Topic 3.3

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

Key Concepts

- Interactions of the Sun and Earth affect climate.
- The atmosphere affects climate around the world.
- The natural greenhouse effect moderates Earth's temperature, indirectly affecting climate.
- The hydrosphere affects global climate.
- Moving continents have a variety of effects on climate.
- The interaction of all natural factors affects climate in ways that are hard to predict.

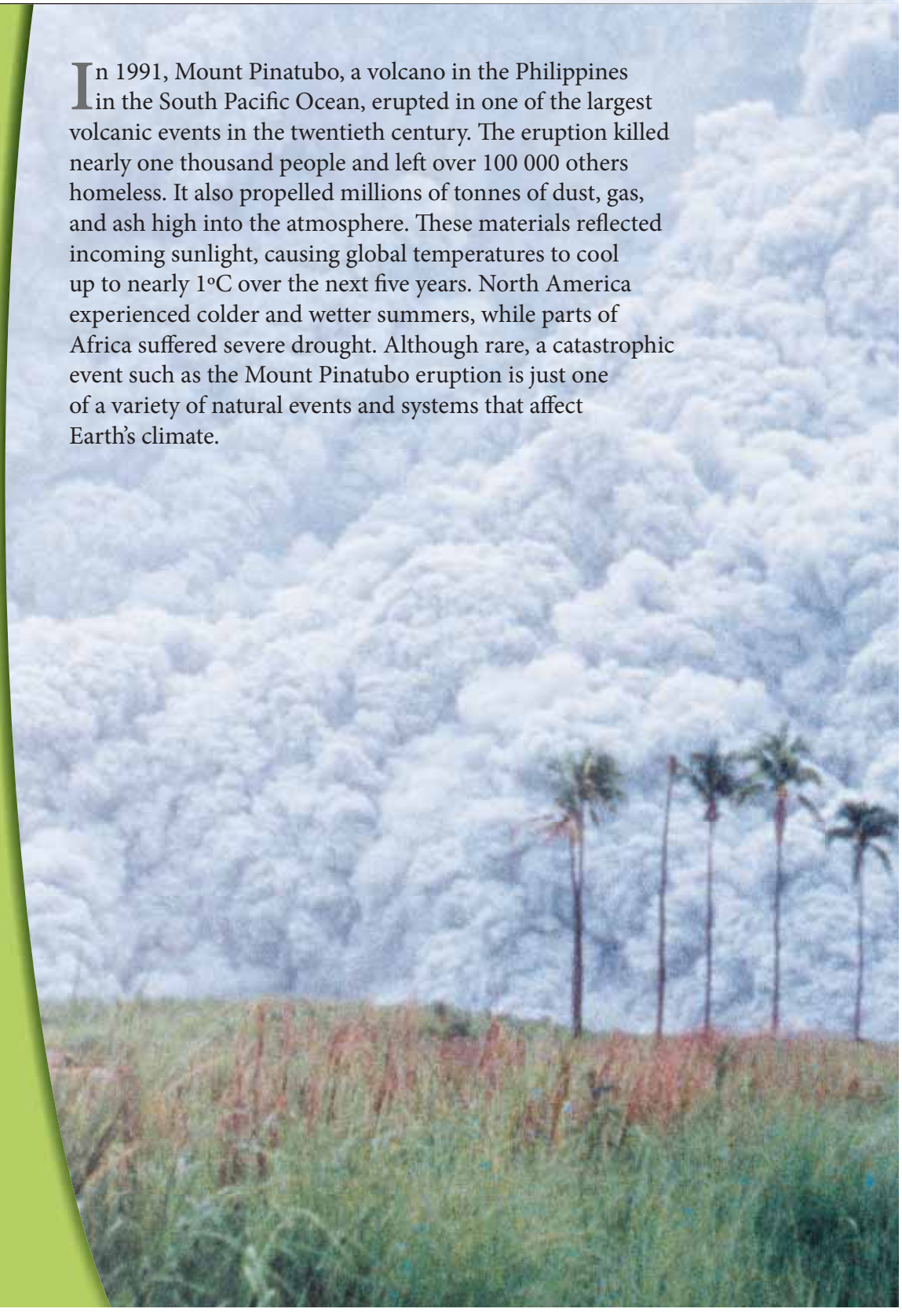
Key Skills

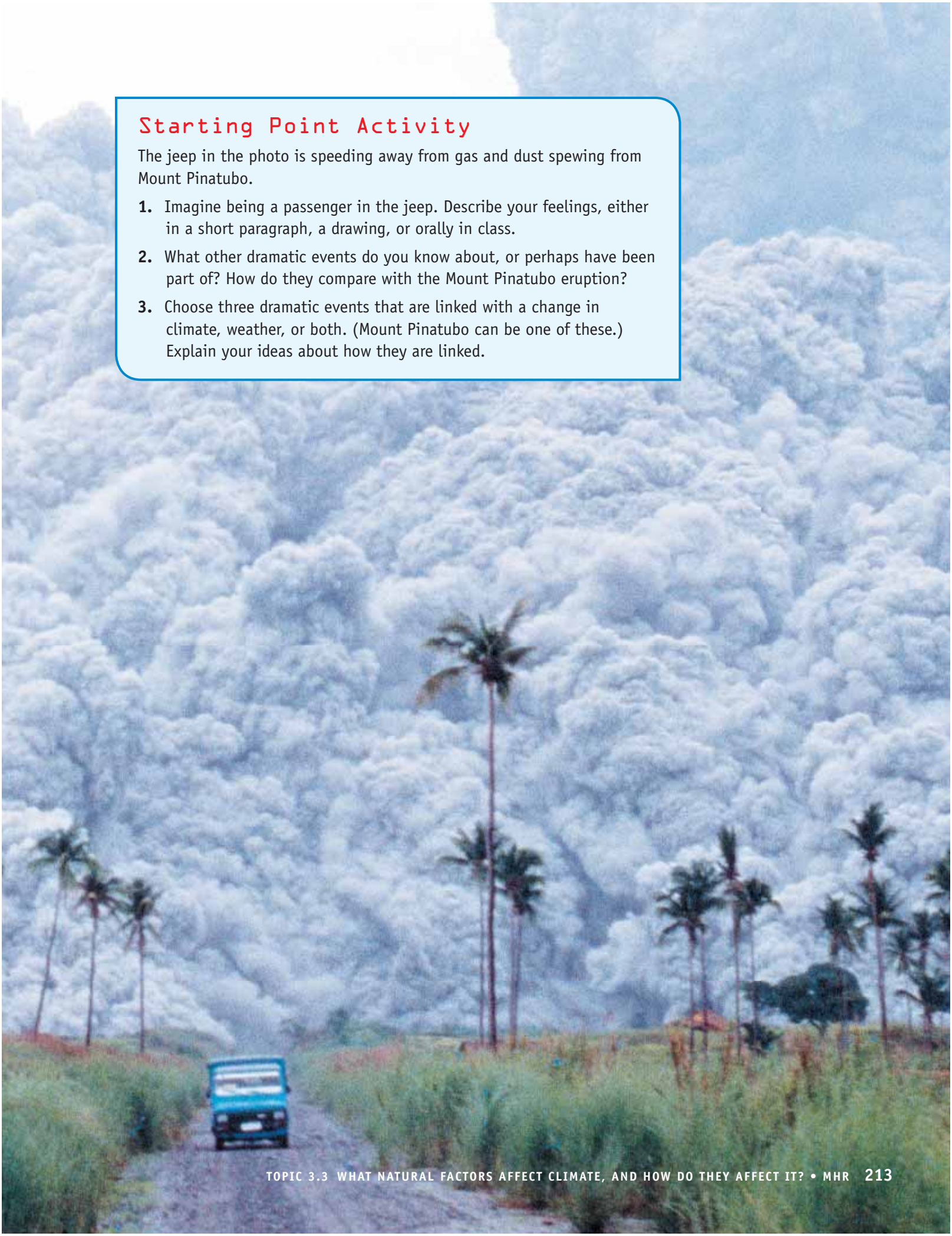
Inquiry

Key Terms

heat sink
greenhouse effect
hydrosphere
carbon sink

In 1991, Mount Pinatubo, a volcano in the Philippines in the South Pacific Ocean, erupted in one of the largest volcanic events in the twentieth century. The eruption killed nearly one thousand people and left over 100 000 others homeless. It also propelled millions of tonnes of dust, gas, and ash high into the atmosphere. These materials reflected incoming sunlight, causing global temperatures to cool up to nearly 1°C over the next five years. North America experienced colder and wetter summers, while parts of Africa suffered severe drought. Although rare, a catastrophic event such as the Mount Pinatubo eruption is just one of a variety of natural events and systems that affect Earth's climate.





Starting Point Activity

The jeep in the photo is speeding away from gas and dust spewing from Mount Pinatubo.

1. Imagine being a passenger in the jeep. Describe your feelings, either in a short paragraph, a drawing, or orally in class.
2. What other dramatic events do you know about, or perhaps have been part of? How do they compare with the Mount Pinatubo eruption?
3. Choose three dramatic events that are linked with a change in climate, weather, or both. (Mount Pinatubo can be one of these.) Explain your ideas about how they are linked.

Interactions of the Sun and Earth Affect Climate

▲ **Figure 3.7** The Sun over Earth's "shoulder"

The Sun is 150 million kilometres from us (**Figure 3.7**). It's amazing that something so far away can have such a huge impact on us. And yet the Sun's energy, and how Earth interacts with this energy, have a powerful effect on Earth's climate.

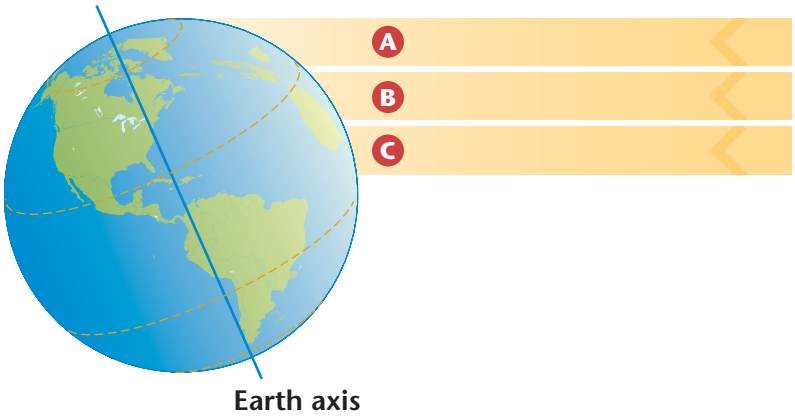
How the Sun's Energy Affects Climate

The Sun is the most important factor that affects Earth's climate. The term *solar energy* refers to the light and other forms of energy that the Sun gives off. The amount of solar energy that the Sun gives off varies from decade to decade. During years when the Sun is very active, it gives off more solar energy. In general, this causes temperatures on Earth to increase. During years when the Sun is less active, it gives off less solar energy. In general, this causes temperatures to decrease. Variations in temperature that result from the Sun's activity also cause changes in patterns of precipitation.

Go to **scienceontario** to find out more

How Earth's Curved Surface Affects Climate

Even when the Sun's activity is constant, the amount of solar energy that reaches different regions of Earth varies. One reason it varies is that our planet is round. Due to Earth's round shape, solar energy strikes the curved surface at different angles, as shown in **Figure 3.8**. As a result, the concentration of light that warms Earth's surface is unequal.



A. Sun's light is spread out over a large area, so warming is more diffuse (less concentrated).

B. Sun's light is spread out over a smaller area, so warming is more concentrated than in A, but less than in C.

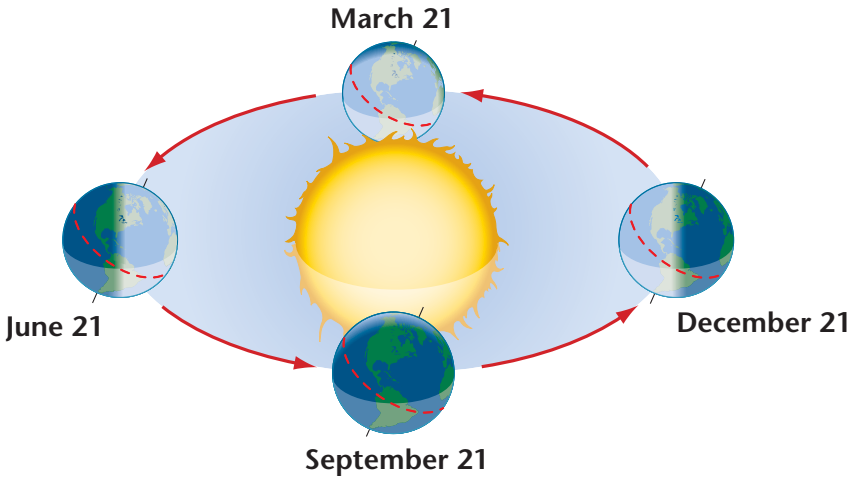
C. Sun's light is very concentrated over a small area, so warming is much more concentrated than at B and A.

▲ **Figure 3.8** How Earth's curved shape affects the concentration of light and warming at different parts of its surface

How Earth's Tilt Affects Climate

Earth's tilt causes the yearly pattern of changes in climate we call the seasons. Refer to **Figure 3.9**. As Earth orbits the Sun, the northern hemisphere is sometimes tilted towards the Sun. At other times, it is tilted away from the Sun. In summer, the northern hemisphere is tilted towards the Sun and solar energy strikes this region more directly, resulting in warmer temperatures. In winter, the northern hemisphere is tilted away from the Sun and solar energy strikes it less directly, resulting in cooler temperatures.

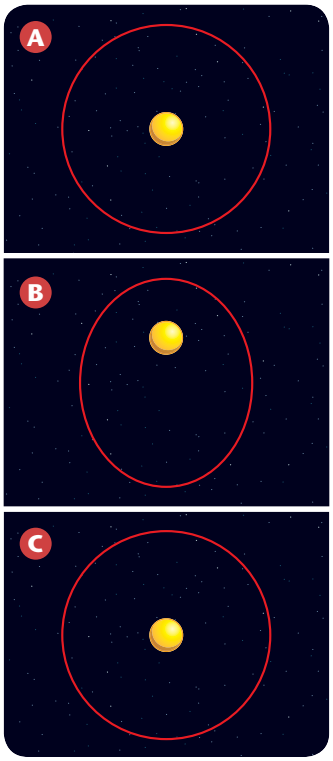
INVESTIGATION LINK
Investigation 3A, on page 226



◀ **Figure 3.9** How Earth's tilt and its position in space at different parts of its orbit around the Sun determine the seasons

How Earth's Orbit Affects Climate

The shape of Earth's orbit also affects how much solar energy our planet receives. **Figure 3.10** shows that Earth's orbit around the Sun changes over a period of time that lasts 100 000 years. It changes from being almost circular, to being more oval, and then back to circular again. When Earth's orbit is more oval, Earth gets much more solar energy when it is nearest the Sun than it does when it is farthest from the Sun. When the orbit is more circular, the amount of solar energy is more evenly balanced throughout the year. All these differences affect the length and intensity of the seasons.



▲ **Figure 3.10** Earth's orbit around the Sun changes from being more circular to being more oval and back again to being more circular. This change in Earth's orbit takes about 100 000 years to complete.

LEARNING CHECK

1. Use a main idea web or a spider map to summarize the ways that the Sun affects Earth's climate.
2. Explain why the Sun is the most important influence on Earth's climate.
3. Use **Figure 3.9** to explain why is it warmer in the northern hemisphere in summer than during the other three seasons.
4. Do you think that changes in Earth's orbit or tilt are causing the fast rate of climate change that we are observing today? Explain your reasoning.

The atmosphere affects climate around the world.

Earth's atmosphere affects climate in two major ways. First, the atmosphere helps to moderate (evens out) temperatures so they are not too extreme. Second, the atmosphere transfers heat around the globe.

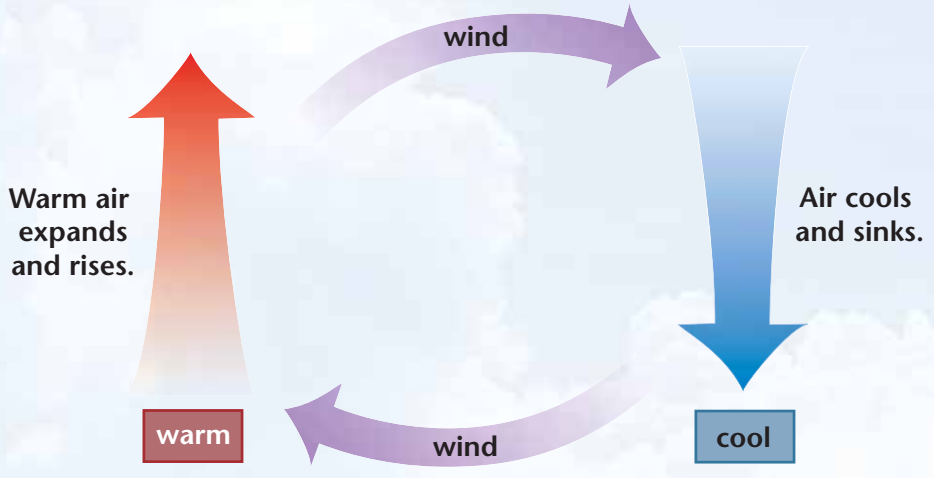
How the Atmosphere Moderates Temperatures

heat sink: something that can absorb heat and store heat

If Earth did not have an atmosphere, temperatures on our planet would swing between two extremes: scorching hot during the day and freezing cold at night. Fortunately for us, Earth's atmosphere is a **heat sink**. This means that it absorbs and stores heat. The atmosphere moderates—has a balancing or evening-out effect on—temperatures so they change gradually over the course of a full 24-hour day.

How the Atmosphere Transfers Heat

Earth receives more direct solar energy at lower latitudes (for example, in Mexico) than at higher latitudes (for example, in Canada). As a result, the atmosphere heats up unevenly. The lower latitudes become warmer than the higher latitudes. However, this unequal heating causes air in the atmosphere to move—that is, it causes wind, which carries heat with it. Figure 3.11 shows the general pattern of air movement that transfers heat from warmer regions of the planet to cooler regions.



▲ **Figure 3.11** Warm air rises and cool air sinks, creating a pattern of air movement (wind) that transfers warm and cool air around the globe.

LEARNING CHECK

1. Explain why the atmosphere is a heat sink.
2. Use **Figure 3.11** to explain how the warming and cooling of air generates wind.
3. Explain why Earth receives more direct energy at lower latitudes than at higher latitudes.

Inquiry Focus

Activity 3.5

MODELLING AIR MOVEMENT

Make a lava lamp to model how warm and cool air move in the atmosphere.

What You Need

- 1 L clear plastic pop bottle
- funnel
- water
- vegetable oil
- food colouring
- effervescent powder (or crushed tablet)

What To Do

1. Using the funnel, add water to the bottle until it is about three-quarters full.
2. Using the funnel, slowly pour vegetable oil into the bottle until it is *almost* full.
3. After the oil and water separate, add 10 drops of food colouring. The drops should pass through the oil and mix with the water.
4. Add half of an effervescent tablet. Observe what happens. To keep the effect going, add another half-tablet. For special effects, shine a flashlight through the bottom of the bottle.

What Did You Find Out?

1. You used effervescent tablets to move the oil in your lava lamp. In a real lava lamp, a heat source at the bottom warms a waxy substance that expands and rises, carrying heat to the top of the lamp. As the wax rises, it cools and then sinks again.
   - **a)** How good a model is a real lava lamp for modelling air movement in the atmosphere?
   - **b)** How good is your lava lamp for modelling air movement in the atmosphere?

The natural greenhouse effect moderates Earth's temperature.

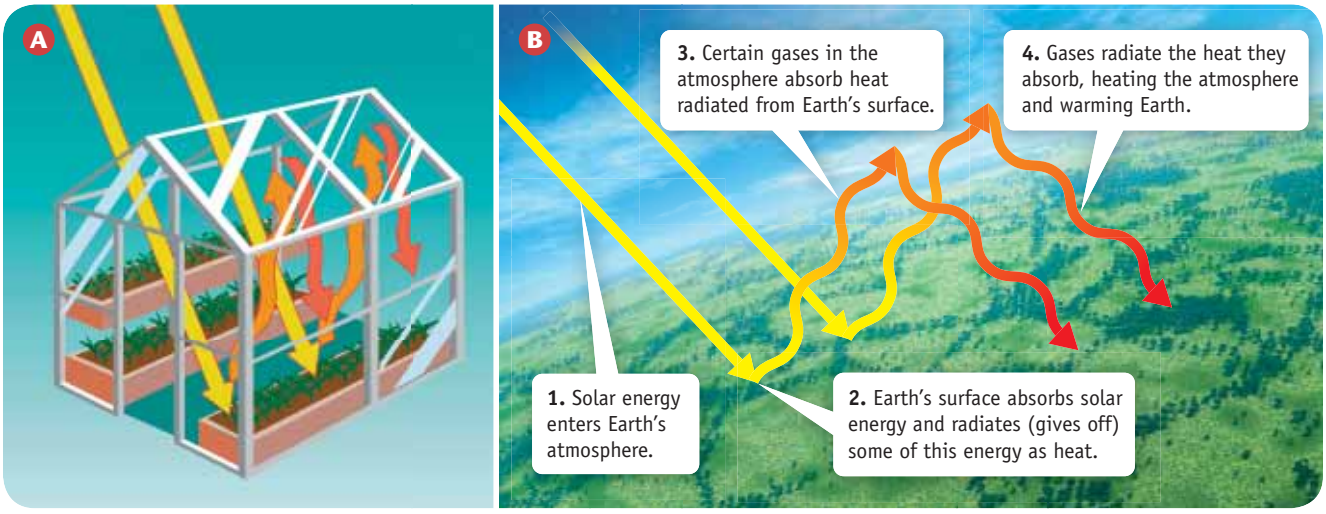
greenhouse effect: a process in which certain gases in Earth's atmosphere absorb heat from the Sun and heat radiated from Earth's surface

The **greenhouse effect** is a process in which certain gases in the atmosphere absorb heat from the Sun, as well as heat that is radiated from Earth's surface. This process results in warming of the atmosphere. The greenhouse effect is a natural part of Earth's climate system. It helps to keep Earth's temperature within a certain range that makes life possible.

How the Greenhouse Effect Works

A greenhouse like the one in **Figure 3.12A** is a building that lets plants grow any time of the year. Solar energy passes through glass or plastic panels. The energy is absorbed by the plants, air, and other objects in the greenhouse. The objects in the greenhouse then radiate some of this energy in the form of heat. The radiated heat cannot pass through the panels of the greenhouse, so the heat is absorbed by the air inside the greenhouse. Air molecules then radiate this heat, warming the inside of the greenhouse.

Now look at **Figure 3.12B**. Certain gases in Earth's atmosphere act like the glass or plastic panels of a greenhouse. These gases are known as greenhouse gases. Like the air in a greenhouse, greenhouse gases in the atmosphere absorb energy from the Sun. They also absorb energy that is radiated from Earth's surface. As a result, heat is trapped in the air of our atmosphere, just as it is trapped in the air of a greenhouse. And like in a greenhouse, the gases radiate the heat they absorb, warming the planet.



▲ **Figure 3.12** How the greenhouse effect (A) keeps the air inside a greenhouse warm and (B) keeps the air surrounding Earth warm.

Natural Greenhouse Gases

Many greenhouse gases occur naturally in the atmosphere. **Table 3.1** lists four of these and their sources.

Table 3.1 Types and Sources of Naturally Occurring Greenhouse Gases

Type of Greenhouse Gas	Common Sources	Other Details
water vapour	• evaporation from water • given off by plants, animals, and other organisms	• most abundant greenhouse gas • scientists believe it accounts for about 70 percent of the greenhouse effect • amount in the atmosphere varies with temperature (higher temperatures result in more water vapour) • produced during cellular respiration and certain plant processes
carbon dioxide	• living organisms • volcanoes, forest fires, decaying organisms, release from oceans	• second-most-abundant greenhouse gas • produced in and by the cells of most living organisms through cellular respiration
methane	• certain species of bacteria and other microorganisms that live in and around bogs, wetlands, melting permafrost • certain species of bacteria that live in the gut of some animals such as cows and termites • vents and other openings in Earth's crust on land and the ocean floor	• a byproduct of certain types of cellular processes that enable some species of microorganisms to extract energy from food in the absence of oxygen
nitrous oxide	• bacteria that live in oceans and wet, warm soils such as those in the tropics	• produced when certain species of bacteria break down nitrogen-rich compounds for food

LEARNING CHECK

1. Use a t-chart or a Venn diagram to compare the greenhouse effect in a greenhouse with the same effect in Earth's atmosphere.
2. Predict what would happen if the concentration of greenhouse gases in the atmosphere increased.
3. Why might scientists believe that water vapour accounts for so much of the greenhouse effect?

INVESTIGATION LINK
Investigation 3B, on page 227

The hydrosphere affects global climate.

Ask someone what their favourite colour is and odds are it will be blue. It's the preferred colour of most people on the planet. Why blue? Perhaps the answer comes from Earth itself. Two-thirds of our planet is covered in oceans, which reflect the blue sky overhead. As shown in Figure 3.13, the water in these oceans covers much of the planet, making up most of the hydrosphere. The **hydrosphere** includes water in all its different forms on Earth. This includes not only the oceans, but also lakes, rivers, ice, snow, and even water vapour in the atmosphere. The hydrosphere's influence on climate is similar to that of the atmosphere. It both moderates temperatures and transfers heat.

hydrosphere: water in all its different forms on Earth

▶ **Figure 3.13** Earth is sometimes called "the water planet" because so much of the surface is covered in water. Certain shots of Earth like this one are also sometimes called "blue marble", again due to our planet's vivid blueness.

How the Hydrosphere Moderates Temperature

It takes much more heat to increase the temperature of water than it does to increase the temperature of an equal amount of air. This means that the hydrosphere can absorb a lot of heat without causing a significant increase in air temperature. In fact, the uppermost 2 m of ocean water holds as much heat as the whole atmosphere. The warmer Earth gets, the more heat large bodies of water absorb. This helps moderate air temperature and affects climate around the world.

Another way the hydrosphere, and especially oceans, moderate temperature is as a carbon sink. A **carbon sink** is something that absorbs and stores carbon dioxide from the atmosphere. By acting as a carbon sink, oceans remove carbon dioxide from the atmosphere for longer periods of time. Since carbon dioxide is a greenhouse gas, removing it from the air helps keep Earth from getting too warm. When there is less carbon dioxide in the air, the oceans release carbon dioxide into the atmosphere again, keeping Earth from getting too cool. In this way the oceans help moderate our planet's temperature, thus affecting climate.

carbon sink: an activity or mechanism that absorbs and stores carbon dioxide from the atmosphere

ACTIVITY LINK
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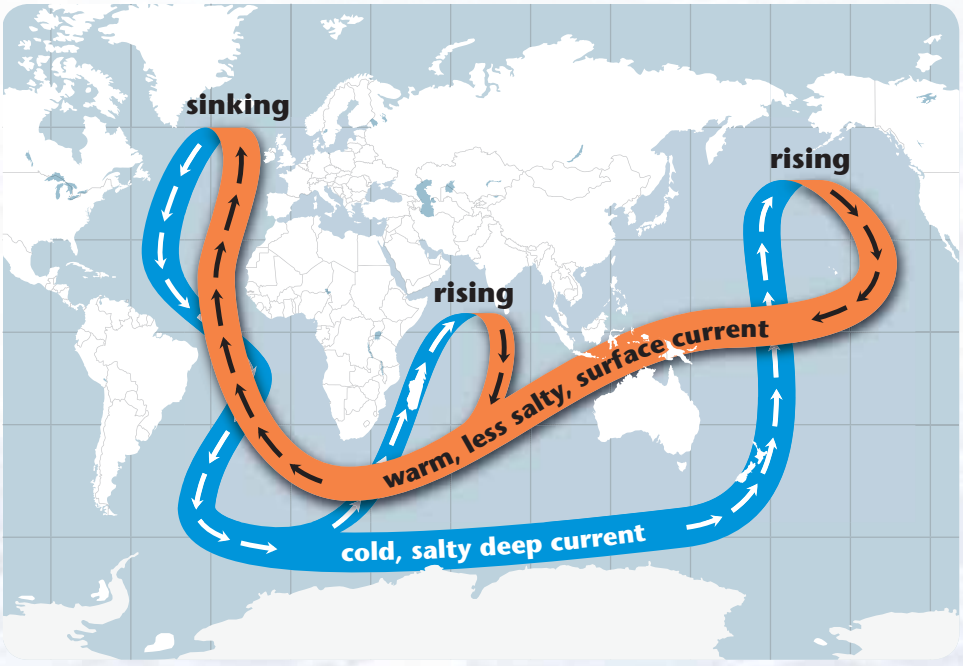
How the Hydrosphere Transfers Heat

Ocean water at the surface moves mostly due to winds. But deeper ocean water moves as a result of differences in the temperature and the salt content of water. Colder water is more dense than warmer water. So colder water sinks and displaces warmer water around it. In a similar way, saltier water is more dense than less salty water. So saltier water sinks and displaces the less salty water around it. Both of these motions produce a massive system of deep-water currents called the *great ocean conveyor belt*. Refer to **Figure 3.14**. This belt of moving water carries heat around the whole world.



◀ **Figure 3.14** The great ocean conveyor belt moves water and heat around the whole Earth.

LEARNING CHECK

1. Water can absorb a lot of heat before its temperature rises. Explain how this moderates air temperature.
2. What is a carbon sink, and how does it moderate air temperature?

Inquiry Focus

Activity 3.6

THE EFFECT OF TEMPERATURE ON WATER MOVEMENT

In one beaker, mix ice and cold water to make 250 mL of ice water. Add about 15 drops of blue food colouring. In a second beaker, add about 250 mL of warm water. Use a clean dropper to transfer some of the coloured ice water on top of the warm water.

What Did You Find Out?

1. Explain what happened and how it might apply to what happens in the ocean?
2. How could you change this activity to observe the effect of mixing very salty water with less salty water?

Moving continents have a variety of effects on climate.

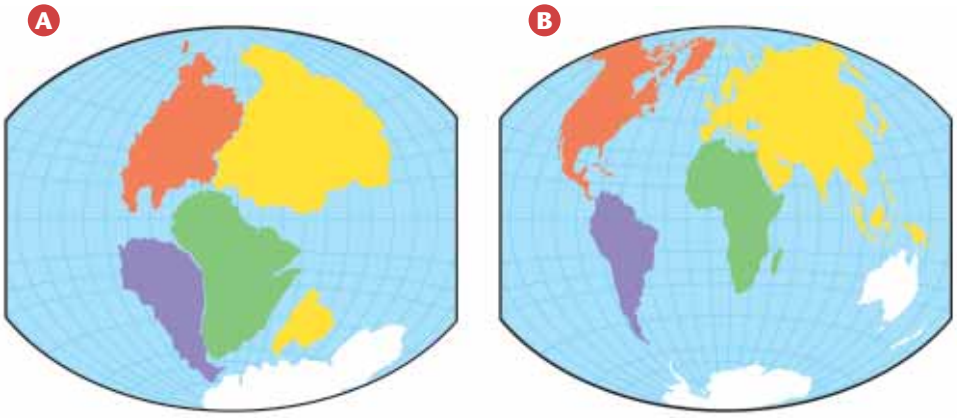
You can't feel it, but the solid surface of our planet—the crust—is always on the move. The crust, and the continents that are attached to it, move at a rate of about 2.5 cm a year. That might not seem like much, but keep in mind that Earth is over 4 billion years old. The continents have been moving for at least three-quarters of that time.

How Moving Continents Affect Climate

About 200 million years ago, the continents were in a very different location than they are today. (Refer to **Figure 3.15**.) The continents were grouped together at the equator. (That's one of the reasons that the frigid continent known today as Antarctica has fossils of lush tropical plants and huge dinosaurs to feed on them, and on each other.) Due to their location, the continents were very warm, and they radiated their heat into the atmosphere. This radiated heat helped make Earth at this time, long ago, a hot, steamy planet.

Today, many of the continents are quite far from one another. And unlike the distant past, there are land masses at Earth's poles. The presence of land masses at the poles has a cooling effect on the atmosphere and, therefore, on the whole planet. Cooler temperatures also affect other aspects of climate, such as precipitation.

Changes in the location of the continents affects more than just temperature and precipitation. Also affected are wind patterns and ocean currents. Changes in these factors affect climate as well. So the combined effects due to location of the moving continents have a great influence on climate over time.



▶ **Figure 3.15** Because the continents move, their locations change over time. For example, the continents were grouped together near the equator about 200 million years ago.

How Mountains and Volcanoes Affect Climate

Moving continents affect climate in another important way. When one mass of continent-carrying crust meets another, rock may be pushed together to form mountains. Mountains force moving air higher in the atmosphere. The air cools as it moves higher, and this cooler air is carried closer to Earth's surface again on the other side of the mountains. The mountains also affect the path of moisture-carrying winds, which affects rain and snowfall.

Another way that moving continents can build mountains is through volcanic activity. Molten rock and gases from deep below the surface can escape into the atmosphere at the boundaries between masses of crust. Sometimes, volcanic eruptions can result.

Figure 3.16 shows the eruption of Mt. St. Helen's in 1980, which spewed millions of tonnes of gas and dust into the atmosphere. These materials reflect incoming solar energy and can have a severe cooling effect. In some cases, the cooling effect can go on for decades or longer. Precipitation patterns are also affected when this happens. On the other hand, volcanic activity releases greenhouse gases into the atmosphere, and this can contribute to global warming.

▲ **Figure 3.16** In 1980 Mount St. Helens erupted in Washington State, sending dust and gases high into the atmosphere. These materials can have both a warming and cooling effect on Earth.

LEARNING CHECK

1. Use a cause-and-effect map to describe how moving continents can affect climate.
2. Repeat question 1 for mountains and volcanoes.

Inquiry Focus

Activity 3.7

MODELLING VOLCANO EFFECTS

How can ash from a volcanic eruption affect global climate?

What To Do

1. Your teacher will fill the aquarium with water and place it on the overhead projector. The water is meant to imitate the atmosphere.
2. When the room is dark and the projector is on, observe the colour of the water from the side of the aquarium.
3. Observe the colour of the light that passes through the aquarium and hits the wall or screen.
4. Your teacher will add 5 mL of coffee creamer to the water and stir. The creamer is meant to imitate the particles of ash from a volcano.
5. Observe the colour of the water and light again.
6. Your teacher will add creamer until more light passes through the side of the aquarium than through the upper surface of the water. Note the changes you observe as more creamer is added.

What Did You Find Out?

1. How did the colour of the light through the aquarium change as ash (creamer) was added to the water (atmosphere)?
2. How does this activity model the effects of volcanic eruptions on the atmosphere?

The interaction of all natural factors affects climate in ways that are hard to predict.

In this topic, you have seen ways that many natural systems and events affect climate. You have looked at these systems and events one by one. You started with interactions of the Sun and Earth. Then you looked at the atmosphere, followed by the hydrosphere, and finally the continents. Perhaps, though, you have begun to sense that matters are more complex than they appear. And you're right. Each of the systems and events affects not only climate, but also each other.

Take water vapour, for example. When average global temperature increases, more water vapour evaporates from soil and water to enter the atmosphere. Water vapour is a greenhouse gas. So an increase in water vapour has a warming effect on our planet. However, increased water vapour in the atmosphere also causes more clouds to form. More clouds reflect more incoming solar energy. This can have a cooling effect on our planet. An increase in clouds also causes an increase in precipitation in some parts of the world. All of these interactions make it hard to predict how climate will change when water vapour increases.

Here is another example that involves the interaction of many more natural factors. Volcanic activity spews carbon dioxide into the atmosphere. Carbon dioxide is a greenhouse gas, so it has a warming effect on our planet. This warming causes oceans to heat up. As water warms, currents that would have been generated by sinking, dense cold water start to slow down. This changes both warm ocean currents and cold ocean currents. Different parts of the world are heated and cooled by these currents. So when these currents change, temperatures in these regions also change. And *these* changes can also affect precipitation patterns.

Complex interactions of natural factors make it challenging to predict changes in Earth's climate system. In the next topic, one more factor will get added into this mix of interacting factors—human activity.

LEARNING CHECK

1. In your own words, explain why Earth's climate is a challenge to understand and make predictions about.
2. Explain why it is hard to understand how an increase in atmospheric water vapour will affect climate.
3. How can increased atmospheric carbon dioxide lead to both higher and lower temperatures in different regions, and yet still cause global warming?

Inquiry Focus

Activity 3.8

HOW MELTING SEA ICE AFFECTS GLOBAL TEMPERATURE

Find out how changes in the hydrosphere affect temperatures around the world in this activity.

Safety

- Be careful when standing near the heat lamps. The bulbs get very hot.

What You Need

- 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

What To Do

1. Design a table to record your observations.
2. Line each tray with black plastic.
3. Label the trays A and B with the marker and masking tape. Cover three-quarters of Tray A with ice. Cover one-quarter of Tray B with ice.
4. Pour water in both trays to fill half the depth of the trays.
5. Set up two 150 W heat lamps about 20 cm from each tray.
6. Position thermometers in each tray to measure the temperature of the water.
7. Turn on the lamps, and make sure that the light shines over the entire tray.
8. Record the temperature of the water in each tray every 30 s for 10 min.

What Did You Find Out?

1. In which tray did the water temperature warm the most? Why do you think this was the case?
2. **a)** What did the black plastic represent in this activity? Hint: After sea ice melts, what lies beneath it?
   b) Why was this lining an important part of the experiment?
3. Use what you have learned in this activity to predict the effect of melting sea ice on average global temperature.

Investigation 3A

Skill Check

- ✓ **initiating and planning**
- ✓ **performing and recording**
- ✓ **analyzing and interpreting**

communicating

Safety

- Do not shine the flashlight directly into another student's eyes.

What You Need

flashlight

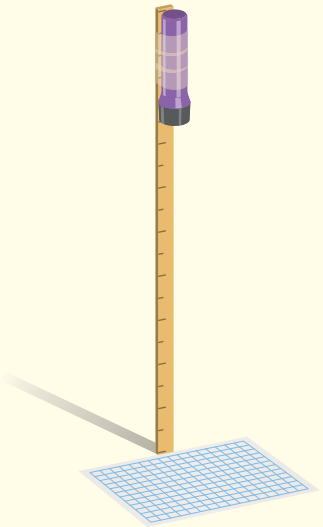
twine or packing tape

metre stick

large sheet of graph paper

pencil

protractor



Solar Radiation and Earth's Surface

Investigate how changing the angle at which sunlight strikes Earth's surface affects the amount of solar energy received.

What To Do

1. Create a data table to record your findings. Hint: Read the following steps to determine what your dependent and independent variables are. These must be recorded in your table.
2. Use the twine or packing tape to bind the flashlight securely to one end of the metre stick.
3. Place the graph paper on the floor. Have one partner hold the flashlight-end of the metre stick so the metre stick is standing upright. The flashlight should be over the graph paper, but turned off.
4. Have another partner use the protractor to confirm that the angle at which the metre stick meets the floor is 90°.
5. Turn on the flashlight, and count the number of squares that are lit up. Record this amount in your table. Turn off the flashlight.
6. Hold the flashlight-and-metre-stick so that it is on an angle of about 60°. Use the protractor to confirm this angle. (It's okay if the angle is slight more or slightly less than 60°.)
7. Turn on the flashlight, and count the number of squares that are lit up. Record this amount in your table. Turn off the flashlight.
8. Repeat steps 6 and 7 with the flashlight-and-metre-stick on an angle of about 30°.

What Did You Find Out?

1. At what angle did the flashlight concentrate its light on the smallest area (fewest number of squares)?
2. At what angle did the flashlight concentrate its light on the largest area (greatest number of squares)?
3. Use your answers to questions 1 and 2 to explain why Earth receives more solar radiation at the equator than at the poles.

Inquire Further

4. You learned that Earth's orbit is sometimes closer to the Sun and sometimes farther from it. Design an investigation to find out how changing the distance between Earth and the Sun affects the amount of solar energy Earth receives. Hint: How can you adjust the distance between a flashlight and graph paper to model this change?

Modelling the Greenhouse Effect

Scientists believe that increasing the amount of carbon dioxide in the atmosphere amplifies the greenhouse effect, which increases average global temperatures. In this investigation, you will test this idea.

What To Do

1. State a hypothesis to predict how the amount of carbon dioxide in the air will affect the temperature of the air. Record your hypothesis.
2. Read all the steps, and design a data table to record your observations.
3. Fill each flask about one-third full with water.
4. Add about 15 mL of effervescent powder to a small test tube.
5. Tilt one of the flasks and gently place the test tube inside. Don't let the test tube fall over and spill its contents into the water.
6. Very gently seal each flask with a stopper. The tip of each thermometer in its stopper should be about 3 cm above the surface of the water in each flask. Use a little modelling clay to seal around the hole where the thermometer is inserted.
7. Place the flasks near the turned-off lamp so that each flask is about 30 cm away from the lamp.
8. Read the temperature showing on each thermometer in each flask. Record these temperatures in your table.
9. Tilt the flask with the test tube so the contents of the test tube spill into the water. Make sure the thermometer doesn't accidently knock into anything when you tilt the flask.
10. Wait until the bubbling in the flask stops. Then turn on the lamp. Wait for 1 min. Then read and record the temperature in each flask. Keep reading and recording the temperature each minute for about 10 min.

What Did You Find Out?

1. Make a line graph of your results.
2. How did your results compare with your hypothesis?
3. Re-read the paragraph at the start of this Investigation. Did your results support what scientists believe will happen if the amount of carbon dioxide in the atmosphere increases? Explain.

Skill Check

- ✓ **Initiating and planning**
- ✓ **Performing and recording**
- ✓ **Analyzing and interpreting**

Communicating

Safety

- Be careful when handling the glassware and thermometers to avoid breakage.
- Be careful when working near the hot bulb of the lamp.

What You Need

2 200-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

effervescent powder

small test tube

timer

Inquiry Focus

Activity 3.9

THE EFFECTS OF OCEAN ACIDITY

Oceans absorb carbon dioxide from the atmosphere. This helps moderate global warming. However, the more carbon dioxide oceans absorb, the more acidic they become. This is because carbon dioxide reacts with water to form carbonic acid. If ocean water gets too acidic, animals such as corals, clams, and sea urchins cannot build their shells or skeletons very well. In this activity, you will explore how shells that contain calcium are affected by different levels of acidity.

What You Need

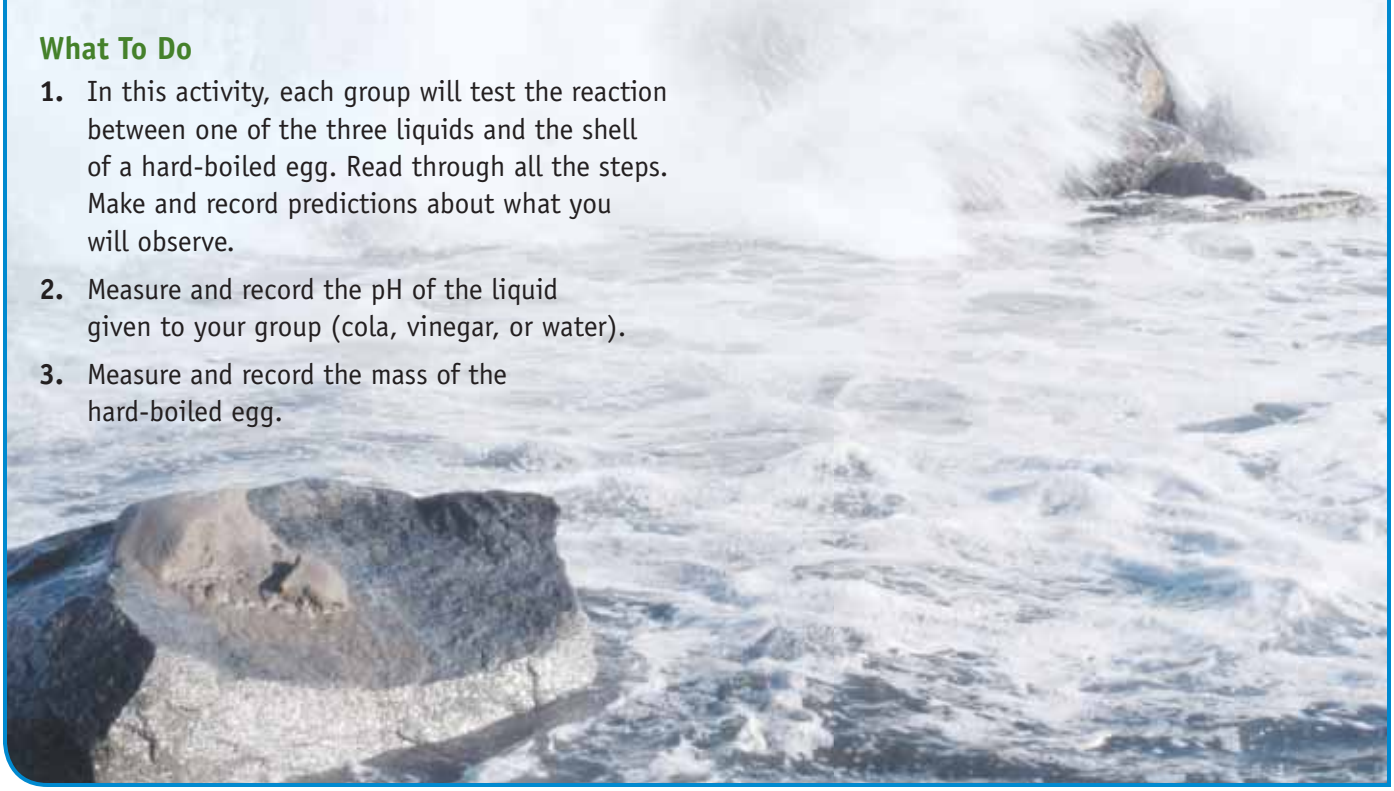
- 3 hard-boiled eggs (or shells from eggs, to minimize food-wasting)
- three containers with lids
- cola
- vinegar
- water
- universal pH paper
- scale

What To Do

1. In this activity, each group will test the reaction between one of the three liquids and the shell of a hard-boiled egg. Read through all the steps. Make and record predictions about what you will observe.
2. Measure and record the pH of the liquid given to your group (cola, vinegar, or water).
3. Measure and record the mass of the hard-boiled egg.
4. Place the egg in a container. Pour enough of your group's liquid into it to just cover the egg. Secure the lid, and place the container where it will be left alone for one day.
5. The next day, carefully remove the egg from its container. Record any changes you observe in the egg.
6. Measure and record the mass of the egg.
7. Measure and record the pH of the liquid.

What Did You Find Out?

1. Describe the changes you observed in your egg.
2. Compare your results with those of other groups. Which egg changed the most? How did this compare with your predictions?
3. Use your results to explain how an animal with a calcium shell might be affected when exposed to ocean water that is too acidic.



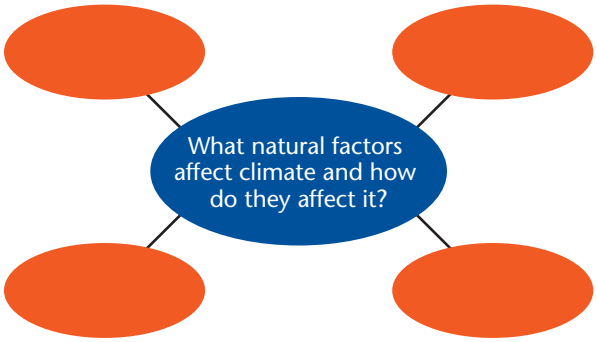
Topic 3.3 Review

Key Concept Summary

- Interactions of the Sun and Earth affect climate.
- The atmosphere affects climate around the world.
- The natural greenhouse effect moderates Earth's temperature, indirectly affecting climate.
- The hydrosphere affects global climate.
- Moving continents have a variety of effects on climate.
- The interaction of all natural factors affects climate in ways that are hard to predict.

Apply the Concepts

1. Answer the question that is the title of this topic. Copy and complete the graphic organizer below in your notebook. Fill in four examples from the topic using key terms as well as your own words.



2. C Show your understanding of the link between the Sun, Earth, and climate in each of the following four cases. Communicate your answer by drawing a labelled diagram, writing a descriptive paragraph, or quietly speaking to a partner or your teacher.

a) how the Sun's energy affects climate

b) how Earth's curved surface affects climate

c) how Earth's tilt affects climate

d) how Earth's orbit affects climate

3. K/U Describe the two major ways that Earth's atmosphere affects climate.

4. T/I Draw diagrams to compare how the greenhouse effect works in a natural greenhouse (the atmosphere) with how the greenhouse effect works in an actual, plant-growing greenhouse.

5. C Refer to **Table 3.1**, which listed types and sources of naturally occurring greenhouse gases. Convert the information in this table into the form of a graphic organizer such as a main idea web or a fishbone diagram.

6. K/U Explain how the hydrosphere moderates temperature and transfers heat.

7. K/U Describe how a mountain range could affect the climate of an area.

8. A Predict the effect on Earth's climate in each of these cases. Explain your answer.

a) Earth's orbit becomes circular. Solar activity is at a minimum.

b) Mount Pinatubo has erupted again, spewing millions of tonnes of ash and carbon dioxide into the atmosphere.

c) Earth is no longer tilted.

d) The ocean currents of the great ocean conveyor belt stop moving.

e) The continents are grouped at the equator.

f) Most of the ice at the North and South Poles has melted.