4–1 The Role of Climate

If you live in Michigan, you know you cannot grow banana trees in your backyard. Bananas are tropical plants that need plenty of water and heat. They won't survive in freezing temperatures. It may not be as obvious that cranberries won't grow in the Rio Grande Valley of Texas. Cranberries need plenty of water and a cold rest period. They cannot tolerate the months of very hot weather that often occur in the Rio Grande Valley.

Bananas and cranberries, like other plants and animals, vary in their adaptations to temperature, rainfall, and other environmental conditions. Species also vary in their tolerances for conditions outside their normal ranges. That's why climate is important in shaping ecosystems—and why understanding climate is important in ecology.

What Is Climate?

In the atmosphere, temperature, precipitation, and other environmental factors combine to produce weather and climate. **Weather** is the day-to-day condition of Earth's atmosphere at a particular time and place. The weather where you live may be clear and sunny one day but cloudy and cold the next. **Climate,** on the other hand, refers to the average, year-after-year conditions of temperature and precipitation in a particular region.

Climate is caused by the interplay of many factors, including the trapping of heat by the atmosphere, the latitude, the transport of heat by winds and ocean currents, and the amount of precipitation that results. The shape and elevation of landmasses also contribute to global climate patterns.

The energy of incoming sunlight drives Earth's weather and helps determine climate. As you might expect, solar energy has an important effect on the temperature of the atmosphere. At the same time, the presence of certain gases in the atmosphere also has an effect on its temperature.

The Greenhouse Effect

Temperatures on Earth remain within a range suitable for life because the biosphere has a natural insulating blanket—the atmosphere. **Carbon dioxide, methane, water vapor, and a few other atmospheric gases trap heat energy and maintain Earth's temperature range.** These gases function like the glass windows of a greenhouse. Just as the glass keeps the greenhouse plants warm, these gases trap the heat energy of sunlight inside Earth's atmosphere. The natural situation in which heat is retained by this layer of greenhouse gases is called the **greenhouse effect,** shown in **Figure 4–1.**

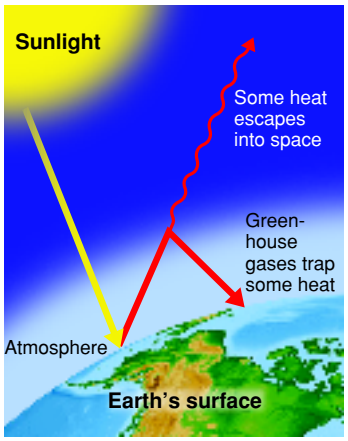
Guide for Reading

Key Concepts
- How does the greenhouse effect maintain the biosphere's temperature range?
- What are Earth's three main climate zones?

Vocabulary
weather • climate
greenhouse effect • polar zone
temperate zone • tropical zone

Reading Strategy: Outlining Before you read, use the headings in this section to make an outline about climate. As you read, fill in the subtopics and smaller topics. Then, add phrases or a sentence after each subtopic to provide key information.

Figure 4–1 Carbon dioxide, water vapor, and several other gases in the atmosphere allow solar radiation to enter the biosphere but slow down the loss of heat to space. These greenhouse gases cause the greenhouse effect, which helps maintain Earth's temperature range.



SECTION RESOURCES

Print:
- ***Teaching Resources,*** Section Review 4–1
- ***Reading and Study Workbook A,*** Section 4–1
- ***Adapted Reading and Study Workbook B,*** Section 4–1
- ***Biotechnology Manual,*** Concept 8
- ***Lesson Plans,*** Section 4–1

Technology:
- ***iText,*** Section 4–1
- ***Transparencies Plus,*** Section 4–1
- ***Virtual Labs CD-ROM,*** The Effect of Temperature on Dissolved Oxygen

Section 4–1

1 FOCUS

Objectives
4.1.1 ***Identify*** the causes of climate.
4.1.2 ***Explain*** how Earth's temperature range is maintained.
4.1.3 ***Identify*** Earth's three main climate zones.

Guide for Reading

Vocabulary Preview
Review the term *latitude* by asking students to describe what the term refers to. (*The distance north and south of the equator*) Display a large world map or globe, and have a volunteer point out the latitude lines on it.

Reading Strategy
Pair students who are not strong readers with proficient readers who can help them select main ideas, subtopics, and relevant details for the outline.

2 INSTRUCT

What Is Climate?

Use Community Resources
Encourage students to interview older family members and friends to find out what the climate was like in their area 25, 50, or more years ago. Instruct students to take notes during the interview. In class, let students compare notes to see whether the people they interviewed agree about climate changes in their lifetimes. L1 L2

The Greenhouse Effect

Make Connections
Physics Ask: **In what forms does Earth receive solar energy?** *(As light and other forms of radiation)* **Besides radiation, how is heat transferred?** *(By conduction [transfer from molecule to molecule within or between objects] and by convection [transfer in currents of a fluid, such as air])* **What causes the greenhouse effect?** *(Earth's atmosphere traps much of the energy from the sun, raising the temperature of the atmosphere.)* L1 L2

Go Online NSTA SCILINKS
Download a worksheet on climate and the greenhouse effect for students to complete, and find additional teacher support from NSTA SciLinks.

The Effect of Latitude on Climate

Use Visuals

Figure 4–2 After students have studied the figure and read the caption, ask: **Why does solar radiation strike different parts of Earth at an angle that varies throughout the year?** *(Earth is a sphere that is tilted on its axis.)* **What are the names given to the latitude lines of 23.5°N and 23.5°S?** *(The Tropic of Cancer and the Tropic of Capricorn, respectively)* **What climate zone is between the Tropic of Cancer and the Tropic of Capricorn?** *(The tropical zone)* **Which climate zone contains the United States?** *(The northern temperate zone)* **Why does the climate of a region in a temperate zone have a relatively wide range of temperatures, depending on the season?** *(The temperate zones are more affected by the changing angle of the sun over the course of a year.)* L1 L2

Heat Transport in the Biosphere

Build Science Skills

Using Models To reinforce students' understanding of how Earth's rotation affects currents and winds, give each pair of students a paper plate. Have one student hold a finger on the center of the plate while slowly turning the plate with the other hand. The second student should put the point of a pencil near the center of the plate and draw a line straight to the plate's edge. Students will see that the line drawn on the plate is not straight but curved, due to the plate's rotation. Explain that Earth's rotation has the same effect on winds and currents. L1 L2

Go Online NSTA SCILINKS
For: Links on climate and the greenhouse effect
Visit: www.SciLinks.org
Web Code: cbn-2041

Greenhouse gases allow solar energy to penetrate the atmosphere in the form of sunlight. Much of the sunlight that hits the surface of our planet is converted into heat energy and then radiated back into the atmosphere. However, those same gases do not allow heat energy to pass out of the atmosphere as readily as light energy enters it. Instead, the gases trap heat inside Earth's atmosphere. If these gases were not present in the atmosphere, Earth would be 30 degrees Celsius cooler than it is today.

The Effect of Latitude on Climate

Because Earth is a sphere that is tilted on its axis, solar radiation strikes different parts of Earth's surface at an angle that varies throughout the year. At the equator, the sun is almost directly overhead at noon all year. At the North and South poles, however, the sun is much lower in the sky for months at a time. Look at **Figure 4–2**, and you will see that differences in the angle of sunlight directed at different latitudes result in the delivery of more heat to the equator than to the poles. The difference in heat distribution with latitude has important effects on Earth's climate zones.

As a result of differences in latitude and thus the angle of heating, Earth has three main climate zones: polar, temperate, and tropical. The **polar zones** are cold areas where the sun's rays strike Earth at a very low angle. These zones are located in the areas around the North and South poles, between 66.5° and 90° North and South latitudes. The **temperate zones** sit between the polar zones and the tropics. Because temperate zones are more affected by the changing angle of the sun over the course of a year, the climate in these zones ranges from hot to cold, depending on the season. The **tropical zone,** or tropics, is near the equator, between 23.5° North and 23.5° South latitudes. The tropics thus receive direct or nearly direct sunlight year-round, making the climate almost always warm. **Figure 4–2** shows Earth's main climate zones.

Checkpoint *What effect does latitude have on climate?*

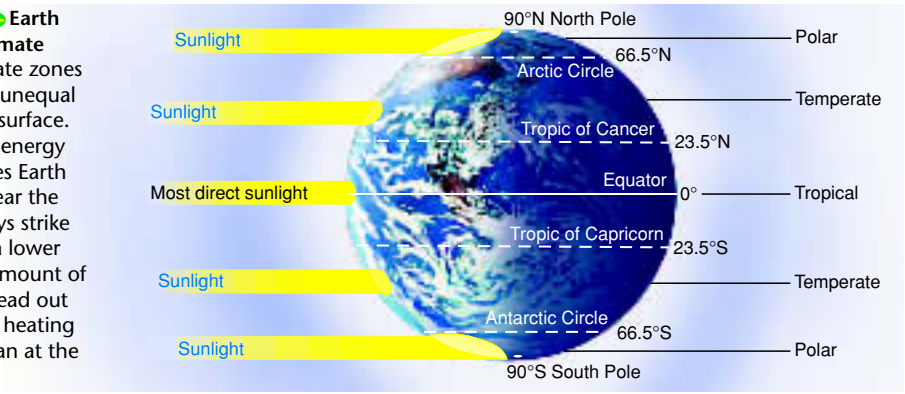


Figure 4–2 **Earth has three main climate zones.** These climate zones are caused by the unequal heating of Earth's surface. Near the equator, energy from the sun strikes Earth almost directly. Near the poles, the sun's rays strike Earth's surface at a lower angle. The same amount of solar energy is spread out over a larger area, heating the surface less than at the equator.

Differentiated Instruction — Solutions for All Learners

Inclusion/Special Needs

To help students who have difficulty grasping the information in the subsection Heat Transport in the Biosphere, read aloud the sentence about why winds form—warm air tends to rise and cool air tends to sink. This concept is common sense for most students, and once they understand that this phenomenon causes winds and ocean currents, they will be better able to understand how heat moves throughout the oceans and the atmosphere. L1

Advanced Learners

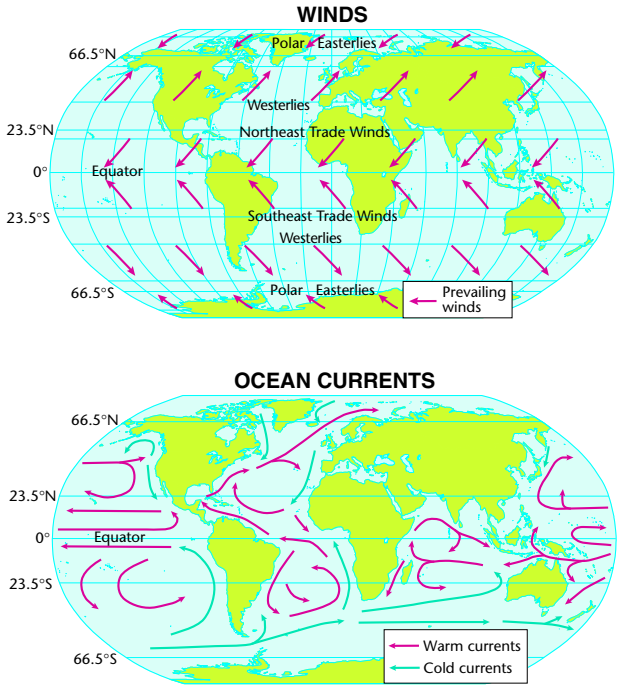
Point out to students who need an extra challenge that the word *tropics* derives from a Latin word for "solstice." Challenge these students to determine the connection between the solstices and the tropics of Cancer and Capricorn. Have them make a presentation of their findings to the class, complete with visual aids. L3

Heat Transport in the Biosphere

The unequal heating of Earth's surface drives winds and ocean currents, which transport heat throughout the biosphere. Winds form because warm air tends to rise and cool air tends to sink. Consequently, air that is heated near the equator rises. At the same time, cooler air over the poles sinks toward the ground. The upward movement of warm air and the downward movement of cool air create air currents, or winds, that move heat throughout the atmosphere, from regions of sinking air to regions of rising air. The prevailing winds, shown in **Figure 4–3**, bring warm or cold air to a region, affecting its climate.

Similar patterns of heating and cooling occur in Earth's oceans. Cold water near the poles sinks and then flows parallel to the ocean bottom, eventually rising again in warmer regions through a process called upwelling. Meanwhile, surface water is moved by winds. In both cases, the water flow creates ocean currents. Like air currents, ocean currents transport heat energy within the biosphere. Surface ocean currents warm or cool the air above them, thus affecting the weather and climate of nearby landmasses.

Continents and other landmasses can also affect winds and ocean currents. Landmasses can interfere with the movement of air masses. For example, a mountain range causes a moist air mass to rise. As this happens, the air mass cools and moisture condenses, forming clouds that bring precipitation to the mountains. Once the air mass reaches the far side of the mountains, it has lost much of its moisture. The result is a rain shadow—an area with a dry climate—on the far side of the mountains.



▲ **Figure 4–3** Earth's winds (top) and ocean currents (bottom) interact to help produce Earth's climates. The curved paths of some currents and winds are the result of Earth's rotation. **Interpreting Graphics** *In what direction do cold currents in Earth's oceans generally move?*

4–1 Section Assessment

1. **Key Concept** What is the greenhouse effect?
2. **Key Concept** Describe Earth's three main climate zones.
3. What are the main factors that determine Earth's climate?
4. Describe two ways in which heat is transported in the biosphere.
5. **Critical Thinking Applying Concepts** A biologist recorded the bird species in her region. Then, she spotted a bird that was not supposed to live in the region. How might variations relate to this occurrence?

Sharpen Your Skills

Modeling

Earth rotates daily on its axis and is tilted at an angle of 23.5° in relation to the sun. Using a flashlight to represent the sun and a globe to represent Earth, demonstrate different levels of light in Earth's three climate zones.

3 ASSESS

Evaluate Understanding

Call on students at random to identify the major climate factors discussed in this section and explain how each factor helps determine climate.

Reteach

Start a simple diagram of the greenhouse effect by drawing a curving section of Earth's surface on the board. Then, have different students in turn add features and labels to the drawing to explain the greenhouse effect step by step.

Sharpen Your Skills

Demonstrate how to hold the globe in a way that models the angle that Earth tilts on its axis, 23.5°. Have students note that if the North Pole is tilted away from the light, then the setup models the positions of sun and Earth during winter in the United States. If the North Pole is tilted toward the sun, then the setup models the positions during summer in the United States. Make sure students find these latitudes on the globe: 66.5° North and South, 90° North and South, 23.5° North and South, and the equator. Have students work in pairs or small groups.

Interactive Textbook

If your class subscribes to the iText, use it to review the Key Concepts in Section 4–1.

4–1 Section Assessment

1. Gases trap heat inside Earth's atmosphere.
2. Tropical zone: near equator; receives direct or nearly direct sunlight year-round, climate is almost always warm. Polar zones: near North and South poles; receive the sun's rays at a low angle, climate is cold. Temperate zones: between the other two zones; receive sunlight at changing angles during the year, climate ranges from hot to cold.
3. Trapping of heat by the atmosphere, latitude, transport of heat by winds and ocean currents, amount of precipitation
4. Winds and ocean currents
5. Animal species show variations in their tolerances for different climatic conditions. The bird was probably just a bit beyond its usual range. Because the species varies in its tolerance, it could survive beyond its range.

Answers to . . .

Checkpoint *Regions at higher latitudes receive less heat energy per unit area than do regions near the equator. As a result, the temperate and polar zones have cooler climates than the tropical zone.*

Figure 4–3 *Cold currents generally move in curving paths toward the equator.*