CONCEPT 1

Solar energy that reaches Earth is absorbed and reflected by Earth's atmosphere and Earth's surface.

Activity

How a Greenhouse Works

People use greenhouses to grow plants during the winter or to plant seeds in the spring so they can germinate and be planted outside when the weather gets warmer. A greenhouse is a building whose walls and ceiling are made of glass or clear plastic. A greenhouse stays warm on the inside even when it is cold outside. Draw a diagram to show how this occurs. How is a greenhouse similar to Earth's atmosphere?

greenhouse gases gases that absorb solar energy in Earth's atmosphere

greenhouse effect process that absorbs outgoing solar energy in Earth's atmosphere

We are all familiar with the feeling of the Sun's energy warming up the ground, grass, or our skin as the Sun rises in the sky each day. But what happens to all of the energy from the Sun as it enters Earth's atmosphere? As shown in **Figure 4.7**, solar energy enters Earth's atmosphere. Most of that energy is absorbed by land and water on Earth's surface. Some of it is reflected by both Earth's surface and the atmosphere and passes through the atmosphere back out into space. Some of the reflected energy is absorbed by gases in the atmosphere and re-emitted in all directions. The gases that absorb solar energy in Earth's atmosphere are called **greenhouse gases**. The process that absorbs outgoing solar energy in Earth's atmosphere is called the **greenhouse effect**.

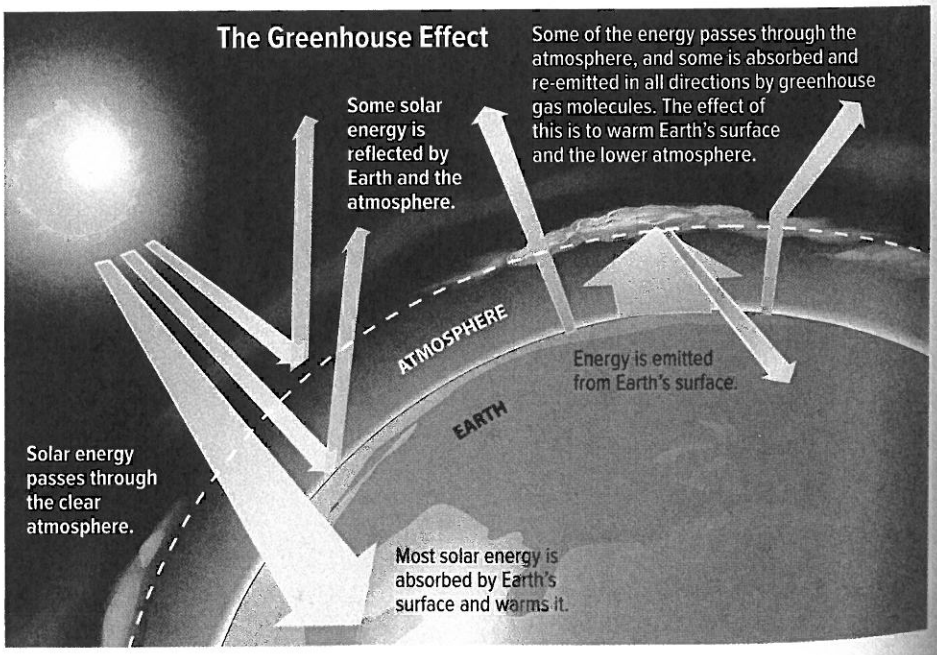

Figure 4.7 The greenhouse effect moderates Earth's temperature. Average global temperature would be a chilly –18°C if greenhouse gases were not naturally found in the atmosphere.

Greenhouse Gases

Many greenhouse gases occur naturally in the atmosphere. Table 4.3 lists four of these, and their sources.

Table 4.3 **Natural Greenhouse Gases**

Greenhouse Gas	Sources	Other Details
water vapour	• evaporation from water • given off by plants, animals, and other organisms	• most abundant greenhouse gas • 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 micro-organisms that live in and around bogs, wetlands, melting permafrost • certain species of bacteria that live in the gut of animals such as cows and termites • vents and other openings in Earth's crust on land and the ocean floor	• a by-product of cellular processes used by some micro-organisms 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

Greenhouse gases can also be released into the atmosphere as a result of human activities. For example, carbon dioxide is released when the fossil fuels oil, natural gas, and coal are burned for electricity, heat, and transportation. Nitrous oxide enters the atmosphere when fertilizer is applied to agricultural crops. Herds of cattle raised as livestock release large amounts of methane into the air. Later in this unit, you will read more about how the excess release of these gases affects nutrient cycles and impacts Earth's climate.

Connect to Investigation 4-C on page 308

Before you leave this page . . .

1. Explain the role that greenhouse gases play in the greenhouse effect.
2. Predict what would happen to Earth's other spheres if the concentration of greenhouse gases in the atmosphere increased.

CONCEPT 2

Solar energy heats Earth's surface unevenly, and global winds help redistribute thermal energy around Earth.

Activity

Three Types of Thermal Energy Transfer

Thermal energy is the total energy of the particles that make up an object. Thermal energy is transferred around Earth by radiation, conduction, and convection. Review the definition of each of these types of energy transfer and provide an example of each. Share your example with a classmate.

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 spherical. Solar energy strikes the curved surface at different angles, as shown in **Figure 4.8**. As a result, the concentration of light that warms Earth's surface is unequal. 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.

Global Wind Systems

What does **Figure 4.8** have to do with wind? Wind, or moving air, results from the unequal heating of Earth's surface. Wind plays an important role in redistributing thermal energy around Earth. Warm air near Earth's surface rises and cools. The cool air is denser and eventually sinks, creating wind that moves warm and cool air around Earth. Study the global wind systems shown in **Figure 4.9**.

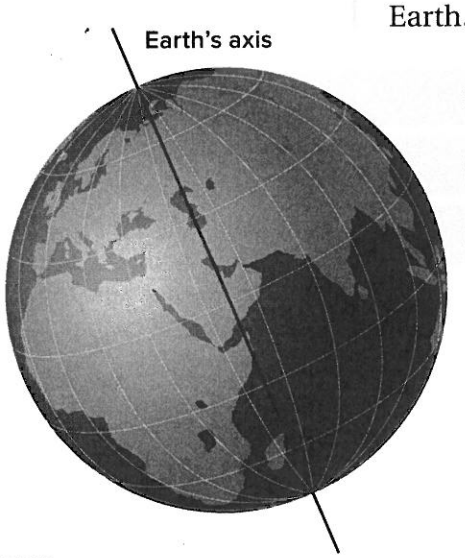

Figure 4.8 Earth's curved surface affects the concentration of light and warming at different parts of its surface.

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

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

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

The wind systems shown in the figure are wide zones of winds. Earth's major wind systems result from a combination of convection currents and the Coriolis effect. The Coriolis effect is a change in the direction of moving air, water, or other objects on or near Earth's surface due to Earth's rotation. Together, global wind systems move thermal energy around Earth and distribute it more evenly throughout the atmosphere.

- The trade winds move from east to west and occur between the equator and 30°N and 30°S latitudes. Air near the equator warms, rises, and travels to 30° north or south latitude. At 30° north or south latitude, the air cools, sinks, and moves west toward the equator.
- The westerlies are winds that move from west to east and occur between 30°N and 60°N and 30°S and 60°S latitudes. The westerlies are steady winds that move much of the weather across parts of North America.
- The polar easterlies move from east to west and occur between 60°N and 90°N and 60°S and 90°S latitudes. These winds move cold air from polar regions back toward the equator.

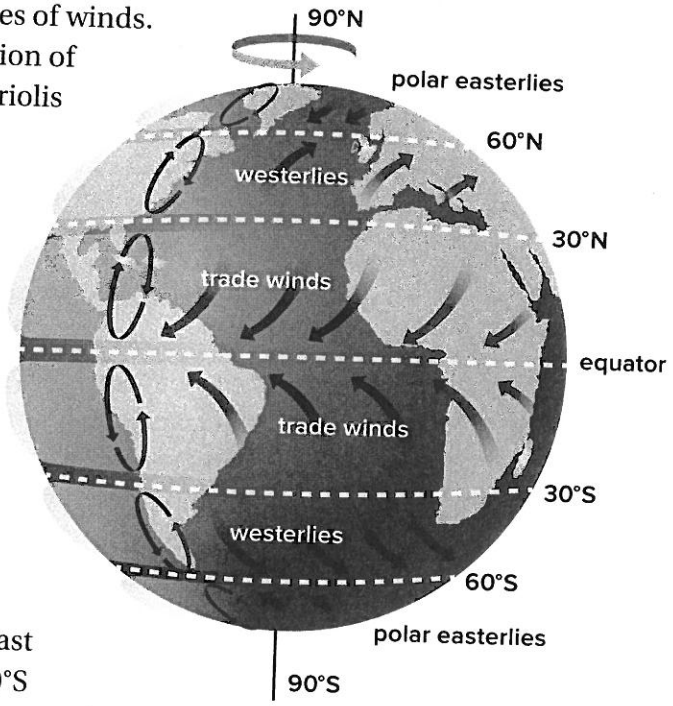

Figure 4.9 The directions of Earth's wind systems vary with the latitudes in which they occur.

Activity

Which Wind System Affects Your Weather?

Using a map that shows latitude, determine which wind system is moving air in your area. How do you think that wind system affects the weather in your area? Which spheres of Earth are interacting to produce wind and weather?

Extending the Connections

Winds and First Peoples Science

Knowledge of winds is an important part of First People's science. What are some examples of Traditional Ecological Knowledge that connect with the winds?

Before you leave this page . . .

1. Explain why Earth receives more direct energy at lower latitudes than at higher latitudes.
2. Write a summary about how the global wind systems move thermal energy around Earth.

CONCEPT 3

Ocean currents also redistribute thermal energy around Earth.

Activity

Ocean Currents Carry More Than Messages in Bottles

In May of 1990, boxes of Nike™ shoes spilled overboard from a container ship in the Pacific Ocean. By early 1991, the shoes were hitting the beaches up and down the coast of B.C. More recently, some of the debris from the 2011 earthquake and tsunami that occurred in Japan washed ashore on B.C. beaches. These are examples of things that we can see with the unaided eye that ocean currents carry. What else do ocean currents carry that is not as easily visible?

Like wind, ocean currents also move thermal energy around Earth. Surface currents, like the ones shown in **Figure 4.10**, are created by wind. There are five major sets of surface currents, one in each main ocean basin—the north Pacific basin, the south Pacific basin, the north Atlantic basin, the south Atlantic basin, and the Indian Ocean basin.

Notice in **Figure 4.10** that in all of the ocean basins, the warm water currents near the equator flow in a westerly direction. When these currents reach a landmass, they turn toward the poles. These poleward-flowing waters carry warm, tropical water into higher, colder latitudes. For example, the warm Kuroshio current moves heat toward the north pole in the north Pacific Ocean.

After these warm waters enter polar regions, they gradually cool. Eventually, they reach a landmass and begin flowing toward the equator. The resulting currents, such as the California current, bring cold water from higher latitudes to tropical regions.

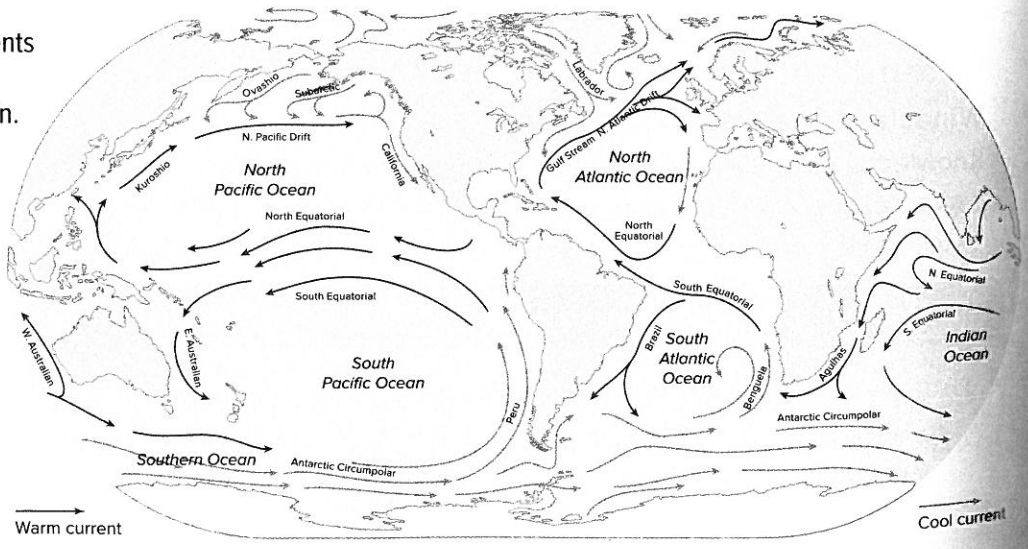

Figure 4.10 Surface currents circulate in predictable patterns in each ocean basin. The red arrows represent warm water currents and the blue arrows represent cold water currents.

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 4.11**. This belt of moving water carries heat around the whole world.

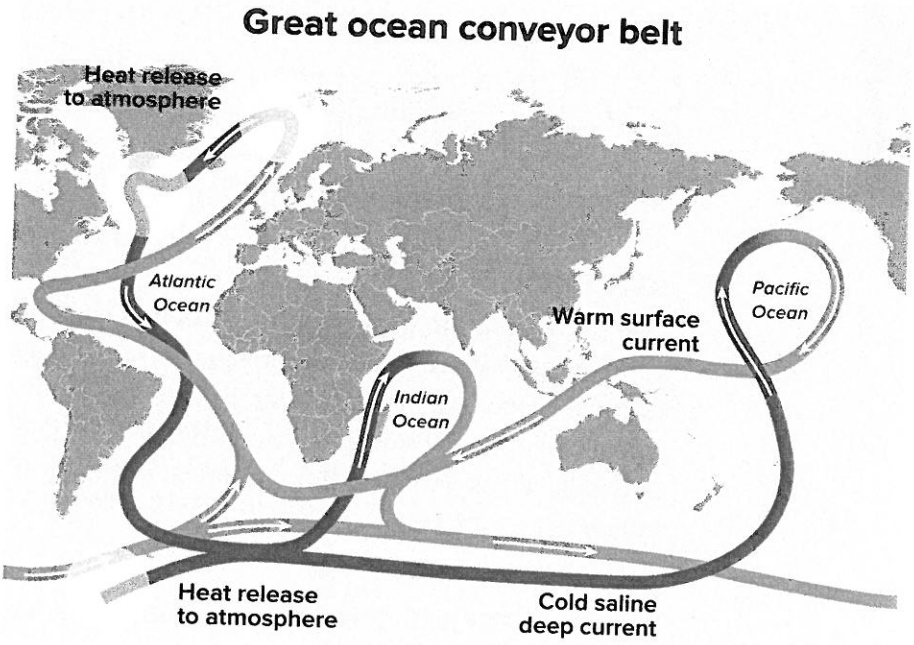

Figure 4.11 The great ocean conveyor belt moves water, nutrients, and thermal energy around Earth.

The great ocean conveyor belt also moves nutrients, such as nitrogen and phosphorus, around the ocean. The surface water that sinks does not contain high amounts of nutrients. After the water sinks, bacteria in deep water break down organic material and return nutrients to the water. When the deep water eventually returns to the surface, it has a high concentration of nutrients.

Activity

Additional Images and Animations

Find satellite images that show the temperature of ocean surface currents, such as the Gulf Stream or the Kuroshio current. How do these images help you understand more about the movement of thermal energy by ocean surface currents? Find an animation that shows the movement of the great ocean conveyor belt. How does the animation help you understand more about the movement of thermal energy by deep ocean currents?

Before you leave this page . . .

1. Describe how surface currents in ocean basins redistribute heat between the equator and the poles.
2. How does the great ocean conveyor belt move heat and nutrients around Earth?