Topic 3.3
What natural factors affect climate, and how do they affect it?

Specific Expectations

- **D2.1** use appropriate terminology related to Earth's dynamic climate, including, but not limited to: *anthropogenic, atmosphere, carbon footprint, carbon sink, climate, greenhouse gases, hydrosphere,* and *weather*
- **D2.2** investigate the principles of the natural greenhouse effect, using simulations, diagrams, and/or models, and compare these principles to those of an actual greenhouse
- **D3.1** describe the principal components of Earth's climate system
- **D3.2** describe the natural greenhouse effect, its importance for life, and the difference between it and the anthropogenic greenhouse effect
- **D3.3** describe how heat is transferred and stored in both hydrospheric and atmospheric heat sinks
- **D3.4** identify different greenhouse gases, and explain how they are produced naturally in the environment

Skills

- formulate scientific questions and/or hypotheses
- select appropriate instruments and materials
- practice safety procedures when working with chemicals and tools
- conduct inquiries to collect data
- gather, organize, and record data
- analyze data and make conclusions
- communicate using appropriate language, in a variety of formats

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see pages TR-47 to TR-49 for a summary of the materials required in this topic.

Overview

In this topic, students will use modelling to investigate the various natural factors that can affect Earth's climate. They will learn about the interaction of Earth and the Sun, how Earth's atmosphere captures and retains heat through a natural greenhouse effect, and how the hydrosphere moderates Earth's temperature.

Common Misconceptions

- **Some students may think that the greenhouse effect is an unnatural and undesirable process.** Explain to students that the gases in Earth's atmosphere naturally absorb heat from the Sun, helping to keep Earth's surface within a range of temperatures necessary to sustain life. When this cycle is unbalanced and too many gases absorb too much heat, global warming occurs. Have students read the opening paragraph on page 218 for additional clarification.
- **Some students may not be aware that Earth's continents are in motion.** Refer students to Figure 3.15 on page 222. Show them that the continents were arranged differently 200 million years ago. Over time, the gigantic continental plates have drifted apart to where we know them today. This process is still going on.

Background Knowledge

The Sun is an average of 149 million km away, depending on where Earth is in its elliptical orbit. Currently, Earth's orbit is very nearly circular, but is still slightly elliptical. It has an eccentricity of 0.0167, where a perfectly circular orbit would have an eccentricity of zero. We are currently about 50 000 years away from Earth's most elliptical orbit. To see a video of Earth's orbit, go to **www.scienceontario.ca** and follow the links. More information on the great ocean conveyor belt can be found in Topic 3.1, Background Information.

Earth is composed of many layers of materials, with all life living on a thin layer of crust 5–40 km thick. Under the crust is a layer called the mantle, which is 2885 km thick. The upper and lower mantles are made of molten rock (ferro-magnesium silicates) and are where most of Earth's internal heat comes from. It is the convection of this heat that causes the movement of the continents in a process called plate tectonics. The core is the last layer and is separated into the solid inner and liquid outer cores. The outer core measures about 2300 km thick and is primarily made of a liquid iron and nickel alloy. Scientists believe that this outer, liquid core is responsible for controlling Earth's magnetic field. The 1200 km thick inner core is almost solid iron. For an interactive site that shows the layers of Earth's core and the convection in the mantle go to **www.scienceontario.ca** and follow the links.

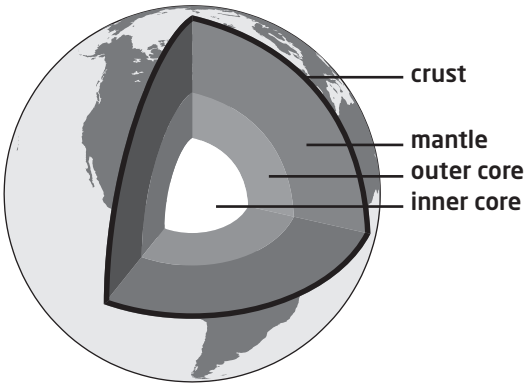


Plate tectonics is the movement of Earth's continents over time. In 1915, Alfred Wegener came up with the concept of "continental drift", the theory that the continents joined together at some point in the past and that Earth's surface changed over time. Although Wegener's theory was controversial, further research (paleontological and paleomagnetic) has supported and expanded his theory into the current theory of plate tectonics. The boundaries of the plates are not exactly the same as the continents, but instead include vast portions of the ocean floor. Where the plates collide or push past each other are regions of volcanic activity and earthquakes, called convergent boundaries or transform boundaries. Pulling apart is called divergent boundaries. For example, a famous earthquake zone is the San Andreas Fault, along the coast of California. This transform boundary is the meeting place of two plates: the Pacific and the North American plates. For an animation of plate tectonics and an interactive map of the plates, go to **www.scienceontario.ca** and follow the links.

Literacy Strategies

Before Reading

- Topic 3.3 has more reading material than the previous topics. As a class, discuss how to approach the reading. Have students brainstorm ways to "chunk" the material for reading, and to help remember and find necessary information.
- Have students skim and scan the visuals in the topic. Ask students what clues the figures provide about the focus of the narrative.
- You may wish to have students fill out **BLM G-44 K-W-L Chart** on what they know about the nature factors affecting climate before they begin this topic.

During Reading

- Have students work in pairs and check each other's comprehension as they read through the topic. You may wish to hand out **BLM G-37 Summarizing** for students to summarize the information in each subsection. Have them stop at each subsection and ask each other one or two questions about the content. Once they agree on the best answers to the questions, have them proceed to the next section.
- DI ELL Encourage English language learners and visual learners to use diagrams and sketches in their study notes. You can also provide English language learners with written notes in cloze format—some key words are missing to be filled in by the student. This allows the student to use contextual clues to make sense of the passage, without becoming overwhelmed by the writing demands of taking their own notes.
- ELL The text passages in this topic include dense information and many interrelated ideas. To assist English language learners, have them partner with other students to share the reading task. One student can read a given section aloud to the partner, while the other listens carefully. At the end of the section, the listener attempts to summarize the information read aloud. The reader assists the listener as required.

After Reading

- Encourage students to use graphic organizers to organize their study notes.
- If you had students fill out **BLM G-44 K-W-L Chart** before reading, instruct them to complete their chart now that they have finished their reading. If they have any unanswered questions, discuss the answers as a class using an informal review.

Assessment FOR Learning		
Tool	**Evidence of Learning**	**Supporting Learners**
Learning Check, page 215	Students explain how interactions between the Sun and Earth affect Earth's climate.	• Have students review pages 214 and 215, and make jot notes using the headings on these pages. • Provide students with **BLM G-45 Main Idea Web** or **BLM G-47 Spider Map** to complete their answers.
Learning Check, page 217	Students explain how Earth's atmosphere affects the climate.	• Explain to students that Earth's atmosphere acts like an insulating blanket over the planet, keeping just enough heat in to maintain a comfortable temperature. • It may be helpful to have students compare other planets in the solar system to Earth. For example, Mercury has no atmosphere and has surface temperatures that swing wildly from scorching to freezing. Venus has a thick atmosphere that traps too much heat, rendering the planet's surface a boiling volcanic inferno. Students may wish to use **BLM G-49 Venn Diagram** (with an additional circle) to compare the three planets.
Learning Check, page 219	Students compare the greenhouse effect in a greenhouse with the same effect in Earth's atmosphere.	• Have students use **BLM G-49 Venn Diagram** to organize their answers. • ELL Encourage English language learners to use diagrams to express their answers, if they wish.
Learning Check, page 221	Students explain how the hydrosphere moderates Earth's climate.	• Suggest to students that they use a sketch, a diagram, or even a cartoon to show how a carbon sink works.
Learning Check, page 223	Students create a cause-and-effect map to show the relationship between moving continents and climate, and mountains, volcanoes and climate.	• Provide **BLM G-39 Cause-and-Effect Map** to students who are struggling.

Topic 3.3 (Student textbook pages 212–229)

Using the Topic Opener

- Before starting this topic, collect other powerful images of volcanic eruptions, such as Mount St. Helen's eruption on May 19, 1980, to show students along with the topic opener image. To find additional images, go to **www.scienceontario.ca** and follow the links.
- As a class, have students study the photograph in the opener. Encourage an open class discussion about the image. Encourage students to share their thoughts and feelings about the image and how the people in the jeep might feel as a prelude to the Starting Point Activity.
- Ensure that students understand that it is not the lava from the volcano but the enormous amounts of gas and ash that are flung into Earth's atmosphere by the force of the eruption that causes climate change.
- Tell students that global climate changes resulting from volcanic eruptions have happened before. The year 1816 was known as the "year without a summer" due to the 1815 eruption of Tambora volcano in Indonesia. Canada and the United States experienced killing frosts in the summer months, which destroyed the seasons' crops.
- Explain to students that volcanoes are not just a problem in other countries. Canada also has volcanoes, some of which are active. To show students the force and power of an eruption that can affect climate globally, show a video of the eruption of Mount Pinatubo. Go to at **www.scienceontario.ca** and follow the links.

Starting Point Activity (Student textbook page 213)

Pedagogical Purpose

This opening activity uses a dramatic example to engage students' interest in natural forms of climate change.

Planning	
Time	20–30 min in class

Activity Notes and Troubleshooting

- If students have trouble with question 1, give them a short activity to help them organize their thoughts. Have students work in pairs and take turns describing the image to each other, as if they were explaining the image to someone who could not see the textbook. The students listening to the description may wish to close their eyes to help them concentrate.
- Question 2 is deliberately open to allow students an opportunity to share their experiences. You may wish to have students concentrate on events that would contribute to climate change.

Additional Support

- DI For students with visual challenges, have partners describe the image aloud. This will also make the students doing the describing really consider and reflect on what they are seeing.
- ELL DI For English language learners and linguistic learners, provide a list of adjectives for students to use in their descriptions in question 1, or encourage students to use sketches and drawings. Have English language learners be the listener first.
- Enrichment—Have students research the results of the eruption on the local community. What happened to the cropland in the short term and in the following years? Have students share their findings with the class.

Starting Point Activity Answers

Answers may vary.

1. Most students will say they would be afraid and worried about escaping the cloud of poisonous gas. They will also be worried about their friends and relatives who are not with them.
2. For example: Mount St Helens in Washington State, USA, erupted May 18, 1980, killing 57 people and causing two to three million dollars worth of damage. The eruption had no noticeable effect on global temperatures.
3. For example: The ash from the eruption of Mount Pinatubo blocked the Sun and caused global temperatures to decrease by approximately 0.5–0.6°C. Hurricane Katrina and the Indian Ocean Tsunami of 2004 might have been caused by climate change or ocean warming. When the ocean increases in temperature by 1°C, the winds coming off the water are stronger and more intense. The ocean warming may be linked to global warming or climate change.

Instructional Strategies for Topic 3.3

Student textbook pages 214–215

- Have students read these pages in "chunks" and make jot notes as they read. Circulate while they read to answer any questions and clear up any misconceptions.
- To demonstrate the effect of the Earth's tilt on the amount of sunlight the continents receive during certain parts of the year, conduct a demonstration with student volunteers. Have one student hold a globe and circle another student with a flashlight. Explain that as the globe Earth orbits the flashlight "Sun", the light illuminates some areas more than others. It is this pattern that creates Earth's seasons.
- Explain to students that, although Earth's orbit around the Sun is elliptical, taking Earth farther away from the Sun at certain points in Earth's orbit, these distances are not responsible for the seasons.
- ELL DI If students, especially English language learners, are struggling with the term "elliptical", do a short demonstration. Have students loop an elastic band over their two index fingers and slowly pull their fingers apart, watching how the shape of the elastic changes. Explain that the oval shape of the elastic is described as *elliptical* and that it is measured in degrees. (A perfect circle is zero degrees.) Bodily-kinesthetic learners will appreciate the demonstration.
- Provide **BLM G-45 Main Idea Web** or **BLM G-47 Spider Map** for those who need it.
- Assign Investigation 3A on page 226. Provide **BLM 3-16 Investigation 3A** and **BLM 3-17 Investigation 3A Data Table,** if needed.

Student textbook pages 216–217

- Have students read page 216 to themselves.
- Draw students' attention to the Figure 3.11. Ask students why the arrows are coloured blue for cold and red for warm. Ask them to think of other examples of this kind of colour coding. Examples could include hot and cold water taps.
- Assign Activity 3.5 when students have completed their reading.
- Assign the Learning Check questions when students have completed the activity, or assign them as homework.
- Enrichment—Have interested students look up information on Mercury, the planet closest to our Sun, and compare its daily temperature range to Earth's. Mercury has no atmosphere, so its daily temperature swings from scorching hot to freezing cold.

Student textbook pages 218-219

- ELL Some students may not be familiar with greenhouses. Cars provide a suitable alternative example. The interior of a car in winter is significantly warmer than the outdoors, if the car has been parked in the Sun. This is exactly the same process as with a greenhouse—the sunlight penetrates the car windows, heats the interior, and the heat is trapped inside. Using this analogy may help English language learners understand how a greenhouse works.
- As a class, read through the information on page 218. Refer students to Figure 3.12. Ensure that students understand what the various arrows represent.
- You may wish to assign Learning Check question 1 at this point to consolidate student understanding. **Provide BLM G-48 T-Chart** or **BLM G-49 Venn Diagram,** if necessary.
- As a class, analyze Table 3.1. Discuss what students may have heard through the media about greenhouse gases. Correct any misconceptions.
- Point out that there are other greenhouse gases besides carbon dioxide.
- Ask students to consider the sources of methane. Ask if they have ever thought or heard of cows as a source of greenhouse gas. Ask how they think the North American diet affects the increase of greenhouse gases. (North Americans consume huge amounts of beef and dairy products, which requires enormous numbers of cattle—a source of methane.)
- Assign Investigation 3B on page 227. Provide **BLM 3-18 Investigation 3B** and **BLM 3-19 Investigation 3B Data Table,** if needed.
- Assign Learning Check questions 2 and 3.

Student textbook pages 220-221

- ELL DI If students and especially English language learners are having trouble with the term *carbon sink,* explain that a "sink", like a kitchen sink, is used to hold something. In the case of a kitchen sink, it is water. In the case of a heat sink, it is heat and in the case of a carbon sink, it is carbon dioxide. Linguistic learners will benefit from the analogies.
- ELL DI Have English language learners, linguistic learners, and other students use **BLM G-38 English Word Study** to analyze the origins and meaning of key terms, such as *hydrosphere*.
- Before reading, do an informal poll of students' favourite colour. Tally students' responses on the chalkboard or on chart paper. Ask students why they think the majority of them chose blue (if this was the case). Then, as a class, read the opening paragraph.
- To capture students' attention, discuss the image of Earth from space. Explain that a similar photograph of the Earth, called Earthrise, was taken by the crew of Apollo 8 in 1968. The image is available from NASA. Go to **www.scienceontario.ca** and follow the links. Explain that this image, taken more than 40 years ago, was the foundation of the environmental movement. Seeing Earth from space, a perfect blue planet surround by black was a compelling image to many people.
- Another image of Earth, taken by Voyager 1 from almost 6 billion km in 1990 shows Earth as a tiny blue dot in the vastness of space. To see the image, and read astronomer Carl Sagan's comments about viewing Earth in this way, from his book *A Pale Blue Dot,* go to **www.scienceontario.ca** and follow the links. You could read Carl Sagan's comments to the class while students study the photograph.
- Have students read pages 220 and 221 on their own. Circulate to ensure students understand the text and to clear up any misconceptions that may arise. Then assign Activity 3.6.
- Once students have completed the activity, draw students' attention to the Figure 3.14, the great ocean conveyor belt. Ask students why this ocean current may have gotten this name. Ask if they feel the name is appropriate in describing what the current system does.
- Assign the Learning Check questions.

Student textbook pages 222–223

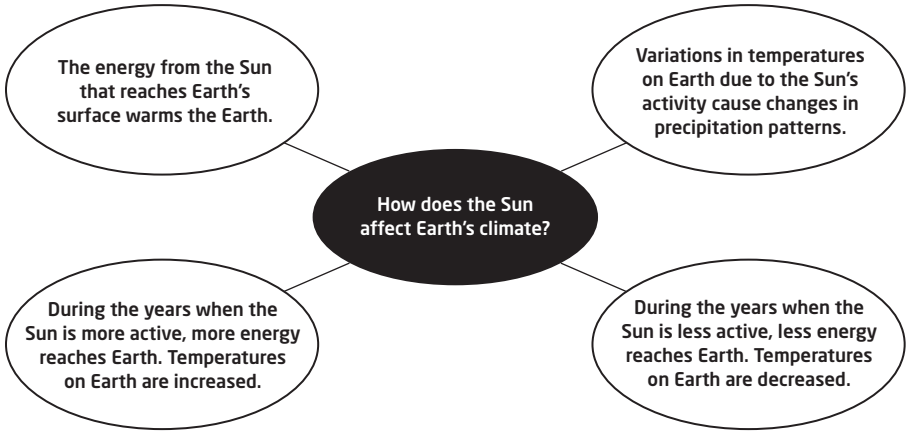
- ELL DI Students may not be familiar with the concept of plate tectonics, the motion of the continents on Earth's crust. Provide English language learners, spatial-mathematical learners, and other students with **BLM 3-20 Continents**. The activity can help them see how the continents will fit together.
- As a class, read the first paragraph on page 222 and have a class discussion about the composition of the Earth. Explain that Earth is not a solid, dead rock. Earth is an active planet of many layers with all life living on a tiny 5–40 km thick crust floating on a layer of molten rock. Earth does have a solid core of iron, but the mantle, the layer the crust floats on, is liquid rock that moves in a convection current, similar to what they saw in Figure 3.11 on page 216.
- Have students read the rest of page 222, and assign Learning Check question 1. Provide **BLM G-39 Cause-and-Effect Map,** if necessary.
- Remind students of the topic opener on Mount Pinatubo and the effects this volcanic eruption had on our climate. If necessary, have students reread the opener to refresh their memories.
- ELL As a class, read page 223. In a class discussion, compare the Mount St. Helen's eruption with the Mount Pinatubo eruption. English language learners may benefit from using **BLM G-49 Venn Diagram** to compare the two eruptions.
- Assign Activity 3.7, then assign Learning Check question 2. You may wish to assign this question as homework.

Student textbook pages 224–225

- As a class, read through page 224. You may wish to use this opportunity for an informal review of what students have learned in this topic so far.
- You may wish to have students work in pairs to complete Learning Check question 1. Or, you may wish to use this question as a starting point for a class discussion.
- Assign Activity 3.8. Provide **BLM 3-21 Activity 3.8 Observation Table,** if needed.
- Assign Learning Check questions 2 and 3.

Learning Check Answers (Student textbook page 215)

1.



2. The Sun is the most important influence on Earth's climate because the Sun's solar energy is responsible for the temperature on our planet.

3. In the northern hemisphere in summer, Earth is tilted toward the Sun. The angle allows for solar energy to strike the region more directly, causing warmer temperatures than in the other three seasons.

4. Answers may vary. Students should understand that the changes in Earth's orbit occur over 100 000 years, which is too long a time period to cause a fast rate of global warming we are experiencing.

Learning Check Answers (Student textbook page 217)

1. The atmosphere is a heat sink because it traps and stores heat and allows it to even out the distribution of heat over the day.
2. Wind blows, heating the air. Warm air will expand and rise. As it rises, it causes wind to form. The wind rises but cools as it reaches higher latitudes. The air cools down and then sinks. Cool air is attracted to heat, so it moves as wind to warm areas, staring the heat transfer cycle again.
3. Earth receives more direct solar energy at low latitudes than at higher latitudes because of the way the Earth is tilted.

Activity 3.5 Modelling Air Movement (Student textbook page 217)

Pedagogical Purpose

In this activity, students will create and observe a model of air movement patterns to demonstrate the circular pattern of air movement in Earth's atmosphere.

Planning	
Materials	Per group: 1 L clear plastic pop bottle funnel 750 mL water 250 mL vegetable oil red or blue food colouring effervescent powder (or tablet) flashlight (optional)
Time	30–40 min in class 20 min preparation
Safety	Remind students to clean up spills immediately. Warn students that food colouring may stain clothes.

Skills Focus

- work safely with chemicals and tools
- draw conclusions based on observations

Activity Notes and Troubleshooting

- You could bring in a lava lamp to show students how it works.
- To reduce materials and waste, have students work in small groups for this activity.
- To save time, fill the pop bottles with water and have students start on step 2.
- A week before this activity, remind students to bring a plastic pop bottle from home.
- Ensure students recycle the pop bottle on completion of the activity.
- To use less class time, students could watch a video of this activity instead. Go to **www.scienceontario.ca** and follow the links.
- Pen or print cartridge ink could be substituted for food colouring.

Additional Support

- For students with fine motor challenges, have one student hold the pop bottle steady or use a stand.
- ELL Some students, especially English language learners may not be familiar with the original lava lamp concept. Ensure that these students have an example. For a video of a lava lamp, go to **www.scienceontario.ca** and follow the links.
- DI To develop students' intrapersonal skills, this activity can be assigned as an individual project.

Activity 3.5 Answers

What Did You Find Out?

Answers may vary. For example:

1. **a)** The movement of wax in a lava lamp is similar to convection currents that occur in the Earth's mantle, and in the air. A heat source can heat up air or liquid, causing it to become less dense and rise. As the air or liquid rises, cooler air or liquid above it sinks because it is denser, and in turn is heated when it gets close to the heat source.

   b) The lamp is an adequate model for air movement in the atmosphere. It shows how warm air rises and then sinks as it cools. The only limitation is that the lamp is a closed environment.

Learning Check Answers (Student textbook page 219)

1.

Greenhouse	Earth's Atmosphere
• solar energy passes through glass panels, solar energy absorbed by plants, air, and other objects • greenhouse objects radiate some of the energy as heat • heat stays inside the closed greenhouse, so it is absorbed by the air inside • air molecules radiate heat, warming the inside of greenhouse	• greenhouse gases in atmosphere absorb solar energy • greenhouse gases absorb energy radiated from Earth's surface • heat is trapped in air of atmosphere • gases radiate the heat they absorb, warming Earth

2. Predictions may vary. For example: If the concentration of greenhouse gases in the atmosphere increased, the Earth would become very hot. Vast deserts would form, and plant and animal life would not be able to survive.

3. Approximately 70% of the Earth's surface is covered with water, so scientists believe that water vapour accounts for 70% of the greenhouse effect.

Learning Check Answers (Student textbook page 221)

1. Water moderates air temperature by absorbing a lot of heat from Earth's atmosphere before getting warm and releasing the heat again. It helps to cool Earth and warm it again when necessary.

2. A carbon sink is something that absorbs and stores carbon dioxide from the atmosphere. Oceans act as a carbon sink. By storing carbon dioxide, the oceans keep the gas from warming Earth too much. When there is less carbon dioxide in the air, the oceans will release the gas to allow for Earth to warm up. This will keep Earth from getting too cool.

Activity 3.6 The Effect of Temperature on Water Movement

(Student textbook page 221)

Pedagogical Purpose

In this activity, students model the effects of temperature on water density to see how this would affect the movement of water on a larger scale, in Earth's oceans.

Planning	
Materials	Per group: two 500 mL beakers 250 mL ice and cold water 15 drops blue food colouring 250 mL warm water eye dropper or pipette **BLM G-37 Summarizing** (optional)
Time	20–30 min in class 20 min preparation
Safety	Remind students to clean up spills immediately. Warn students that food colouring may stain clothes. Ensure students handle glassware carefully. Have a glass cleanup kit ready.

Skills Focus

- work safely with chemicals and equipment
- draw conclusion based on data

Activity Notes and Troubleshooting

- To save time and materials, this activity could be done as a demonstration.
- Have students work in small groups.
- Ink could be substituted for food colouring.
- Students can record their observations in their notebooks or create an observation chart.

Additional Support

- ELL DI Have English language and visual learners use sketches or diagrams to record their results.
- DI Students with strong interpersonal and bodily-kinesthetic skills will enjoy this group activity. This activity will also provide other students with the opportunity to develop these skills.
- DI To help students develop linguistic skills, have them write a short paragraph summarizing their observations. Provide **BLM G-37 Summarizing,** if necessary.
- Enrichment—Have students write a prediction of what they expect to see in this activity. After the activity, have them compare their results to their prediction and explain any discrepancies.

Activity 3.6 Answers

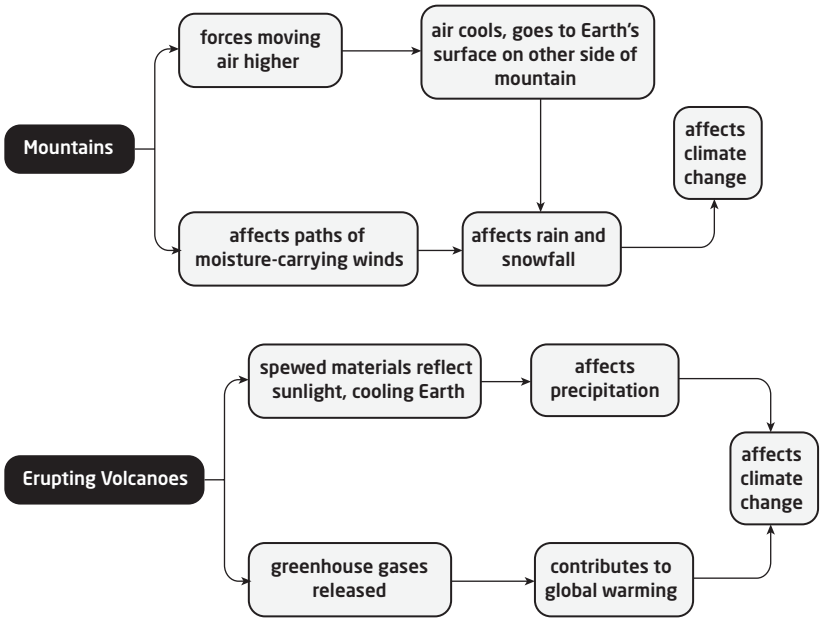
What Did You Find Out?

1. The cold water moved to the bottom of the warm water beaker. The warm water moved to the top of the beaker. You could see a current being created. This shows how oceans transfer heat. The cold water is denser than warm water, so it sinks to the lower depths. It displaces the warm water around it. This produces a current.
2. Change the cold water beaker to coloured, salty water at room temperature. Add two tablespoons of salt to 250 mL of room temperature water. Change the beaker with warm water to one with room temperature water. Transfer some of the salty water to the unsalted water beaker. You should see the same current effect as with the cold and warm water.

Learning Check Answers (Student textbook page 223)

1. Cause-and-effect map should include the following points.
   Moving continents affect temperature, precipitation, wind patterns, and ocean currents. These all affect climate change.

2.



Activity 3.7 Modelling Volcano Effects (Student textbook page 223)

Pedagogical Purpose

With large-scale atmosphere changes, it may be difficult for students to visualize the effects. In this activity, students observe a model of the effects of volcanic ash in Earth's atmosphere.

Planning	
Materials	5 L or 10 L aquarium 4 to 9 L water overhead projector 5 mL coffee creamer stir stick **BLM A-1 Making Observations and Inferences Checklist** (optional) **BLM G-39 Cause-and-Effect Map** (optional)
Time	15–30 min in class 20 min preparation
Safety	Ensure that students remain seated while lights are out. Clean up any water spills immediately. Have a glass cleanup kit ready in case of broken glass.

Skills Focus

- draw conclusion based on observations

Activity Notes and Troubleshooting

- To save time, prepare the aquarium and projector beforehand. You might want to do the experiment once before the demonstration to check that everything works properly.
- Before beginning the activity, have students refer to the topic opener and the photograph of the eruption of Mount Pinatubo. As a class, review the information

about the climactic effects of the eruption. Explain that this activity will model the effects of volcanic ash in Earth's atmosphere.

- You may wish to use **BLM A-1 Making Observations and Inferences Checklist** to assist you in assessing students' observations. If you plan to assess students, ensure you provide them with a copy of the blackline master so they are aware of what is expected of them.
- You may wish to have students use a graphic organizer such as **BLM G-39 Cause-and-Effect Map** to record their observations.

Additional Support

- ELL DI Encourage English language learners and students with linguistic challenges to use diagrams and sketches to record their observations.
- ELL English language learners may wish to record their observations in their first language and translate their notes into English later.
- Provide students with visual impairments with partners who can describe the activity to them.

Activity 3.7 Answers

What Did You Find Out?

1. The colour of the light changed from being bright white to a pale yellow then greyish as more creamer was added to the water. The creamer (ash) seemed to block the light passing through the water.
2. This activity models the effect of volcanic ash in the atmosphere by showing how little light can get through the water (atmosphere) once the creamer (ash is added).

Learning Check Answers (Student textbook page 225)

1. Earth's climate is a challenge to understand and make predictions about because everything has an effect on other things. The heating of Earth has an effect on wind and ocean currents, which affect climate change. Natural features like mountains and volcanoes also affect wind patterns, which in turn affect precipitation patterns and so on. Every system and event seems to be connected to climate change.
2. It is hard to understand how an increase in atmospheric water vapour will affect climate because when surface temperatures increase, more water evaporates from soil and water. More water vapour goes into the atmosphere to warm the Earth. But more water vapour also means more clouds form. Clouds reflect solar energy, therefore cooling the Earth. More clouds also mean more precipitation in some parts of the world. So it is hard to predict how the climate will change.
3. Carbon dioxide heats the Earth, which causes the oceans to heat up. As water warms, ocean currents that would have been generated by sinking cold water start to slow down. This changes both warm and cold currents. When these currents change, temperatures in surrounding regions change, which in turn affects precipitation patterns. Carbon dioxide causes global warming because it is a greenhouse gas that absorbs and then radiates heat, therefore warming the planet.

Activity 3.8 How Melting Sea Ice Affects Global Temperature

(Student textbook page 225)

Pedagogical Purpose

In this activity, students investigate how changes in the hydrosphere can affect global temperatures.

Planning	
Materials	Per group: 2 plastic trays black plastic cold water ice cubes 2 heat lamps 2 thermometers 2 clamps 2 retort stands with clamped thermometers masking tape waterproof marker timer **BLM 3-21 Activity 3.8 Observation Table** (optional)
Time	30–40 min in class 15 min preparation
Safety	Remind students to clean up spills immediately. Ensure students handle thermometers carefully. Have a glass cleanup kit ready. Ensure students are cautious when using electrical devices and water. Remind students to be careful with the heat lamps. The bulbs get very hot.

Skills Focus

- work safely with chemicals and equipment
- conduct inquiries to collect data

Activity Notes and Troubleshooting

- Dark green or black garbage bags can be used instead of black plastic.
- Inexpensive trays and garbage bags can be purchased from dollar stores.
- Ballpoint pens can be substituted for waterproof markers, if necessary.
- Have students work in small groups for this activity to save time and materials. Assign roles to students so every group member feels accountable. Roles could include a timer, a recorder, and an observer. Group members should share the task of setting up and cleaning up.

Additional Support

- ELL DI Have English language learners and students who need scaffolding use **BLM 3-21 Activity 3.8 Observation Table** to record their observations.
- DI Students with stronger interpersonal skills should work with students still developing these skills.
- Enrichment—Have students repeat the activity with two trays: one with black plastic and the other with white plastic. Have them predict the results before they begin.

Activity 3.8 Answers

What Did You Find Out?

1. The water temperature warmed the most in Tray B. This was because there was less ice to reflect the light and more water to absorb the heat energy from the lamp.
2. **a)** The black plastic represents the deep water of the ocean.
   b) The lining is an important part of the experiment because it acts as a control and models the water's absorption of energy from the light.
3. Melting sea ice will raise the average global temperature because as more water is available, more heat will be absorbed by the water, then be released again into the atmosphere.

Investigation 3A Solar Radiation and Earth's Surface

(Student textbook page 226)

Pedagogical Purpose

Conceptualizing the angle of the Sun's rays is a difficult but important idea to grasp. In this investigation, students explore how changing the angle at which sunlight strikes Earth's surface affects the amount of solar energy received.

Planning	
Materials	Per group: flashlight twine or packing tape metre stick large sheet of graph paper pencil protractor **BLM G-9 Data Tables** (optional) **BLM 3-16 Investigation 3A** (optional) **BLM 3-17 Investigation 3A Data Table** (optional)
Time	40–60 min in class 10 min preparation
Safety	Remind students no to shine the flashlight in their eyes or their classmates' eyes.

Background

Earth is tilted 23.5 degrees on its axis to the plane of the elliptic. That means that some continents receive more sunlight during certain parts of the year than others. Any globe will show Earth's slight tilt. All planets in our solar system orbit the Sun in a single plane. Drawing an imaginary line perpendicular to this plane determines the axis of a planet.

The orbit of the Earth around the Sun, or an Earth revolution, occurs every 365.26 days. Earth orbits in an elliptical, or oval, path around the Sun. Earth's closest approach to the Sun, the perihelion, occurs every January 3. Earth is approximately 147 million kilometres away at this point. The aphelion, Earth's farthest point from the Sun in its orbit, occurs every July 4, when Earth is approximately 152 million kilometres away. The distance of Earth from the Sun at any given point is not responsible for the seasons.

Skills Focus

- select appropriate materials
- work safely with chemicals and equipment
- conduct inquiries to collect data
- gather and record data
- draw conclusions from data
- communicate using appropriate language, in a variety of formats

Activity Notes and Troubleshooting

- Assign this investigation after students have read pages 214 and 215.
- Have students work in pairs or small groups.
- Duct tape and masking tape can be substituted for twine or packing tape.
- You may wish to have students bring a flashlight from home.
- Provide students with **BLM G-9 Data Tables** to record their observations.
- To streamline this investigation, you may wish to assign each group a different angle to test and then consolidate the information in a class table that students can copy into their notes.

Additional Support

- ELL Provide English language learners and students who need scaffolding with **BLM 3-17 Investigation 3A Data Table** to use to record their findings.
- Enrichment—Have students repeat Investigation 3A but with the flashlight at different distances from the graph paper. Have students record their answers in the second table (labelled Enrichment) of **BLM 3-17 Investigation 3A Data Table**.

Investigation 3A Answers

What Did You Find Out?

1. 60°.
2. 30°.
3. The Earth receives more solar radiation at the equation because the angle at which the sun's rays hit the equator is approximately 90°. This means more sunlight reaches a smaller area making the energy more concentrated.

Inquire Further

4. Answers may vary. For example: Repeat the steps of Investigation 3A but hold the flashlight at distances of 5 cm, 10 cm, and 20 cm away from the graph paper. Record the number of squares that were lit up for each distance and angle.

Investigation 3B Modelling the Greenhouse Effect

(Student textbook page 227)

Pedagogical Purpose

In this investigation students use a model to test the theory of the greenhouse effect.

Planning	
Materials	Per group: two 200 mL Erlenmeyer flasks 2 stopper-and-thermometer setups (one-holed rubber stopper with thermometer inserted partway into the hole) modelling clay 100 W incandescent bulb and lamp water 15 mL effervescent powder test tube timer **BLM 3-18 Investigation 3B** (optional) **BLM 3-19 Investigation 3B Data Table** (optional) **BLM G-26 Developing a Hypothesis** (optional) **BLM A-38 Hypothesizing Rubric** (optional)
Time	30–40 min in class 20 min preparation
Safety	Ensure students handle glassware and thermometers carefully. Have a glass cleanup kit ready. Remind students to be careful with the lamps. The bulbs get very hot.

Background

Greenhouses are built of glass or plastic. The Sun shines through the transparent walls and the Sun's heat is trapped inside the building, allowing us to grow plants that would die in cold outdoor temperatures. The greenhouse effect is the increase in the Earth's surface temperature as a result of atmospheric gases, such as carbon dioxide, nitrous oxide, and methane, trapping the Sun's heat. Without these gases, the Sun's energy would escape back into space and the temperature of the Earth would be too cold to sustain life. Our position in the solar system is sometimes called the "Goldilocks zone." Like the porridge in the fairy tale, Mars is too cold, Venus is too hot, and Earth is just right. Earth has the perfect temperature to maintain liquid water, necessary for life.

Skills Focus

- formulate scientific questions and hypotheses
- work safely with chemicals and equipment
- gather and record data

Activity Notes and Troubleshooting

- Assign this investigation after students have read pages 218 and 219.
- Have students work in pairs or small groups.
- Ensure that students working in groups are sharing the tasks equally. For this investigation, one student may act as the investigation's timer and another as the recorder.
- You may wish to use **BLM A-38 Hypothesizing Rubric** to assist you in assessing your students. If you plan to assess your students' work on this investigation, distribute copies of the assessment criteria beforehand so they are aware of what is expected.

Additional Support

- ELL DI You may wish to support English language learners and linguistic learners by working on writing a hypothesis as a class. Alternatively, have students use **BLM G-26 Developing a Hypothesis**.
- ELL Ensure that English language learners are actively participating in this investigation and are given appropriate tasks. Students may wish to be the timer for this investigation.
- Provide **BLM 3-19 Investigation 3B Data Table** for those who need it.

Investigation 3B Answers

What Did You Find Out?

Answers may vary.

1. Both graphs should show the same temperature at 0 min (room temperature). The graph for the CO_2 filled container will show a steeper curve than the graph for the container with no CO_2. The temperatures for the CO_2 filled container will be greater for almost every minute relative to the container with no CO_2.
2. For example: I hypothesized that the container with CO_2 would be warmer than the one without CO_2 after being heated because the CO_2 gas molecules would absorb the heat from the lamp and radiate it back into the container. My hypothesis was correct.
3. For example: Yes, my results support what scientists believe. With the heated CO_2 gas molecules, the heat is absorbed and radiated back to Earths atmosphere. If the Earth's atmosphere were a closed system, then what scientists predict is true.

Activity 3.9 The Effects of Ocean Acidity

(Student textbook page 228)

Pedagogical Purpose

In this activity, students explore how shells are affected by different levels of acidity to gain an understanding to the effect of increased ocean acidity on marine life.

Planning	
Materials	Per group: 3 hard-boiled eggs, or shells only 3 containers with lids cola vinegar water universal pH paper scale **BLM A-1 Making Observations and Inferences Checklist** (optional)
Time	15–20 min in class (day 1) 15–20 min in class (day 2) 10–15 min preparation
Safety	Remind students to never eat or drink anything in the science classroom. Students with egg allergies should avoid handling the eggs.

Skills Focus

- work safely with chemicals and equipment
- conduct inquiries to collect data

Activity Notes and Troubleshooting

- Remind students to never eat or drink anything in the science classroom.
- You may wish to use a non-allergen source of calcium carbonate instead of the eggshells. Seashells or basic antacids (for example, Rolaids® and Tums®) will also work. If you choose to use seashells, students can still record observations about the changes in the shells' shape, size, and mass. If you choose to use an antacid, omit steps 3 and 6 as the antacid will completely dissolve in the liquid.
- Seashells should be readily available at grocery stores or pet shops that have aquarium supplies. Wash seashells thoroughly before use. Students with shellfish allergies should not touch the seashells.
- You may wish to conduct this activity as a demonstration. If so, ensure that students make notes of their observations.
- To conserve materials and time, you may wish to have students work in small groups for this activity. If so, ensure that tasks are divided up appropriately. You may wish to divide the class into three test groups: cola, vinegar, and water. Each group will test the eggshells with their assigned liquid and report their findings to the class. Students can copy the class data into their notes.
- You may wish to use **BLM A-1 Making Observations and Inferences Checklist** to assist you in assessing your students for this activity. If you choose to assess students, ensure you provide a copy of the blackline master to them beforehand so they are aware of how they will be evaluated.

Additional Support

- ELL DI Encourage English language learners and students with linguistic challenges to use diagrams and sketches to record their observations.
- ELL English language learners may wish to record their observations in their first language and translate their notes into English later.
- Students with fine motor challenges should be paired with students who can assist in these tasks.
- DI Working in small groups will benefit interpersonal learners.

Activity 3.9 Answers

What Did You Find Out?

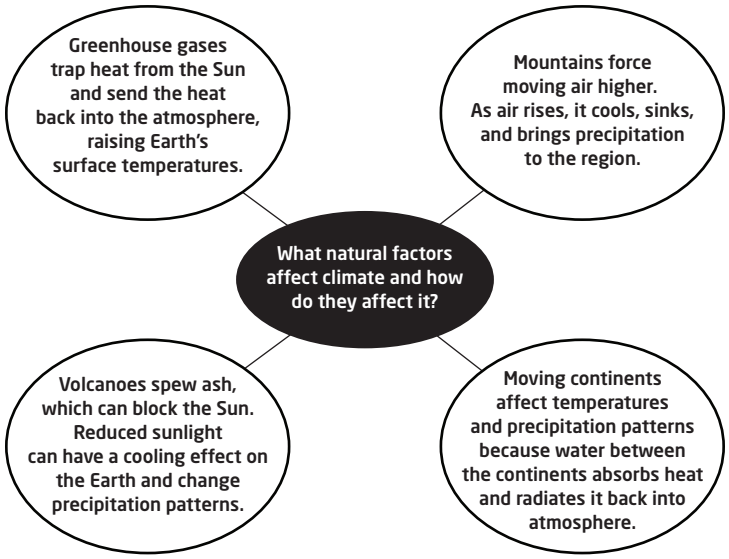
1. The eggshells became thinner the longer they are in the vinegar and the cola.
2. The egg in the vinegar changed the most. Since vinegar is more acidic than cola, the shell dissolved the fastest in vinegar. It did not dissolve in water because water is not acidic.
3. The animal's shell will become thinner and might break. The acidic water would enter the animal's body, causing damage and eventual death.

Topic 3.3 Review (Student textbook page 229)

Please see also **BLM 3-22 Topic 3.3 Review (Alternative Format).**

Answers

1. Answers may vary. For example:



2. a) The Sun's energy affects climate by the amount of activity that occurs. During active periods, more solar energy is given off and Earth's temperatures increase. During less active periods, less solar energy is given off and Earth's temperatures decrease. The variations in the Sun's activity also cause changes in precipitation patterns.

b) The Earth's curved surface affects climate because of the amount of Sun that hits the curved surface at different angles. The concentration of light that warms Earth's surface is not equal.

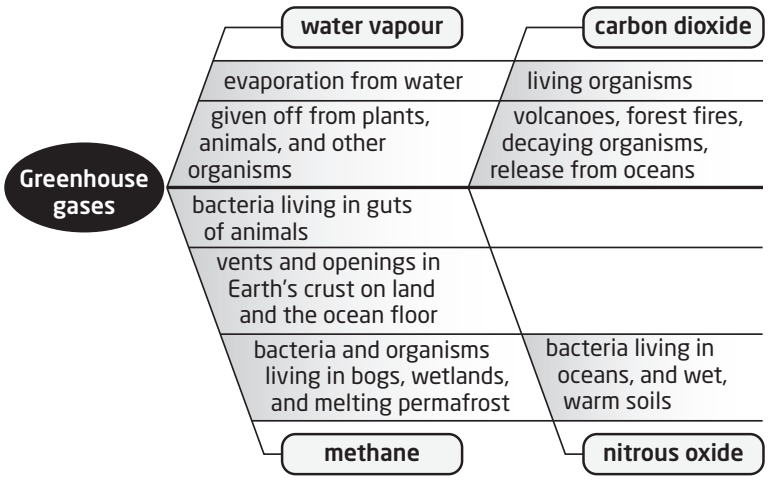
c) The Earth's tilt affects climate by limiting the amount of solar energy that strikes Earth as it orbits around the Sun. During summer in the northern hemisphere, Earth is tilted towards the Sun. More direct energy strikes the region closer to the Sun, resulting in warmer temperatures. During winter in the northern hemisphere, Earth is tilted away from the Sun, resulting in cooler temperatures.

d) Earth's orbit affects climate by controlling the amount of solar energy Earth receives. Earth's orbit changes very slowly over 100 000 years from circular to elliptical to circular. When it is circular, Earth gets more solar energy when it is nearest the Sun and the energy received is more balanced throughout the year.

3. The Earth's atmosphere affects climate by moderating temperatures and transferring heat.

4. Diagrams should resemble Figure 3.12 on page 218.

5.



6. The hydrosphere moderates temperature by absorbing a lot of heat without causing a great increase in Earth's atmospheric temperature. Water has a high heat capacity. It also moderates temperature by acting as a carbon sink, removing and storing carbon dioxide. Carbon dioxide is a greenhouse gas that warms the atmosphere. The hydrosphere transfers heat through ocean currents. Cold and salty water is denser than warm and less salty water. This causes the cold and salty water to sink, displacing the warm and less salty water, and generating ocean currents that transfer heat around the world.

7. A mountain range could affect the climate of an area by making moving air rise up over one side of the mountain range. The air will become cooler and pick up moisture as it moves. The moisture will form precipitation, which will fall on the other side of the range.

8. a) When solar activity decreases, less sunlight reaches Earth, so it is cooler, and seasonal temperatures vary less.

b) If Mount Pinatubo erupts again, the ash it will send into the atmosphere will reduce the amount of sunlight reaching Earth. So, Earth will be cooler.

c) If Earth is no longer tilted, the same amount of sunlight energy would be available all year round. There would be no seasons.

d) If the ocean currents of the great conveyor belt stopped moving, then the transfer of heat around Earth would stop. Some regions would have less variation in seasonal temperatures.

e) If the continents were grouped at the equator, they would receive a lot of sunlight, experience very little differences between seasons, and would be very hot and steamy. The areas on the coastlines of the continents would be the coolest due to the moderating effects of the surrounding water.

f) If most of the ice at the North and South Poles melted, then the Earth would heat up. The ice has a cooling effect on Earth's temperatures.