool. As a result, the glass becomes negatively charged and the wool becomes positively charged. Although students did not know which type of charge was produced on their materials, they can still verify their results based on the attraction and repulsion effects they observed.

Pause & Reflect The question, "What holds an atom together?" is intended to help students realize that atoms are held together by the attraction of their positively charged protons and their negatively charged electrons. Since all matter is made up of atoms, students should find themselves in agreement with the statement. Encourage students who disagree to give reasons for their opinion.

READING Check The three rules of static electricity are (1) oppositely charged objects attract, (2) like-charged objects repel, and (3) charged objects attract uncharged (neutral) objects.

USING STATIC ELECTRICITY

SCIENCE BACKGROUND

- **Using Electrostatics:** Useful applications for electrostatics (static electricity) are being developed very quickly. Listed below are several examples of modern uses for electrostatics.
  - Electrostatic precipitators: Electrostatic precipitators remove airborne pollutants as they pass through the smokestacks of factories. The precipitator electrically charges waste particles so they can be extracted from the exhaust when they are attracted to metal plates carrying an opposite charge. The particles are then neutralized, shaken from the plates and disposed of.
  - Home dust removal: Electronic air cleaners and some brooms remove dust by generating a charge opposite to that of dust. These devices are often installed next to the furnace where air is brought into a home.
  - Electrostatic stickers: Electrostatic decals are held to surfaces using electrostatics. This type of decal leaves no sticky residue when removed.
  - Photocopiers and laser printers: These devices rely on electrostatic principles to carry out their function.
  - Electrostatics and farming: More farmers are using air-assisted electrostatic sprayers to produce charged spray droplets that are evenly attracted to all parts of a plant. This means that spray will stick to even the undersides of leaves. Coating these hidden surfaces provides the best attack on plant pests while reducing overspray and chemical wastage.
  - Negative ions and health: A negative air ion is an oxygen atom or molecule that has gained an electron, and a positive air ion is usually a carbon dioxide molecule that has lost an electron. To increase negative ion levels, devices such as negative ion generators or ionizers can be installed in homes or attached to a person's body. Some studies suggest that high negative ion levels may encourage positive feelings. Excess negative ions are also useful for ridding indoor environments of allergens (such as dust, animal dander, pollen, and moulds) in the air. Negative ions cause microscopic particles floating in a room (which could potentially cause allergic reactions) to clump together and fall to the floor where they can be vacuumed up.

TEACHING STRATEGIES

- Invite students to observe what you are doing as you sprinkle a mixture of salt and pepper on a sheet of paper. Challenge students to come up with a way to separate the two substances, without touching either of them. Give them a little time to brainstorm and discuss ideas and approaches. Ideally, someone will suggest charging a material (a plastic ruler, for example, or a balloon), and bringing it close to the mixture. (If done slowly and carefully, the lighter pepper will be attracted to the charged object, leaving the salt in place on the paper.) Inform students that they have just used or invented technology: a solution to a practical problem.
- Ask students if they have ever noticed dust that has collected on a TV screen or computer monitor, even soon after the screen or monitor has been cleaned. Invite explanations, and confirm that charges that build up on the screen or monitor attract airborne dust to them. Tell students further that despite the nuisance of static cling and other static electric effects, static electricity has some beneficial uses thanks to technology. Direct students to read the introductory text, which leads to the making of a high-interest model of a photocopier.

Supporting Diverse Needs

- Strongly motivated students might be interested in discovering various technologies that employ static electricity. The example described in the student textbook, at Teck Cominco, is an electrostatic precipitator. Students could be invited to research: home dust removal, electrostatic stickers (decals), home dust removal, the use of static electricity on farms (for dusting crops with pesticides or fertilizer), and negative ion generators (for health effects).

FIND OUT ACTIVITY 4-D
MAKE A PEPPER COPIER

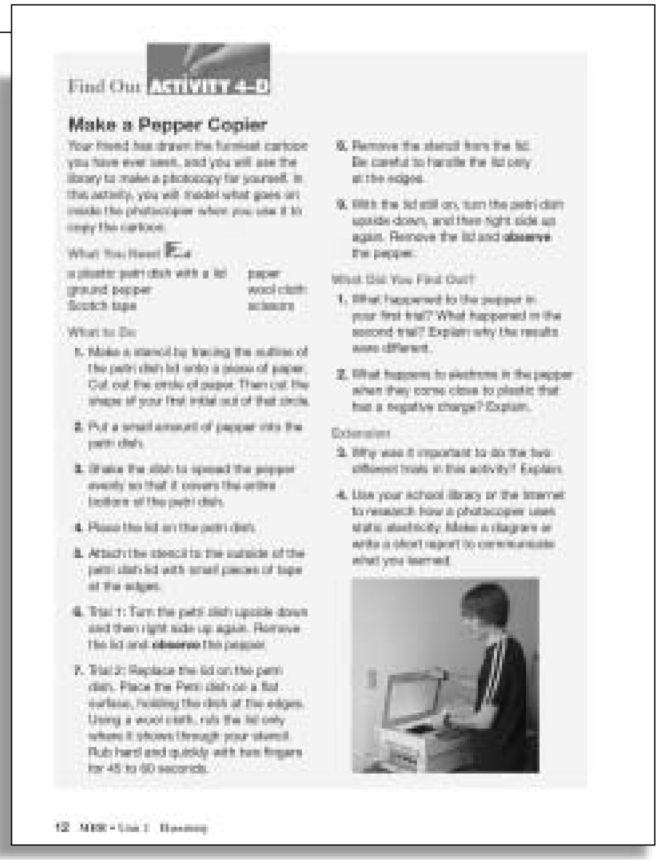
Purpose

- Students model the process used to make photocopies.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
1 day before	• Gather the apparatus and materials.

APPARATUS	MATERIALS
– plastic Petri dish with lid – scissors – wool cloth	– paper – ground pepper


Find Out ACTIVITY 4-D

Make a Pepper Copier

Your friend has drawn the funniest cartoon you have ever seen, and you will use the library to make a photocopy for yourself. In this activity, you will model what goes on inside the photocopier when you use it to copy the cartoon.

What You Need

a plastic petri dish with a lid, ground pepper, Scotch tape, paper, wool cloth, scissors

What to Do

1. Make a stencil by tracing the outline of the petri dish lid onto a piece of paper. Cut out the circle of paper. Then cut the shape of your first initial out of that circle.
2. Put a small amount of pepper into the petri dish.
3. Shake the dish to spread the pepper evenly so that it covers the entire bottom of the petri dish.
4. Place the lid on the petri dish.
5. Attach the stencil to the outside of the petri dish lid with small pieces of tape at the edges.
6. Trial 1: Turn the petri dish upside down and then right side up again. Remove the lid and **observe** the pepper.
7. Trial 2: Replace the lid on the petri dish. Place the Petri dish on a flat surface, holding the dish at the edges. Using a wool cloth, rub the lid only where it shows through your stencil. Rub hard and quickly with two fingers for 45 to 60 seconds.
8. Remove the stencil from the lid. Be careful to handle the lid only at the edges.
9. With the lid still on, turn the petri dish upside down, and then right side up again. Remove the lid and **observe** the pepper.

What Did You Find Out?

1. What happened to the pepper in your first trial? What happened in the second trial? Explain why the results were different.
2. What happens to electrons in the pepper when they come close to plastic that has a negative charge? Explain.

Extension

3. Why was it important to do the two different trials in this activity? Explain.
4. Use your school library or the Internet to research how a photocopier uses static electricity. Make a diagram or write a short report to communicate what you learned.

Time Required

- 20–25 min

Safety Precuations

- Caution students to handle the scissors carefully.
- Students should be careful not to ingest any of the pepper through the mouth or nose. (Do be prepared for some sneezing.)

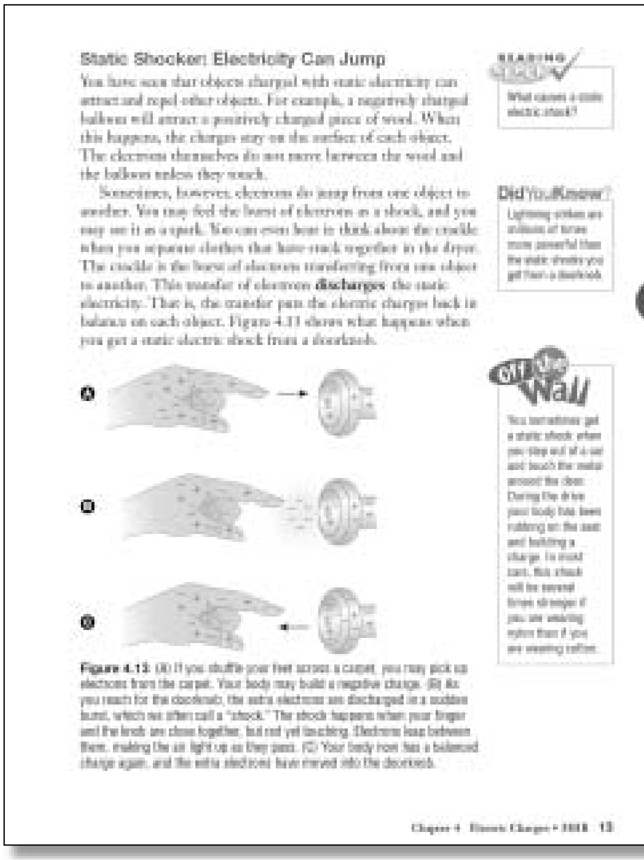
- To minimize time and maximize safety, you could prepare stencils ahead of time. The Petri dish can be used to trace a circle onto paper using a sharp pencil. Cutting the stencil shape (*by the teacher only*) might be easier using a razor blade, a scalpel, or an arts/utility knife.
- Remind students not to touch the area where the stencil is exposed.

Implementing the Activity

- Students will enjoy this activity. However, if time is an issue, consider conducting the activity as a demonstration with assistance by student volunteers.

What Did You Find Out? Answers

1. In the first trial, the pepper just fell back to the bottom of the dish. In the second trial, the pepper stuck to the part of the lid that the stencil did not cover. The pepper stuck to the uncovered part of the lid because that part was charged.


Static Shocker: Electricity Can Jump

2. Electrons in the pepper are repelled by the negatively charged pepper, so they move away, leaving the positive charges together and separated from them.

Extension Answers

3. The difference between the two trials was a change in one variable. In the first trial, the entire lid was uncharged, while in the second trial the uncovered portion of the lid was charged while the covered portion remained uncharged. It was important to do the two trials because the second trial established the cause of the sticking effect—the charging of the part of the lid that was exposed to the rubbing.
4. A photocopier works by projecting an image of the page to be copied onto a rotating drum. The drum is positively charged, but loses the charge on the parts that are illuminated by the projecting light. The remaining parts of the drum hold the image from the original page, and are still positively charged. Negatively charged toner is attracted to the positively charged parts of the drum. As paper is pulled over the drum, the toner is transferred to the paper, producing a copy of the original. A helpful animation of the process may be viewed on the Howstuffworks website (www.howstuffworks.com/photocopier.htm). A "static" diagram of the process is provided on BLM 4-5, How a Photocopier Works, if you wish to provide students with an information handout.

STATIC SHOCKER: ELECTRICITY CAN JUMP/LIGHTNING IS A GIGANTIC STATIC SPARK

SCIENCE BACKGROUND

- Lightning occurs when strong winds and the collision of water droplets and ice particles in the clouds strip electrons from some particles and deposit them on others. For reasons that meteorologists do not completely understand, negative charges collect at the bottom of the clouds, while the higher parts of clouds are positively charged. It is believed that this contact between different materials, followed by their wide separation, is what causes the cloud to become electrified. The negatively charged bottom portion of the clouds repels electrons on the surface of Earth, leaving the ground positively charged just below the cloud. The strong attraction between the negative cloud and the positive ground pulls electrons off atoms and molecules in the air. Once a chain of ions (charged particles) forms, the gigantic discharge (which we call lightning) occurs between the cloud and the ground.
- The safest place to be during a thunderstorm is in a building, preferably with a lightning rod. In a car with the windows rolled up is another safe place to be, as long as you don't touch any of the metal parts. The car's metal body conducts the charge of a lightning strike down to the ground. Contrary to popular belief, the rubber of the car's tires offers no protection from a lightning strike.

ASSESSING STUDENT LEARNING

ACTIVITY	CONCEPTS/OUTCOMES	ASSESSMENT OPTIONS
Find Out Activity 4-D: Make a Pepper Copier, p. 13	– model a practical application of static electricity – describe the properties of static electric charges, including attraction and repulsion	– discuss answers to What Did You Find Out? questions

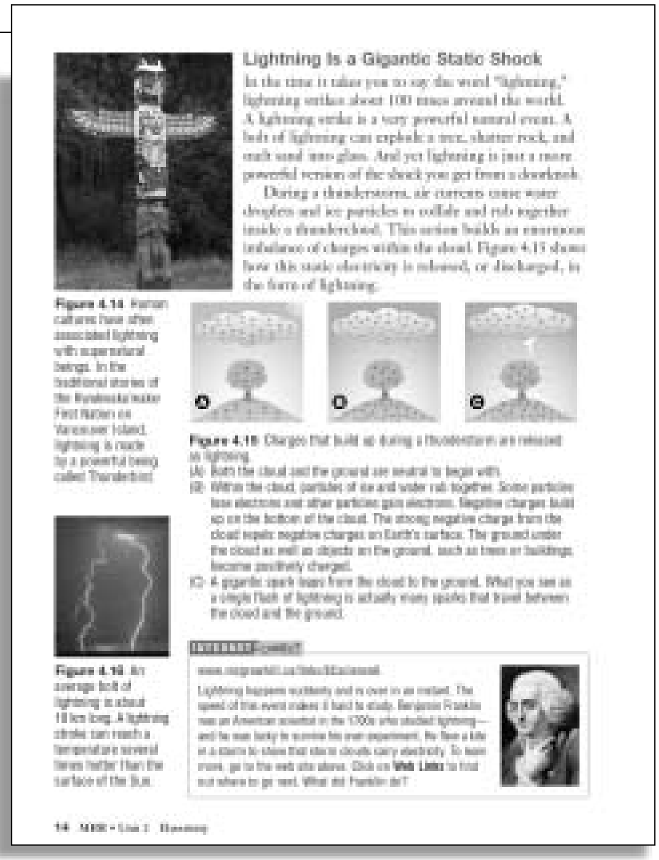

Lightning Is a Gigantic Static Shock

Figure 4.14

Figure 4.15

Figure 4.16

- The record holder for being hit by lightning a number of times, and surviving, is an American ranger named Roy C. Sullivan, who experienced seven different lightning strikes. According to the *Guinnes Book of Records*, Sullivan was first hit by lightning in 1942, which caused him to lose his big toenail. Over the next 35 years, lightning burned off his eyebrows, seared his left shoulder, set his hair on fire, struck his legs, injured his ankle, and burned his stomach and chest.
- The cloudiest and wettest city in Canada, Prince Rupert, British Columbia, is also the city with the fewest thunderstorms—only three per year, on average.

TEACHING STRATEGIES

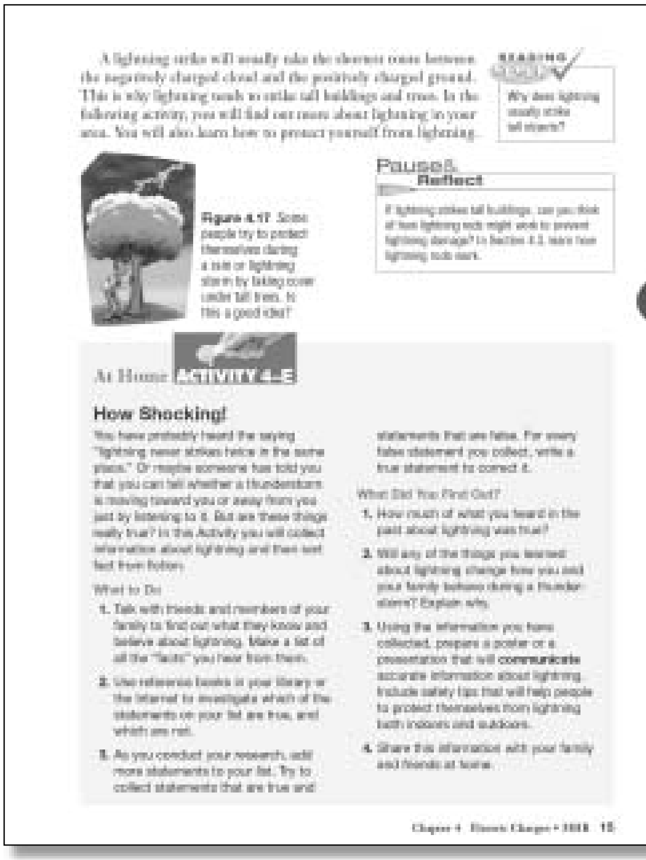
- Two excellent videos are available on the topic of lightning. One is a NOVA production called *Lightning*. The other is a BBC production called *Electric Skies*. Either one would make an excellent introduction to this topic.
- Pique students' interest in investigating lightning with some "weather trivia." For example:
  - Over 100 bolts of lightning strike the Earth every second.
  - The total amount of energy released as light, heat, and sound during one major thunderstorm is much greater than that released from a nuclear bomb.
  - The energy of an average lightning strike (which is about 5 km long) would—if it were possible to harness it in its entirety—keep a 100 W light bulb lit for 116 consecutive days.
  - About 65 percent of all lightning bolts go from one cloud to another, without ever hitting the ground.
  - Earth is not the only planet with lightning. Scientists have observed lightning on Venus, Jupiter, Saturn, Uranus, and Neptune.

Reading Check A static electric shock is caused when a negatively charged object approaches, but does not quite touch, a positively charged object. The electrons transfer suddenly ("jump" or "leap"), which we experience as a shock.

Off the Wall Ask students to review the list of materials in the Did You Know? feature on page 10. Nylon does not appear on this list. Based on what they read in the Off the Wall feature, ask students to predict where nylon would appear in this list: above or below cotton. (For nylon to produce a bigger shock than cotton, nylon must transfer electrons more readily than cotton does. Therefore, nylon would appear above cotton.)

Reading Check Lightning usually strikes tall objects because lightning usually takes the shortest path between a charge and the ground. Since tall objects are higher than ground level, they are more likely to be struck.

Pause & Reflect Students might know, or be able to infer, that a lightning rod—being placed on the roof of a building—would be more likely to be struck than the roof or any other lower location.



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

Reading Check

Why does lightning usually strike tall objects?

Figure 4.17 Some people try to protect themselves during a rain or lightning storm by taking cover under tall trees. Is this a good idea?

Pause & Reflect

If lightning strikes tall buildings, can you think of how lightning rods might work to prevent lightning damage? In Section 4.3, learn how lightning rods work.

At Home ACTIVITY 4-E

How Shocking!

You have probably 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 things really true? In this Activity you will collect information about lightning and then sort fact from fiction.

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 reference books in your library or the Internet to investigate which of the statements on your list are true, and which are not.
3. As you conduct 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 why.
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 to protect themselves from lightning both indoors and outdoors.
4. Share this information with your family and friends at home.

Chapter 4 Electric Charges • MHR 15

AT HOME ACTIVITY 4-E HOW SHOCKING!

Purpose

- Students apply their understanding of electric charges and develop their researching skills as they investigate facts and fictions associated with lightning.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO
At least 1 week before	• Book the library or computer room to allow students Internet access. • Request that related reference material be gathered and set aside in the library. • Send a letter home to parents advising them that students will be interviewing them informally about their experiences and knowledge of lightning and thunderstorms.

APPARATUS	MATERIALS
– computers and/or print reference materials	– poster paper – drawing, writing, and colouring supplies

Time Required

- at least 60 minutes, plus out-of-class time for presentation development

HINTS & HELPS

- Prior to assigning the activity, preview and bookmark relevant sites on the Internet. Possibilities include:
  http://www.lightningrodguy.electrical-contractor.net/custom2.html
  http://www.mb.ec.gc.ca/air/summersevere/index.en.html
  http://www.lightningstalker.com/weather/lightningstalker/myths.html
  http://www.fema.gov/kids/thfac.htm
  http://www.culverco.com/sseng/sky/
  http://www.factmonster.com/ipka/A0875672.html
- Whether searching the Internet or using a library database, students should choose suitable keywords to help them locate the information they need. (This will fulfill ICT Outcomes for Foundation Skills.)

Implementing the Activity

- Depending on the needs of individual students, this activity could be done as an independent task or in small groups of 3 or 4.

Supporting Diverse Student Needs

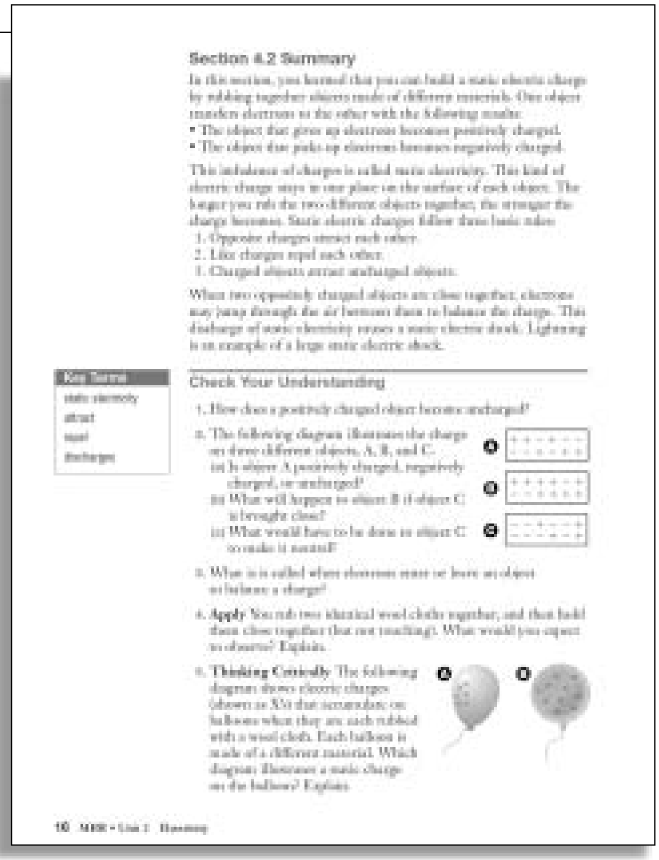
- Instead of a poster, interested students could design educational comic strips for a younger (or older) audience that advise what to do, and not do, during a thunderstorm.

What Did You Find Out Answers

1. Students likely will find that at least some of what they had heard or thought they knew about lightning was mistaken or inaccurate.
2. Students likely will say they and their families will act and react differently, because they are better informed about how lightning.
3. Students' posters or presentations should be assessed on criteria established ahead of time.

ASSESSING STUDENT LEARNING

ACTIVITY	CONCEPTS/OUTCOMES	ASSESSMENT OPTIONS
At Home Activity 4-E: How Shocking!, p. 15	– identify and communicate safe practices related to electricity – challenge assumptions about information based on misconceptions or misperceptions	– use Assessment Rubric 8, Research Project Rubric – Use Assessment Rubric 10, Presentation Rubric


Section 4.2 Summary

Check Your Understanding

SECTION 4.2 SUMMARY

Read the section summary together as a class. Invite students to discuss any questions they have among themselves, turning to you for clarification or assistance, rather than as a source for answers. You might wish to have students design a concept map or other graphic organizer that includes the points of the summary. Be sure students understand that the section summary can serve as a study aid, for a test or a quiz, for example. As an additional reinforcement activity, students could work in pairs to write questions that match each of the points in the summary. The questions and answers could be displayed on a class bulletin board under the heading, “What We Learned about Static Electricity in Section 4.2.”

✓ SECTION ASSESSMENT IDEAS

- The Check Your Understanding questions provide one assessment option, and can be reviewed individually, within small group discussion, or with the whole class.
- Encourage students to design their own summary of the section so that the concepts, processes, skills, and attitudes they are learning and developing are meaningful at a personal level. Their summaries could be done in the form of a graphic organizer, a FAQ, a blog, or even a game show. Students could also exchange their summaries to challenge their classmates’, and their own, understanding.
- Students could create a multimedia presentation to summarize their understanding of charges, the three rules of static electric charges, and the science and safety of lightning. Note: This activity will help fulfill ICT Outcomes for Presentation.

Check Your Understanding Answers

1. A positively charged object can become uncharged by bringing a negatively charged object near it (to create a discharge). (It could also become uncharged by wiping it with a damp cloth, or just by leaving it along for a period of time; contact with air will eventually rebalance the charges on the object.)
2. Two objects with opposite charges will repel each other when they approach each other.
3. (a) Object A has no charge. It is electrically neutral.
   (b) Object B will be attracted to Object C.
   (c) Object C would need to discharge its extra electrons (through a shock, for example) to become neutral.
4. Electrons entering or leaving an object to balance a charge is called a discharge.
5. **Apply** You would expect to observe no interaction between the two cloths, because no transfer of electrons occurred between them; they are still electrically neutral.
6. **Apply**
   (a) The purpose of the wire is to “lead” electrons away from the body of the truck so that a large charge does not build up on it.
   (b) Students may infer that the conducting wire works in a way similar to a lightning rod; i.e., that it provides a route for electrons to flow away from the truck.
7. **Thinking Critically** Students should be able to say that the materials, and therefore their properties, are different, because the charges are separated on one balloon and more evenly spread out on the other. (By the end of the next section, students will be able to state that one balloon is probably made of an insulating material and the other is made of a conducting material.)