DISCOVERING SCIENCE 7
TEACHER'S RESOURCE

UNIT 4: EARTH'S CRUST

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UNIT 4: OVERVIEW

Earth's Crust introduces students to geosciences—the study of Earth's structure and geological processes. Because geoscientists may be separated from their subject by thousands of kilometres (in the case of Earth's core) or millions of years (in the case of geological processes), they rely on observations made from the surface of Earth to draw inferences about the inner structure and ancient history of our planet. Over the course of this unit, students learn how scientists develop and work with models based on direct and indirect evidence. Through an exploration of the rocks, minerals, and soil that make up Earth's surface, and the events that continually reshape these structures, students develop an understanding of the forces at work within our planet. They are also introduced to some of the new technologies that are increasing our ability to study Earth, the ways in which our increased understanding is used to help prepare communities for events such as earthquakes and volcanoes, and the importance of preserving and protecting our precious topsoil.

Chapter 10: Earth's crust is made up of rocks and minerals.

Section 10.1 examines minerals found at Earth's surface and how these minerals can be identified and classified according to their physical properties. Section 10.2 introduces students to the terminology used to describe the three main families of rocks, and explores how these rocks are formed. Section 10.3 builds from students' understanding of individual rocks and minerals. It begins by exploring the long-term processes that make up the rock cycle. Students have an opportunity to model the various processes at work in the rock cycle. In section 10.3, students also consider the many uses for rock and mineral resources, in particular, those found in our province.

Chapter 11: Earth's crust is constantly changing.

In section 11.1, students are introduced to a current and generally accepted model that describes the four main layers thought to make up the structure of Earth. This model shows how currents within the liquid inner layer may account for the movement of the plates that make up the outer rigid layer of Earth's crust. This section introduces the theory of continental drift, examining evidence to support it. As part of this exploration, students learn about some of the technologies that have been used to study movements in Earth's crust. These technologies have enabled new discoveries that have extended the theory of continental drift into the theory of plate tectonics and detail the interaction of the plates of Earth's crust as they converge, collide, or drift apart. This understanding sets the stage for students' exploration of earthquakes, volcanoes, and mountain building later in this chapter. In section 11.2, students study the sudden and explosive processes that result in earthquakes and volcanoes. They learn that earthquakes release stress that builds up in Earth's crust as a result of the movement of tectonic plates and that volcanoes release heat from within the planet. In section 11.3, students study the long slow processes of mountain building and the divisions of geologic time. They learn about the importance of rock and fossil discoveries in our province as evidence of the movement of plates.

Chapter 12: Soil is the living component of Earth's crust.

In section 12.1, students examine processes of physical and chemical weathering, and learn how erosion and deposition work together to change the features on Earth's surface. Students also learn that the in-between process of weathering and rock formation is the production of sediments, and how sediments gradually evolve into soil. In section 12.2, students take a look at the formation of soil and the importance of organic matter. They examine different types of soil, learning about texture, porosity, and permeability. This understanding provides a basis for section 12.3, in which students consider the importance of topsoil to humans and to the health of all organisms. Students are presented with information about how modern farming practices can deplete the soil, and also how ecological practices can enrich the soil. The unit ends with a project in which students model geological processes at work in their community, and an integrated research investigation in which students discover how other schools have developed and used a composting program.

MULTIPLE INTELLIGENCES CORRELATION FOR UNIT 4 ACTIVITIES AND INVESTIGATIONS

The table on the next page identifies possible multiple intelligences that could be incorporated into activities and investigations in this unit. For more information about differentiated instruction and multiple intelligences, see the Introduction and Implementation section in this *Teacher's Resource*.

Multiple Intelligences:	VL	VS	BK	MR	LM	N	E	IA	IE
UNIT 4: Earth's Crust									
Find Out Activity: What Makes a Rock a Rock?	■	■	■		■	■			■
Chapter 10: Earth's crust is made up of rocks and minerals.									
Find Out Activity 10-1A: Sand Detective	■	■	■		■	■			
Think About It-1B: Mapping Minerals and Their Uses	■	■	■		■	■			■
Conduct an Investigation 10-1C: A Mineralogist's Mystery	■	■	■			■			
Find Out Activity 10-2A: Write about Rocks	■	■	■		■	■			■
Conduct an Investigation 10-2B: Cool Crystals, Hot Gems!	■	■	■		■	■			
Find Out Activity 10-2C: Settling Sediments	■	■	■		■	■			
Find Out Activity 10-2D: Sort It Out	■	■	■		■	■			
Think About It 10-3A: Recycling the Rocks	■	■	■		■	■			
Think About It 10-3B: Research the Resource	■	■			■			■	■
Conduct an Investigation 10-3C: Rolling Out the Rock Cycle	■	■	■		■	■			
Chapter 11: Earth's crust is constantly changing.									
Find Out Activity 11-1A: Examine the Evidence	■		■						■
Think About It 11-1B: A Model Planet									
Think About It 11-1C: Pangaea Puzzle	■	■			■			■	
Think About It 11-1D: Evidence from the Sea Floor	■	■			■				
Conduct an Investigation 11-1E: Building a Model of Plate Tectonics	■	■	■		■				
Find Out Activity 11-2A: Seismic Sandpaper	■	■	■		■				
Think About It 11-2B: Seismic Safety	■							■	■
Think About It 11-2C: Seismic Stories	■						■		■
Design an Investigation 11-2D: Shake It!	■	■	■		■				■
Think About It 11-2E: Patterns in Earthquake and Volcano Locations	■	■			■				
Find Out Activity 11-3A: Make a Mountain	■	■	■		■				
Think About It 11-3B: Tell-Tale Layers	■	■			■				
Think About It 11-3C: Canada—Past, Present, and Future	■	■			■	■			■
Think About It 11-3D: Rock Stars	■	■			■				■
Find Out Activity 11-3E: Model Mountains of Moving Magma	■	■	■		■				■
Find Out Activity 11-3F: Building a Mountain-Building Theory	■	■			■				
Chapter 12: Soil is the living component of Earth's crust.									
Find Out Activity 12-1A: Use the Force	■	■	■		■	■		■	
Conduct an Investigation 12-1B: Rocks That Fizz	■	■	■		■	■			
Find Out Activity 12-1C: Crystals in a Cave	■	■	■		■	■			
Find Out Activity 12-1D: Weathered Lettering	■	■			■	■			
Find Out Activity 12-2A: Comparing Dirt and Soil	■	■			■	■			
Conduct an Investigation 12-2B: Be a Soil Sleuth	■	■	■		■	■			
Find Out Activity 12-3A: Save the Soil	■	■	■		■				
Think About It 12-3B: Agriculture in the News	■				■	■		■	■
Find Out Activity 12-3C: Maintaining Moisture	■	■	■		■	■			
Find Out Activity 12-3D: Fertilizer Formulations	■				■				■
Conduct an Investigation 12-3E: Decomposing Dinner	■	■	■		■	■			
Unit 4 Project: Modelling Geological Processes in Your Community	■	■	■	■	■	■		■	■
Unit 4 Integrated Research Investigation: Soil Super Stars	■				■	■			■

Multiple Intelligence codes:
VL = Verbal-Linguistic Intelligence; VS = Visual-Spatial Intelligence; BK = Body-Kinesthetic Intelligence; MR = Musical Rhythmic Intelligence; LM = Logical-Mathematical Intelligence; N = Naturalist Intelligence; E = Existential Intelligence; IA = Intrapersonal Intelligence; IE = Interpersonal Intelligence

Planning Chart for Activities and Investigations for Unit 4: Earth's Crust

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Unit 4: Earth's Crust			
Find Out Activity: What Makes a Rock a Rock?	• 1 week before: – Gather materials.	For each group: – selections of materials, such as chalk, pottery shards, pieces of cement and brick, marbles, iron nail or iron ore, petrified wood, coal, piece of glass (smooth edges), quartz, salt, sand, pumice, assorted rocks, etc.	• 15 min
Chapter 10: Earth's crust is made up of rocks and minerals.			
Find Out Activity 10-1A: Sand Detective	• 3 days before: – Gather materials.	For each group: – sand – white cardboard (for dark sand) or dark cardboard (for light sand) – hand lens – tweezers	• 15 min
Think About It 10-1B: Mapping Minerals and Their Uses	• 2 weeks before: – Book library and/or computer lab. • 1 day before: – Photocopy BLM 4-3, Mapping Minerals and Their Uses.	For each group: – BLM 4-3, Mapping Minerals and Their Uses	• 40–60 min
Conduct an Investigation 10-1C: A Mineralogist's Mystery (Core Lab)	• 1 week before: – Gather materials. – Label each sample with a number, and make a list of the identities of the minerals and their corresponding numbers. • 1 day before: – Photocopy BLM 4-4, A Mineralogist's Mystery	For each group: – numbered mineral samples – streak plate – copper penny – iron nail – glass plate or jar – steel file – sandpaper – emery cloth – hand lens – optional: magnet – Tables 10.1 and 10.2 from pages 318 and 319 (BLM 4-4, A Mineralogist's Mystery)	• 40–50 min
Find Out Activity 10-2A: Write about Rocks	• 3 days before: – Gather materials. – Photocopy BLM 4-9, Write about Rocks.	For each group: – rock samples – clear adhesive tape – marker – hand lens – plastic knife or other scraping tool – index cards – sand in plastic cup (optional)	• 30 min
Conduct an Investigation 10-2B: Cool Crystals, Hot Gems!	• 1 day before: – Gather materials. – Make or purchase the crushed ice.	For each group: – measuring cup or graduated cylinder – tap water – small pot – heat source – measuring spoons – 90 mL Epsom salts – stirring rod or stirring spoon – two small beakers – two bowls – hot water – ice (crushed or broken) – labels – hand lens	• Day 1: 30–45 min • Day 2: 15–20 min

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Find Out Activity 10-2C: Settling Sediments	• 1 week before: – Ask students to bring in jars with screw-cap lids. – Purchase or gather clay powder, sand, fine gravel, and coarse gravel. • 1 day before: – Remind students to bring in jars.	For each group: – dampened clay powder – sand – fine gravel – coarse gravel – clear glass jar or soft drink bottle (2 L or larger) with a screw-cap lid	• 5–10 min set-up • 30–40 settling time
Find Out Activity 10-2D: Sort It Out	• Several weeks before: – Collect, identify, and number rocks from local outcrops. – Organize purchased and collected rocks.	For each group: – a set of rocks, including rocks from your geographic area – rocks students have found and brought to class – hand lens or binocular microscope	• 30 min
Find Out Activity 10-3A: Recycling the Rocks	• 1 day before: – Gather materials.	For each group: – index cards or other pieces of paper – coloured pencils or felt pens – poster paper – glue – optional: yarn, string, and other materials	• 30–40 min
Think About It 10-3B: Research the Resource	• 2 weeks before: – Reserve the library or computer lab, if desired. – Decide what sort of format(s) will be accepted for this activity. Consider whether assessment rubrics will be used. • 1 day before: – Photocopy BLM 4-13, Research the Resource	For each group: – BLM 4-13, Research the Resource – red and black pens – research materials – access to the Internet and/or other research material	• 30–60 min
Conduct an Investigation 10-3C: Rolling Out the Rock Cycle	• 1 day before: – Ask students to bring in old wax crayons or purchase approximately 30 wax crayons per class.	For each group: – different colours of wax crayons – coin – aluminum foil – rolling pin or heavy weight – hot mitts – tongs – water – hot plate or electric kettle – plastic spoon – small aluminum dish – beaker or small glass bowl	• 40 min
Chapter 11: Earth's crust is constantly changing.			
Find Out Activity 11-1A: Examine the Evidence	• 1 week before: – Collect a number of the same size aand type of containers with lids, such as film canisters or small yogurt or margarine containers (several per group in the class). • 3 days before: – Put together, seal, and number each container.	For each group: – sealed containers provided by the teacher	• 30 min
Think About It 11-1B: A Model Planet	• 3 days before: – Ask students to look for or make items or photographs that might be used to model Earth. • 1 day before: – Remind students to bring their models to class for the activity.	For each group: – students bring in their own materials	• 10-30 min presentation time

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Think About it 11-1C: Pangaea Puzzle	• 1 day before: – Photocopy BLM 4-23, Pangaea Puzzle.	For each group: – BLM 4-23, Pangaea Puzzle – blue paper – coloured pencils – scissors – glue	• 60 min
Think About It 11-1D: Evidence from the Sea Floor	• Day of instruction: – No advance preparation necessary	For each group: – student book	• 15 min
Conduct an Investigation 11-1E: Building a Model of Plate Tectonics	• 1 month ahead: – (Optional) Order a case (10 kg) of corn starch. • 1 day before: – Collect all materials for the activity.	For each group (or whole class): – 1 large plastic tub – disposable gloves (optional) – spoon – two 1 kg boxes of cornstarch – measuring container – water For each group: – 4 petri dishes – puzzle pieces, marbles, building blocks, bingo chips, etc.	• 30–60 min
Find Out Activity 11-2A: Seismic Sandpaper	• 1 day before: – Gather materials.	For each group: – 2 wooden blocks, each about 5 cm by 10 cm by 15 cm – 2 sheets of medium grade sandpaper – masking tape	• 5–10 min
Think About It 11-2B: Seismic Safety	• Day of instruction: – No advance preparation necessary	For each group: – None	• 20–30 min
Think About It 11-2C: Seismic Stories	• 2 weeks before: – Book the library or computer lab, or select resources from the library for class use. • 3 days before: – Students can begin their research at home using the Internet or library resources.	For the class: – various art materials and/or recording equipment depending on the formats you wish students to use	• 30 min for research (could be done at home) • 30 min for retelling and illustrating/ rehearsing the story
Design an Investigation 11-2D: Shake It!	• 3 days before: – Assign the reading of the investigation for homework so students can start thinking about their design. Ask students to bring materials from home. • 1 day before: – Gather materials. – (optional) Photocopy BLM 4-31, Shake It!	For each group: Suggested list: – marbles or small rocks – masking tape – modelling clay – paper (sheets of paper or adding machine paper) – paper clips – paper plates and cups – pencils – pieces of wood – rubber bands – shoebox – soup can or oatmeal cylinder – springs – string – washers – water	• 40–60 min

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Think About It 11-2E: Patterns in Earthquake and Volcano Locations (Core Lab)	• 1 day before: – Photocopy BLM 4-32, Patterns in Earthquake and Volcano Locations for students to use. You may also wish to photocopy it on acetate to use as an overhead projection.	For each group: – BLM 4-32, Patterns in Earthquake and Volcano Locations – blue, red, and green coloured pencils or markers	• 40 min
Find Out Activity 11-3A: Make a Mountain	• 3 days before: – Obtain enough Styrofoam™ (in three colours) for each partner/group.	For each partner/ group: – 3 sheets of flexible, spongy Styrofoam™ of different colours	• 10 min
Think About It 11-3B: Tell Tale Layers	• Day of instruction: – No advance preparation necessary	For each group: – a copy of the student book	• 15 min
Think About It 11-3C: Canada—Past, Present, and Future	• 2 weeks before: – Book computer lab or library if necessary.	For each group: – research materials	• 60 min
Think About it 11-3D: Rock Stars	• 2 weeks before: – Book computer lab or library if necessary.	For each group: – research materials	• 40–60 min
Find Out Activity 11-3E: Model Mountains of Moving Magma	• 2 days before: – (Optional) Ask students to bring in a tube of toothpaste. • 1 day before: – Gather materials.	For each group: – scissors – clear plastic disposable glass – 125 mL soil – tube of toothpaste	• 15 min
Conduct an Investigation 11-3F: Building a Mountain-Building Theory	• 2 weeks before: – Collect atlases or arrange for research time in the library or computer lab. • 1 day before: – Make transparencies or copies of BLM 4-36, Building a Mountain-Building Theory	For each group: – BLM 4-36, Building a Mountain-Building Theory – 3 colours of coloured pencils or markers – atlas or other source of mountain locations	• 45–60 min
Chapter 12: Soil is the living component of Earth's crust.			
Find Out Activity 12-1A: Use the Force	• 1 day before: - Gather materials.	For each group: – a mixture of sand and gravel – a stream table or metal pan	• 30 min
Conduct an Investigation 12-1B: Rocks that Fizz	• 1 week before: – Collect local examples of weathered rock specimens. - Organize the speci-mens for testing. • 1 day before: – Gather all materials. Make a few drop-per bottles of 1% HCl. – Photocopy BLM 4-39, Rocks that Fizz.	For each group: – small pieces of identified rock – two unidentified rock samples from your geo-graphic area – watch glass – tongs or tweezers – medicine dropper – 1% hydrochloric acid	• 30–45 min
Find Out Activity 12-1C: Crystals in a Cave	• 1 day before: – Gather materials.	For each group: – 2 small beakers or jars (such as baby food jars) – Epsom salts or baking soda – tap water – spoon – 2 washers – 30 cm cotton string or yarn – sheet of dark construction paper	• 10–15 min set-up • 1 week or longer to grow crystals

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Find Out Activity 12-1D: Weathering Lettering	• 2 weeks before: – (Optional) Make arrangements for visiting weathered headstones in a cemetery. • 1 day before: – Download and print photographs of weathered headstones. – Photocopy BLM 4-40, Weathered Lettering.	For each group: – photographs of headstones – BLM 4-40, Weathered Lettering	• 15–20 min (if viewing photo-graphs)
Find Out Activity 12-2A: Comparing Dirt and Soil	• 3 days before: – Gather materials.	For each group: – 250 mL dirt/ground rocks – paper – 250 mL rich garden soil – hand lens – stir stick – optional: goose-neck camera to magnify and view specimens	• 10–15 min
Conduct an Investigation 12-2B: Be a Soil Sleuth (Core Lab)	• 1 day before: – Test the drainage time for clay to gauge time needed for activity. – Photocopy BLM 4-45, Be a Soil Sleuth.	For each group: – soil sample, sand, gravel, clay – paper – hand lens – ruler – 4 large plastic cups – thumbtack or pushpin – cheesecloth – rubber bands – scissors – 4 plastic coffee-can lids – 4 glasses or beakers (250 mL) – measuring cup or graduated cylinder – water – watch	• 60–90 min
Find Out Activity 12-3A: Save the Soil	• 1 day before: – Gather materials.	For each group: – cutting board – knife – apple	• 10 min
Think About It 12-3B: Agriculture in the News	• 2 weeks before: – Book computer lab or library if necessary.	For each group: – research materials	• 30 min
Find Out Activity 12-3C: Maintaining Moisture	• 3 days before: – Gather materials. • Day of activity: – Set up a demonstration of the activity, if desired.	For each group: – 3 metal baking pans or similar pans – garden soil or potting soil – organic material, such as wood shavings, grass clippings, or leaves – water – fan (optional) – grow light or heat lamp (optional) – paper towel – soils moisture meter (optional)	• 20 min to set up • 10 min (sev-eral hours after set up)
Find Out Activity 12-3D: Fertilizer Formulations	• 1 week before: – Arrange to visit a garden store or nursery, or to have a fertilizer dealer or knowledgeable person speak with the class.	For each group: – None	• 40 min

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Conduct an Investigation 12-3E: Decomposing Dinner	• 3 days before: – Ask students to start collecting test materials. • 1 day before: – Have students bring in their test materials and begin formulating their hypotheses about what will happen to each of the materials. – Gather the materials.	For each group: – 4 identical plastic pots with drainage holes – saucers to go under pots – pieces of window screen or similar material – magnifying glass – small stones – labels for pots – garden soil (not sterilized) – water – approximately 250 mL of 2 items from List A and 2 items from List B List A: banana peels, cabbage leaves, grass clippings, potato peels, carrot peels, egg shells List B: aluminum foil, small pieces of plastic, shredded wax paper, shredded paper	• Part 1: 40 min • Part 2: 40 min over several weeks
Unit 4 Project: Modelling Geological Processes in Your Community	• 2 weeks before: – Book computer lab and library if needed.	For each group: – research materials – other materials as required depending on project	• 60–90 min
Integrated Research Investigation: Soil Super Stars	• 2 weeks before: – Book computer lab and library if needed.	For each group: – access to the Internet	• 40–60 min

TALKS AND TOURS

Possible sources of speakers on topics related to the material in Unit 4 include local colleges and universities or businesses that use or develop related technology. Many of these organizations may have a speaker's bureau or may be able to provide an opportunity to see science in action. In addition, consider contacting:

- Johnson Geo Centre in St. John's or an outdoor education centre to examine soils, rocks, and minerals
- a jeweller or geologist to discuss the rocks and minerals of Newfoundland and Labrador
- a local organic farmer to discuss ecological farming practices

UNIT 4 BLACKLINE MASTERS

CONTENT-RELATED BLACKLINE MASTERS	ASSESSMENT-RELATED BLACKLINE MASTERS
Unit BLM 4-1, Unit 4 Summary BLM 4-2, Unit 4 Key Terms	Assessment Checklist 1, Making Observations and Inferences Assessment Checklist 2, Asking Questions Assessment Checklist 5, Investigating an Issue Assessment Checklist 6, Developing Models Assessment Checklist 7, Scientific Drawing Assessment Checklist 8, Science Fair Display Assessment Checklist 9, Oral Presentation Assessment Checklist 10, Computer Slide Show Presentation Assessment Checklist 11, Poster Assessment Checklist 12, Classification System Assessment Checklist 13, Concept Map Assessment Checklist 14, Events Chain or Flowchart Assessment Checklist 15, Venn Diagram Assessment Checklist 20, Assessment Record Form Assessment Checklist 21, Project Self-Assessment Assessment Checklist 22, Project Group Assessment Assessment Rubric 1, Concept Rubric Assessment Rubric 7, Scientific Research Planner Rubric Assessment Rubric 8, Research Project Rubric Assessment Rubric 9, Communication Rubric Assessment Rubric 10, Presentation Rubric Assessment Rubric 11, Using Tools, Equipment, and Materials Rubric Process Skills Rubric 1, Developing Models Process Skills Rubric 8, Interpreting Data Process Skills Rubric 9, Questioning
Chapter 10 BLM 4-3, Mapping Minerals and Their Uses BLM 4-4, A Mineralogist's Mystery BLM 4-5, Mineral Identification Quiz BLM 4-6, Birthstone Research BLM 4-7, Birthstone Chart BLM 4-8, A Mineral Identification Story BLM 4-9, Write about Rocks BLM 4-10, Two Groups of Igneous Rocks BLM 4-11, Processes in the Rock Cycle BLM 4-12, A Rock Cycle Model BLM 4-13, Research the Resource BLM 4-14, Rocks and Minerals Crossword Puzzle BLM 4-15, Igneous Rocks BLM 4-16, The Rock Cycle BLM 4-17, Rock Cycle Word Search Puzzle BLM 4-18, Chapter 10 Review	Assessment Checklist 1, Making Observations and Inferences Assessment Checklist 2, Asking Questions Assessment Checklist 3, Designing an Experiment Assessment Checklist 7, Scientific Drawing Assessment Checklist 9, Oral Presentation Assessment Checklist 10, Computer Slide Show Presentation Assessment Checklist 11, Poster Assessment Checklist 12, Classification System Assessment Checklist 13, Concept Map Assessment Checklist 14, Events Chain or Flowchart Assessment Checklist 15, Venn Diagram Assessment Checklist 22, Project Group Assessment Assessment Rubric 1, Concept Rubric Assessment Rubric 3, Co-operative Group Work Rubric Assessment Rubric 4, Scientific Drawing Rubric Assessment Rubric 5, Conduct an Investigation Rubric Assessment Rubric 6, Design an Investigation Rubric Assessment Rubric 7, Scientific Research Planner Rubric Assessment Rubric 8, Research Project Rubric Assessment Rubric 9, Communication Rubric Assessment Rubric 10, Presentation Rubric Assessment Rubric 11, Using Tools, Equipment, and Materials Rubric Process Skills Rubric 1, Developing Models Process Skills Rubric 2, Hypothesizing Process Skills Rubric 3, Controlling Variables Process Skills Rubric 4, Problem Solving Process Skills Rubric 5, Fair Testing Process Skills Rubric 6, Designing Experiments Process Skills Rubric 7, Predicting Process Skills Rubric 8, Interpreting Data Process Skills Rubric 9, Questioning Process Skills Rubric 10, Measuring and Reporting Process Skills Rubric 11, Rubric Template

CONTENT-RELATED BLACKLINE MASTERS	ASSESSMENT-RELATED BLACKLINE MASTERS
Chapter 11 BLM 4-19, A Model of Earth BLM 4-20, Pangaea Map BLM 4-21, Biological Evidence—Fossil Locations BLM 4-22, Geological Evidence—Rocks and Rock Layers BLM 4-23, Pangaea Puzzle BLM 4-24, Evidence from the Sea Floor BLM 4-25, A Mission on the *Alvin* BLM 4-26, Convection Currents BLM 4-27, Three Types of Faults BLM 4-28, Earthquakes in One Month in Canada BLM 4-29, The Ring of Fire BLM 4-30, Seismic Stories BLM 4-31, Shake It! BLM 4-32, Patterns in Earthquake and Volcano Locations BLM 4-33, Converging Plates BLM 4-34, Major Mountain Ranges BLM 4-35, Geologic Time Scale BLM 4-36, Building a Mountain-Building Theory BLM 4-37, Chapter 11 Review	Assessment Checklist 1, Making Observations and Inferences Assessment Checklist 6, Developing Models Assessment Checklist 7, Scientific Drawing Assessment Checklist 9, Oral Presentation Assessment Checklist 10, Computer Slide Show Presentation Assessment Checklist 11, Poster Assessment Checklist 19, Graph from Data Assessment Rubric 1, Concept Rubric Assessment Rubric 2, Science Notebook Rubric Assessment Rubric 4, Scientific Drawing Rubric Assessment Rubric 5, Conduct an Investigation Rubric Assessment Rubric 7, Scientific Research Planner Rubric Assessment Rubric 8, Research Project Rubric Assessment Rubric 9, Communication Rubric Assessment Rubric 10, Presentation Rubric Assessment Rubric 11, Using Tools, Equipment, and Materials Rubric Process Skills Rubric 1, Developing Models Process Skills Rubric 2, Hypothesizing Process Skills Rubric 4, Problem Solving Process Skills Rubric 7, Predicting Process Skills Rubric 8, Interpreting Data Process Skills Rubric 9, Questioning
Chapter 12 BLM 4-38, Weathering and Erosion Quiz BLM 4-39, Rocks that Fizz BLM 4-40, Weathered Lettering BLM 4-41, Comparing Dirt and Soil BLM 4-42, From Weathered Rock to Soil BLM 4-43, Layers of Soil BLM 4-44, Major Factors that Determine how Soil Develops BLM 4-45, Be a Soil Sleuth BLM 4-46, Land Use and Soil Loss BLM 4-47, Chapter 12 Review BLM 4-48, Unit 4 Review BLM 4-49, Unit 4 Answers	Assessment Checklist 1, Making Observations and Inferences Assessment Checklist 2, Asking Questions Assessment Checklist 5, Investigating an Issue Assessment Checklist 6, Developing Models Assessment Checklist 15, Venn Diagram Assessment Checklist 16, Science Portfolio Assessment Checklist 18, Data Table Assessment Checklist 20, Assessment Record Form Assessment Checklist 23, Learning Skills Assessment Checklist 24, KWL Assessment Checklist Assessment Checklist 25, Safety Checklist Assessment Rubric 1, Concept Rubric Assessment Rubric 2, Science Notebook Rubric Assessment Rubric 5, Conduct an Investigation Rubric Assessment Rubric 7, Scientific Research Planner Rubric Assessment Rubric 8, Research Project Rubric Assessment Rubric 9, Communication Rubric Assessment Rubric 10, Presentation Rubric Assessment Rubric 11, Using Tools, Equipment, and Materials Rubric Process Skills Rubric 1, Developing Models Process Skills Rubric 2, Hypothesizing Process Skills Rubric 3, Controlling Variables Process Skills Rubric 4, Problem Solving Process Skills Rubric 5, Fair Testing Process Skills Rubric 7, Predicting Process Skills Rubric 8, Interpreting Data Process Skills Rubric 9, Questioning Process Skills Rubric 10, Measuring and Reporting

Teaching Notes
for
Pages 310 to 453 of the Student Book

UNIT 4 OPENER, pp. 310–311

The unit begins by examining the properties and uses of minerals and rocks. Students learn how rocks are recycled through the rock cycle. Then the unit discusses the structure of Earth, including the development of the theory of plate tectonics. This material leads to consideration of earthquakes, volcanoes, and mountain building, and a glimpse into geologic time. The unit concludes with an examination of how soil is formed, the characteristics of soil, and the importance of preserving topsoil.

USING THE UNIT OPENER

Students can examine the photograph of lava erupting from a volcano and read the caption. You might begin by asking students where volcanic lava comes from and to predict why it is so hot. Most students will know that lava comes from beneath Earth's surface. Ask students to share any prior knowledge they have of what lies below the surface of Earth and what the surface is made of. Introduce the term "Earth's crust" to students if none of them use it in their descriptions.

Passing around a few beakers of volcanic dust and asking questions about its origin is a great motivator. A good source of simulated volcanic dust is available at your local pet store in the form of chinchilla dust. Depending on the pet store, it may actually be volcanic ash.

You may want to hand out BLM 4-1, Unit 4 Summary, and BLM 4-2, Unit 4 Key Terms, to help students record their understanding of the unit and important terms.

GETTING STARTED, pp. 312–313

USING THE TEXT

The Getting Started feature can help students realize that the subject matter of this unit is very close to home, and that the rock around them is both useful and economically important to the province. After students have read the Getting Started section, ask them to help you list all the different uses for rock that are mentioned, and then, as a class, brainstorm other uses of rock that students know. Accept all suggestions, and help steer the discussion to the question, "What is a rock?" The Find Out Activity, "What Makes a Rock a Rock?" will help students gain some experience in considering the properties and characteristics of materials. These are skills they will be using in this unit when they examine minerals, rocks, and soil.

USING THE ACTIVITY

Find Out Activity

What Makes a Rock a Rock?, p. 313

Purpose

- Students examine objects to determine which ones are rocks.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Gather materials.	For each group: – selections of materials, such as chalk, pottery shards, pieces of cement and brick, marbles, iron nail or iron ore, petrified wood, coal, piece of glass (smooth edges), quartz, salt, sand, pumice, assorted rocks, etc.

Time Required

- 15 min

Safety Precautions

- Students should take care if any of the objects have sharp edges.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

The two classifications that students use might be rocks/not rocks or rocks/made from rocks or other classifications that they devise. The important point is that students realize that not all small hard objects are rocks, and that they can use the characteristics of objects to classify them.

Activity Notes

- The intent of this activity is to expose students to specimens that help them realize that, perhaps, they need more information about rocks before they are able to define them. Students' understanding of rocks will evolve as the chapter progresses. The list of characteristics that they make in this activity could be revisited later, at the end of the chapter or the unit.
- After students are finished, they could share their ideas with another pair or small group and discuss similarities and differences in their systems of classification.
- At this stage, students may not be aware of the distinction between rocks and minerals and could group both under the heading "Rocks." If there are students who understand the distinction, they

could try to group the objects into the categories Rocks, Minerals, and Neither.

Supporting Diverse Student Needs

- Students with weaker academic skills benefit from working with a partner or in a small group of students with stronger academic skills that they can discuss their ideas and classifications.
- For enrichment, some students could consult several on-line and print dictionaries for definitions of "rock" and then collate and summarize the definitions into one definition to present to the class.

CHAPTER 10 OPENER, pp. 314–315

USING THE PHOTO AND TEXT

Students should be very familiar with sand, although they may not have realized many of its uses or that it is made up of minerals. Before students read the Chapter Opener, you may wish to ask them to describe what colour sand is, and why different sands on different beaches are different colours.

After students have read the opener, ask them what uses they know of for sand. Students may know that sand is used in making concrete; in manufacturing glass; as filters for drinking water; in landscaping, gardens, and golf courses; to fill sandbags for protection from flooding; and to provide traction on snowy roads; in aquariums; in road beds; and in railroad beds, among other things.

USING THE WHAT YOU WILL LEARN/WHY IT IS IMPORTANT/SKILLS YOU WILL USE

Invite students to share any previous background information they have about rocks and minerals. List the various rocks and minerals that they have seen or have used in their everyday life. You may wish to note to students that rocks are made from minerals, and that there are hundreds of different minerals on our planet. New uses for rocks and minerals continue to be discovered.

Students are probably aware that their bodies require very small amounts of many minerals in order to stay healthy. Ask them to list the names of minerals they find on the label of a multivitamin or a cereal box. Ask them what other foods/products have minerals added to them (e.g., some milk is now available in a calcium-enriched form).

Ask students to suggest what minerals and mineral resources come from the sea. Students should be familiar with salt (about one third of all table salt comes from the sea) and oil and gas deposits.

Invite students to bring pictures to class showing how rocks are used by people in different occupations.

USING THE FOLDABLES™ FEATURE

See the Foldables™ section of this resource.

10.1 INVESTIGATING MINERALS

SCIENCE BACKGROUND

Minerals may form in many ways, including the following:

- Lava and magma cool to form crystals.
- Existing minerals may be dissolved in a solution. The solution later evaporates, and the crystals reform.
- Existing minerals may be exposed to extreme heat and pressure. Eventually they will form new minerals.

COMMON MISCONCEPTIONS

- Students often use the terms *minerals* and *rocks* interchangeably. In this section they will learn the definition of minerals (pure, naturally occurring, inorganic, solid substances). In the following section they will learn that rocks are mixtures of two or more minerals.

ADVANCE PREPARATION

- You may need to book library or computer time several weeks in advance for use with Activity 10-1B on page 321 of the student book.
- You will need containers of mineral samples for Activity 10-1C on page 322 of the student book.
- Consult the unit front matter for a list of BLMs that can be used when teaching this section.

INTRODUCING THE SECTION, pp. 316–317

Using the Text

Ask students how they would tell the difference between several metals, such as gold, silver, and copper, or between aluminum and iron. Students may mention that they would use colour and hardness. If you have several mineral samples on hand, such as chalk and calcite, ask students to describe how they would tell these samples apart. They may be able to identify differences in "shininess" (lustre). If possible, show two different minerals with similar appearances and colour, such as quartz and calcite and ask students how they could tell which is which. Stress that not all mineral properties are equally reliable for identification purposes.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the text and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, which lists the Key Terms given in the unit, can be used to assist students.

Using the Did You Know, p. 317

Micrometeorites are very small pieces of rock, often metallic, and usually weighing less than a gram. Their formation may date back to the time of the formation of the solar system. Micrometeorites have been found on all parts of Earth, including Antarctica and northern polar regions. Ice from these areas is collected, melted, and filtered so that the micrometeorites can be studied. Some students may be aware of the hazard micrometeorites pose to vehicles and travellers in space. Students can read more about meteorites in the feature on page 338 of the student book.

USING THE ACTIVITY

Find Out Activity 10-1A

Sand Detective

Purpose

- Students examine and classify mineral grains in sand.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Gather materials.	For each group: – sand – white cardboard (for dark sand) or dark cardboard (for light sand) – hand lens – tweezers

Time Required

- 15 min

Safety Precautions

- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Depending on the source of the sand, students may find both angular and rounded mineral grains. For example, quartz sand that has been recently weathered from granite or gneiss will be more angular than sand that has been transported long distances by wind or water. The number and types of colours present will also vary according to the type of sand students are examining, but if it is local sand, it is likely that quartz, mica, and feldspar will be present.

Activity Notes

- This activity helps students realize that there is also diversity in the near-micro world of rocks and minerals. Having explored minerals in grade 4, students likely will recall the names of some of the minerals that are easier to identify, such as quartz.
- If available, use a goose-neck camera to magnify images of sand onto a computer screen.
- Encourage students to try to keep the sand on the cardboard and to observe only a few grains at a time.
- Students could work with a partner so that they can discuss their observations as they make them.

Supporting Diverse Student Needs

- This is an excellent activity for students who are visual–spatial and naturalist learners.
- For enrichment, students could be challenged to try to identify the grains of sand according to their answers to What Did You Find Out question 3.
- Students who lack the manual dexterity to isolate and move grains of sand can be paired with a partner and record observations.

What Did You Find Out? Answers

1. and 2. Answers will depend on the type of sand used and students' familiarity with minerals. It may be that students can recognize quartz (white, pink, brown, clear), mica (thin, black, flaky), and feldspar (white or grey).
   It is not essential that students identify the grains correctly, but it is important that they begin to get a sense of the different characteristics of the grains.
3. Students may suggest that they could search the Internet or a mineral guidebook, talk to an expert, or compare their samples to larger, labelled minerals.

Using a Demonstration

Students enjoy examining minerals such as galena, calcite, and halite cleave when hit by a hammer. Other minerals with cleavage include gypsum, hornblende, feldspar, mica, and fluorite. Take care not to confuse cleavage surfaces (from breaking the mineral) with crystal faces (the flat surfaces that formed as the crystal formed). Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

TEACHING THE SECTION, pp. 318–320

Using Reading

Pre-reading—K-W-L (Know-Want to Know-Learned)

As students read the section, have them record questions that come to mind (at least one question per subhead). Later, students can share their questions as class and together the class can discuss the answers to the questions.

During Reading—Note-Taking

Encourage students to take notes as they read the assigned text material. It can be helpful to reword the topic titles as questions and then use the questions to guide note-taking.

After Reading—Reflect and Evaluate

When students have completed note-taking, they can create their own wallet-size charts of the Mohs Hardness Scale. They should include references to everyday objects and may include pictures. If possible, laminate these cards so students can use them for the rest of the unit.

Reading Check Answers, p. 321

1. Three types of lustre are dull, glassy, and metallic.
2. The Mohs Hardness Scale is used for measuring the hardness of a mineral.
3. Cleavage
4. Fracture

USING THE ACTIVITIES

- Activity 10-1B on page 321 of the student book can be used at any time during this section.
- Activity 10-1C on pages 322–323 of the student book is best used after students have finished all the reading of this section.

Detailed notes on doing the activities follow.

Think About It 10-1B

Mapping Minerals and Their Uses, p. 321

Purpose

- Students research the locations and uses of minerals in Canada.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before	Book library and/or computer lab.	For each group: – BLM 4-3, Mapping Minerals and Their Uses
2-3 days before	Photocopy BLM 4-3, Mapping Minerals and Their Uses.	

Time Required

- 40–60 min

Safety Precautions

None

Expected Results

There are many minerals found in Canada. A sampling includes the following:

- Alberta: gypsum, garnet, ammolite
- British Columbia: quartz, jade, fluorite, barite
- Manitoba: gypsum, beryl
- New Brunswick: wolframite, sphalerite
- Newfoundland and Labrador: labradorite, hematite, fluorite
- Northwest Territories: diamond, silver, tourmaline, gold
- Nova Scotia: copper, agate, gypsum
- Nunavut: galena, pyrite, sapphire, graphite
- Ontario: amethyst, calcite, corundum, gold, magnetite
- Quebec: talc, amazonite, chalcopyrite
- Saskatchewan: sylvite, halite
- Yukon: emerald, gold, lazulite

(Commercial deposits of minerals have not yet been found in Prince Edward Island.)

Activity Notes

- If time is limited, you might want to assign each group one province or territory to research, or assign a mineral to each student.
- This is an excellent activity for students to create a brochure about a mineral found in Canada. If students are working on computer, it would be helpful for them to find or be provided with a template to design their brochure. A variety of Microsoft™ products, as well as the freely available OpenOffice suite, have an assortment of templates that can be used or adapted for such purposes. The template

could include, for example, a map for finding the mineral location or mine, a picture of the mineral, a description of it, uses, and economic value.
- Students' information could be collected and bound into a book for the classroom or school library.

Supporting Diverse Student Needs

- Academically weaker students could be paired with students with strong language skills and could help with drawing and making the booklet or poster.
- For enrichment, students could research other minerals of the world and share the information they find with the class.

Conduct an Investigation 10-1C

Core Lab: A Mineralogist's Mystery, pp. 322–323

Purpose

- Students record various distinguishing characteristics of mineral samples in a chart and then try to identify the samples based on the characteristics examined.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Gather materials. Number a large container, place all minerals of the same type into it, and make a list of the minerals and their correspon-ding numbers.	For each group: – mineral samples – streak plate – copper penny – iron nail – glass plate or jar – steel file – sandpaper – emery cloth – hand lens – optional: magnet
2-3 days before	Photocopy BLM 4-4, A Mineralogist's Mystery.	– Tables 10.1 and 10.2 from pages 318 and 319 (BLM 4-4, A Mineralogist's Mystery)

Time Required

- 40–50 min

Safety Precautions

- Caution students about sharp objects.
- Student should not taste the samples.
- Remind students to wash their hands when they are finished this activity.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Students will discover that colour alone is not a reliable way of indentifying a mineral and that they may need to compare their observations of several properties to determine which mineral is which.

Activity Notes

- Do a trial run to identify possible problems.
- Make sure that you have one set of equipment per group of two to four students.
- Give each group a few samples and then have them trade with another group when they have finished examining the samples.
- Each group should have at least one easy-to-identify sample.
- If students have access to a computer, they can set up a spreadsheet to organize their data.
- As a wrap-up, discuss the difficulties and challenges that are involved in identifying minerals. Explain that experienced geologists must sometimes rely on special tools and techniques, such as microscopes, X-rays, and chemical analysis.
- Evaluate students on the identification process, not on how many samples they correctly identified.

Supporting Diverse Student Needs

- Model the identification process with a sample for academically weaker students. It will help if you fill in one row of the table of observations for students.
- This is a good hands-on activity for tactile and visual learners.
- For enrichment, some students could create a "Mineral Guidebook" for the class or school library resource centre

Analyze Answers

1. Some similar-coloured minerals, such as quartz and gypsum, will resemble each other.
2 (a) Talc will be the softest of the recommended minerals.
   (b) Quartz will be the hardest of the recommended minerals.
3. (a) Several will be the same.
   (b) Hematite, pyrite and mica are among the minerals that will have unpredictable streaks.
4. Magnetism, cleavage, heft (heaviness) and feel are among the special properties that can aid in a mineral's identification.

Conclude and Apply

1. (a) and (b) Answers will depend on the samples. Students will likely suggest observing the way a rock breaks apart.
2. Students are likely to answer the following: (a) Hardness is one of the best and most practical ways to identify minerals. (b) Colour is often unreliable, but it is the most obvious characteristic.
3. Accept all reasonable answers, such as grinding the mineral to observe the powdered form.

USING THE FEATURE

www Science: Labradorite, p. 324

If possible, provide a sample of labradorite for students to examine, or ask students to describe any experiences they have had observing labradorite. Ask students to predict why this mineral was chosen as our provincial mineral.

SECTION 10.1 ASSESSMENT, p. 325

Check Your Understanding Answers

Checking Concepts

1. A mineral is a pure, naturally occurring, inorganic, solid substance.
2. (a) Three types of lustre are dull, glassy, and metallic.
   (b) Examples may include chalk (dull), calcite (glassy), and pyrite (metallic).
3. Streak is a useful way to identify a mineral because it is always the same colour for the same type of mineral.
4. (a) The softest mineral on the Mohs Hardness Scale is talc.
   (b) The hardest mineral on the Mohs Hardness Scale is diamond.
5. Answers will vary slightly. You could use the mineral to scratch progressively harder objects until it could no longer make a scratch. Then you would know that your mineral had a hardness greater than the last object that it could scratch but less than the one it could not. You could then find out which mineral(s) had the same hardness.
6. Cleavage is a split along a smooth, flat surface or plane, whereas fracture is a break that leaves a rough, jagged edge.

Understanding Key Ideas

7. Colour alone is not a reliable clue for identifying minerals because several minerals could have the same colour, and one mineral could have several different colours.
8. Glass has a hardness of 5.5, so it could be cut by a steel file but not by an iron nail.
9. Students' answers could include a description of how to determine the hardness of the minerals, how to determine the lustre, how to check for cleavage and fracture, or other properties such as colour, crystals, odour, heft, magnetism, and whether the surface feels powdery, soapy, or greasy.
10. Accept all reasonable answers.

Pause and Reflect Answer

Students may be surprised to realize that ice is considered to be a mineral. Ice is a pure, naturally occurring, inorganic, solid substance. It has a hardness of 1.5 on the Mohs Hardness Scale.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment BLMs.

10.2 INVESTIGATING ROCKS

BACKGROUND INFORMATION

Igneous rock forms when molten rock cools and solidifies either below Earth's surface (intrusive) or at the surface (extrusive). Igneous rock provides information about the composition of Earth's mantle, the layer below Earth's crust. The majority of Earth's crust is made of igneous rocks (estimates range from 75% to 95%), but most are found below the surface under the sedimentary and metamorphic rock.

Sedimentary rock is formed when sediments settle in layers called beds. This settling usually occurs in oceans and lakes. Sediments settle at the bottom and the weight of the water and sediments eventually compact the lower layer of sediments (compaction). Some minerals dissolve in the water, then reform as crystals that act like cement to bind the sediments together (cementation). Some sedimentary rock is made up of the remains of once-living things. Limestone and coal are examples.

Metamorphic rock is formed when igneous, sedimentary, or other metamorphic rock is subjected to heat and/or pressure and/or hot fluids. Sometimes, if the heat is excessive, the rock will melt to form magma and then cool to form igneous rock. The word *metamorphic* means "changed form."

COMMON MISCONCEPTIONS

- Students sometimes call all small, hard specimens rocks. Remind them that minerals and rocks are quite different. Minerals are made of elements and compounds; rocks are mixtures of two or more minerals.

ADVANCE PREPARATION

- If students are doing Activity 10-2C on page 336 of the student book themselves (rather than having a teacher demonstration) you will need to ask them to bring in jars with screw-cap lids. You will also need to purchase or gather clay powder, sand, fine gravel, and coarse gravel.

- You will need local rock samples for Activity 10-2D on page 337 of the student book. Tips for collecting rock samples are provided in the Activity Notes for the activity in this Teacher Resource.
- Consult the Unit front matter for a list of BLMs that can be used when teaching this section.

INTRODUCING THE SECTION, pp. 326–327

Using the Text

Ask students if they recall from earlier studies (grade 4) the names of the three main types of rock. Students can verify their answers by reading the text on page 326, which provides a natural lead-in to Find Out Activity 10-2A on the facing page.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the text and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, which lists the Key Terms given in the unit, can be used to assist students.

Using the Did You Know, p. 327

If you have a sample of pumice, allow students to examine its structure and compare its mass to another rock of a similar size. Some students may be familiar with using pumice as a skin cleanser, because of its abrasive properties. Ground-up pumice is also sometimes added to toothpaste for these same properties.

USING THE ACTIVITY

Find Out Activity 10-2A

Write about Rocks, p. 327

Purpose

- Students examine properties of rocks for clues about how the rocks formed.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Gather materials. Photocopy BLM 4-9, Write about Rocks.	For each group: – rock samples – clear adhesive tape – marker – hand lens – plastic knife or other scraping tool – index cards – sand in plastic cup (optional)

Time Required

- 30 min

Safety Precautions

- Remind students not to taste anything in the science room.
- Students should wash their hands after they finish this activity.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Students should propose questions that could lead to investigations, such as "How do the crystals or minerals form in a rock?" or "Why do some rocks have layers?" or "Why do some rocks have rounded particles and other rocks have angular particles?"

Activity Notes

- Ideally, students should examine specimens that have large and small crystals (granite), small and large rounded particles (sandstone and conglomerate), layers (shale and bedded sandstone), and deformed layers (schist and gneiss).
- Encourage students to consider colour, grain shape, grain size, and strength (how crumbly the rock is when scraped) as they make their observations.
- Remind students to be specific when describing colour, for example, "brown" is not as specific as "reddish brown" and "reddish brown" is different from "dark brown."
- Students can describe lustre as well and could use percentages, for example, 70% shiny white grains and 5% dark brown dull grains.

Supporting Diverse Student Needs

- This activity is excellent for students who are body kinesthetic and naturalist learners.
- For enrichment, students could try their ideas for What Did You Find Out question 2 after checking their procedure with you.

What Did You Find Out? Answers

1. Students' earlier study of rocks and minerals, along with their reintroduction to the three rock families on page 326 and their observations of the rock samples in this activity, should enable them to state with certainty that not all rocks have a similar history. The explanations they offer will depend on the samples they have observed. For example, students who have examined granite can cite the presence of crystals of various sizes. These differ from the more rounded grains and particles visible in sandstone and the larger pebbles and gravel-sized stones visible in conglomerate; such differences suggest a different history. As well, shales and many sandstone samples exhibit noticeable layering, which suggests a different history compared with granite. Due to the presence of layering (albeit deformed) patches or layers of crystal-like areas in gneiss, some students might link the history of gneiss (metamorphic) to the history of either granite (igneous) or sandstone or shale (sedimentary). Other students might instead, focussing on differences, suggest that this is evidence of a different history for gneiss. Either response is acceptable, although the linkage response demonstrates some keener observations and higher-order thinking at work.
2. Students could suggest adding glue or cement to sand and letting it harden. Some students could also suggest adding small rocks or shells to the mixture. Students might also mention heating (melting) the sand, which would result in a glass-like rock.

TEACHING THE SECTION, pp. 328–333

Using Reading

Pre-reading—Key Term Concept Maps

Consider discussing the Key Terms of this section with students before they begin reading. For instance, focus on the three rock families. Tell students that the word igneous comes from a Latin word that means fire or fiery; sedimentary comes from a Latin word that means to settle; metamorphic comes from a Greek word that means to change form. Invite students to suggest English words that remind them of these rock family names (e.g., ignite, ignition, sediment, morph). Suggest that students design a three-column table with one rock family at the head of each column. As they study each rock family, or at the end of the section as a synthesizing review, students can fill in the table with the other key words from the section. Students could also add any other words they think are appropriate. For example:

IGNEOUS	SEDIMENTARY	METAMORPHIC
extrusive rock intrusive rock lava magma heat cool (harden)	beds cementation compaction settling squeeze layers	parent rock igneous sedimentary squeeze heat pressure

During Reading—Note-taking

Encourage students to take notes as they read the assigned text material. It can be helpful to reword the topic titles as questions and then use the questions to guide note-taking. Students can add the notes to their Key Term concept maps they began in pre-reading.

After Reading—Semantic Mapping

Students can reflect on their concept maps and link terms that describe the same family or process. They can then create a flow chart or chain of events.

Reading Check Answers, p. 329

1. Intrusive rock is formed beneath Earth's surface.
2. Extrusive rock is formed at Earth's surface.
3. Magma is molten material found below Earth's surface. Lava is molten material that breaks through Earth's surface.
4. Three examples of igneous rock are granite, basalt, and obsidian.

Reading Check Answers, p. 331

1. Any three of rock particles, mineral particles, decaying plants, and decaying animals.
2. Compaction and cementation
3. We call layers of sedimentary rocks beds.
4. (a) shale
   (b) sandstone
   (c) conglomerate
   (d) limestone

Reading Check Answers, p. 333

1. Igneous, sedimentary, and other metamorphic rocks can all become metamorphic rock.
2. Heat, pressure, and hot fluids can form metamorphic rock.
3. Parent rock is the type of rock that has been changed into metamorphic rock.
4. Granite (parent rock) can turn into gneiss. Shale (parent rock) can turn into slate. Limestone (parent rock) can turn into marble.

USING THE ACTIVITIES

- Activity 10-2B on page 334 of the student book can be used before or after students read about igneous rock on pages 328–329.
- Activity 10-2C on page 336 of the student book can be used before or after students read about sedimentary rock on pages 330–331.
- Activity 10-2D on page 337 of the student book is best used after students have finished reading the whole section.

Detailed notes on doing the activities follow.

Conduct an Investigation 10-2B

Cool Crystals, Hot Gems! pp. 334–335

Purpose

- Students relate the temperature and time of cooling to the formation of intrusive and extrusive rocks.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Gather materials. Make or purchase the crushed ice.	For each group: – measuring cup or graduated cylinder – tap water – small pot – heat source – measuring spoons – 90 mL Epsom salts – stirring rod or stirring spoon – two small beakers – two bowls – hot water – ice (crushed or broken) – labels – hand lens

Time Required

- Day 1: 30–45 min
- Day 2: 15–20 min

Safety Precautions

- Students should wash their hands after each day of the activity.
- Students should not eat or taste the Epsom salts.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

The Epsom salts in the glass with the hotter water should form the larger crystals because the solution took longer to cool. This is similar to intrusive rocks forming below Earth's surface. The Epsom salts in the glass with the cooler water should form smaller crystals because the solution cooled more quickly. This is similar to extrusive rock cooling at Earth's surface.

Activity Notes

- To save time, and to minimize accidents, demonstrate this experiment. Show students the different beakers as the solutions cool.
- Prepare a safe area for letting the crystals grow undisturbed.
- Have students divide the responsibilities of the investigation so that everyone participates.
- It is better to use Epsom salts from scientific sources or drugstores (bathing type).
- Use non-metallic spoons because metal spoons will get hot.
- Students may need help pouring so that they do not disturb the crystals.
- Have students prepare their "hot" and "cold" labels before making the solution.
- To help avoid confusion and spills, consider having a central station for picking up and returning apparatus and materials.
- Compare the terms intrusive/interior/inside Earth and extrusive/exterior/outside Earth to help students remember where different kinds of igneous rocks form.

Supporting Diverse Student Needs

- Students who have difficulty expressing themselves in writing may find it easier to draw the results or to provide their answers orally.
- For enrichment, encourage students to record the temperatures of their hot and cold mixtures. They can compare the temperatures and size of crystals with those of other groups. This could be an excellent graphing activity.

Analyze Answers

1. The Epsom salts in the glass with the hotter water formed larger crystals.
2. The solution that cooled at a slower rate took longer to crystallize.
3. The controlled conditions or variables were the amounts of water and Epsom salts, and the environment in which the solution was created.
4. The manipulated variable was the temperature of the water surrounding the solution.
5. The responding variable was the size of the crystals that formed.

Conclude and Apply

1. Crystals formed more quickly in the cooler solution, resulting in small crystals. Crystals grew more slowly in the solution that cooled more slowly, resulting in larger crystals.

2. Extrusive rocks are like the Epsom salt crystals that cooled quickly because extrusive rocks are exposed to the cool environment at or above Earth's crust.
3. Intrusive rock has a longer period of time to cool, so it is more likely to form larger crystals.
4. Larger gems are found deep in the ground because the magma takes longer to cool and the crystals form over a longer period of time.

Find Out Activity 10-2C

Settling Sediments, p. 336

Purpose

- Students observe how sediments settle into layers.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Ask students to bring in plastic bottles with screw-cap lids. Purchase or gather clay powder, sand, fine gravel, and coarse gravel.	For each group: – dampened clay powder – sand – fine gravel – coarse gravel – clear glass jar or plastic soft drink bottle (2 L or larger) with a screw-cap lid
1 day before	Remind students to bring in bottles.	

Time Required

- 5–10 min set-up
- 30–40 settling time

Safety Precautions

- Advise students to avoid inhaling dust from the clay and gravel.
- It is best to use plastic bottles to ensure safety.
- Have students wash their hands after completing the activity.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Most likely, the coarse gravel will settle first, forming the bottom layer. Above that will be the fine gravel layer covered by a sand layer, which is covered by a clay layer. Above the layers the water will likely be murky from clay particles that are suspended and have not yet settled.

Activity Notes

- This activity can be a teacher demonstration.
- Coloured gravel and sand make it easier to distinguish the levels.
- The jars may be very heavy. Lend a hand if some students are having trouble shaking the jars.
- Put white paper behind the jars to improve visibility.
- As a wrap-up, ask students to predict when the clay will finish settling. Re-examine the results in future classes to find out how long it actually takes. Some small particles may never settle out.
- Have students make labelled sketches of their results. If you have provided coloured sand or gravel, encourage students to use the same colours for their sketches.

Supporting Diverse Student Needs

- For enrichment, challenge students to explain why sediments might sometimes settle in a different order.

What Did You Find Out? Answers

1. Coarse gravel settled first.
2. Clay took the longest time to settle. (**Note:** The clay materials take a long time to settle completely, and some particles may still be suspended.)
3. (a) No, the water was clear when it was added but now looks murky.
   (b) The water now has clay particles suspended in it.
4. Several factors (weight of sediments, buoyant forces, specific gravity) affect settling. Students will likely say the larger, heavier sediments (coarse gravel) settled first, which is an adequate response.

Find Out Activity 10-2D

Sort It Out, p. 337

Purpose

- Students create a classification system to classify rocks based on how they were formed.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Several weeks before	Collect and identify rocks from local outcrops. Organize purchased and collected rocks.	For each group: – a set of rocks, including rocks from your geographic area – rocks students have found, brought to class – hand lens, binocular microscope, and/or gooseneck computer camera if available

Time Required

- 30 min

Safety Precautions

- Student should be careful not to drop the samples.
- Students should wash their hands when they are finished the activity.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Crystal size, layering, and the evidence of what the rock is formed from are useful characteristics for identifying rocks. It is not very helpful to look for characteristics of minerals in this investigation. Colour, size, and shape are also not good characteristics to use in identifying rocks. Students might first determine whether the rock was made of compacted and cemented sediments (sedimentary), whether it shows evidence of having been heated and cooled (igneous), or whether it has thin, leaf-like wavy layers (metamorphic).

Activity Notes

- There are many sources for sets of rocks. If you are just starting your collection, you might want to invest in the largest specimens you can find for your students. Small specimens of rocks are more difficult to identify because they do not have the distinguishing characteristics such as layering, foliation, and crystal size that make identifying the rocks easier. A good collection of rocks helps ensure that students will have more success in constructing and using their classification key.
- Some students may have a rock collection at home they could bring and share.
- If you are collecting local rock specimens, go to a rock outcrop, such as one exposed by a highway.
- Do not just collect the rocks beside a road or backyard, as they may be imported specimens carried by a glacier or transport truck.
- A local geologist will be able to tell you where you can collect some indigenous rocks, and help you correctly identify the rocks you collect.
- Displaying a few correctly labelled rocks will help students. If this is not possible, provide the best quality photographs you can find.
- Students would benefit from working in groups, sharing their methods, and considering their classmates' ideas.

Supporting Diverse Student Needs

- Academically weaker students would benefit from pictures and labelled specimens of these rock categories.
- This is a good hands-on activity for tactile and visual learners and for students with naturalist intelligence.
- For enrichment, students could create a classification flow chart that other students could use in identifying rocks.

What Did You Find Out? Answers

1. Students may have used the size of visible crystals and the presence of gas holes.
2. Students may have used the presence of compacted and cemented layers or visible sediments of different sizes.
3. Students may have used the presence of wavy layering, a shiny lustre, and a large amount of crystallization.
4. The identification of rocks can be quite difficult for students at this age unless you spend several days studying the different rock families. The main goal of this activity is to have students practise constructing and using a classification key. The accuracy of the key is not as important as the process.

USING THE FEATURE

www Science: Space Rocks on Earth, p. 338

Before students read the feature, you may wish to ask them to share any prior knowledge or experience they have about meteorites. Students may recall the Did You Know on page 317 about the presence of micrometeorites in sand.

SECTION 10.2 ASSESSMENT, p. 339

Check Your Understanding Answers

Checking Concepts

1. A rock is a mixture of two or more minerals.
2. (a) An igneous rock is rock formed from the cooling of melted rock.
   (b) Igneous rock forms when magma cools below Earth's surface or lava cools at Earth's surface.
3. Magma is molten rock below Earth's surface, whereas lava is molten rock that breaks through Earth's surface.
4. (a) Intrusive rocks form below Earth's surface, whereas extrusive rocks form at Earth's surface.
   (b) Intrusive—granite; extrusive—obsidian or basalt

5. Sedimentary rock is rock formed from the compaction and cementation of sediments into beds (layers).
6. (a) Four examples of sedimentary rock are shale, sandstone, conglomerate, and limestone.
   (b) Shale has the smallest particles, sandstone has medium-sized particles, conglomerate has large particles, and limestone has particles made of the remains of organisms that were once alive.
7. Metamorphic rock is rock that is made when heat, pressure, and/or hot fluids change one type of rock into another type.
8. Metamorphic rocks are formed in a long, slow process when igneous, sedimentary, or other metamorphic rocks are placed under heat, pressure, and/or hot fluids.
9. (a) Any two of: slate, marble, gneiss
   (b) Any two of: The parent rock of slate is shale. The parent rock of marble is limestone. The parent rock of gneiss is granite.

Understanding Key Ideas

10. Crystal size in igneous rock can help you predict how it was formed because the larger the crystal size, the slower the cooling. This means that igneous rocks with large crystals formed below Earth's surface, whereas those with small crystals formed at Earth's surface.
11. (a) Compaction is the process in which layers of sediment are squeezed together by the weight of other sediment and water on top. Cementation is the process in which large pieces of sediment are stuck together by natural cement formed when water soaks into rock.
    (b) Students' drawings should show the weight and pressure of layers for compaction. Drawings for cementation should show water dissolving minerals as it soaks into rocks.
12. Students' answers might include first determining whether the rock was made of compacted and cemented sediments (sedimentary), whether it shows evidence of having been heated and cooled (igneous), or whether it has thin, leaf-like layers (metamorphic). Students would benefit from sharing their answers and considering their classmates' ideas.
13. (a) Sedimentary rocks (The photograph shows a shale outcrop.)
    (b) The rocks formed in layers and looked like compacted mud. There is no sign of crystal formation (igneous) or of wavy layers (metamorphic).

Pause and Reflect Answer

Accept all reasonable answers, such as: How do the crystals or minerals form in a rock? Why are crystals different sizes in rocks? Why do some rocks have layers? How does sediment settle into layers? Why do some rocks have rounded particles and other rocks have angular particles?

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment BLMs.

10.3 THE ROCK CYCLE AND ROCK AND MINERAL RESOURCES

BACKGROUND INFORMATION

The rock cycle is one of many natural cycles that redistribute materials in the environment so that they can be used over and over. Millions of years ago, volcanic eruptions created igneous rock. Weathering and erosion break down igneous rock, and the sediments settle to form sedimentary rock. If there is enough heat and pressure put on igneous rock and sedimentary rock, they will change to metamorphic rock.

Canada is rich in mineral resources, which are mined, processed, and used in many industries. Mineral resources are defined as a concentration or occurrence of natural, solid, inorganic, or fossilized organic material in or on Earth's crust in such form and quantity and of such a grade or quality that they have reasonable prospects for economic extraction.

Mineral resources are important to the economy of Newfoundland and Labrador. Minerals are used in many different ways and in many different products, ranging from gold and gemstones to iron ore excavation and steel making. Other uses of minerals include marble for statues, granite for buildings, crushed gravel for roadbeds, fertilizer production, and road salt for winter driving conditions.

Examples of rock and mineral resources are the energy resources: oil, gas, and coal. Other mineral resources are the metallic minerals: gold, silver, and uranium. A third group is the industrial mineral resources: sand, gravel, limestone, salt, and potash.

COMMON MISCONCEPTIONS

- Often students do not realize the full range of uses a mineral may have. Gold is a good example. Most students will know that gold is used in jewellery and coins, but fewer students realize that gold is used as a conductor in electronics (such as in a computer). Gold is also used in the aerospace industry.
- Most students do not realize how many of the items they use in their daily lives come from petrochemicals. Petrochemicals are used to make plastic, nylon, acetate, polyester, and many other products that students wear, play with, or use every day.

ADVANCE PREPARATION

- You may need to book the computer lab or library for students to use in their research for Activity 10-3B on page 347 of the student book.
- Consult the Unit front matter for a list of BLMs that can be used when teaching this section.

INTRODUCING THE SECTION, pp. 340–341

Using the Text

Ask students to recall what natural cycles they know about. They should be able to identify the water cycle from previous studies. Introduce the topic of the rock cycle and ask students to predict what might happen in the rock cycle. *(The rock cycle, like any natural cycle, represents a change process where the same materials are cycled throughout, producing different products under varying conditions. The materials found in rocks undergo constant change to produce new types of rocks under different conditions.)* Then have students examine the diagram on page 340 and ask for their ideas about how one type of rock changes into another type. Students can then read the introductory text on pages 340 and 341 of the student book.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the text and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, which lists all the Key Terms given in the unit, can be used to assist students.

Using the Did You Know, p. 341

Ask students to describe how a rock in the schoolyard is part of the rock cycle. How did the rock get to be in the schoolyard? How is the rock changing? What might eventually happen to it?

Using the Activity

Think About It 10-3A

Recycling the Rocks, p. 341

Purpose

- Students represent the rock cycle with a flow chart.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Gather materials.	For each group: – index cards or other pieces of paper – coloured pencils or felt pens – poster paper – glue – optional: yarn, string, and other materials

Time Required

- 30–40 min

Safety Precautions

None

Expected Results

Students should be able to show the interconnectedness of the three families of rocks and the processes of the rock cycle. The flow charts should show rocks being weathered and eroded, compacted, cemented, melted, cooled, and subjected to heat, pressure, and hot fluids.

Activity Notes

- Students might find it easier to begin with a sketch on scrap paper.
- If students need help organizing their ideas, they could start by placing the three families of rocks as shown in the illustration on page 340 of the student book. However, this is not the only arrangement for these families, so if students have other ideas encourage them to go ahead with them.

Supporting Diverse Student Needs

- Academically weaker students could be paired with students with stronger language skills.
- For enrichment, students could try to find an alternative way to represent the rock cycle from the one they have just completed.

Using a Demonstration

You may wish to use food items (or pictures of food items) to demonstrate the processes that change one family of rocks into another family. For example, you could use chocolate fudge to demonstrate the heating and cooling of igneous rocks, a granola bar to show sediments cemented together in sedimentary rock, and a grilled cheese sandwich to show how heat transforms a rock into a metamorphic rock.

TEACHING THE SECTION, pp. 342–346

Using Reading

Pre-reading—Predict–Read–Verify

Break the section into manageable chunks:

- Processes in the Rock Cycle
- Rock and Mineral Uses
- Putting Rocks and Minerals to Work

Ask students to say what they think each title means and make a prediction about what they will learn. They can then read the chunks and compare their predictions to what they learned.

During Reading—GIST

GIST helps students distil text material into its most important ideas or concepts. Have students write the subheadings, then read the text for each subheading and write a summary of ideas presented. They should reduce the passage to just 20 words that capture the gist of the text.

After Reading—Reflect and Evaluate

When students have finished taking notes, they can quietly review their notes and choose three interesting facts. Students can then share these facts as a class or in a small group discussion. Students could create a class list of "Rocks and Minerals in Our Lives" and add to it from time to time throughout the unit.

Reading Check Answers, p. 343

1. The rock cycle is ongoing processes in which rocks continue to change.
2. Igneous and metamorphic rocks become sedimentary rocks through the processes of weathering and erosion, and compaction and cementation.
3. Igneous and sedimentary rocks become metamorphic rocks through the processes of heat and pressure and being subjected to hot fluids.
4. Metamorphic rocks become igneous rocks through melting, cooling, and crystallizing.

Reading Check Answers, p. 346

1. A resource is a rock or mineral that can be mined for a specific purpose.
2. Students' answers may include any two of petroleum, coal, any type of gem or metal, any of the resources listed in Table 10.3, or other selections of rocks and minerals.
3. Gems are highly prized minerals that are rare and beautiful.

USING THE ACTIVITIES

- Activity 10-3B on page 347 of the student book is best used after students have finished reading the section.
- Activity 10-3C on pages 348–349 is best used after students have finished reading about the rock cycle on page 343.

Detailed notes on doing the activities follow.

Think About It 10-3B

Research the Resource, p. 347

Purpose

- Students demonstrate basic skills in handling information technology tools to find the rock and mineral resources mined in Newfoundland and Labrador.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before	Reserve the library or computer lab, if desired. Decide what format(s) will be accepted for this activity. Consider whether assessment rubrics will be used.	For each group: – BLM 4-13, Research the Resource – red and black pens – research materials – access to the Internet and/or other research material
2-3 days before	Photocopy BLM 4-13, Research the Resource.	

Time Required

- 30–60 min

Safety Precautions
None

Expected Results
Active and dormant mines include gold (Nugget Pond), copper (Buchans), iron (Bell Island and Labrador West), granite (Lumsden), slate (Burgoyne's Cove), nickel (Voisey's Bay), gypsum (Flat Bay), and others, such as antimony (Beaver Brook), limestone and dolomite (Lower Cove), and talc and pyrophyllite (Conception Bay).

Newfoundland and Labrador has a rich and diverse mining history and many of our communities were established for the purpose of extracting rocks to obtain the minerals. The minerals cited here are from recent mining operations. More historical examples include Daniels' Harbour (zinc) and Tilt Cove (copper), and many others.

Students may ask about copper, iron, and nickel. Remind students that these elements are extracted from minerals. For example, copper is extracted from the mineral chalcopyrite. Native elements (e.g., gold and silver) are referred to as minerals. Many minerals occur together, so they are mined together.

Activity Notes
- If your class does not have access to the Internet, provide students with a list of the mines and resources from the mines. Students could complete the activity by making a legend of minerals and noting their location on BLM 4-13, Research the Resource.
- If students use the Internet, be sure to divide the list of mines among groups.
- If you are providing the names of the minerals at each mine, demonstrate how to make and use a legend on BLM 4-13, Research the Resource.
- Ask students to highlight sites with a variety of minerals.

Supporting Diverse Student Needs
- Students with weak research skills could be paired with students with stronger research skills. Additionally, students with demonstrated artistic skills could be asked to enlarge the map as a poster so that the class results could be posted on the bulletin board.
- For enrichment, students could research historical sites of mines and share the information they find with the class.

What Did You Find Out? Answers

Note: Answers will vary because of changing commodity prices affect the number of minerals mined. Web sites may or may not be kept up to date. In addition, the mine may list all of the minerals removed at the mine, not just the main ones.

1. (a), (b), and (c) Answers will depend on the location of the school.
2. (a) and (b) See Table 10.3 on page 346 of the student book for sample answers.
3. Students' answers could include the following considerations: increasing the temperature of ocean water; polluting ocean water with chemicals, oil, grease, and exhaust from machinery; disturbing the habitat of the plants and animals that live in the ocean; the safety of the miners; and disturbing the complex ecosystems that exist in the ocean. Note that many mining companies take steps to reduce their negative effects on the environment. For example, to reduce their sulphur dioxide emissions, some mining companies capture the sulfur dioxide they produce before it is released into the atmosphere and convert it into compounds that are used by fertilizer companies, paint manufacturers, and the food industry.

Conduct an Investigation 10-3C

Rolling Out the Rock Cycle, pp. 348–349

Purpose
- Students use wax crayon shavings as sediments to model the processes of the rock cycle.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Ask students to bring in old wax crayons or purchase approximately 30 wax crayons per class.	For each group: – different colours of wax crayons – coin – aluminum foil – rolling pin or heavy weight – hot mitts – tongs – water – hot plate or electric kettle – plastic spoon – small aluminum dish – beaker or small glass bowl

Time Required
- 40 min

Safety Precautions
- Supervise the use of boiling water. Students should use care when handling the hot water and when working around the heat source.

- Remind students to carefully unplug the hot plate at the end of the investigation and let it cool completely before putting it away.
- Using a coin, such as a penny, to scrape the crayons is very effective. Do not give students sharper implements.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards. Ensure that students wear safety goggles, aprons, and hot mitts.

Expected Results

Students model the creation of sedimentary rocks in Part 1, metamorphic rocks in Part 2, and igneous rocks in Part 3.

Activity Notes

- Try to collect as many light-coloured crayons as possible. Yellow, red, orange, and white make great coloured rocks. If too many dark colours are used, the sediments created are hard to distinguish. Help distribute the crayons.
- Demonstrate how to hold the crayon and scrape down with the coin to create a pile of sediments.
- You may wish to discuss what crayons are made from, and how they differ from rocks. Crayons are a mixture of wax, oil, pigments, and plastic. Sometimes minerals are used for pigments.

Supporting Diverse Student Needs

- For enrichment, students could design other ways to use crayon shavings to model processes in the rock cycle. With your approval, they could explain or demonstrate their models to the class.

Analyze Answers

1. (a) and (b) In Part 1 of the investigation, students modelled the creation of sediments or the process of weathering. Students may also say they modelled erosion, which is acceptable because the sediments were transported from one area to another. Students also modelled the creation of sedimentary rocks by compaction.
2. (a) and (b) In Part 2 of the investigation, students modelled the creation of metamorphic rocks or the process of heat and pressure being applied to rocks.
3. (a) and (b) In Part 3 of the investigation, students modelled the creation of igneous rocks by melting and cooling sediments.

Conclude and Apply

1. (a) Students were not able to model crystallizing and cementation in this activity.
   (b) Crayons do not form crystals when they cool. Cementation was not shown because no cementing agent was applied to the sediments. Sediments were compacted, melted, and cooled.
2. Students could add glue to some of the sediments to represent the process of cementation. To illustrate the process of crystallization, students would have to have minerals or other pure substances, which after being melted, would cool and grow into crystals.

USING THE FEATURE

Science Watch: Holding History Together, p. 350

Ask students what is the oldest building they know of. How old do they think the building is? What holds the parts of the building together? Then ask "What holds the school building together? How many years will the school building last?"

Science Watch Answers

1. Cement is a mixture of mineral resources, mostly limestone and sand or clay, used to bond or glue rocks and bricks together in building construction.
2. The ingredients need to be heated in order to change the chemicals in the mixture.
3. The ancient Romans did not have to heat their cement ingredients because the ash had already been heated by the volcano.

SECTION 10.3 ASSESSMENT, p. 351

Check Your Understanding Answers

Checking Concepts

1. Students' diagrams could be similar to the illustrations on pages 342 or 343 of the student book. Check that:
   - all three families of rocks are shown
   - all three families undergo the processes of weathering and erosion
   - heat and pressure transform sedimentary and igneous rock (and other metamorphic rock) into metamorphic rock
   - rocks melt to form magma that cools and crystallizes to form igneous rock
   - sediments are compacted and cemented to become sedimentary rock
2. Students' answers could include that they are both part of the rock cycle and that igneous rocks are weathered to become sediments,

which become compacted and cemented to form sedimentary rocks.
3. Students' answers could include that they are both part of the rock cycle, that sedimentary rocks can become rocks when subjected to heat and pressure and hot fluids, and that metamorphic rocks can be weathered to form sediments that can be compacted and cemented to become sedimentary rocks.
4. Students' answers could include that they are both part of the rock cycle, that metamorphic rocks can melt to become igneous rocks, and that igneous rocks can be subjected to heat and pressure and hot fluids to become metamorphic rocks.
5. (a) and (b) Students' answers could include minerals such as graphite for writing, talc for powder, clay for dishes, and quartz crystals in watches. They could also name metals (gold, iron, nickel), petroleum resources (coal, oil, gas), or rock resources (limestone, marble, etc.) they have used.
6. (a) and (b) Students could choose any two resources and their uses from Table 10.3 on page 346.
7. On the left-hand side (either order): sedimentary rocks, metamorphic rocks
   On the right-hand side from top to bottom: sedimentary rocks, metamorphic rocks, igneous rocks

Understanding Key Ideas

8. The rock cycle, like any natural cycle, represents a process where the same materials are cycled throughout, producing different products under varying conditions. The materials found in rocks undergo constant change to produce new types of rocks under different conditions.
9. You may wish to expand this question somewhat for students by changing the wording from "rocks" to "rock and mineral resources." Students' examples could include the development of technology to extract iron from ore for use in making tools and structures to improve life. The use of limestone and marble in building are also good examples.

Pause and Reflect Answer

Students' answers could include benefits from having a family member working in the mineral resource industry and mining, refining, manufacturing, or selling products made from mineral resources. Answers might also include mention of structures (school, home, etc.) that incorporate rock and mineral resources.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment BLMs.

CHAPTER 10 ASSESSMENT, pp. 352–353

PREPARE YOUR OWN SUMMARY

Student summaries should incorporate the following main ideas:

1. Properties of Minerals
   - Three types of lustre are dull, glassy, and metallic.
   - Mohs Hardness Scale ranks minerals with a hardness of 1 to 10.
   - Colour alone is not a reliable way to identify minerals. The colour of streak is more reliable.
   - Cleavage means splitting along smooth, flat surfaces, whereas fracture means breaking with rough or jagged edges.
   - Other properties of minerals include crystals, heft, odour, magnetism, and how the surface feels.
2. Three Families of Rocks
   - Igneous rocks are formed when hot lava or magma cools.
   - Sedimentary rocks are formed when sediments are compacted and cemented.
   - Extreme heat and/or pressure and/or hot fluids can change other rock to metamorphic rock.
3. The Rock Cycle
   - Rocks are constantly being changed through the rock cycle. Each process in the rock cycle can take thousands of years.
4. The Uses of Rocks and Minerals
   - A rock or mineral resource is a rock or mineral that can be mined and used for a specific purpose.
   - Petroleum, metals, and gems are all examples of rock and mineral resources.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. (a) Rocks are mixtures of two or more minerals.
   (b) Minerals are pure, naturally occurring, inorganic (non-living), solid substances.
2. (a) Properties used to identify minerals include lustre, hardness, colour, streak,

cleavage, and fracture. (Students could also mention magnetism, odour, heft, crystals, and how the surface feels.)
(b) You can decide whether a mineral has glassy, dull, or metallic lustre by looking at it. You can scratch a mineral with different objects and use the Mohs Hardness Scale to help you decide which mineral it is. You can observe the mineral's colour and the colour of its streak on a streak plate. You can break the mineral and observe its cleavage and fracture.

3. The difference between cleavage and fracture is that in cleavage a mineral splits along smooth, flat surfaces whereas minerals with fracture break with rough or jagged edges.
4. Diamond does not leave a streak on a streak plate because streak plates have a hardness of 7 on the Mohs Hardness Scale and diamonds have a hardness of 10. Diamonds scratch the plate. They do not crumble and leave mineral fragments.
5. An iron nail has a hardness of 4.5 on the Mohs Hardness Scale, while glass has a hardness of 5.5. Therefore, the unknown mineral must have a hardness of 5.0.
6. Magma is molten rock beneath Earth's surface, whereas lava is molten rock at Earth's surface.
7. Intrusive rocks are formed beneath Earth's surface, whereas extrusive rocks are formed at Earth's surface. Intrusive rocks have larger crystals, whereas extrusive rocks have smaller crystals.
8. Sediments come from the weathering and erosion of rocks.
9. Any three of limestone, sandstone, conglomerate, and shale. Other answers may also be acceptable.
10. Students' diagrams could be similar to the illustrations on pages 342 or 343 of the student book. Check that:
    - all three families of rocks are shown
    - all three families undergo the processes of weathering and erosion
    - heat and pressure transform sedimentary and igneous rock (and other metamorphic rock) into metamorphic rock
    - rocks melt to form magma which cools and crystallizes to form igneous rock
    - sediments are compacted and cemented to become sedimentary rock

Understanding Key Ideas

11. The rock cycle shows how all types of rock can become sediment, and in turn, become a sedimentary rock, such as a conglomerate. In other words, granite and slate can be weathered to form sediments that are then cemented to form conglomerate.
12. (a) metamorphic rock
    (b) The presence of wavy layers shows that the rock has been subjected to great heat and pressure. Also, the absence of obvious crystals or sediments suggests that the rock is not sedimentary or igneous.
13. Sample answer:

	What It Is Formed From	Where It Is Formed	Distinguishing Features	Examples
Igneous rock	molten rock	beneath or at Earth's surface	presence of crystals	basalt, obsidian, granite
Sedimentary rock	sediments	at Earth's surface, often at bottom of lakes and oceans	presence of layers and/or sediments of various sizes	sandstone, shale, conglomerate, limestone
Metamorphic rock	other rocks	deep within Earth's crust where there is great heat and pressure	presence of wavy layers; appearance may be very different than that of parent rock	slate, marble

14. Students' diagrams should show that the crystals (which they may model as chocolate chips) melt and spread out into the dough.
15. Students' diagrams should show that the parent rock is subjected to heat, pressure, and/or hot fluids that transform it into another type of rock.
16. You can easily break diamonds because they have the property of cleavage. Diamond cutters often use this property when cutting large diamonds.
17. (a) When volcanic rocks are cooling, gas that was dissolved in the molten rock separates from the liquid to form bubbles or pores. When the material cools, these bubbles of gas leave behind holes in the solidified rock. The bubbles offer proof that the rock came from a volcano.

(b) and (c) Igneous rocks with bubbles are likely to be extrusive because they formed on the surface of Earth, near volcanoes.

18. Metamorphic rocks can only be created deep in Earth because that is the only place where the pressure and heat are high enough to make metamorphic rocks.
19. Both minerals have a glassy lustre, just like the glass bottle, so lustre would not be much help in determining the identity of the sample. You could use the Mohs Hardness Scale to help differentiate between them. The steel knife (hardness 5.5) would scratch calcite (hardness 3) but would not scratch quartz (hardness 7). You could also examine the cleavage of each. Calcite would demonstrate cleavage perfectly, but the cleavage of quartz would be indistinct.

Pause and Reflect Answer

The formation of ice in a glacier or snowbank is similar to the formation of sedimentary rock beds because each layer is compacted by the weight of layers above it. As more snow falls, more layers are created and greater pressure is exerted on the layers below.

CHAPTER 11 OPENER, pp. 354–355

USING THE PHOTO AND TEXT

Invite students to share their experiences making pizza dough or bring in some ingredients to demonstrate how pizza dough can sometimes stretch and stretch, but other times it breaks. Compare these qualities to Earth's crust and identify that a break in Earth's crust is called a fault. After the discussion, have students read the Chapter Opener on page 354.

The San Andreas Fault marks a transform boundary between the Pacific Plate and the North American Plate. The land to the east of the fault moves slowly northwest while the land to the west of the fault moves to the southwest. Some sections of the plates can slide past each other without creating an earthquake, but in other places the rock moves suddenly. The rate of movement along the fault averages approximately 33–37 mm/year across California.

USING THE WHAT YOU WILL LEARN/WHY IT IS IMPORTANT/SKILLS YOU WILL USE

Ask students to describe the damage that can result from an earthquake or volcano. Invite students to predict why earthquakes occur. Then ask, "Where do earthquakes happen?" and "Where are volcanoes located?"

USING THE FOLDABLES™ FEATURE

See the Foldables™ section of this resource.

11.1 A MOVING, CHANGING CRUST

BACKGROUND INFORMATION

Earth's internal structure was first discovered by studying the changes in the speed of earthquake (seismic) waves. Seismic wave velocities increase to a depth of about 100 km, proving that the outer layer of Earth is quite rigid. This depth marks the boundary of the lithosphere, which includes the crust and upper mantle. The lithosphere is relatively thick compared to the rest of the interior of Earth. The speed of seismic waves decreases rapidly beneath the lithosphere, indicating a zone that is close to melting and rocks that have lost their rigidity.

Earth's crust ranges from approximately 5 km to approximately 70 km in thickness and contains valuable resources such as metals, gems, oil, and coal. The crust also contains clues to Earth's past.

Rocks in the interior of Earth are very hot. The rocks are often at temperatures well above their melting points, but, because of the high pressure, the rocks do not melt. Instead, the rocks flow very slowly, creating convection currents. However, rocks at great depths can sometimes melt and flow into areas of weakness, such as cracks and fissures.

The concept that continents have moved relative to one another (called continental drift) and the early evidence that led to the development of the plate tectonics theory came to light at the beginning of the 1900s. Evidence from a variety of sources led to our present theory of plate tectonics. The following are used in arguments to support the continental drift theory:

- Paleogeographic evidence: South America and Africa seem to fit together.
- Geological evidence: There is a correlation of sequence of layers of rock across the Atlantic.
- Biological evidence: Fossils (trilobites) from the Avalon Peninsula correspond with those found in Northern Africa.
- Meteorological evidence: Evidence of coal, which forms in warm climates, has been found in Antarctica.

Starting in the 1950s, studies of magnetic reversals, the structures and ages of the ocean floor, sedimentary rock correlations, and fossils provided the basis of a unifying theory of plate tectonics. Sonar provided a more detailed picture of the sea floor, such as the Mid-Atlantic Ridge; magnetometers provided evidence for sea floor spreading; and deep sea drilling provided evidence for the internal structure of the crust.

The theory of plate tectonics provides an explanation for some of the most exciting processes on Earth, such as earthquakes, volcanoes, the Ring of Fire, and mountain building. The theory does not, however, provide all the answers, and some scientists use other explanations for these geological features. A new theory could be introduced eventually to account for some of Earth's unexplained geologic features.

While most geologists agree that convection currents are responsible for the movement of the tectonic plates, the exact cause of the convection currents and the depth to which they occur are still being debated. The source of energy that creates the heat that drives these convection currents is thought to be the result of intense pressure. One theory states the entire mantle is convecting in large convection cells. Another theory involves a two-layered convection mantle.

Fossil evidence from Newfoundland presents the most compelling evidence of continental drift. The *Paradoxides davidis* species of trilobite (shown on page 395 of the student book) found in the Manuels Gorge on the Avalon Peninsula is identical to the species found in Wales, and nowhere else in the world.

COMMON MISCONCEPTIONS

- Students may have many misconceptions about the internal structure of Earth. Scientists can only make inferences about how Earth is constructed.
- A common misconception that students may have is that the crustal plates correspond to the continental boundaries. Activity 11-1C, on page 363, will help to dispel this misconception. You may also wish to have students trace the plate boundaries in Figure 11.11, on page 368, with their fingers. Ask, "Is all of North America on the North American plate? What else is on the North American plate?"
- Students may confuse meteorites and meteorology. You may wish to clarify the meaning of the two terms. One way to help students understand the difference is to point out that weather announcers on television are often called meteorologists.
- Students may not be aware that some scientific theories cause great controversy among scientists. This is a good opportunity for class discussion about current theories that may be in the news. It is important for students to realize that new theories and ideas are constantly being introduced, tested, and rejected by the scientific community.

ADVANCE PREPARATION

- For Activity 11-1A on page 357 of the student book, you will need to collect a number of the same size and type of containers with lids, such as empty 2 L milk containers or margarine containers (several per group in the class). A few days before doing the activity you will need to prepare contents for the containers.
- Several days before doing Activity 11-1B on page 359 of the student book, advise students to find or make their models of Earth's layers.
- You may need to order cornstarch for Activity 11-1E on page 370 of the student book.
- Consult the Unit front matter for a list of BLMs that can be used when teaching this section.

INTRODUCING THE SECTION, pp. 356–357

Using the Text

You may wish to introduce this topic by asking students how Earth's inner layers are portrayed in literature and movies. Ask students to comment on how accurate they believe media representations to be. Students could draw pictures of Earth's interior based on information in movies or books. These drawings could be posted and compared with the information in this section.

Some students may not know what core sampling means. Explain to students that taking a core sample is similar to someone putting the end of a straw into a pudding and keeping the sample of the pudding in the straw by putting a finger in top of the straw. The sample can then be easily removed and examined.

One of the best motivators and visual aids for this topic is a very large map of the ocean floor. Most scientific supply catalogues carry a wide variety of ocean floor maps. You can also purchase a magnetic globe with tectonic plates that move around. You may wish to make the point that sea floor maps are works-in-progress and are revised as new technological processes (such as multi-beam sonar studies) become available.

It might be helpful if you have some samples of fossils for students to look at.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the text and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, which lists the Key Terms given in the unit, can be used to assist students.

Using the Did You Know, p. 357

Ask students, "Why might it be useful to learn more about the type and state of matter in Earth's inner layers?" *(Understanding more about the inner layers helps us to understand and predict movements in Earth's crust.)*

USING THE ACTIVITY

Find Out Activity 11-1A

Examine the Evidence, p. 357

Purpose

- Students make observations to infer the contents of sealed containers.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Collect a number of the same size and type of containers with lids , such as empty 2 L milk containers or margarine containers (several per group in the class).	For each group: – sealed containers – suggested materials to be included in the containers: a marble plus one type of other material, such as modelling clay, fabric, dried peas, cotton balls, pop cans, small plastic bottle
3 days before	Put together, seal, and number each container.	

Time Required
- 30 min

Safety Precautions
- None

Expected Results
Students will encounter similar difficulties with this activity to those scientists face when studying the inner layers of Earth, for example, how to describe something they cannot observe directly. The easiest contents to identify will likely be the container that contains only a marble.

Activity Notes
- There are a variety of ways to set up the sealed containers and their contents. For containers, clean 2 L milk cartons work well. The contents for the cartons could be set up as follows (assuming one carton per group and six groups):
  – Carton 1: contains a marble
  – Carton 2: contains a pop can that itself contains a marble
  – Carton 3: contains a plastic water bottle that itself contains a marble
  – Carton 4: contains a marble and one or more cotton balls
  – Carton 5: contains a marble and a piece of fabric
  – Carbon 6: contains a marble and some dried peas
- Number the containers and keep a list of their contents.
- Seal the containers securely with masking tape.
- You may wish to put a list of possible contents on the blackboard for students. Be sure to include some substances that are not in the containers so as not to make the activity too easy.
- Discuss the challenges scientists face when trying to study Earth's inner layers.

Supporting Diverse Student Needs
- For enrichment, students can research technologies used to gather evidence of Earth's inner layers.

What Did You Find Out? Answers
1. Usually the container with only the marble is the easiest to identify.
2. Usually the most difficult contents to identify are those with materials that do not make a distinctly recognizable sound when hit by the marble, such as a cotton ball or fabric.
3. Usually the fabric or cotton balls cause the most confusion.

Using a Demonstration
- If your class has not yet studied heat, introduce the concept of convection. The discussion will help students understand how convection currents in the magma under Earth's crust cause the plates to move. Students have often seen convection currents in action at home when they have seen boiling liquid. You could model this concept for students by using a hot plate, water, and clear pot with some grains of rice or pieces of macaroni added to boiling water. Take care when using boiling water.
- Have students join you in demonstrating the three kinds of rock movement along boundaries with their hands.
- To show convergent movement, make your hands flat, with your fingers pointed toward each other. As your hands approach each other, have one hand go underneath the other. The upper hand should show some building of mountains.
- To show divergent movement, make your hands flat, with your fingers pointed toward each other. Slowly pull your hands apart.
- To show transform movement, make your hands flat, with fingers pointed away from your body. Put your thumbs in your palms, and place your hands together so that your index fingers touch. Use significant force to push together and try to make one hand go away from you at the same time. This will illustrate how the sudden release of pressure causes an earthquake.

TEACHING THE SECTION, pp. 357–369

Using Reading

Pre-reading—Predict-Read-Verify

Break the section into manageable chunks:

- A Model of Earth
- Earth's Moving Crust and Rejection of Wegener's Ideas
- Evidence from the Sea Floor
- Toward a New Theory and Plate Tectonics
- Convection Currents

Ask students to say what they think each title means and make a prediction about what they will learn. They can then read the chunks and compare their predictions to what they learned.

During Reading—Elaborative Interrogation

Students can generate and then answer "Why?" questions. They can record at least one interesting fact from each subhead and ask a "Why?" question about it and then answer it in their notebook. For example, from the fact "Earth's crust is constantly changing" could come the question "Why is Earth's crust constantly changing?" and the answer "Earth's crust is broken into pieces that are moved around by convection currents."

After Reading—Reflect and Evaluate

Have students copy the plate names, as well as a legend with the kinds of plate boundaries onto a map of the world, such as BLM 4-32, Patterns in Earthquake and Volcano Locations; or have students define the three kinds of plate boundaries (convergent, divergent, and transform), providing an example of each in their notebooks. Students could use any type of movement activity to simulate the movement of the crustal plates, for example, "The Plate Tectonic Jive" in which they could do divergent, convergent, and transform dance steps, set to music.

Reading Check Answers, p. 359

1. (In any order) crust, mantle, outer core, inner core
2. Oceanic crust, continental crust
3. The inner core is solid because there is enormous pressure.
4. In the lower part of the mantle, the rock is plastic-like.

Reading Check Answers, p. 362

1. Pangaea is the name given to all the continents joined together in a huge land mass that broke apart about 200 million years ago.
2. Wegener proposed the theory of continental drift.
3. Wegener used paleogeographical evidence (shape of continents); biological evidence (fossils); geological evidence (rocks and rock layers); and meteorological evidence (climate change).
4. Wegener could not satisfactorily explain what forces might be causing the continents to move.

Reading Check Answers, p. 369

1. Sonar, magnetometers, sea floor drilling
2. At plate boundaries plates can move together (convergence), move apart (divergence), or slide past each other (transform boundary).
3. J. Tuzo Wilson helped develop the theory of plate tectonics.
4. A subduction zone is the area where one part of the crust is forced below another part.

USING THE ACTIVITIES

- Activity 11-1B on page 359 of the student book is best used after students read about Earth's layers on page 357.
- Activity 11-1C on page 363 of the student book is best used after students read about Wegener on page 362.
- Activity 11-1D on page 366 of the student book is best used after students read about evidence from the sea floor on page 366.
- Activity 11-1E on pages 370–371 of the student book is best used after students finish reading the whole section.

Detailed notes on doing the activities follow.

Think About It 11-1B

A Model Planet, p. 359

Purpose

- Students find or build a model to represent the structure of Earth.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Ask students to look for or make items or photographs that might be used to model Earth.	For each group: – students bring in their own materials
2-3 days before	Remind students to bring their models to class for the activity.	

Time Required

- 10–30 min presentation time

Safety Precautions

- Check for any food allergies before allowing any food into the classroom.
- Students should not eat anything in the science room.
- If a knife is used to cut apart the layers, remind students to take care not to cut themselves.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Models might include a hard-boiled egg, soft-centred candy, or a sandwich. For example, if using a boiled egg, the shell represents the crust, the white of the egg represents the mantle, and the yolk represents the inner and outer cores. This analogy can be further developed when discussing crustal plates by simply cracking the eggshell. The sections of shell would represent the various plate and the cracks would be the boundaries.

Activity Notes

- You may wish to have students draw a picture of their models rather than bring them in.
- You may wish to have students make labels to accompany their models so that the models can be displayed rather than presented orally.
- Bring in a kitchen knife so that you can cut apart apples, oranges, etc.
- Encourage students to be creative and original.

Supporting Diverse Student Needs

- Kinesthetic learners should enjoy this activity. You might have an assortment of clearly labelled pictures of cross-sections in the class to share with kinesthetic learners.
- For enrichment, students could research the thickness of each of Earth's layers and devise a model that would correctly show the relative thickness.

What Did You Find Out? Answers

1. –3. All answers will depend on the models used by students. You may wish to discuss students' answers as a class.

Think About It 11-1C

Pangaea Puzzle, p. 363

Purpose

- Students examine evidence of continental drift.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Photocopy BLM 4-27, Pangaea Puzzle.	For each group: – BLM 4-27, Pangaea Puzzle – blue paper – coloured pencils – scissors – glue

Time Required

- 60 min

Safety Precautions

- Remind students to take care when using the scissors.

Expected Results

Students sometimes notice that the continents do not fit together exactly. This is because the part of the continents visible on the surface does not include the continental slopes and continental shelves. When these features are included, the continents fit together very well. The continental shelf is a very gently sloping surface that extends from the shoreline to the continental slopes. The continental slopes are more steeply sloping surfaces that extend from the continental shelf to the ocean trench or continental rise.

Activity Notes

- *Cynognathus* was a reptile that lived about 230 to 210 million years ago. It had a long snout, strong jaws, and carnivore-type teeth. It is now extinct.
- You may wish to provide a colour legend for students to follow so that there is uniformity in their maps.
- Create your own map on a sheet of acetate so that students can check their maps for accuracy from the overhead screen.
- You may wish to divide the investigation into two parts and possibly two classes.
- Have students mark the equator on their world maps for a good point of reference.

Supporting Diverse Student Needs

- Read aloud the instructions for lower academic-level students, while they follow along in their student book. Provide visual clues for completing the activity. Model what is expected by showing at least one example of each piece of evidence. Have students use the same colours that you modelled for each piece of evidence.
- For enrichment, students could write two letters to the editor of a scientific newspaper. One letter should defend Alfred Wegener's theory of continental drift while the other should oppose his

theory. Students could use scientific evidence for both arguments.

What Did You Find Out? Answers

1. Accept all reasonable answers. Discuss answers as a class.
2. Sample answers: (a) The hardest pieces to fit together were North America and Europe.
   (b) These pieces might have been joined differently 300 million years ago in another supercontinent before Pangaea was formed.
   (c) I could test my ideas by doing research on the Internet.
3. (a) and (b) Based on the available information and technology at the time, Wegener's theory seemed reasonable. His theory took in consideration many pieces of evidence (paleogeographical, geological, biological, and meteorological). When his ideas were modelled, they seemed to work, unlike other theories of the time.
4. (a) and (b) Accept all reasonable answers. Discuss answers as a class.
   (c) In this activity, students drew upon several different sources of scientific evidence on which they based their conclusions. The strength of the evidence might have required some students to put aside previously held, unchallenged assumptions or beliefs that they had about Earth's distant past. Likewise, scientists of the time also might have held assumptions or beliefs about Earth's past that were in conflict with the evidence before them.

Think About It 11-1D

Evidence from the Sea Floor, p. 366

Purpose

- Students use data plotted on a graph to analyze the age and position of rocks on the sea floor.

Advance Preparation

- Photocopy BLM 4-24 a few days in advance.

Time Required

- 15 min

Safety Precautions

None

Expected Results

Evidence indicates that new rock has been coming up at the Mid-Atlantic Ridge and pushing the old rock farther away from the ridge. As a result, the sea floor is spreading outward as the old rock moves farther away from the ridge.

Activity Notes

- Use BLM 4-24, Evidence from the Sea Floor, as an overhead projection.
- Take up the answers as a class or in consultation with individual students, discussing how the data shows that the sea floor is spreading.

Supporting Diverse Student Needs

- To enhance understanding for academically weaker students, create a chart with age and distance for each dot on the graph. (Refer to the dots on the overhead with numbers.) Then students can easily see which dot represents the oldest and youngest rocks, as well as their distances from the Mid-Atlantic Ridge.
- For enrichment, students can research the Mid-Atlantic Ridge and share the information they find with the class.

What Did You Find Out? Answers

1. The oldest rock is 102 million years old. The youngest rock is 17 million years old.
2. You would have to travel about 900 km.
3. The farther Atlantic Ocean rocks are from the Mid-Atlantic Ridge, the older they are.
4. Evidence indicates that new rock has been coming up at the Mid-Atlantic Ridge and pushing the old rock farther away from the ridge. As a result, the sea floor is spreading outward as the old rock moves farther away from the ridge.

Conduct an Investigation 11-1E

Building a Model of Plate Tectonics, pp. 370–371

Purpose

- Students use a model to help them develop a hypothesis about why Earth's crust moves as it does.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 month ahead	Order a case (10 kg) of corn starch. (optional)	For each group (or whole class): – 1 large plastic tub – disposable gloves (optional) – spoon – two 1 kg boxes of cornstarch – measuring container – water For each group: – 4 petri dishes – puzzle pieces, marbles, building blocks, bingo chips, etc.
2-3 days before	Collect all materials for the activity.	

Time Required

- 30–60 min

Safety Precautions

- Caution students not to pour any of the cornstarch down the sinks. It can clog drains.
- Students should wash their hands after working with the mixture.
- Remind students not to taste or eat anything in the science room.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

The mixture in this activity behaves similarly to Earth's upper mantle. When the mantle is pushed slowly, the plates can move. If pressure has built up from a fault or tectonic movement, the crust will break. Pushing the puzzle pieces across the mixture causes folding of the cornstarch into features similar to folded mountains. There are many weak bonds in the mixture because the starch is a large polymer of sugars. If force is applied slowly to the polymer, each bond can be broken easily, and the suspension behaves like a liquid. If force is applied quickly to the polymer, the weak bonds act as a group and the cornstarch breaks. Other examples of mixtures that behave this way include water-saturated beach sand, paint, and water-saturated clay during an earthquake.

Activity Notes

- You may wish to have each group of students make its own mixture using two 1 kg boxes of cornstarch. Alternatively, you could have one mixture per class, but students will have longer to wait for their turn at the tub. If you are making only one mixture per class, you may wish to double the recipe so that there will still be plenty of mixture after students take their portions for the petri dishes.
- If the mixture is shared among many classes, be sure that students wash their hands or wear gloves.
- Let the mixture dry before disposing of it.
- Show students how cornstarch can break like a solid and run through the fingers like a liquid.
- Ask students to explain and discuss their hypotheses and the features of Earth's plates they modelled.

Supporting Diverse Student Needs

- This is an excellent activity for students with body kinesthetic intelligence.
- For enrichment, students could use the Internet to locate satellite images of plate margins. They could locate one example of each of a divergent, convergent, and transform plate margin.

Analyze Answers

1. (a) Accept all reasonable answers.
   (b) A freshly broken piece of cornstarch first appears to be solid, but then quickly changes to liquid.
   (c) Sample answer: Earth's lower layer of crust behaves like a solid when it breaks (earthquakes) and like a liquid when it slowly moves the plates.
2. The substances that are denser than the mixture will sink. The substances that are less dense will float.

Conclude and Apply Answers

1. The cornstarch mixture resembles a liquid when it is at rest or not disturbed. It takes the shape of the container, flows easily, cannot be compressed, and is easily forced by pressure.
2. The cornstarch mixture resembles a solid when it is stressed or put under pressure. Then it breaks up.
3. –5. Accept all reasonable answers.

USING THE FEATURE

Career Connect: Geophysicist

Charlotte Keen served as a senior research scientist with the Bedford Institute of Oceanography, the largest ocean research centre in Canada. The Bedford Institute has more than 300 multidiscipline scientists who are interested in the ocean area off the eastern shores of Canada. Keen has also been involved in the Lithoprobe Project in eastern Canada, writing many articles on this topic. Keen is now retired.

SECTION 11.1 ASSESSMENT, p. 373

Check Your Understanding Answers

Checking Concepts

1. Students' diagrams may resemble Figure 11.1 on page 358 of the student book. The crust should be represented as a very thin outer layer, and the inner core should be shown as a solid sphere. The labels from the outside in are crust, mantle, outer core, and inner core.
2. (a) Scientists use direct and indirect evidence to determine the inside of Earth.
   (b) Students' answers could include the following: direct evidence includes studying volcanoes, mountain ranges, and rock samples from deep within the sea floor. Indirect evidence includes studying earthquake waves, satellite images, and convection currents in laboratories.

3. (a) Sonar uses a device that sends out sound waves and then records the time the waves take to bounce back. The sound waves are sent to the sea floor and returned to the ship. Technology can then display the profile of the sea floor.
   (b) Sonar has shown that there are mountain ranges and other features on the sea floor.
4. Using magnetometers, scientists noticed a pattern of stripes of magnetic reversals travelling along a path parallel to the Mid-Atlantic Ridge on both side of the ridge. The stripes that are lined up to the south must have formed at a time when Earth experienced a reversal of its magnetic field.
5. When rock samples from deep-sea drilling were tested, it was discovered that the younger rock is closer to the Mid-Atlantic Ridge and the older rock is closer to the continents.
6. (a) Scientists now think that convection currents are causing the continents to move.
   (b) "Continental drift" is no longer appropriate because we now know that the sea floor is also moving.

Understanding Key Ideas

7. Scientists are not sure what is inside Earth's inner layers because we cannot observe Earth's inner layers directly.
8. Sample answer

Type of Evidence	Example of Evidence	Why the Example Suggests that Continents Have Moved
Paleogeographical	shape of continents	The continents look as though they were once joined together.
Biological	fossils	Fossils of the same animals are found on different continents (e.g., Avalon Peninsula and Wales).
Geological	rocks and rock layers	Rock layers in eastern North America and Britain look as though they formed and were pushed up into mountains together but are now separated by the Atlantic Ocean.
Meteorological	climate change	Coal beds are formed in tropical, swampy environments but are now found in Antarctica where it is much colder.

9. New rock is being formed at the sea floor where magma breaks through the crust along the ridges.
10. Students' diagrams should resemble Figure 11.12 on page 369 of the student book, with large circles in the mantle. The plates should be shown resting on top of the currents and moving along as though they were on a conveyor belt as the magma cools and begins descending.
11. The theory of plate tectonics infers that convection currents are responsible for the movement of the continents. The theory of continental drift did not use convection currents as a method for moving the plates nor did it take into account the movement of the seafloor. Plate tectonics also differs from continental drift in that some of the plates have visible continents on them and some are underwater.
12. Students' answers should indicate that the movement of one plate affects other plates.

Pause and Reflect Answer

There will be a wide variation in students' diagrams. Students may design a drill or pump for obtaining evidence. Remind students of the intense heat and pressure their invention would need to withstand. You may want to ask students whether their invention would be set up on continental crust (which is generally thicker) or on oceanic crust (which is generally thinner). Students could display their designs for other students to see.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment BLMs.

11.2 HOW EARTHQUAKES AND VOLCANOES SHAPE EARTH'S CRUST

BACKGROUND INFORMATION

A simple definition of earthquake is "a shaking of Earth." Seismographs are devices that measure and record earthquakes. In the past, the main component of a seismograph was a pendulum. Today, most seismographs are electromagnetic. The mass is a large magnet and the outside case contains coils of fine wire. When the magnet moves, it creates small electrical signals in the coils of wire. These signals are amplified and recorded on paper or magnetic tape.

Seismographs and related technologies are useful for more than just locating earthquakes. Seismic waves are created and recorded to locate oil and gas deposits.

Eruptions of volcanoes, underground nuclear tests, and dynamite blasts in quarries, road work, and mines can also be detected by seismographs. The first lunar seismograph was installed by the Apollo 11 astronauts in 1969, to help determine the internal structure of the Moon. The Viking 1 and 2 landers left seismometers on Mars to detect any internal movement on the surface of Mars.

The Richter scale is a logarithmic scale. The magnitude numbers differ by a factor of 10 (the amplitude of a magnitude 3 earthquake is 10 times greater than that of a magnitude 2 earthquake). The energy released by an earthquake increases 30 times for each magnitude (a magnitude 7 earthquake releases $30 \times 30 = 900$ times the energy of a magnitude 5 earthquake).

Aftershocks are generally a result of re-adjustments of Earth along fault lines. They can occur months after the initial earthquake if the magnitude was large enough. The intensity of the aftershocks decreases over time.

Rocks respond to stress depending on the type of stress applied, the pressure, temperature, and the mechanical properties of the rock. If the stress is light, the rock can deform and return to its original shape. If the stress goes beyond the elastic limit of the rock, very small cracks can form. Another response to stress is folding, either in small layers or very large layers. If the rock has reached its elastic limit and can no longer fold, it will fracture or break. If there is movement along a fracture, a fault is created. A fault is a fracture in the bedrock along which rocks on one side have moved relative to the other side.

Volcanic activity provides a great deal of information about the internal structure and composition of Earth. By studying the magma, lava, gases, and rocks from eruptions, geologists can infer the chemical conditions as well as the temperatures and pressures within Earth.

Volcanic eruptions vary in nature and degree of explosive violence because of the different composition of the magma from which the volcanoes originate. The size and shape of volcanoes and lava flows and their pattern of distribution on Earth also corresponds to the composition of their lavas.

There are over 600 active volcanoes on Earth with recorded eruptions. Over two thirds of these are at the margins of the Pacific Ocean, an area known as the Ring of Fire. Several thousand volcanoes exist that have not erupted in recorded history. Over 50 000 volcanoes have been discovered on the floor of the Pacific Ocean.

COMMON MISCONCEPTIONS

- Many students think that an earthquake means huge cracks in the crust that swallow people. In fact, the disturbance on the surface of Earth does not do the most damage; falling buildings and collapse of other structures are the most dangerous to human life.
- Many students think that it is the lava that endangers people during an eruption. In fact, more deaths and damages occur from other volcanic features such as the resulting ash fallout and landslides.

ADVANCE PREPARATION

- You may need to book the computer lab or library several weeks before students do Activity 11-2C on page 384 of the student book.
- Ask students to bring in materials from home several days before they do Activity 11-2D on page 385 of the student book.
- Consult the Unit front matter for a list of BLMs that can be used when teaching this section.

INTRODUCING THE SECTION, pp. 374–375

Using the Text

Ask students to relate what they know about tsunamis. Ask, "Do we experience tsunamis in our region?"

Ask students what information they already know about earthquakes. Summarize their answers on a chart. Where do they think earthquakes happen? Mark their answers on a wall map. As they work through this topic, revisit the chart and/or map and add new knowledge to it.

Discuss with students the driving forces behind the invention of the seismograph.

Ask students, "Why are there more earthquakes reported today than 100 years ago?" *(With the development of very sensitive technology, many earthquakes that are not felt by people can now be recorded.)*

Ask students to contribute their prior knowledge of volcanoes. Summarize their contributions using a 2-column Fact/Opinion chart. Ask students to help decide whether each contribution is fact or opinion. Ask, "How do you know which is fact and which is opinion?"

Ask, "Is there evidence for geological processes like earthquakes and volcanoes in our region?" This will allow for an assessment of students' prior knowledge as well as motivate students to begin considering these topics in their immediate environment.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the text and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, which lists the Key Terms given in the unit, can be used to assist students.

Using the Did You Know, p. 375

Students may be surprised to learn that there are landslides and volcanoes underwater and that these events can cause tsunamis. You may wish to ask some students to research causes and locations of tsunamis over the last few years.

USING THE ACTIVITY

Find Out Activity 11-2A

Seismic Sandpaper, p. 375

Purpose

- Students model how movement along a transform boundary can cause an earthquake.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Gather materials.	For each group: – 2 wooden blocks, each about 5 cm by 10 cm by 15 cm – 2 sheets of medium grade sandpaper – masking tape

Time Required

- 5–10 min

Safety Precautions

- Students should be careful not to stand too close to other students when they try this activity. The blocks can move suddenly, and students may get hit.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

- The blocks will initially resist movement as pressure is applied and then will suddenly move.

Activity Notes

- To save class time, you may want to tape the sandpaper to the blocks ahead of time.
- This activity can be done as a teacher demonstration, however, if possible allow at least some of the students to perform it.
- If students find it very easy to move the blocks, remind them to press the blocks tightly together and then try to move them past each other.

Supporting Diverse Student Needs

- This is an excellent activity for students with body kinesthetic intelligence.
- For enrichment, students can be challenged to devise other ways to model plate movement.

What Did You Find Out? Answers

1. Students will most likely answer that the blocks resisted moving and then suddenly moved past each other.
2. In an earthquake, the pressure between two tectonic plates may suddenly release with a movement.

Using a Demonstration

- You could demonstrate the concept of seismic waves by dropping a pebble into a container of water. If an overhead projector is available, you can do the same thing with a beaker of water, so that the whole class can observe the effect at once. (You could ask students to visualize what happens when a rock is thrown into a still body of water.) The circular waves that move from the centre are analogous to seismic waves.
- You could demonstrate how a seismograph works by moving a piece of paper under a stationary pencil.

TEACHING THE SECTION, pp. 376–384

Using Reading

Pre-reading—K-W-L (Know-Want to Know-Learned)

Before students read the section, have them record information that they know about earthquakes and volcanoes and record questions that they have. Later, students can share their questions as class and together the class can discuss the answers.

During Reading—Think-Pair-Share

Ask students to read a section of text independently, record their thoughts, and then pair up with another student to discuss and share their thoughts about the text. Partners can come up with one shared response.

After Reading—Semantic Mapping

Students can create a Venn diagram to compare and contrast earthquakes and volcanoes. This strategy will help students recall and organize text information.

Reading Check Answers, p. 379

1. A seismograph is attached to bedrock in order to detect the vibrations that result from an earthquake.
2. An earthquake measuring 7 on the Richter scale is stronger than one measuring 5.
3. Three types of faults are normal, reverse, and transform.
4. Most earthquakes occur along active plate boundaries.

Reading Check Answers, p. 384

1. Volcanic ash increases soil fertility, magma heats groundwater that can be used as a source of heat, and volcanoes release water and carbon dioxide into the atmosphere.
2. Any three of: volcanoes can destroy homes, trees, crops, and landscapes; the ash can cause cool temperatures by blocking sunlight, bury fields and roads, and cause breathing difficulties.
3. Volcanoes occur where plates collide, where plates separate, and where plates are thin.

USING THE ACTIVITIES

- Activity 11-2B on page 380 of the student book is best used after students read about earthquakes on page 379.
- Activity 11-2C on page 384 can be used at any time in this section.
- Activity 11-2D on page 385 is best used after students read page 376.
- Activity 11-2E on pages 386–387 of the student book can be used at any time in this section, such as after students read about volcano locations on page 382.

Detailed notes on doing the activities follow.

Think About It 11-2B

Seismic Safety, p. 380

Purpose

- Students identify how they could prepare for a sudden movement in Earth's crust.

Advance Preparation

None

Time Required

- 20–30 min

Safety Precautions

None

Expected Results

Changes to students' bedrooms might include moving heavy objects from higher to lower shelves, removing pictures from above the bed, moving heavy, breakable objects away from the bed, and keeping a flashlight near the bed.

Students might include some of the following items in their emergency kits:

- written family emergency plan
- flashlights with extra batteries
- cellular telephone with extra batteries
- radio with extra batteries
- first aid book with handbook and any necessary medications for one week
- about 15 L of water per person, in plastic containers
- enough food for the family (and pets) for about one week
- matches
- personal hygiene items for one week
- manual can opener
- comfortable footwear, blankets, at least one change of clothes, and work gloves
- money, in various denominations
- emergency reflector blankets
- leash for pet, if needed
- whistle
- pipe and crescent wrenches for shutting off gas and water
- pocket knife
- fire extinguisher
- rope
- emergency telephone numbers
- emergency tent

Students could store their emergency kits in an area (such as the front hall closet) that is easily accessible to all family members, as determined in the family emergency plan.

Activity Notes

- Tell students that it is better to stay inside a building if they are already inside, and stay outside if they are already outside. Many people are not injured by the earthquake itself, but rather by collapsing buildings and falling debris. If inside, students should take cover under something like a desk, avoiding mirrors, windows, and other things that might fall. If outside, they should avoid buildings and electrical power lines where possible.
- As a class, discuss the importance of being prepared for an emergency, such as an earthquake, tsunami, or fire. Find out how students view fire drills and their implications for a real crisis.
- You might wish to assign this activity for students to complete at home as homework.
- Before students complete this activity independently, encourage them to examine the classroom carefully to see what dangers might exist and what would have to be changed to prevent injury if an earthquake or tsunami occurred. List these ideas as a class.
- After students finish this activity, they can share their ideas with a partner and then with a group. Each group could create a general plan to record in a class manual.

Supporting Diverse Student Needs

- Students with weaker language skills could be paired with a partner with strong language skills.
- For enrichment, students could create a booklet or instructions to post on the class web page about preparations for seismic events.

Think About It 11-2C

Seismic Stories, p. 384

Purpose

- Students' research and share stories or explanations about earthquakes or volcanoes from various cultures around the world.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before	Book the library or computer lab, or select resources from the library for class use.	For the class: – various art materials and/or recording equipment depending on the formats you wish students to use
3 days before	Students can begin their research at home using the Internet or library resources.	

Time Required

- 30 min for research (could be done at home)
- 30 min for retelling and illustrating/rehearsing the story

Safety Precautions

None

Expected Results

A few examples of information students might find include:

- Pele, Hawaiian goddess who makes the mountains shake and lava flow at Kilauea, Hawaii
- Ancient Greek explanation that powerful winds are trapped and held in caverns in Earth's crust and that earthquakes are the result of the winds' struggle to escape
- René Descartes, French philosopher who believed an incandescent Earth core was the source of volcanic heat

Activity Notes

- Read one of the from BLM 4-30, Seismic Stories, to the class as a model.
- Brainstorm with the class a list of words that might be used in a myth,
- Have students write their researched myths or stories in their own words.
- Have students compare their myths as a class and discuss the similarities and differences among them.
- Display the students' work in the classroom.
- Have students retell their myths to the class, a small group, or without notes. Students may wish to dress in the role of a storyteller.

Supporting Diverse Student Needs

- Academically weaker students could present their myths to you individually or could be given extended time for completing the activity.

- For enrichment, students could develop their own story or legend and show how their story or legend reflects what actually occurs during an earthquake or a volcanic eruption.

Design an Investigation 11-2D

Shake It!, p. 385

Purpose
- Students design and build a seismograph.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before 2-3 days before	Assign the reading of the investigation for homework so that students can start thinking about their design. Ask students to bring materials from home. Gather materials. (Optional) Photocopy BLM 4-31, Shake It!	For each group (possible materials): – marbles or small rocks – masking tape – modelling clay – paper (sheets of paper or adding machine paper) – paper clips – paper plates and cups – pencils – pieces of wood – rubber bands – shoebox – soup can or oatmeal cylinder – springs – string – washers – water

Time Required
- 80–120 min

Safety Precautions
- If students need to cut materials or use tools for any other purposes in the classroom, they should follow appropriate safety precautions.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results
Students' models should be made of common, recycled materials and should be able to measure relative magnitude (size) of vibrations. The models should be capable of measuring vibrations continuously for at least one minute and be able to measure slight vibrations (such as student jumping up and down) as well as stronger vibrations (such as the table beneath it shaking).

In a typical seismograph, a heavy weight is fastened to a horizontal rod, and the rod hangs free from a pole. A pen is at one end of the rod directly over a piece of paper rolled around a cylinder. As the cylinder rotates, the pen draws an ink line along the moving paper.

Activity Notes
- Have students work in pairs or groups of three.
- Stress the importance of using environmentally friendly materials.
- Check the "blueprints" before construction begins.
- Encourage students to keep a written record of their work in this activity.
- You may wish to test the seismographs by using a piece of plywood across two or three desks. Have each group place their seismograph on the plywood, one at a time. Create vibrations through the plywood using a hand sander (if available) in the designated area on top of the plywood. **Note:** An adult should operate the sander and proper eye protection should be worn by all.
- As a wrap-up, students may be able to make inferences regarding future trends in the development of the seismograph.

Supporting Diverse Student Needs
- For enrichment, students can make refinements and improvements to their model.

Conclude and Apply Answers
1. –3. Answers will be based on students' success with their design.

Think About It 11-2E

Patterns in Earthquake and Volcano Locations, pp. 386–387

Purpose
- Students investigate and interpret a pattern in the location of earthquakes, volcanoes, and plate boundaries around the world.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Photocopy BLM 4-32, Patterns in Earthquake and Volcano Locations for students to use. You may also wish to photocopy it on acetate to use as an overhead.	For each group: – BLM 4-32, Patterns in Earthquake and Volcano Locations – blue, red, and green coloured pencils or markers

Time Required
- 40 min

Safety Precautions

None

Expected Results

Most of the earthquake and volcano locations will appear along the eastern shores of the Pacific Ocean (western edge of North America down to South America) and along the western shores of the Pacific Ocean (eastern edge of Asia). Other earthquakes and volcanoes may appear along 30°N latitude in Europe and Asia.

Activity Notes

- Read over the activity with the class. Point out that there are questions to answer on both pages of the activity.
- Review colours for students to use in the legend.
- Map at least one volcano, earthquake, and plate boundary together using the overhead projection.
- Review the characteristics of a good map: title, date, name, legend, and compass.
- Put the correct data on an overhead projection and use this to mark students' work.

Supporting Diverse Student Needs

- For enrichment, students could use the Internet to locate satellite images of volcanoes formed at convergent zones, divergent zones, and hot spots. They could also compare satellite imagery of the Pacific Ring of Fire with a map of plate boundaries in the area.

Analyze Answers

1. Most earthquakes are located near volcanoes along the eastern and western shores of the Pacific Ocean and approximately 30°–40°N latitude through Europe and Asia.
2. The pattern of earthquakes, volcanoes, and plate boundaries goes around the edge of the Pacific Ocean, or along the west coast of North America.
3. There are not many earthquakes or volcanoes in or around the Atlantic Ocean, but there are many of both around the edge of the Pacific Ocean.
4. In North America, most earthquakes occur along the western edge, along the shores of the Pacific Ocean.
5. A large number of volcanoes and earthquakes happen in Asia (Japan), and along the west coast of South America. Students may have other answers, depending on whether they plotted additional data from recent earthquakes.

Conclude and Apply Answer

1. There is a definite pattern to earthquake and volcano locations. Earthquakes and volcanoes appear in the same general areas.
2. Accept all reasonable answers, such as "Earth's crust is more active in some areas than in others" or "The areas of Earth's crust where earthquakes and volcanoes are found are at plate boundaries."

USING THE FEATURE

Science Watch: Exploring the Big Deep

You can capture students' interest by discussing the following: "Did you know that Mount Everest is NOT the tallest mountain in the world? It may sound strange, but it is true. Even stranger is the fact that you would have to go down to climb the highest mountain. And you would have to be in a submarine!" Students may be aware that the ocean is being explored by submersibles. For example, they may have seen the IMAX movie *Ghosts of the Abyss*, which explores the *RMS Titanic*. Students may also have some knowledge of the features of the sea floor.

Science Watch Answers

1. The sea floor is a dangerous place to visit because it is cold and dark and there is enormous pressure from all the layers of water. (Students may have also commented on the fact that very little is known about the creatures that live there.)
2. Any three of: exploring, filming, gathering samples, surveying, mapping, and measuring surrounding temperatures.
3. Pilots and technicians in the mother ship navigate ROPOS with the help of sonar tracking system and Global Positioning System satellites.

SECTION 11.2 ASSESSMENT, p. 389

Check Your Understanding Answers

Checking Concepts

1. An earthquake is a shaking of the ground.
2. Earthquakes are measured by attaching a seismograph to the bedrock to detect vibrations. The Richter scale describes the strength of an earthquake.
3. (a) In a normal fault, rock above the fault moves downward.

(b) In a reverse fault, rock above the fault moves up and over the rock below the fault.
(c) In a transform fault, rock breaks as the plates try to slide past each other.

4. The focus is the centre of the earthquake underground where the rock breaks, producing seismic waves. The epicentre is the location of the earthquake directly above the focus, on Earth's surface.
5. A volcano is an opening in Earth's crust.
6. Volcanoes can occur where plates collide, where plates separate, and where plates are thin.
7. Most volcanoes occur along plate boundaries.
8. The Ring of Fire encircles the Pacific Ocean.
9. Seismic waves that travelled out from the source of the earthquake caused the buildings to move up and down and collapse.

Understanding Key Ideas

10. British Columbia is located next to an active plate boundary, whereas Newfoundland and Labrador is not.
11. The earthquake in Alaska was stronger.
12. Sample answer:

	How Are They Similar?	How Are They Different?
Locations of earthquakes and volcanoes	Both earthquakes and volcanoes are found along active plate boundaries where plates collide or separate.	Some volcanoes are found in areas where plates are thin. Earthquakes are found along transform boundaries.
Causes of earthquakes and volcanoes	Both are caused by pressure.	Earthquakes are caused by pressure building up in rocks. Volcanoes are caused by magma rising up in cracks in rocks until it exerts enough pressure to erupt.

13. You can predict *where* an earthquake will occur because earthquakes happen where tectonic plates meet, and are more likely where earthquakes have happened already. It is more difficult to predict *when* an earthquake will happen because it is not known how much stress plates can withstand before they break or shift.
14. Volcanoes support the theory of plate tectonics because many of them are found along plate boundaries where plates collide or separate.

Pause and Reflect Answer

An unusually low tide can be an indication that a tsunami is about to occur because the trough of the wave sometimes arrives before the crest.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment BLMs.

11.3 MOUNTAIN BUILDING AND GEOLOGIC TIME

BACKGROUND INFORMATION

Most mountains are formed either because of the motion of the tectonic plates or because of the heating and expansion of the crust and mantle. The movement of the plates creates folding and faulting of the rock layers. The heat in the crust and mantle can create a hot spot or plume of magma that rises in the form of a volcano or causes the middle of the plates to expand. Lava, ash, and cinders from an active volcano can build up and form a mountain.

A fold is a bending in rock layers, whereas a fault is a break in rock layers. When massive blocks of rock are separated by a layer of rock that slides down between them, fault block mountains are created. These mountain ranges are characterized by sharp, jagged peaks.

Sedimentary rock may contain fossils. However, fossils are not easily or commonly found. For a once-living organism to become fossilized, its remains must be buried quickly in sediments that prevent oxygen from reaching them. In the oxygen-free environment, decomposition does not continue. The softer tissues of organisms tend to decompose more quickly than the harder parts, such as shells and skeletons, so the hard parts are usually what survived to be buried in the sediments. As the sedimentary layers form into rock over time, the remains of the once-living things also change to rock, becoming fossilized.

Trilobites existed about 250 to almost 600 million years ago (throughout the Paleozoic Era). Their fossilized remains are found all over the world, including most areas of Canada and at the top of the Himalaya Mountains. Trilobites' exoskeletons are divided into three distinct lobes or parts. The soft parts and legs are rarely preserved.

The *Paradoxides davidis* trilobite shown in the student book is found in the Manuels Gorge on the Avalon Peninsula and is identical to the species found in Wales, and nowhere else in the world. The name *davidis* originates from St. David, a place on the west coast of Wales.

COMMON MISCONCEPTIONS

- Most students do not appreciate the magnitude of time involved in most geological processes and events and that all eras are defined by major events in Earth's natural history. You could support the concept of geologic time by selecting students as particular organisms and placing them in a relative position along a corridor wall on a time scale. Emphasize that human existence on Earth represents a very small proportion of geological time.
- It is important that students understand the vast span of time represented by the Precambrian and that much of that time was practically lifeless. Our knowledge of geologic time after the Precambrian is directly linked to fossil evidence reflective of that time. You could present material to enrich students' appreciation for geological time by showing how fossil evidence explains Earth's evolution from the beginning of life in the Precambrian to present day. Some students may have already collected fossil specimens that may be placed along a time line.

ADVANCE PREPARATION

- You may need to book the library or computer lab two weeks before doing Activities 11-3C and Activity 11-3D on page 399 of the student book.
- You will need to collect atlases or book the library or computer lab two weeks before students do Activity 11-3F on page 401 of the student book.
- Consult the Unit front matter for a list of BLMs that can be used when teaching this section.

INTRODUCING THE SECTION, pp. 390–391

Using the Text

Ask students to read the introductory text on page 390 and then discuss the questions posed there. You may wish to record students' responses on a chart and then invite students to make changes to the information after they have read Section 11.3.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the text and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, which lists the Key Terms given in the unit, can be used to assist students.

Using the Did You Know, p. 390

Ask students to predict what processes are wearing down the Appalachians *(weathering and erosion)*. Invite students to predict how old the Appalachians are. *(Recent studies suggest they formed in several events between 480 and 300 million years ago.)* Ask students how they think scientists determine the age and height of mountains. It is thought that Mount Everest is "growing taller" by an average of about four millimetres per year.

Using the Activity

Find Out Activity 11-3A

Make a Mountain, p. 391

Purpose

- Students model how layers of sedimentary rock form into mountains.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Obtain enough Styrofoam™ (in three colours) for each partner/group.	For each partner/group: – 3 sheets of flexible, spongy Styrofoam™ of different colours

Time Required

- 10 min

Safety Precautions

- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

The Styrofoam™ layers will fold in the middle when students apply pressure from the sides.

Activity Notes

- If resources are limited, you may wish to demonstrate this activity for the class.
- After they are finished the activity, students should take apart the layers and store them separately for future use.
- Have students draw their models in their notebooks, along with descriptions of the folding they saw.

Supporting Diverse Student Needs

- This is a good activity for tactile learners.
- For enrichment, students can design other models of how mountains form.

What Did You Find Out? Answers

1. The middle of the Styrofoam™ bent upwards.
2. The objects bend when they are squeezed.
3. (a) Yes.
   (b) You can see wavy layers in mountains and in rocks.
4. Sample answer: Some of the layers might have moved over or under other layers.

TEACHING THE SECTION, pp. 391–397

Using Reading

Pre-reading—Predict-Read-Verify

Break the section into manageable chunks:

- Rocks under Pressure
- Putting Newfoundland Together
- Fossils and Geologic Time Scale
- The Fossil Record

Ask students to say what they think each title means and make a prediction about what they will learn. They can then read the chunks and compare their predictions to what they learned.

During Reading—Note-Taking

Encourage students to take notes as they read the assigned text material. It can be helpful to reword the topic titles as questions and then use the questions to guide note-taking.

After Reading—Semantic Mapping

Students can quietly review their notes and pick out three pieces of information they have learned that they find most interesting. These interesting facts can be shared in a class discussion.

Reading Check Answers, p. 393

1. Fold mountains are formed when plates collide and the rock is placed under great heat and pressure.
2. Fault block mountains are formed when pressure (squeezing) is exerted on rocks and they break, forming a fault.
3. Mountains and volcanoes are found together at the convergence of continental plates and oceanic plates.

Reading Check Answers, p. 398

1. A fossil is the remains of an organism that lived long ago.
2. Divisions of the geologic scale are based on the appearances of different kinds of life forms in the fossil record.
3. Fossils provide evidence of Earth's age and evolution, and evidence for the theory of plate tectonics.
4. Earth is approximately 4.6 billion years old.

USING THE ACTIVITIES

- Activity 11-2B on page 398 of the student book is best used after students have read about the fossil record on page 397.
- Activity 11-2C on page 399 of the student book is best used after students have read about geologic time on page 396.
- Activity 11-2D on page 399 of the student book can be used at any time in this unit.
- Activity 11-2E on page 400 of the student book is best used after students have read about volcanic eruptions on page 392.
- Activity 11-2F on page 401 of the student book is best used after students have read about major mountain ranges on page 393.

Detailed notes on doing the activities follow.

Think About It 11-3B

Tell-Tale Layers, p. 398

Purpose

- Students investigate how fossils can be used to determine the age of rock layers.

Advance Preparation

None

Time Required
- 15 min

Safety Precautions
None

Expected Results
The oldest rock layer is probably layer C, and the youngest layer is probably layer A.

Activity Notes
- You might wish to put the diagrams on an overhead projector and discuss them with the class to ensure that students understand them.

Supporting Diverse Student Needs
- You may want to work individually with academically weaker students to help them with the concepts.
- For enrichment, students can research examples of index fossils and how they are used.

What Did You Find Out? Answers
1. Rock layer A probably formed between 438 and 286 million years ago.
2. Rock layer B probably formed between 438 and 408 million years ago.
3. Rock layer C probably formed between 505 and 408 millions of years ago. (Some students might suggest between 505 and 438 millions of years ago since there are no other fossils present.)

Think About It 11-3C
Canada—Past, Present, and Future, p. 399

Purpose
- Students describe how a region of Canada has changed in the past and predict how it might change in the future.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before	Book computer lab or library if necessary.	For each group: – research materials

Time Required
- 60 min

Safety Precautions
None

Expected Results
Students' descriptions of the past should correspond with the divisions on the geologic time scale in terms of the types of organisms that were alive. Their representations of the future can include changes in climate resulting from the movement of the continents and new species of organisms.

Activity Notes
- Students can work with partners or in small groups.
- You may wish to divide this activity so that each pair/group has either the past or the future to represent.
- You may wish to assign a format that all groups can use, such as a class mural or timeline.
- Students could begin their research at www.discoveringscience.ca.

Supporting Diverse Student Needs
- Pair academically weaker students with students with strong language skills.
- For enrichment, students could choose another area of the world (such as India or Antarctica) and show its past and future.

What Did You Find Out? Answers
1. Answers will depend on students' experiences. Sample answer: the most difficult part was deciding how the land looked before the mountains formed.
2. Answers will depend on region and era.
3. Students could respond that they had to consider the movement of plates and changes in climate.

Think About It 11-3D
Rock Stars, p. 399

Purpose
- Students research the contributions of a Canadian earth scientist.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before	Book computer lab or library if necessary.	For each group: – research materials

Time Required
- 40–60 min

Safety Precautions
None

Expected Results

Students will discover that Canadian earth scientists have made many important discoveries that have increased our understanding of plate tectonics and Canada's (and the world's) past. Students should also discover why scientists come from all around the world to study the rocks of Newfoundland and Labrador.

Activity Notes

- Students could work with a partner or in groups of three.
- Students could begin their research at www.discoveringscience.ca.
- You may know of local earth scientists who could be contacted to interview directly.
- Other Canadian scientists you might assign include Joseph Burr Tyrrell, J. Tuzo Wilson, Charlotte E. Keen, and Harold Williams. There are also many non-Canadian scientists who have made important contributions to earth science in Newfoundland and Labrador, such as Riccardo Levi-Setti (Manuels River Gorge trilobites) and S.B. Misra (Ediacaran fossils at Mistaken Point). In addition, students might wish to profile faculty members of the geology department of Memorial University or scientists with the Geological Survey of Newfoundland and Labrador or the Johnson Geo Centre in St. John's.
- You may wish to assign a format for students to use, such as pages of a book, so that the information can be saved in the class library for future classes to use.

Supporting Diverse Student Needs

- Academically weaker students should be paired with students who have strong language skills.
- This is a good activity for students who may be interested in a career related to earth sciences.
- For enrichment, students could create a web site (or add a page to the school's web site) describing the highlights of Canadian earth science.

Find Out Activity 11-3E

Model Mountains of Moving Magma, p. 400

Purpose

- Students model the formation of domed mountains and other features caused by the movement of magma.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	(Optional) Ask students to bring in a tube of toothpaste.	For each group: – scissors – clear plastic disposable glass – 125 mL soil – tube of toothpaste
2-3 days before	Gather materials.	

Time Required

- 15 min

Safety Precautions

- Tell students to be careful not to poke themselves with the scissors when they make a hole in the bottom of their glass.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Domed mountains are broad, circular mountains formed when layers of rock are uplifted. The toothpaste should uplift soil (and rocks) as it is squeezed into the soil. The uplifted soil will likely take a dome shape.

Activity Notes

- You may wish to do his activity as a teacher demonstration.
- Have some small stones on hand for students to confirm their answers for What Did You Find Out question 2(a).

Supporting Diverse Student Needs

- For enrichment, students could create a 3-D model of a volcano to illustrate how it can become a mountain.

What Did You Find Out? Answers

1. This activity is similar to the formation of domed mountains because domed mountains are formed as magma is forced up by pressure from deep within Earth that uplifts the rocks at the surface
2. (a) and (b) Accept all reasonable answers. If time allows, have students test their predictions.
3. Moving magma may also create hotspots. (Students will most likely not be aware of various igneous features such as dikes, sills, batholiths, and laccoliths.)
4. If the toothpaste hardened under the surface of the soil, it would represent intrusive rock. If the toothpaste hardened at the surface of the soil, it would represent extrusive rock.

Conduct an Investigation 11-3F

Building a Mountain-Building Theory, p. 401

Purpose

- Students investigate and interpret patterns in the structure and distribution of mountain ranges.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before	Collect atlases or arrange for research time in the library or computer lab.	For each group: – BLM 4-36, Building a Mountain-Building Theory – 3 colours of coloured pencils or markers – atlas or other source of mountain locations
2-3 days before	Make transparencies or copies of BLM 4-36, Building a Mountain-Building Theory.	

Time Required

- 45–60 min

Safety Precautions

None

Expected Results

Mountain ranges that are close to earthquakes and volcanoes include the following: Coast Ranges, Andes Mountains, Himalayas, Alps, Carpathians, Balkan Mountains, Zagros Mountains, Sayans Mountains, and Caucasus Mountains. Mountain ranges that are not close to earthquakes and volcanoes include: Ural Mountains, Appalachians, Chersky Range, Kolyma Range, Koryak Range, Great Dividing Range, and Chukotsk Ranges.

Activity Notes

- Students may need help locating mountains in the atlases. You can list the names of the largest mountain ranges to help them.
- This investigation can take one or two class periods, depending on the amount of background information provided. You could approach this activity as a cross-curricular activity and have the social studies teacher help your students locate the mountain ranges.
- This investigation works well as a group activity where group members divide the responsibilities.
- If time permits, allow students to present a few maps to the class along with their new theories on mountain building.

Supporting Diverse Student Needs

- A great way to empower your academically weaker students is to choose their maps as an example to show the entire class.
- For enrichment, students could write a newspaper article that announces the development of plate tectonic theory and how it explains the formation of mountains.

Analyze Answers

1. Most students will probably suggest some of the following: folded mountains, faulted mountains, volcanic mountains, mountains made at divergent boundaries, mountains made at convergent boundaries, and possibly even land mountains and ocean mountains. The last two categories are not actual types of mountains, but since this is a question about process, it does not matter whether students can correctly classify all the mountains of the world.
2. Students may state that most mountains occur at plate boundaries.
3. (a) and (b) Many, but not all, volcanoes occur near mountain ranges.

Conclude and Apply Answers

1. (a) Most, but not all, mountains occur at plate boundaries.
   (b) The Rockies, the Himalayas, and mountains in Africa do not occur at the present plate boundaries.
2. Students' answers could include the points from their answer to Analyze question 1.
3. (a) and (b) Discuss students' predictions and reasons as a class. Accept all reasonable answers.
4. Accept all reasonable answers, such as "a large area of Earth's surface that has been uplifted by geological processes."

USING THE FEATURE

Science Math Connect: Keeping Track of All Those Zeros, p. 402

Ask students to describe how big a million is and how big a billion is. Pose the following problem to them: If you were to save $100.00 per day, how long would it take you to save one million dollars?

(1 000 000 divided by 100 dollars per day = 10 000 days, or 27.4 years)

How long would it take you to save one billion dollars?

(1 000 000 000 divided by 100 dollars per day = 10 000 000 days or 27 397.26 years)

Science Math Connect Answers

1. 1.0×10^{12}
2. 213 mya (.213 bya)
3. Accept all reasonable answers. Students' answers could include counting the number of stars in a galaxy, the number of galaxies in the universe, the number of grains of sand on a beach, etc.

SECTION 11.3 ASSESSMENT, p. 403

Check Your Understanding Answers

Checking Concepts

1. Students' diagrams should show wavy layers formed by rock under heat and pressure.
2. Students' diagrams should show a break through layers with layers on one side of the break higher than those on the other side.
3. Volcanic activity contributes to mountain forming when magma is forced up by pressure from deep within Earth and the rock is uplifted.
4. Rock along a fault can move up or slide down, forming fault block mountains. (Rock on each side of a fault can also slide past each other, causing an earthquake.)
5. Some of the rock in the Western Zone has come from the sea floor. Rock in the Central Zone is the remains of volcanic islands. Rock in the Eastern Zone is related to the rock of Africa and Europe.
6. Fossils are the remains of organisms that lived long ago.
7. The geologic time scale is a way of dividing Earth's history into smaller units, based on the appearance of different kinds of life forms.
8. (a) Four major eras in Earth's history are (in any order) Cenozoic, Mesozoic, Paleozoic, and Precambrian.
   (b) Cenozoic: human-like organisms, placental mammals; Mesozoic: flowering plants, birds, mammals, dinosaurs; Paleozoic: cone-bearing plants, reptiles, seed plants, amphibians, land plants, jawed fish, algae, animals with and without backbones; Precambrian: bacteria-like organisms, Ediacarans
9. Joseph Burr Tyrrell discovered the world's richest collection of dinosaur fossils and proof that the climate of Alberta had once been much warmer.

Understanding Key Ideas

10. Students' answers could include that the Rockies are growing taller because of continuing forces that are causing them to uplift. The Appalachians are getting smaller because they are slowly eroding and there are no other forces building them up.
11. There is little fossil representation in the Precambrian rock record because during most of the Precambrian era, life was microscopic.
12. Dinosaur fossils have been found in areas where they would not be able to live today because the land masses have moved and areas that were once tropical and swampy are now in colder regions.
13. The percentages of the graph should be approximately Precambrian 87%, Paleozoic 7.6%, Mesozoic 3.9%, Cenozoic 1.5%.

Pause and Reflect Answer

Mountains become taller when colliding plates cause the rock to uplift. Mountains also become taller when ash and lava are added to volcanic mountains. Mountains become smaller when they are worn down through the processes of weathering and erosion.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment BLMs.

CHAPTER 11 ASSESSMENT, pp. 404–405

PREPARE YOUR OWN SUMMARY

Student summaries should incorporate the following main ideas:

1. Plate Tectonics
   - According to the theory of plate tectonics, Earth's crust is made up of plates that interact.
   - The theory of plate tectonics grew out of the theory of continental drift and is based on evidence gathered by sonar, magnetometers, and deep-sea drilling.
   - Supporting evidence for continental drift includes evidence from paleogeography, biology, geology, and meteorology.
   - The shape of the continents and the way they appear to fit together are paleogeographic evidence.
   - Biological evidence includes fossils of the same types of living things found on different continents.

- Geological evidence includes similarities in age and type of rocks on both sides of the Atlantic Ocean.
- Meteorological evidence includes the presence of coal beds in places such as Canada and Antarctica, where the climate is too moderate to have supported the growth of the tropical plants that form coal.
- Convection currents are the driving mechanism behind plate movement.
- Plates move together at convergent boundaries. Plates move apart at divergent boundaries. Plates slide past each other at transform boundaries.
- Whenever moving tectonic plates meet, there is stress, causing either subduction (leading to volcanoes and mountain building) or release (earthquakes).

2. Earthquakes
   - An earthquake is a shaking of the ground.
   - Seismographs measure and record earthquakes. The Richter scale measures the strength of an earthquake.
   - Seismic waves are energy waves that travel outward from the source of an earthquake.
   - The focus of an earthquake is deep in the crust where the earthquake begins. The epicentre is the surface location directly above the focus.
   - Most earthquakes occur along active plate boundaries.
3. Volcanoes
   - A volcano is an opening in Earth's crust
   - Volcanic eruptions have benefits as well as risks.
   - Volcanoes can be found where plates collide, where plates separate, and in areas where plates are thin.
   - The volcanoes encircling the Pacific Ocean are called the Ring of Fire.
4. Mountains
   - There are folded mountains, fault block mountains, and volcanic mountains.
   - Some mountains, such as the Rockies and Himalayas are still growing. Others, such as the Appalachians are being worn down.
5. Geologic Time
   - Earth is approximately 4.6 billion years old.
   - The geologic time scale divides the history of Earth into smaller sections based on when certain organisms appear and disappear in the fossil record.
   - The four main eras include the Precambrian, Paleozoic, Mesozoic, and Cenozoic.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. The four layers from the outside in are crust, mantle, outer core, and inner core. The crust should be shown as a very thin layer and the inner core should be shown as a solid sphere.
2. (a) Pangaea was a huge land mass that existed over 200 million years ago and included all the continents, which fit together.
   (b) Pangaea no longer exists because the plates are moving, causing the continents to move apart.
3. (a) Any three of: shape of continents (paleogeographical), rocks and rock layers (geological), fossils (biological), and climate change (meteorological).
   (b) Three types of evidence are features on the sea floor detected by sonar, stripes of magnetic rocks on sea floor detected by magnetometers, and differences in ages of rocks, detected by deep-sea drilling.
4. Sample answer: Convection currents help explain plate movement because molten rock rises and moves the plates along like a conveyor belt.
5. The Richter scale helps geologists describe earthquakes by providing a scale that measures the strength of earthquakes.
6. Students' diagrams should resemble the illustrations in Table 11.2 on page 377 of the student book. The normal fault should show the rock above the fault moving downward. The reverse fault should show the rock above the fault moving up and over the rock below the fault. The transform fault should show the plates trying to slide past each other.
7. (a) Most of the world's earthquakes happen along active plate boundaries.
   (b) Rock at active plate boundaries moves relative to rock on the other side of the boundary and breaks, causing an earthquake.
8. (a) Most of the world's volcanoes are found along plate boundaries.
   (b) The pressure at plate boundaries can force magma to the surface where it erupts.
9. Mountains can be formed by folding, by fault blocks, and by volcanic eruptions.
10. (a) Most of the world's mountain ranges are formed near converging plates.
   (b) If plates collide, their leading edges crumple, forming mountains. If one plate

subducts under the other, melting occurs, forming volcanoes and mountain ranges.
11. In a fold, the rock bends. In a fault, the rock breaks.
12. Sample answer: Life forms in the Mesozoic included dinosaurs but no humans. Life forms in the Cenozoic included humans, but no dinosaurs.
13. (a) Subduction zone
 (b) Volcanoes and mountains form at a subduction zone.
 (c) The rock melts and the molten rock uplifts crust to form mountains and erupts to form volcanoes.

Understanding Key Ideas

14. (a) The journalist referred to the epicentre as being located below the surface. This is incorrect. The epicentre is found at Earth's surface. The journalist should have used the term *focus*.
 (b) Kobe is a large, populated Japanese city, with many high-rise buildings and a large transportation infrastructure. The Bolivian earthquake hit a rural community with large tracts of farmland.
15. We do not have fossil evidence of all the species that once lived because some species were microscopic and other species had soft body parts that were not preserved as fossils.
16. Accept all reasonable questions, such as:
 (a) Whose theory of continental drift was rejected by scientists of his time?
 (b) What Canadian scientist proposed the existence of transform boundaries?
 (c) Who discovered the world's richest deposits of fossils?
17. Accept all reasonable answers. Violent eruptions are due to gases dissolved in the magma. When the gas-infused magma reaches the surface of a volcano, the gas explodes from magma, causing violent eruptions. Different lavas have different mineral compositions that can cause a difference in the type of eruption.
18. This discovery supports the theory of continental drift because it is unlikely that the same species lived in two countries separated by an ocean and nowhere else at the same time.
19. Students' answers could include the following suggestions. Convection currents can be demonstrated by boiling noodles or rice, etc., in water. When the water boils, the water near the bottom of the pot gets hot and rises. The water near the top of the pot is cooler and sinks. The surface of the water is always changing as different parts of the water move up and down; the movement of the solids in the liquid shows how the water is moving. Another example students may have used is that of air in a room may feel hotter higher in the room and cooler along the floor.
20. Sample answer: Convection currents have changed the surface of Earth from one land mass to seven continents. Convection currents have also caused the formation of mountain ranges, volcanoes, and earthquakes.
21. The time line should include the four types of evidence that Wegener considered for continental drift as well as evidence from sonar, magnetometers, and deep-sea drilling. The time line should also include Tuzo Wilson's contributions and indicate that more evidence continues to be found. The time line can begin in the 1900s (or even earlier as the fit of the continents has been noted for several hundred years) and continue to the present day.

Pause and Reflect Answer

Accept all reasonable answers. Most computer models have the Mid-Atlantic Ridge, Africa, and Eurasia moving closer to North America.

CHAPTER 12 OPENER, pp. 406–407

USING THE PHOTO AND TEXT

Have students read the chapter opener on page 406. Ask students to describe soil they are familiar with, such as that in their garden at home, in the school yard, or used in house plants. Ask, "Where does soil come from? Why does soil from different areas look and feel different?"

If any students point out that soil was classified as abiotic in Chapter 1 and question the chapter title, "Soil is the living component of Earth's crust," tell them that the term "living" in this context refers to soil being organic. The abiotic/biotic distinction is not used here. (During Chapter 1 discussions, some students may have argued that soil is biotic because approximately 5% of soil is humus, which is an organic (material.)

USING THE WHAT YOU WILL LEARN/WHY IT IS IMPORTANT/SKILLS YOU WILL USE

Have students read the Why It Is Important section on page 407 of the student book. Then ask students to work with a partner to list as many reasons as they can why soil is important to use. Partners can then meet in small groups to exchange ideas and add to their lists.

12.1 WEATHERING, EROSION, AND SOIL FORMATION

BACKGROUND INFORMATION

Weathering is the process that breaks rocks down into smaller and smaller fragments. Weathering results from the action of rain, the freezing of water, the force of the wind, the growth of plants, and the movement of water and ice. Mechanical weathering breaks down rock physically without changing its chemical composition. Chemical weathering breaks down rock by altering its chemical composition. Chemical weathering can occur in three different ways. Rocks and minerals can dissolve in water and then combine chemically with the many ions dissolved in the local water table. Oxidation, the combining of minerals and rocks with oxygen, is very common.

Water is the most powerful of geological forces. The Dungeon in the Bonavista area is a good local example of water as both a weathering and erosion agent.

Caves result from the action of slightly acidic groundwater on soluble rocks like limestone and dolomite. Water makes its way through limestone via cracks and other weaknesses. The minerals in the limestone, primarily calcite and dolomite, are dissolved. The minerals and water can be washed away in an underground river or continue to seep underground.

Erosion is the result of forces that act on rocks and soil to change their shape. The force that drives most types of erosion is gravity. Gravity gives water its potential, or stored, energy. When this energy is changed into kinetic energy (energy of motion), water becomes a powerful force, strong enough to move mountains. When kinetic energy abates, gravity ensures that the sediment carried by the water (or the wind) is deposited.

Deposition is the last stage in the erosion process. Glaciers have left boulders, known as erratics, over much of the land. Some erratics are as large as houses.

Coastal erosion is a problem in many shoreline communities. In areas where the shoreline is rocky, erosion is not as noticeable because it takes a much longer time to erode solid rock. In coastal areas where the coast is composed of loose sand, gravel, and mud, erosion rates may be very high. In Atlantic Canada, erosion rates of up to 12 m per year have been recorded.

Humans accelerate all forms of weathering by creating more acid rain, digging, excavating, tunnelling, blasting, and removing soil and rock that would otherwise remain undisturbed. Humans cause erosion any time they disturb rocks, soil, and/or landforms. When homes, businesses, and roads are built, the rocks, soil, and plants are loosened and more easily eroded. Land cleared for farming can be eroded by floods or wind during drought or fallow periods.

Weathering is the first stage in soil formation. Soil is a combination of weathered rock and minerals, organic matter, air, and water.

COMMON MISCONCEPTIONS

- Students may confuse weathering and erosion. Weathering is the process of breaking down rock into sediments. Erosion is the process of loosening and transporting sediments over Earth's surface.
- While students are usually aware of the power of high winds or floods, they often underestimate the power of erosion. Ask them to start making a list of areas in their own neighbourhood that have been affected by erosion.
- Students may be unaware that they cause erosion by their actions, such as making paths in heavily travelled areas of parks, grass, and hills, and destroying the plants that anchor the soil.

Students can decrease the amount of erosion they cause by using pre-existing paths and not cutting across land.

ADVANCE PREPARATION

- Several weeks before doing Activity 12-1B on pages 416–417 of the student book, collect local examples of weathered rock specimens. Organize the specimens for testing.
- Activity 12-1C on page 418 of the student book requires about a week's time after set-up for crystals to develop.
- If you wish to include a field trip as part of Activity 12-1D on page 419 of the student book, you will need to make arrangements several weeks in advance.
- Consult the Unit front matter for a list of BLMs that can be used when teaching this section.

INTRODUCING THE SECTION, pp. 408–409

Using the Text

Ask students to describe the shape of river stones or rocks on most beaches. The rocks are smooth from the weathering effects of water and sand rubbing over them repeatedly. Explain that all rocks weather over time. Some rocks crack, some buckle, and others crumble into sediment. Ask, "Are there different ways in which rocks can be weathered?" and "How long does it take to weather some types of rocks?" to further investigate the phenomenon of weathering.

Ask students to share their prior knowledge of the effects of chemical weathering. Discuss how acid rain affects rocks and minerals. Ask, "Where do the minerals that are dissolved by the acid rain go?"

Ask students if they know of roads or bridges being washed into the water. Students may also know of waterfront homes that are at risk of falling in the water because of the erosion of the shoreline.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the text and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, which lists the Key Terms given in the unit, can be used to assist students.

Using the Did You Know, p. 409

This Did You Know can serve as a bridge between the discussion of mountain building in Section 11.3 and the processes of weathering and erosion introduced in this section. Students may be able to identify local examples of rolling hills or other features that are in the process of being worn down.

USING THE ACTIVITY

Find Out Activity 12-1A

Use the Force, p. 409

Purpose

- Students use a stream table or metal pan to help model how sediment is moved from location to location.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Gather materials.	For each group: – a mixture of sand and gravel – a stream table or metal pan

Time Required

- 30 min

Safety Precautions

- Remind students to wash their hands when they have completed the activity.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

The sand and gravel represent sediments. Blowing on the sand and gravel represents wind erosion. The water represents precipitation and water erosion. Tapping, shaking, and tilting the pan represents movement of sediments through earthquakes or changes in the landscape.

Activity Notes

- Use old metal cake pans or disposable foil cake pans. (Students will be tilting, shaking, and tapping the pans. Rocks and sand can be abrasive.)
- Use clean sand and gravel. Make sure that the sand and gravel are dry. If you have more than one class, you may wish to do the activity on alternate days or replace any wet sand with dry sand between classes.
- If possible, use large containers. The containers should be deep in order to keep sediments inside. Shoeboxes work well, as do metal pans, though they may be scratched.
- You might wish to put one large plastic tray at the front of the class and challenge different students to come forward and move the sediment in different ways.
- Remind students that all the sediment must stay in the container.
- Be sure to have students dispose of the sediment in a large bucket and not down the sink. You can separate the sand and gravel with a wide-mesh kitchen strainer.
- You may need to demonstrate how to shake, tilt, and tap the pan or table to move the sand and gravel.
- Foil pans will bend a little, so students may need to be told to steady them by holding both sides of the pan.
- Students should get water after they have done the shaking. This will help avoid spills during the first part of the activity.

Supporting Diverse Student Needs

- For enrichment, students could model how features such as valleys are formed, or how obstacles such as boulders change the movement of sediment.

What Did You Find Out? Answers

1. In addition to adding water, students' methods probably included tilting, shaking, and tapping on their pans or the table. Some students may have tried blowing on the sand and gravel.
2. Most students will answer that water was the most effective method. Ice cubes are also very effective. Accept all reasonable answers.
3. Blowing resembles the wind. Tilting the box creates a steep slope that allows gravity to pull sediments downhill. Pushing on the sediments with a piece of cardboard or ice represents the effects of glaciers.
4. Students' answers could include some of the following:
   - Roads cause water run-off that is not absorbed or that is channelled to sewers.
   - In house construction, layers of soil are moved or exposed, and drainage systems are changed.
   - Human diversions of water systems (including sewers and storm pipes, dams, and canals) change the natural flow of water, affecting the distance, direction, and amount of sediment that is carried and deposited.
   - Farming exposes large areas of soil to the wind and rain when trees are cleared and fields are ploughed.
   - Forestry removes trees and exposes soil.
   - Open-pit mining cuts rocks from the land and exposes the remaining rocks to erosion.
   - Acid rain can kill trees, increasing erosion.
5. Accept all reasonable answers.

Using a Demonstration

- To demonstrate that rocks break apart and erode due to a physical change, place two rocks in a plastic jar and shake them. After a short period of shaking, students will notice some dust. The dust can be placed under a viewer or hand lens to see the particles.
- You can demonstrate deposition by mixing soil with water in a clear container and allowing the soil mixture to settle.
- Rainy days are good days to take the class on a trip around the schoolyard to investigate the processes of erosion and deposition taking place in a field or stream near the school.
- To demonstrate erosion due to falling water, place a bar of soap on a sponge and place the sponge under a faucet in a sink. Use the faucet as usual for a day or two, allowing the water to hit the centre of the soap. An indentation eventually will form in the middle of the soap. Compare what happens to the soap to what happens to rocks under a waterfall: eventually the rocks break apart from the force of the running water.

TEACHING THE SECTION, pp. 410–415

Using Reading

Pre-reading—Predict-Read-Verify

Break the section into manageable chunks:
- Mechanical Weathering
- Chemical Weathering
- Erosion and Agents of Erosion
- Glacial Erosion, Deposition, and Formation of Soil

Ask students what they think each title means and to make a prediction about what they will learn. They can then read the chunks and compare their predictions to what they learned.

During Reading—Note-Taking

Encourage students to take notes as they read the assigned text material. It can be helpful to reword the topic titles as questions and then use the questions to guide note-taking.

After Reading—Semantic Mapping

After students have finished reading, they can create a flow chart showing how weathering, erosion, and deposition work together to create and transport sediments. This strategy can help students recall and organize text information.

Reading Check Answers, p. 412

1. Weathering is the mechanical and/or chemical breakdown of rock.
2. Two types of weathering are mechanical and chemical.
3. Three causes of mechanical weathering are frost wedging, plant action (root wedging), and animal action.
4. Three causes of chemical weathering are acidic groundwater, acidic rainwater, or acidic action of some organisms.

Reading Check Answers, p. 415

1. Erosion is the process that loosens and moves weathered rock particles over Earth's surface.
2. Water is the most powerful agent of erosion.
3. Deposition is the dropping of sediment, the final stage of erosion.
4. The main components of soil are eroded rocks and minerals, water, air, and organic matter.

USING THE ACTIVITIES

- Activity 12-1B on pages 416–417 of the student book is best used after students read about chemical weathering on page 412.
- Activity 12-1C on page 418 of the student book is best used after students read about chemical weathering on page 412.
- Activity 12-1D on page 419 of the student book is best used after students read about chemical weathering on page 412.

Detailed notes on doing the activities follow.

Conduct an Investigation 12-1B

Rocks that Fizz, pp. 416–417

Purpose

- Students study the effects of acid on rocks.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Collect local examples of weathered rock specimens. Organize the specimens for testing.	For each group: – small pieces of identified rock – two unidentified rock samples from your geographic area – watch glass – tongs or tweezers – medicine dropper – 1% hydrochloric acid
2-3 days before	Gather all materials. Make a few dropper bottles of 1% HCl. Phtocopy BLM 4-39, Rocks that Fizz.	

Time Required

- 30–45 min

Safety Precautions

- If 1% HCl acid is spilled on the skin, immediately wash the area with lots of cold water.
- It is safe to wash dilute HCl down the sink; it will help remove some of the lime build-up caused by hard water.
- Remind students to wash and dry the specimens.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards. Ensure that everyone, including you and any helpers, wears safety goggles and aprons when using the acid.

Expected Results

A positive result with the acid on the rock will be the formation of bubbles of carbon dioxide gas. When a rock or mineral reacts with hydrochloric acid, it indicates that the specimen has calcium carbonate in it. Chalk gives a wonderful positive reaction with hydrochloric acid because it is formed from the shells of ancient sea creatures. Most sandstone is cemented with silica. However, if you have sandstone that reacts with HCl, then it has been cemented with calcite.

Activity Notes

- The unknown local rocks should be collected from a local outcrop. Ideally, they would include limestone and sandstone.
- Chalk can be taken from the chalkboard supplies.
- You may wish to include an animal shell, such as a clam shell for testing. This will help students understand that the chemicals in the shell are the same as those in marble and limestone and these chemicals act as a glue to hold the rock together.
- Remind students that when a rock or mineral reacts with hydrochloric acid, it indicates that the specimen has calcium carbonate in it.

Supporting Diverse Student Needs

- Students with weaker language skills could work with students with strong language skills.
- For enrichment, students could, with your permission and following correct safety procedures, test their predictions from Analyze question 3.

Analyze Answers

1. (a) The manipulated variable was the type of rock being tested.
   (b) The responding variable was whether or not the rock reacted with the acid and produced a gas.
2. (a) The types of rocks most affected by chemical weathering are limestone, chalk, and marble. Unknown rocks A and/or B would be included in this group if either or both reacted positively to the HCl.
   (b) The rocks that bubbled the most were the ones most affected by chemical weathering.
3. Accept all reasonable answers.

Conclude and Apply Answers

1. The minerals are reacting with the HCl and dissolving.
2. (a) and (b) Answers will vary depending on the identity of the unknown rock.
3. Chemical weathering could weaken the rock so that it could more easily be mechanically weathered.

Find Out Activity 12-1C

Crystals in a Cave, p. 418

Purpose

- Students model the formation of stalactites and stalagmites.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Gather materials.	For each group: – 2 small beakers or jars (such as baby food jars) – Epsom salts or baking soda – tap water – spoon – 2 washers – 30 cm cotton string or yarn – sheet of dark construction paper

Time Required

- 10–15 min set-up
- 1 week or longer to grow crystals

Safety Precautions

- Remind students not to taste or eat anything in the science room.
- Take care if using glass jars that the jars do not break.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Water containing Epsom salts (or baking soda) moves through the string and drips on the paper. Crystals are deposited on the paper as the water evaporates. In caves, water drips from cracks in the walls and ceilings. The water contains calcium ions dissolved from limestone. If the water evaporates from the ceiling of a cave, a deposit of calcite is left behind. Stalactites (hanging from the ceiling) form. Where drops of water fall to the floor of the cave and evaporate, a stalagmite forms. Both stalactites and stalagmites can be seen in the photograph on this page. The cave show is in Buchan Cave Reserve, Victoria, Australia.

Activity Notes

- Clear plastic disposable glasses can be used instead of jars or beakers.
- This activity could be done as a teacher demonstration.

Supporting Diverse Student Needs

- For enrichment, students could research other features formed in caves and share their information with the class.

What Did You Find Out? Answers

1. In caves, water containing dissolved minerals drips from cracks in the walls and ceilings. When the water evaporates, it leaves mineral deposits behind.
2. Crystal formation would likely be faster in a warm, humid classroom because chemical weathering occurs faster in a warm, humid environment.

Find Out Activity 12-1D

Weathered Lettering, p. 419

Purpose

- Students observe evidence of weathering on headstones.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before	(Optional) Make arrangements for visiting weathered headstones in a cemetery.	For each group: – photographs of headstones – BLM BLM 4-40, Weathered Lettering.
2-3 days before	Download and print photographs of weathered headstones. Phtocopy BLM 4-40, Weathered Lettering.	

Time Required

- 15–20 min (if viewing photographs)

Safety Precautions

- If visiting a cemetery, follow provincial field trip safety guidelines.

Expected Results

In general, for headstones of the same age, those in warmer, more humid areas will weather faster than headstones in cooler, drier areas. Headstones in exposed, windy areas will also likely weather faster than headstones in protected areas. Headstones of marble, limestone, and sandstone will likely have weathered more than headstones made of harder rock, such as granite. Students may find examples of more recent headstones that have weathered more than some of the older ones. If visiting a cemetery, students may also note some headstones made from wood, and headstones that have been repaired and/or cleaned.

Activity Notes

- If possible, provide students with samples of marble, limestone, sandstone, slate, and granite to help them identify the rocks they view.
- Students should notice that the legibility of the letters is only one aspect of the weathering of the headstones. Many headstones also show staining from acid rain, the results of plant growth, or signs of erosion due to wind-borne particles.
- Links to photographs of weathered headstones can be found at www.discoveringscience.ca.

Supporting Diverse Student Needs

- Pair students with weaker language skills with students with strong language skills.
- For enrichment, students could research the types of headstone used in recent times and how their rate of weathering compares to the rate of older headstones.

What Did You Find Out? Answers

1. (a) The action of water in mechanical weathering breaks down the headstones as it runs over them and as it freezes and thaws in the cracks in the rock. Students will likely view evidence of frost wedging in the cracks and missing pieces of rock.
   (b) In chemical weathering, acidic rainwater and acids from lichens, bacteria, or fungi react with the rock and slowly dissolve the rock, causing cracks and crevices. Students may note stains and places where rock has been dissolved due to acid rain, lichens, and other chemical weathering.
2. (a) Students will likely answer no.
   (b) Headstones made of different materials will weather at different rates. Depending on the headstones viewed, there may also be climatic differences or differences in exposure to wind and rain.
3. Answers will may include marble, limestone, sandstone, granite, and slate. In some cemeteries there may be metal headstones, such as iron or zinc.
4. Answers will depend on the headstones students viewed, but there will likely be some differences.
5. Accept all reasonable answers, such as climatic conditions and pollution (acid rain).
6. Answers will depend on the headstones viewed, but students may note an increase in the number of headstones made from harder rock, such as granite in recent times. Headstones in the past may have been chosen for their softness and ease of engraving. Tools and technologies for engraving harder rock are now more readily available.

USING THE FEATURE

www Science: Sails Made of Stone

Some students may have visited the tolts and can share their experience with the class. You may wish to read this feature aloud to the class, pausing after each paragraph to check understanding. Academically weaker students may experience some difficulty understanding all the terms and would benefit from a group discussion.

SECTION 12.1 ASSESSMENT, p. 421

Check Your Understanding Answers

Checking Concepts

1. Students' drawings should show water entering a rock, freezing and expanding, and causing (or expanding) a crack.
2. Chemical weathering is different from mechanical weathering because in chemical weathering chemical reactions occur with rocks to create new substances. In mechanical weathering, rocks are simply broken into smaller pieces.
3. (a) Plants contribute to mechanical weathering when their roots enter the cracks of a rock and break the rock apart as they grow.
   (b) Plants contribute to chemical weathering when acidic fluids that they produce dissolve the rock.
4. In chemical weathering, acidic rainwater and acids from lichens, bacteria, or fungi react with the rock and slowly dissolve the rock causing cracks and crevices. The action of water in mechanical weathering breaks down rock as it freezes and thaws in the cracks in the rock.
5. Erosion
6. Two processes that cause erosion are meteorological processes such as rain and wind, and geological processes such as gravity and glaciers.
7. Glaciers move sediments when they push loose rocks and soil out of their path and when they drag rocks and sediments far away.
8. Deposition is the final stage of erosion.
9. (a) Erosion is considered to be a destructive process because it wears down land and features and carries them away.
   (b) Deposition is considered to be a constructive process because it produces and builds up land features.
10. Sediments are the in-between stage in the rock cycle between a parent rock and a sedimentary rock.

Understanding Key Ideas

11. (a) Mechanical weathering breaks up larger rocks into smaller pieces, just like the larger candy is broken into smaller pieces. The smaller pieces are weathered faster because there is more surface area exposed.
    (b) There are chemical reactions in your mouth that help digestion, just as chemical weathering helps to break down the pieces of rocks.
12. Students' answers may include soil, broken sidewalks, and cracked basements.
13. Students' illustrations should include that the rock is broken down and/or cracked through weathering. Then erosion loosens the rock and gravity (erosion) causes it to fall.

Pause and Reflect Answer

Students' articles could include both mechanical and chemical weathering and both meteorological processes (rain, wind, moving water) and geological processes (gravity, glaciers) of erosion.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment BLMs.

12.2 SOIL TYPES AND CHARACTERISTICS

BACKGROUND INFORMATION

Weathering is the first stage in soil formation. The soil type that forms depends on the rock type that is being weathered. For example, when shale is weathered, clay type soil results. As the rock crumbles into smaller fragments, plants begin to grow in the weathered rock. Worms, insects, bacteria, and fungi live among the plant roots and add organic matter, such as leaves and twigs, to the soil. Finally, as the plants and animals die, they form humus. Humus is a source of nutrients for plants, providing nitrogen, phosphorus, potassium, and sulfur.

Soil is influenced by climate, type of rock, slope, and amount of moisture, as well as the length of time it has been weathering. Soils will develop at a faster rate in warmer climates since these climates allow for faster chemical weathering. Living creatures can speed up the process of making soil. Soil can take thousands of years to form, so soil preservation is extremely important.

Large gritty particles mean there are air spaces between the particles of soil. These spaces allow water to drain quickly, so this kind of soil is dry or arid most of the time. Clay has fine particles that fill the spaces between the other kinds of particles, leaving little room for air and water. Clay holds a lot of water and does not drain quickly. Gardeners prefer loam (a mixture of clay, sand, and silt) because its nutrient content, permeability, water-holding capacity, and drainage are good.

Porosity is the amount of empty space in a soil or rock. Permeability is defined as a measure of how easily liquids and gases pass through a soil or a rock.

COMMON MISCONCEPTIONS

- Some students believe that soil does not change. In fact, weathering and the activities of organisms, such as earthworms, are constantly changing soil.

ADVANCE PREPARATION

- You will need samples of garden soil and dirt for Activity 12-2A on page 423.
- You will need samples of clay, gravel, and sand for Activity 12-2B on pages 428–429. Each group of students will need to bring a local soil sample they have collected.
- Consult the Unit front matter for a list of BLMs that can be used when teaching this section.

INTRODUCING THE SECTION, pp. 422–423

Using the Text

To introduce this topic, you may wish to ask students what they think soil is composed of. Students may suggest rocks, sand, roots, beetles, worms, dead roots, plants, and insects, water, air, animal droppings, nutrients, and clay. Write the list of soil components on the chalkboard or on an overhead transparency and then discuss with students whether they think all of the items generated are found in every soil sample.

Ask students to think about which of the components listed are the most important. Students should rank their list in order from the most to the least important.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the text and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, which lists the Key Terms given in the unit, can be used to assist students.

Using the Did You Know, p. 423

Ask students "When you hold a handful of soil, how many states of matter are you holding?" The answer is all three—the liquid part is water held in the spaces between the particles in the soil. The gas part is air, which is also found in those spaces. The solid part of soil is minerals and organic matter.

Using the Activity

Find Out Activity 12-2A

Comparing Dirt and Soil, p. 423

Purpose

- Students compare and contrast soil and dirt.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Gather materials.	For each group: – 250 mL dirt/ground rocks – paper – 250 mL rich garden soil – hand lens – stir stick – optional: goose-neck camera to magnify and view specimens

Time Required

- 10–15 min

Safety Precautions

- Students should wash their hands after they finish this activity.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

The sample of soil will likely have a stickier texture, more organic material, and more identifiable components. It might also be darker, richer, and less powdery than the dirt sample.

Activity Notes

- Use BLM 4-41, Comparing Dirt and Soil, to show students how to use a Venn diagram.
- Encourage students to consider size of particles, colour, organic material, and consistency.

Supporting Diverse Student Needs

- Academically weaker students could be paired with students with strong language skills in case they need assistance in describing their observations.
- For enrichment, students could design an investigation to compare dirt and soil as growing mediums for plants. Students could do the investigation and share their results with the class.

What Did You Find Out? Answers

1. Venn diagrams should show that the soil sample included organic material and the dirt sample did not. Depending on the samples, the dirt sample may have been composed of only powdered rocks. Students may benefit from discussing the similarities and differences and hearing each other's observations.
2. Accept all reasonable answers. Depending on the soil sample, students should have been able to identify some organic matter.
3. Accept all reasonable answers, such as that animals have lived (and died) in the soil.
4. Students will likely respond that soil contains more nutrients and provides more stability for the plant to anchor itself.

Using a Demonstration

Students could be shown samples of soil and asked to relate them to the type of process that occurred in their formation. For example, soil formed by glacial movement will contain particles of a wide variety of sizes as glaciers cannot separate the particles, according to size, as water can.

TEACHING THE SECTION, pp. 423–427

Using Reading

Pre-reading—Predict-Read-Verify

Break the section into manageable chunks:

- Humus
- Soil Profiles
- How Do Soils Develop?
- Particle Size, Porosity, and Permeability and Types of Soil

Ask students what they think each title means and to make a prediction about what they will learn. They can then read the chunks and compare their predictions to what they learned.

During Reading—GIST

GIST helps students distil text material into its most important ideas or concepts. Have students write the subheadings, then read the text for each subheading and write a summary of ideas presented. They should reduce the passage to just 20 words that capture the gist of the text.

After Reading—Reflect and Evaluate

When students have completed taking notes, they can quietly review their notes and choose three interesting facts. Students can then share these facts as a class or in a small group discussion.

Reading Check Answers, p. 426

1. Leaching dissolves elements and minerals from upper soil layers.
2. Three layers in a soil profile are topsoil, subsoil, and weathered bedrock.
3. Five factors that determine how soils develop are parent material, climate, vegetation, landscape, and time.

Reading Check Answers, p. 427

1. Porosity is the amount of empty space in soil or a rock.
2. Permeability is a measure of how easily liquids and gases pass through a soil or rock.
3. Clay has the smallest particle size.
4. Three main types of soil are sandy/gravelly, clay, and loam

USING THE ACTIVITY

- Activity 12-2B on pages 428–429 of the student book is best used after students finish reading this section.

Detailed notes on doing the activity follow.

Conduct an Investigation 12-2B

Be a Soil Sleuth (Core Lab), pp. 428–429

Purpose

- Students observe soil type and soil characteristics, including permeability and drainage rates.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2-3 days before	Test the drainage time for clay to gauge time needed for activity. Photocopy BLM 4-45, Be a Soil Sleuth.	For each group: – soil sample, sand, gravel, clay – paper – hand lens – ruler – 4 large plastic cups – thumbtack or pushpin – cheesecloth – rubber bands – scissors – 4 plastic coffee-can lids – 4 glasses or beakers (250 mL) – measuring cup or graduated cylinder – water – watch

Time Required

- 60–90 min

Safety Precautions

- Remind students to be careful with sharp or pointed objects.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Clay particles are so small (less than 0.002 mm) that there is very little texture, especially when wet. Clay-rich soils feel sticky or greasy. Sand has a high permeability and tends to feel dry and well-drained most of the time. The relatively big spaces between the particles mean that there is a lot of air in the soil. The relatively large particles 0.05 mm to 2.0 mm) feel gritty when you roll them through your fingers. Gravel has extremely high permeability with very large (over 2 mm), sharp, angular particles.

Activity Notes

- You will need one set of equipment per group of four students.
- You may wish to distribute BLM 4-45, Be a Soil Sleuth for students to use in recording their observations.
- Each student in the group should have a chance to use the hand lens and to feel the wet and dry texture of the soil.
- Remind students to note the area where they got their soil sample.
- You can standardize the number and size of the holes by putting the holes in the cups for students.
- Students tend to use similar descriptions for different soils and later have difficultly recognizing or understanding the differences between the samples as easily. Emphasize using good descriptions for their qualitative observations. Their observations should draw comparisons between the samples.
- To get more accurate results, students can average their drainage rate results with other groups' results, as long as each group uses the same amount of water and the same soil type. This would be a good opportunity to practise using averaging skills.

Supporting Diverse Student Needs

- It may be helpful to guide academically weaker students through the test for water drainage by demonstrating as they follow your lead.
- For enrichment, students could research the location of agricultural areas on Earth and describe the types of soil present in each.

Analyze Answers

1. (a) The grittiest sample was gravel.
   (b) The stickiest sample was clay.
   (c) Students' answers will depend on the type of area where the sample was collected.
2. (a) The gravel drained the most quickly. The clay drained the most slowly.
   (b) The gravel drained much faster than the others.
   (c) Students' answers will depend on the type of area where the sample was collected.

Conclude and Apply Answers

1. Adding sand and gravel to clay will increase the speed of drainage of a soil.
2. To increase the speed of drainage in the area sample, gravel and/or sand could be added. To decrease the speed of drainage in the area sample, clay could be added. Students' answers about why this is useful to know may include that people change the drainage rate of a soil to suit a particular purpose. For example, if you were making a dirt road, gravel could be added to a clay-based soil to increase drainage, making the road safer to drive on in the rain.
3. (a) Three characteristics of soil are particle size, permeability, and porosity.
   (b) Students may answer that permeability is the characteristic that most affects how quickly water drains through the soil.
4. The size of soil particles from largest to smallest are gravel, sand, and clay.

5. Garden soils should be a good mix of clay, sand, and silt. Humus is also needed for keeping the soil drained and allowing for air and water to pass through easily. A concentration of clay would make it more difficult for the roots of a plant to go through.

USING THE FEATURE p. 430

National Geographic: Visualizing How Dunes Form and Migrate

Ask students to share any prior knowledge they have of sand dunes. They may have visited dunes and be able to describe the types of plants growing there and the local wildlife.

SECTION 12.2 ASSESSMENT, p. 431

Check Your Understanding Answers

Checking Concepts

1. The main components of soil are weathered and eroded rock, humus, air, water, and living things.
2. The role of humus in the soil is to provide nutrients, promote good soil structure, and help keep water in the soil.
3. (a) and (b) Students' illustrations should show three layers labelled from the top down as topsoil, subsoil, and weathered bedrock.
   (c) Topsoil is the most fertile part of the soil, ranging from a few centimetres to more than a metre, consisting of soil that contains humus and small grains of rock and is home to many organisms. Subsoil is more tightly packed and lighter in colour than topsoil and less productive because it contains less water and organic nutrients. Weathered bedrock is beginning the long, slow process of rock evolving into soil and closely resembles the bedrock below.
4. Five major factors that determine how soils develop include parent material, climate, vegetation, landscape, and time.
5. From smallest to largest particle size: clay, sand, gravel
6. Porosity is the amount of empty space in a soil or rock, whereas permeability is a measure of how easily liquids and gases pass through the soil or rock.
7. (a) Three basic types of soil are sandy/gravelly, clay, and loam,
   (b) Sandy/gravelly soil has a high permeability, is dry and well-drained, and has a gritty texture. Clay soil has small particles and feels sticky or greasy. Loam is medium-textured and may feel gritty and sticky at the same time.

Understanding Key Ideas

8. As you go deeper into a soil profile, the amount of weathered rock increases.
9. Leaching is a harmful process because it removes soil material dissolved in water.
10. (a) Organisms include fungi, mould, bacteria, and earthworms. Other answers are also acceptable.
    (b) Organisms help to recycle nutrients as they dig and burrow in the soil. Their burrows also add spaces for air and water. When the organisms die, their remains are broken down to produce humus.
11. (a) Clay
    (b) You could add equal amounts of sand and loam. Students may have answered that you could add compost or earthworms or other organisms.
12. The rain forest profile would have a thicker, darker (more humus) topsoil than the desert profile. The rain forest soil would have more moisture.
13. Accept all reasonable answers, such as that deciduous trees cannot grow in sandy desert soil.
14. Accept all reasonable answers, such as that there is relatively little farmland in Newfoundland because there is so much wind erosion and the relatively hard rock weathers very slowly.
15. Sample answer:

Factor	Meteorological	Geological	Biological	Chemical
Acidic action				X
Glaciers		X		
Gravity		X		
Plants			X	
Rain	X			
Wind	X			

Pause and Reflect Answer

Students' investigations should include controlling the amount of water added to the soil and the amount of time it takes for a set amount of water to drain. Their manipulated variable will likely include what type of additions they will make to the soil (clay, sand, or gravel, etc.). Their responding variable will likely be the amount of water that drains from the soil in a given time.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment BLMs.

12.3 SUSTAINING FERTILE SOILS

BACKGROUND INFORMATION

Fertilizers are substances that provide nutrients for plants. Composts, manure, and chemical fertilizers could be addressed when looking at ways to enrich soils. It is not necessary to delve into the chemical nutrients of soils and the various soil deficiencies. It is sufficient to note that some of the organic material is either leached out or utilized by other living things, such as plants and other organisms.

Composting is the breakdown of plant material (decomposition). A classroom composting program could help students see the value of such a process. The composted material could be used at year end to help with school beautification programs.

Organic matter has been described as the lifeblood of the soil. The addition of organic matter can improve almost all soil properties. Adding organic matter results in looser and more porous soil, lower bulk density, higher water-holding capacity, greater aggregation, increased aggregate stability, less erosion, and ultimately greater soil fertility.

Preventing the soil from becoming too dry or too wet can usually reduce soil erosion due to wind and water. Many techniques involve leaving crop residues such as straw or chaff on the soil surface. Vegetative residues on the soil surface improve infiltration of water into the soil, reduce evaporation, and aid in maintaining organic matter. Residues (such as stubble) left upright all winter help to trap snow, which in turn increase soil moisture. Snowmelt moisture is more than four times as effective in moisture storage than is the moisture from a summer rainstorm.

Soils that are eroded, overused, and under- or over-irrigated can become degraded. Land degradation in arid, semi-arid, and sub-humid areas results from various factors, including climatic variations such as droughts and human activities such as deforestation, overgrazing, overcultivation, and poor irrigation practices. Degraded soil has fewer nutrients, so fewer plants can grow in it. When no plants are growing in it, no nutrients are returned to the soil. If little rain falls, the soil becomes dry and the ecosystem is at risk of desertification. Desertification is the process in which nutrient-depleted soils are formed through erosion of fertile soil. Students should understand that many of the problems associated with our use of soils can be solved using more ecological farming practices.

COMMON MISCONCEPTIONS

- Students may be unaware that there are unintended negative effects from using chemical fertilizers. Enriching soils with commercial chemical fertilizers may help produce larger crop yields in the short term. However, it may also harm the soil if used at the expense of regular crop rotation, which naturally enriches the soil and provides humus to keep it more stable. Chemical fertilizers containing phosphates may runoff into nearby aquatic environments and may result in algal blooms, which remove dissolved oxygen from the water. The resulting low oxygen levels prevent fish from living in the aquatic environments.

ADVANCE PREPARATION

- Two weeks before doing Activity 12-3B on page 436 of the student book, you may need to book the library or computer lab.
- One week before doing Activity 12-3D on page 439 of the student book, arrange to visit a garden store or nursery, or to have a fertilizer dealer or knowledgeable person speak with the class.
- One week before doing Activity 12-3E on pages 440–441 of the student book, ask students to start collecting test materials. Note that after set-up, the activity needs to continue for several weeks.
- Two weeks before students do the Unit Project on page 448 of the student book and/or the Integrated Research Investigation on page 449 of the student book, you may wish to book computer lab or library.
- Consult the Unit front matter for a list of BLMs that can be used when teaching this section.

INTRODUCING THE SECTION, pp. 432–433

Using the Text

Ask students what happens when trees and vegetation are removed from an area. Ask, "What impact does soil loss have on humans?" You may wish to structure an opportunity for students to investigate, debate, and discuss the use and misuse of soil in your region through the use of a role-play or a case study analysis.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the text and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, which lists Key Terms, can be used to assist students.

Using the Did You Know, p. 432

Ask students, "How is your health directly related to the health of the soil where your food is grown?" Discuss where and how the food is grown.

Using the Activity

Find Out Activity 12-3A

Save the Soil, p. 433

Purpose

- Students develop an understanding of the limited amount of topsoil available on Earth.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Gather materials.	For each group: – cutting board – knife – apple

Time Required

- 10 min

Safety Precautions

- Remind students that knives are sharp and can cause cuts if not handled correctly.
- Remind students that they should never eat anything in the science room.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Students will likely be very surprised that the peel from one-thirty-second of the apple represents all the topsoil that can support life.

Activity Notes

- Be environmentally conscious by using only as many apples as needed and by composting waste if possible.
- This activity can also be done effectively as a teacher demonstration.

Supporting Diverse Student Needs

- Students who have difficulty with fractions may have trouble doing this activity on their own.
- This is an excellent activity for visually oriented students. Emphasize the connection between the apple and Earth, and the representation of topsoil by the apple peel.
- For enrichment, students could write to an organization that is involved with the care and use of soils to find out what they can do to preserve soils in your region

What Did You Find Out? Answers

1. (a) If topsoil was lost in a region that had special climatic or growing conditions, the availability of this food might be limited. For example, specific regions supply pineapples and bananas. If these regions lost topsoil, production would decrease, prices of these items would increase, and eventually these items might no longer be available.
   (b) As with any ecosystem, other species also would be affected. The animals that lived in or near the crops, or that used by-products of the crops, would be affected by the decreased availability of the crops.
2. Loss of topsoil can lead to a total environmental change in a region. Topsoil holds the roots of all the plants and trees, so other plants are unable to grow if topsoil is lost. This, in turn leads to changes in animal species that inhabit the region.

Using a Demonstration

To demonstrate how vegetation cover and organic matter help reduce soil erosion, place a small potted plant in a mesh bag (such as an onion bag). A plant that is root-bound works best. Place a clump of soil from a dry, frequently tilled field in a second mesh bag. Place another clump of soil from an area where there is some vegetation and organic matter in a third mesh bag. Fill an aquarium with water and plunge the bags into the tank. Students can observe the amount of soil held by each soil sample.

TEACHING THE SECTION, pp. 433–438

Using Reading

Pre-reading—K-W-L (Know-Want to Know-Learned)

As students read the section, have them record questions that come to mind (at least one question per subhead). Later, students can share their questions as class and together the class can discuss the answers to the questions.

During Reading— Think-Pair-Share

Ask students to read a section of text independently, record their thoughts, and then pair up with another student to discuss and share their thoughts about the text. Partners collaborate to come up with one shared response.

After Reading—Reflect and Evaluate

When students have completed taking notes, they can quietly review their notes and choose three interesting facts. Students can then share these facts as a class or in a small group discussion. Students who compost at home can describe what they do with the composted material.

Reading Check Answers, p. 436

1. Desertification is the process in which nutrient-depleted soils are formed through the erosion of fertile soils.
2. Three types of plant nutrients are nitrogen, phosphorus, and potassium.
3. The intended positive effect of using fertilizers is enhanced plant growth.
4. The unintended negative effect of fertilization is increased pollution of water resources by run-off, leading to increased algal growth.

Reading Check Answers, p. 438

1. An ecological approach means considering the relationship of living things to their environment and with each other.
2. Four ecological farming practices include reducing reliance on chemical fertilizers, limiting run-off, no-till farming, and planting windbreaks.
3. Trees and shrubs are left near streams in forestry conservation practices to minimize soil loss.

USING THE ACTIVITIES

- Activity 12-3B on page 436 of the student book can be used at any time during this section.
- Activity 12-3C on page 439 of the student book can be used at any time during this section.
- Activity 12-3D on page 439 of the student book is best used after students have read about fertilizers on page 436 of the student book.
- Activity 12-3E on pages 440–441 of the student book can be used at any time during this section, such as after students have read about composting on page 435 of the student book.

Detailed notes on doing the activities follow.

Think About It 12-3B

Agriculture in the News, p. 436

Purpose

- Students research current issues related to agriculture.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before	Book computer lab or library if necessary.	For each group: – research materials

Time Required

- 30 min

Safety Precautions

None

Expected Results

Results will depend on what events are currently in the news. There will likely be items concerning genetic engineering of food crops, negative effects of chemical fertilizer use and/or feedlots, and benefits of organic farming and gardening. In addition, there may be issues in forestry, land use, and subdivisions that you could have students research.

Activity Notes

- Students can start their research at www.discoveringscience.ca.

Supporting Diverse Student Needs

- Academically weaker students should be paired with students with strong language skills.
- For enrichment, students could research and role-play various stakeholders in an environmental/economic impact meeting concerning forest or agricultural land as it relates to soil.

What Did You Find Out? Answers

1. (a) and (b) Students' answers will depend on the information that they find.

Find Out Activity 12-3C

Maintaining Moisture, p. 439

Purpose

- Students devise ways to maintain soil moisture.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before Day of activity	Gather materials. Set up a demonstration of the activity, if desired.	For each group: – 3 metal baking pans or similar pans – garden soil or potting soil – organic material, such as wood shavings, grass clippings, or leaves – water – fan (optional) – grow light or heat lamp (optional) – paper towel – soils moisture meter (optional)

Time Required

- 20 min to set up
- 10 min (several hours after set up)

Safety Precautions

- Ensure that electrical equipment is kept away from water and sinks.
- Review safety hazards of using fans, heat lamps, and electrical equipment.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Uncovered soil will dry out faster than soil that is covered or that contains organic material. Adding organic material such as wood shavings, grass clippings, or leaves to the surface of soil to slow evaporation of water is called mulching. Mulch also helps adjust soil temperature, control weeds, and prevent or control erosion

Activity Notes

- You may wish to do this activity as a teacher demonstration.
- Brainstorm with students different ways to measure soil moisture. *(Press paper towel on soil surface and compare moisture; use soil metre; squeeze water out of soil)*
- You may wish to have one group of students set up the activity with only the fan, another group with only a lamp, and a third group with both the fan and the lamp, so that results can be compared.

Supporting Diverse Student Needs

- This is a good activity for tactile learners.
- For enrichment, students could investigate the effect of different amounts of mulch and determine the ideal thickness of a layer of mulch.

What Did You Find Out? Answers

1. Trays with organic matter had more soil moisture.
2. There may be little difference in soil moisture between the trays with organic matter. The organic matter layered on top of the soil may retain the moisture for the short term, but it will eventually dry out. When organic matter is mixed throughout the soil, the moisture content stays high.
3. Students' answers may include using commercially available moisture meters or "squeezing" water out of soil.

Find Out Activity 12-3D

Fertilizer Formulations, p. 439

Purpose

- Students learn about the nutrients present in fertilizers and what fertilizers are used for

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Arrange to visit a garden store or nursery, or to have a fertilizer dealer or knowledgeable person speak with the class.	For each group: None

Time Required

- 40 min

Safety Precautions

- Students should be very careful about handling packages or containers of fertilizer. If you bring fertilizers into the classroom, ensure that there are no leaks in the packaging. Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

Three macronutrients are required by plants: nitrogen, phosphorus, and potassium. Plants receive natural supplies of these nutrients from organic matter and soil minerals, but these nutrients usually are not absorbed in sufficient amounts to satisfy the demands of crop plants. Fertilizers are added to increase the amounts of these nutrients during periods of plant growth and to replenish soil reserves after the crop has been harvested.

Nitrogen is an essential component of amino acids, which include chlorophyll, and is credited with producing new leafy growth and greater yield in crop plants. Phosphorus is an essential part of enzymes and nucleic acids and is important in stimulating root growth. Potassium is considered the fruit and flower nutrient because it is responsible for the storage of sugars and proteins in fruits.

Carbon, hydrogen, and oxygen are also considered to be macronutrients, but since they are freely available from air and water there is no need to add them to fertilizer. Calcium, sulphur, and magnesium often occur in parent material in high enough concentrations and are not usually added to fertilizers.

Activity Notes

- You might invite a knowledgeable person to speak to the class or have the class visit a nursery or garden store. Alternatively, you could have students use the Internet or other resources to find answers to the questions. Students may need extra time if they are completing the research on their own.
- If an expert is coming to address the class, have students read the activity ahead of time and be prepared to ask questions.
- You may wish to photocopy the instructions from a variety of fertilizer packages and make these available to your students.
- As a wrap-up, ask students to consider which fertilizers they would use in their own yard or garden.

Supporting Diverse Student Needs

- Academically weaker students may need extra assistance reading the instructions on the fertilizer packages.
- For enrichment, students could research which foods can be grown in your region because of our ability to enrich soils.

What Did You Find Out? Answers

1. Students' tables should include fertilizer uses, formulations, and types of fertilizers.
2. (a) Students' answers will vary according to package instructions.
   (b) Yes
   (c) Sample answer: What effect will application of different quantities of fertilizer have on the growth of plant X?

Conduct an Investigation 12-3E

Decomposing Dinner, pp. 440–441

Purpose

- Students investigate the process of composting and design their own experiments to see what factors affect the rate of decomposition.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Ask students to start collecting test materials.	For each group: – 4 identical plastic pots with drainage holes – saucers to go under pots – pieces of window screen or similar material – magnifying glass – small stones – labels for pots – garden soil (not sterilized) – water – approximately 250 mL of 2 items from List A and 2 items from List B List A: banana peels, cabbage leaves, grass clippings, potato peels, carrot peels, egg shells List B: aluminum foil, small pieces of plastic, shredded wax paper, shredded paper
2-3 days before	Have students bring in their test materials and begin formulating their hypotheses about what will happen to each of the materials. Gather the materials.	

Time Required

- Part 1: 40 min
- Part 2: 40 min over several weeks

Safety Precautions

- Remind students never to eat anything in the science room.
- Students should wash their hands thoroughly after each part of the investigation.
- Safety eyewear, lab coats, and gloves must be worn in accordance with provincial safety standards.

Expected Results

There are four main factors that affect the speed at which material composts. (1) The more surface area of material available, the faster microorganisms can break down and digest material. Surface area can be increased by chopping material into small pieces. (2) Oxygen and (3) moisture are needed throughout the decomposing material. This is why compost needs to be turned with a shovel regularly. (4) Temperature is also very important. The more heat available, the faster the material will decompose.

Activity Notes

- Encourage students to discuss environmental and economic reasons for composting.
- If you or any of your students have a composter at home, bring in a sample of well-decomposed compost to show students.
- Arrange the class into groups of up to four students. Each group can examine the same materials composting, or you may prefer to have each group compost several different materials. This gives more total information but does not allow for direct comparison between groups.
- After the investigation is finished, have students share some of their hypotheses and conclusions with one another. See if the results were consistent among most of the groups. If not, try to determine why any differences exist.
- As a class, discuss the role that composting and decomposition play in our daily lives.
- Encourage students to share their knowledge and experience of composting at home. Check their knowledge by asking them how the class investigation differs from their own experiences with composting.

Supporting Diverse Student Needs

- This is a very good hands-on activity for tactile and visual learners. They can be challenged to observe the changes carefully and to record the results.
- For enrichment, students could do research on factors that affect how quickly organic matter decomposes.

Analyze Answers

1. (a) Sample answer: Banana peels, orange peels, potato peels, and carrot peels decomposed most rapidly.
   (b) Accept all reasonable answers.
2. (a) Sample answer: Cabbage leaves, grass clippings, paper, and egg shells decomposed more slowly than the peelings.
   (b) Accept all reasonable answers.
3. (a) Sample answer: Aluminum foil, glass, and plastic did not decompose over the course of the investigation.
   (b) Students' answers may include that these items take many hundreds of years (or longer) to decompose.
4. Encourage students to revisit their hypotheses and refine them based on their results.

Conclude and Apply Answer

1. (a) Sample answer: Increasing temperature will speed up the rate of decomposition for items that are slow to decompose.
   (b) Sample answer: Use three different pots with identical materials to be composted. Place one of the pots in direct sunlight, one on a counter away from sunlight, and one in a refrigerator. Compare the rates of decomposition.

USING THE FEATURE

Science Watch: Putting a Stop to Desertification, p. 442

Ask students, "Even if desertification is not happening in your own backyard, does it still affect you? How?"

Science Watch Answers

1. Humans cause desertification by overcultivation, overgrazing by livestock, deforestation, and poor irrigation practices.
2. Desertification is a serious problem because it makes the land almost useless.
3. Planting trees helps combat desertification by acting as a wind break, helping bind soil and nutrients together, and providing shade, moisture, and nutrients to the soil.

SECTION 12.3 ASSESSMENT, p. 443

Check Your Understanding Answers

Checking Concepts

1. Sample answer: Topsoil is valuable because it takes hundreds of years to form a few centimetres of soil and the health of all animals, including humans, is directly related to the health of the topsoil.
2. (a) Desertification is the process in which nutrient-depleted soils are formed through erosion of fertile soil.

(b) Desertification occurs when natural vegetation is removed from land that receives little rain. (Other causes include overcultivation, overgrazing by livestock, deforestation, and poor irrigation practices.)
(c) Desertification is currently happening all over the world (in more than 110 countries, affecting about 30 percent of land).

3. Five modern farming practices that contribute to soil loss or destruction of the environment are ploughing long straight lines, cutting down trees and windbreaks, draining marshes, ploughing to the edge of rivers and streams, and using machinery that relies on combustion of fossil fuels (also: over-irrigation and removal of vegetation).
4. (a) Fertilizers are substances that provide nutrients for plants.
   (b) Three types of fertilizers are compost, manure, and chemical fertilizers.
5. Composting is the process of breaking down various organic materials, such as dry leaves, manure, and vegetable peelings.
6. Students' flow charts should include use of chemical fertilizers, leading to increased pollution in run-off, which increases algae in water, which results in less oxygen available, which makes it impossible for fish and other aquatic creatures to survive.
7. Any five of the following: reducing reliance on chemical fertilizers, limiting run-off, no-till farming, planting windbreaks, replanting harvested forest areas, and leaving trees and shrubs around streams.

Understanding Key Ideas

8. Sample answer: The impact of soil loss on humans is that variety and types of food could become limited, animals that lived in or near the crops, or that used by-products of the crops, would be affected by the decreased availability of the crops, further limiting food, and there could be a total environmental change in a region.
9. Sample answer: I do not want to add to pollution or to kill the soil microorganisms that provide a balanced diet for plants.
10. Limiting run-off helps to reduce the amount of soil lost to erosion when water flows along the surface.
11. Benefits of limiting reliance on chemical fertilizers are that pollution is reduced and microorganisms that provide a balanced diet for plants can flourish.
12. Students' diagrams should include the stubble left in the ground from the previous year's crop, and the seeds being planted in the stubble. A windbreak of trees should be included in the diagrams.
13. (a) When the trees and undergrowth are removed there is greater run-off and less water soaks into the soil. The soil is exposed to wind erosion.
    (b) This erosion could be reduced by leaving some of the trees and ground cover in place and by planting forage grasses or other ground cover on exposed soil.

Pause and Reflect Answer

Students' answers should show they know that the health of the soil influences the health of the plants, which in turn influences our own health. Students should describe ecological practices they would put into effect, such as reduced reliance on chemical fertilizers, composting and adding humus to the soil, encouraging soil organisms such as earthworms, planting ground cover when crops are not growing, and so on.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment BLMs.

CHAPTER 12 ASSESSMENT, pp. 444–445

PREPARE YOUR OWN SUMMARY

Student summaries should incorporate the following main ideas:

1. Weathering
   - Sediments are formed from rocks through weathering, which is the breakdown of rock.
   - Mechanical weathering includes frost wedging, plant roots wedging into cracks, and animals burrowing in the soil.
   - Chemical weathering includes acidic groundwater dissolving minerals, acidic rainwater reacting with rocks, and acidic action of some organisms.
2. Erosion
   - Erosion is the process that loosens and moves weathered rock particles (sediment) over Earth's surface.

- Water is the most powerful agent of erosion.
- Erosion is caused by meteorological processes, such as rain and wind, and by geological processes, such as gravity and glaciers.
- Deposition is the final stage of erosion and occurs when sediment is dropped.

3. Soil Formation
   - Soil forms in three layers: topsoil, subsoil, and weathered bedrock.
   - Leaching is the removal of soil materials dissolved in water.
   - Five major factors affect the rate of soil formation: parent material, climate, vegetation, landscape, and time.
   - The amount of empty (pore) space in soil is called porosity.
   - The permeability of a soil is a measure of how easily fluids pass through it.
   - Three common types of soil are sandy/gravelly, clay, and loam.
4. Soil Loss
   - Desertification is a worldwide problem that happens when nutrient-depleted soils are formed through erosion of fertile soil.
   - It is in the best interests of a farmer to take steps to reduce the impact that large-scale farming can cause. Methods and benefits include planting tree windbreaks to decrease soil erosion; reduced reliance on chemical fertilizers; no-till farming, which provides cover for the soil all year, thus reducing soil erosion; and limiting run-off.
5. Soil Enrichment
   - Soil enrichment includes adding compost, manure, and chemical and natural fertilizers.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. Animals that dig in the soil help to weather rocks by loosening sediments underground and pushing the sediments to the surface where they can be weathered further.
2. The acids in chemical weathering come from acidic groundwater, acid rain, and acid secreted by some organisms that live on rocks.
3. In warm, humid climates chemical weathering is more rapid because the chemical reactions happen faster in these climates.
4. Water is the most powerful agent of erosion on Earth.
5. (a) Weathering is the breaking down of rock, whereas erosion is the loosening and transporting of sediments.
   (b) Erosion is the loosening and transporting of sediments, whereas deposition is the dropping off of sediment.
6. (a) Any three of wind, water, ice (glaciers), and gravity
   (b) Any three of: Wind picks up fine particles, like clay and sand, which act like sandpaper on Earth's surface. Water breaks down shores and coastlines and rocks in rivers and streams. Glaciers push loose rock out of their way and scrape the land below them. Gravity pulls rock and sediment down from higher places to lower places.
7. (a) Humus is material produced by breaking down plant and animal remains.
   (b) Humus provides nutrients for plants, promotes good soil structure, and helps keep water in the soil.
8. The topsoil is the most fertile layer of soil and home to insects, earthworms, rodents, and microorganisms. The subsoil contains minerals that have leached from the topsoil and contains fewer nutrients and less water than the topsoil. The weathered bedrock is at the beginning of the long, slow process of rock changing into soil.
9. (a) Porosity is the amount of empty space in a soil or rock.
   (b) Permeability is a measure of how easily liquids and gases pass through a soil or rock.
   (c) The particle size determines how large the spaces will be in the soil. Sandy/gravelly soil has a high permeability. Clay has a very low permeability. Loam allows water to permeate at a moderate rate.
10. (a) Three main soil types of sandy/gravelly, clay, and loam.
    (b) Sandy/gravelly soil feels gritty. Clay soil feels sticky or greasy. Loamy soil feels gritty and sticky at the same time.
11. Two problems that can be caused by the overuse of chemical fertilizers are water pollution caused by the run-off and reduction in the microorganisms that provide a balance diet for plants.

Understanding Key Ideas

12. (a) Sample answer: Weathering and erosion are harmful to life on Earth because they break down, loosen, and remove soil.

(b) Sample answer: Weathering and erosion are helpful to life on Earth because they create and deposit sediments that can become soil.

13. Sample answer: Humans can cause erosion by ploughing, irrigating, and fertilizing soil, mining, removing trees, changing drainage patterns, using soil for non-agricultural developments, and disposal of wastes. Suggestions for how humans can prevent erosion include following ecological practices any time the soil is disturbed.

14. (a) Erosion has carved and shaped the sea stack.
    (b) Students' drawings should show a much larger rock, or show the rock still attached to a cliff on the shore.
    (c) Students' drawings should show a much thinner stack, or a stack that has collapsed and is continuing to be eroded.

15. Sample answers: Cement walls have been built to prevent erosion by ocean waves on the coastlines. Trails and pathways through parks have signs reminding people to stay on the path and have some reinforcements in places that could be eroded such as wiring, bolting, and boardwalks.

16. (a) Sample answer: Soils that develop under grassland would not have as much organic matter as the soils that develop under forest vegetation. The organisms living in each type of the soil would also be different.
    (b) Sample answers: The soils develop differently because each may have different bedrock and different rates of weathering and erosion. Different types and amounts of humus are added to each type of soil, there are different climates, and the different landscapes affect drainage, warmth, and protection. It may be that either or both regions were covered by glaciers in the past, which would have affected the type of sediments present in the soil.

17. (a) Sample answers: You could examine the soil and test it its ability to hold water. You could grow some test plants in it to see how well they grow. You could consult a soil expert.
    (b) Sample answer: Organic matter helps to retain moisture, supports soil structure, and provides nutrients for the plants.
    (c) Sample answer: You could add compost and manure, or plant ground covers that could be ploughed into the soil.

18. (a) Farming practices that damage the soil include exposing it to direct action of rain and wind; removing natural vegetation; over-irrigation, overcultivation, and overgrazing; cutting down wind breaks; ploughing to the edges of streams; and using large equipment that requires farmers to plough in long, straight rows.
    (b) Farmers can plant windbreaks to decrease soil erosion; reduce reliance on chemical fertilizers; practise no-till farming, which provides cover for the soil all year, thus reducing soil erosion; and limit run-off.

19. Accept all reasonable answers, such as: a slope—build some obstacles so that water does not erode the slope; the plains—plant windbreaks and keep the soil covered so that wind does not carry away the topsoil; ocean shoreline—build breakwaters so that the waves do not reach the shore with their full force.

Pause and Reflect Answer

Accept all reasonable answers. Some students may have viewed glacial deposits that have not yet produced soil and comment that having too much sediment might slow down the process of soil formation.

UNIT 4 ASSESSMENT

PROJECT

Modelling Geological Processes in Your Community, p. 448

Purpose

- Students' model and display local geological processes.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before	Book computer lab and library, if needed.	For each group: – research materials – other materials as required depending on project

Time Required

- 60–90 min

Expected Results

Students will model geological processes at work in the community or elsewhere in the province.

Activity Notes

- Students can work with a partner or in a small group.
- Students could choose their own topic or you could assign topics.
- Students could choose their own format and ask for your approval, or you could assign formats.
- Topics might include the following:
  - a display of minerals found in the province and explanations of why they are found where they are
  - locations and uses of mineral resources
  - evidence of movement of Earth's crust
  - evidence of volcanic activity
  - evidence of mountain building and/or how rocks have been uplifted
  - evidence of ancient climates and /or life in ancient seas
  - geological processes in one of Newfoundland's three zones
  - examples of mechanical and/or chemical weathering in your community
  - examples of erosion in your community
  - examination of the soil profile of a cutaway bank, identifying the different types of soil present
  - methods used to make soils economically valuable (e.g., fertilizers, screening sand for cement, road building)
  - analysis of the amount of money spent each year in Newfoundland and Labrador for repairing roads that are damaged as a result of weathering.
  - how soils are maintained and fertilized in your region
  - a situation where the use of fertilizers caused harm to the environment
  - foods that can be grown in your region because of our ability to enrich soils
  - a comparison of the soil and/or rocks from your neighbourhood with those from other neighbourhoods

Supporting Diverse Student Needs

- For enrichment, students could make video or sound recordings of their presentations.

Report Out Answers

Students can present their findings to other classes in the school and answer questions from their audiences. Perhaps you can hold a school-wide fair together with other classes.

INTEGRATED RESEARCH INVESTIGATION

Soil Super Stars, p. 449

Purpose

- Students discover the steps needed to start a school composting program.

Activity Notes

- You might wish to assign each student one of the questions from the list to research.
- You might arrange for an organic gardener to visit the class and answer questions about composting.
- You may wish to correspond with classes in schools that have started a composting program.
- If your school already has a composting program in place, students can learn more about it, or can design a program for the community.

Supporting Diverse Student Needs

- ESL students can work with a partner with strong language skills.
- This is a good activity for students who are naturalist learners.
- For enrichment, students could write up their composting success and submit it to the local newspaper.

UNIT 4 REVIEW ANSWERS, pp. 450–453

Visualizing Key Ideas

1. Top three boxes, any order: convergent, divergent, transform
   Left hand lower box: mechanical
   Left centre box: weathering
   Right hand boxes (any order): wind, rain, water, gravity, glaciers (ice)

Using Key Terms

2. (a) True
   (b) False. Metamorphic rocks form through being subjected to heat, pressure, and hot fluids. OR Sedimentary rocks form through the processes of compaction and cementation.
   (c) True
   (d) False. Two plates pull apart at a divergent boundary. OR One plate subducts under another at a subduction zone.
   (e) True
   (f) True (4600 million is equal to 4.6 billion)
   (g) False. Weathering affects natural and human-made features and objects.
   (h) False. Leaching is the removal of minerals dissolved in water.

Checking Concepts

3. (a) Six properties you could use to identify minerals are lustre, hardness, cleavage, fracture, streak, and colour. (Students might also mention any of heft, odour, magnetism, crystals, and how the surface feels.)
   (b) You can decide whether a mineral has glassy, dull, or metallic lustre by looking at it. You can scratch a mineral with different objects and use the Mohs Hardness Scale to help you decide which mineral it is. You can observe the mineral's colour and the colour of its streak on a streak plate. You can break the mineral and observe its cleavage and fracture.
4. A mineral is a pure, naturally occurring, inorganic (non-living), solid substance. A rock is a mixture of two or more minerals.
5. Sedimentary and metamorphic rocks come from other rocks, and igneous rocks come from magma and lava cooling.
6. Sediments settle and are compacted by all the layers above them (often at the bottom of lakes and oceans). A natural cement holds them together.
7. Igneous rocks form as melted rock cools. Metamorphic rock forms when heat and pressure is applied to other rocks. They are not melted in the process.
8. (a) The rock is a sedimentary rock.
   (b) Sediments of different sizes are visible in the rock, and they arranged in layers. Students may have also explained how they ruled out igneous and metamorphic rocks.
9. Students' diagrams could be similar to the illustrations on pages 342 or 343 of the student book. Check that:
   - all three families of rocks are shown
   - all three families undergo the processes of weathering and erosion
   - heat and pressure transform sedimentary and igneous rock (and other metamorphic rock) into metamorphic rock
   - rocks melt to form magma, which cools and crystallizes to form igneous rock
   - sediments are compacted and cemented to become sedimentary rock
10. The two coastlines might have once been connected land in a super continent many millions of years ago.
11. Mid-ocean ridges are mountain ranges on the sea floor.
12. New crust is being formed at mid-ocean ridges as the sea floor spreads.
13. In subduction zones, one plate subducts below another and the rock is melted in the mantle. The melted rock may eventually rise and cool to form igneous rock.
14. False. An earthquake starts at the focus, deep in the ground under the epicentre.
15. A volcano has both beneficial effects (increased fertility of soil, groundwater is heated, water and carbon dioxide are released) and negative effects (structures, trees, crops, and landscapes are destroyed, and the ash can cause breathing difficulties).
16. (a) Most earthquakes, volcanoes, and mountains occur on major plate boundaries, where there are enormous rock surfaces pulling apart or sliding past each other.
    (b) Students might have answered countries that border the eastern and western shores of the Pacific Ocean and approximately 30°–40°N latitude through Europe and Asia.
17. In a mountain formed by folding, pressure pushes against the rock layers and causes them to bend. In a mountain formed by faulting, the rock breaks when pressure is applied, and some of the rock is uplifted.
18. The presence of trilobites in the rocks of Newfoundland indicates there was once a large body of salt water covering the location where the fossils were found. Since trilobites only lived in the Paleozoic Era, we know that the ocean existed over 250 million years ago.
19. Water expands when it freezes.
20. (a) Wind can change Earth's surface when it picks up fine particles, like clay and sand, which act like sandpaper on Earth's surface.
    (b) Gravity can change Earth's surface when it pulls down rock and sediment from higher places to lower places, such as after a heavy rain or an earthquake.
21. (a) Soil is a mixture of weathered and eroded rock, humus, air, water, and living things, such as fungi, mould, bacteria, and earthworms.
    (b) Soil forms differently in different places according to the type of parent material, climate, landscape, vegetation, and amount of time it has been forming.

22. Topsoil is the most fertile part of the soil, ranging from a few centimetres to more than a metre deep; it consists of soil that contains humus and small grains of rock and is home to many organisms. Subsoil is more tightly packed and lighter in colour than topsoil and less productive because it contains less water and organic nutrients.
23. Students could have answered particle size, permeability, porosity, or texture.
24. (a) Humus is material produced by breaking down plant and animal remains. Compost is the breakdown of plant material, which is transformed into humus.
    (b) Compost and humus help the soil retain moisture, provide nutrients for plants, and improve soil structure.
25. When vegetation is removed by overgrazing, clear cutting, and farming, the soil is exposed to the direct action of wind and rain. Topsoil can be eroded and carried away. Without plants, soil development slows and sometimes stops because humus is no longer being produced. If the land receives little rain, plants do not return. All of these conditions can contribute to the destruction of the natural ecosystem and lead to desertification.
26. You could plant tree windbreaks to decrease soil erosion; reduce reliance on chemical fertilizers; practise no-till farming to provide cover for the soil all year, thus reducing soil erosion; and limit run-off. Other answers, such as adding compost, may also be acceptable.

Understanding Key Ideas

27. Stories should include the processes of melting, cooling, compaction, cementation, and crystallization.
28. Students most likely will answer that no, a rock is not permanent because it is subjected to weathering and erosion and will eventually be reduced to sediments or recycled into another type of rock. Some students might have pointed out that the components of the rock are never lost, they are simply recycled.
29. (a) When volcanic rocks are cooling, gas that was dissolved in the molten rock separates from the liquid to form bubbles or pores. When the material cools, these bubbles of gas leave behind holes in the solidified rock. The bubbles offer proof that the rock came from a volcano.
    (b) Igneous rocks with bubbles are likely to be extrusive because they are formed on the surface of Earth, near volcanoes.
30. Students will likely respond that they were uplifted by the action of plate tectonics.
31. Students' songs and poems could include reference to the cause of earthquakes and volcanoes, to the effects of earthquakes and volcanoes, and to the location where earthquakes and volcanoes often occur.
32. Accept all reasonable answers, such as that it took a very long time for life to evolve from being microscopic into being more complex, or that the environment and climate might have been inhospitable to life.
33. People would not be appropriate in a dinosaur display because humans did not co-exist with dinosaurs. Dinosaurs became extinct at the end of the Mesozoic era, and humans did not appear until the late Cenozoic era.
34. (a) Water can break up rocks into smaller pieces without changing the chemical composition of the rock in the process of mechanical weathering, usually by freezing (expanding).
    (b) Water can dissolve rocks when it becomes acidic and changes the rocks chemically in the process of chemical weathering.
    (c) Water is the most powerful agent of erosion, eroding shorelines, forming canyons, and carrying rock and sediment along.
    (d) Water is necessary for fertile soils and, along with air, makes up about half the volume of fertile soil.
35. Students' diagrams could include heavy rain, landslides, glaciers, and/or gravity moving rock from higher places to rivers.
36. Glaciers have deposited ice age sediments such as sand, gravel, silt, and clay that provide excellent drainage and important building materials.
37. (a) Organisms create burrows that allow more air and water to enter the soil, they mix the humus with the fragments of rock, and their bodies decompose to add to the humus.
    (b) When organisms burrow and bring sediment to the surface where it can be weathered, they are contributing to mechanical weathering. When organisms secrete acid that breaks down rock, they are contributing to chemical weathering.

38. (a) Three processes that build up Earth's surface are volcanic eruptions, mountain building, and creation of new crust at the mid-ocean ridges.
    (b) No, Earth's crust is not getting thicker because the processes of weathering and erosion are wearing it down, and crust is being pushed or pulled down into ocean trenches and recycled back into the mantle.
39. (a) Sample answer: Two examples of gradual change in Earth's crust are mountain building and weathering.
    (b) Mountain building is caused by plates colliding or subducting or the formation of volcanoes, and weathering is caused by mechanical or chemical factors.
40. (a) Sample answer: Two sudden changes in Earth's crust are earthquakes and volcanoes.
    (b) Earthquakes are caused by the movement of the plates, and volcanoes are caused by a build-up of pressure of magma.

Thinking Critically

41. (a) and (b) Students' answers may include that the area may have been near or on a beach, allowing for the accumulation of sand. Over time, the water level may have increased, so there was more pressure (weight) on the sand layer. Also, over time, the clay would have settled out. Then the water level might have dropped off, leaving a pebble beach that would account for the eventual layer of conglomerate.
42. Accept all reasonable responses. Sample answer: Rock A is granite, an igneous rock with large crystals because it cooled deep in Earth. After cooling, it was lifted slowly to Earth's surface through the movement of the plates. The rock is now on the top of a mountain in Labrador and is slowly being weathered away. Rock B is limestone, a sedimentary rock formed by the accumulation of sediments in a large ocean many millions of years ago. The limestone is on the edge of a continental plate and is slowly being pushed by plate tectonic movement into a deep ocean trench off the coast. If it melts, it will eventually cool to become igneous rock.
43. Sample answers: The mountains would probably look the same because erosion takes a long time to create changes. Streams and rivers would have caused the greatest amount of erosion and weathering. More landslides would have occurred; glaciers will have retreated.

Developing Skills

44. Accept all reasonable responses. You might wish to encourage students to keep this chart in their science notebook or to create a file of topics they would like to research.
45. Students' responses will depend on the article they chose.
46. Students should identify manipulated, responding, and controlled variables. They should state the question or hypothesis they will be investigating.

Pause and Reflect Answer

Accept all reasonable answers, such as looking for signs of weathering and erosion, identifying the families of rocks present, looking for signs of volcanic activity, examining the type and amount of topsoil present, searching for fossils, and so on.