# LESSON 1
# Introduction to Global Systems

**READING TOOL** **Make Connections** The chart below shows key terms from the lesson with their definitions. As you read, complete the chart by writing a strategy to help you remember the meaning of each term. Two examples have been filled in for you.

| Term | Definition | How I'm Going to Remember the Meaning |
|------|------------|----------------------------------------|
| Biosphere | consists of all life on Earth and all parts of Earth in which life exists | |
| Ecology | the scientific study of the interactions between organisms and between organisms and their surroundings | |
| Species | group of organisms that breed and produce offspring | |
| Population | a group of individuals that belong to the same species and live in the same area | |
| Community | a group of different populations that live together in a defined area | |
| Ecosystem | all of the organisms that live in a place, together with their physical environment | an ecosystem includes the organisms exchanging energy in an environment |
| Biotic factor | any living part of the environment | |
| Abiotic factor | any nonliving part of the environment | the prefix a- means "without," and bio- means "life": *abiotic* = nonliving |
| Atmosphere | a layer of all the gases that surround Earth | |
| Hydrosphere | all the water of the Earth's surface as well as the water vapor and rain in the atmosphere and water underground | |
| Geosphere | solid earth which consists of rocks, continents, and the ocean floor | |

As you read, circle the answers to each Key Question. Underline any words you do not understand.

## BUILD Vocabulary

**biosphere** part of Earth in which life exists including land, water, and air or atmosphere

**ecology** scientific study of interactions among organisms and between organisms and their environment

**species** a group of similar organisms that can breed and produce fertile offspring

**population** group of individuals of the same species that live in the same area

**community** assemblage of different populations that live together in a defined area

**ecosystem** all the organisms that live in a place, together with their nonliving environment

**Understand Prefixes** The prefix *bio-* means "life." ☑ Which vocabulary words in this lesson contain this prefix and what are their meanings?

_____

_____

_____

_____

_____

_____

# Ecology: Studying Our Living Planet

**KEY QUESTION** *Why is ecology important?*

The **biosphere** includes all parts of Earth in which life exists, underground, on land, and in the water and air. The biosphere therefore includes humans and all other living things.

**The Science of Ecology** All forms of life interact with each other and with their environments. **Ecology** is the scientific study of interactions among organisms, populations, and communities and their interactions with their environment.

**Why Study Ecology?** When human populations were small and scattered, humans only had local effects on the environment. As human populations have grown and the power of technology has increased, human impact on the environment has increased. Humans depend on healthy ecological systems for clean water and good soil for growing food. We need to understand ecology so that human activity does not continue to damage the environment.

**Levels of Ecological Organization** Ecologists study organisms and their environment at different levels. A **species** is a group of similar organisms that produce offspring together. A **population** is a group of individuals that belong to the same species and live in the same area. Different populations that live in the same area form a **community**. A community and its physical environment form an **ecosystem**. Similar ecosystems around the world form a biome. The biosphere is all living things on Earth.

# Gathering Ecological Data

**KEY QUESTION** *What methods are used in ecological studies?*

Ecologists generally rely on three main approaches, all of which are part of scientific methodology: observation, experimentation, and modeling. Many studies involve all three approaches. Ecologists may use tools ranging from DNA analysis to data gathered from satellites.

**Observation** Observation is often the first step in asking ecological questions. Questions can lead to new scientific hypotheses that can be tested during experimentation.

**Experimentation** Experiments are designed to test hypotheses. Experiments gather data that support or reject hypotheses. In some experiments, ecologists may carefully alter conditions in parts of natural environments. Or ecologists may design artificial environments. In these experiments, ecologists examine how organisms react to changes in the environment.

**Modeling** Many ecological models consist of mathematical formulas. These formulas are based on data that have been collected through observation and experimentation. Useful models can lead to new hypotheses and new experiments to test them.

# Biotic and Abiotic Factors

**KEY QUESTION** *What are biotic and abiotic factors?*

An organism's environment consists of all the conditions, or factors, around the organism that affect it in any way. These factors are divided into biotic factors and abiotic factors.

**Biotic Factors** Living things affect one another. A biotic factor is any other living thing with which an organism might interact. Biotic factors include animals, plants, mushrooms, and bacteria.

**Abiotic Factors** Physical factors also affect living organisms. An abiotic factor is any nonliving part of the environment, such as sunlight, heat, precipitation, humidity, wind or water currents, and soil type.

**Biotic and Abiotic Factors Together** Biotic factors can influence abiotic factors. For example, soils contain decomposing plant and animal material. Decomposing plant matter can make soil more or less acidic. Plants can affect how much sunlight reaches the ground.

# Modeling Global Systems

**KEY QUESTION** *How can we model global systems?*

One way to understand global systems is to develop a model that shows those systems, the processes that operate within each system, and the ways those systems and processes interact. One model, that is shown in Figure 3-4 of your textbook, begins with the four major global systems. The biosphere includes all living organisms and the environments they live in. The atmosphere includes all the gases that surround Earth. The hydrosphere consists of all Earth's fresh and salt water, including the water vapor and rain in the atmosphere and the water underground. The geosphere includes the rocks, continents, ocean floor, and the interior of the planet.

**READING TOOL**

**Connect to Visuals**
Study Figure 3-3 in your textbook. Think about the biotic factors, the abiotic factors, and the factors that are both biotic and abiotic in the pond ecosystem shown. ☑ **What factors can be both abiotic and biotic? How so?**

_____

_____

_____

_____

**BUILD Vocabulary**

**atmosphere** relatively thin layer of gases that form Earth's outermost layer

**hydrosphere** portion of Earth that consists of water in any of its forms, including oceans, glaciers, rivers, lakes, groundwater, and water vapor

**geosphere** the densest parts of Earth, which includes the crust, mantle, and core

**Related Words** Think of other words that start with *geo-*. such as *geography*. This prefix comes from the Greek word meaning "earth."
☑ **What field of science studies the rocks and solid materials that make up our planet?**

_____

**Global Systems and Change** Our model of Earth systems has three main parts, or rings. Each ring represents an ecological category.
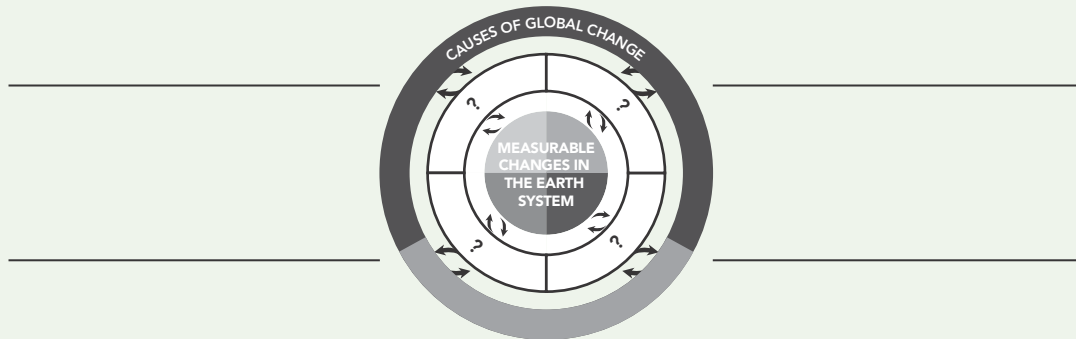
The outer ring, "Causes of Global Change," represents human and non-human causes of change in global systems.

The middle ring, "How the Earth System Works," represents processes within each of the four global systems. It includes the global climate system, cycles of matter, energy flow, and interactions of organisms.

The inner ring, "Measurable Changes in the Earth System," represents changes in global systems that can scientists can measure.

**Building and Using the Model** You will learn about many events, processes, and interactions in this unit. Alone, these facts are like pieces in a jigsaw puzzle. The Understanding Global Change model organizes this information so that you can see how the pieces fit together. You will be able to use the model to explore connections among causes and effects in global change.

---

**Visual Reading Tool: Modeling Global Systems**



Adapted from *Understanding Global Change*, UC Berkeley

1. Label Earth's four global systems on the circle diagram above and color in each with a different color. Use the same colors to highlight the definitions of these spheres on the previous page.

2. How do the global systems interact to affect ecosystems?

_____

_____

_____

3. What features of the geosphere could affect ecosystems?

_____

_____

_____

# Climate, Weather, and Life

**READING TOOL** **Cause and Effect** As you read your textbook, identify the cause-and-effect relationships that the text describes. Record your work in the table.

| Cause → | Effect |
|---|---|
| Sunlight, carbon dioxide, water vapor, methane | |
| Earth's curvature and tilt | |
| Uneven heat distribution | |
| Winds, surface current | |
| Slow climate change | |
| Giant meteorite hits Earth | |
| Rapid climate change | |

# Lesson Summary

## Climate and Weather

🔑 **KEY QUESTION** *What is the difference between weather and climate?*

Climate is defined by patterns and averages of temperature, precipitation, clouds, and wind over many years. It also includes the frequency of extreme weather events such as heat waves, droughts, and floods. Weather consists of short-term changes in temperature, precipitation, clouds, and wind from day to day, or minute to minute. Weather can change rapidly and can be difficult to predict. Climate is usually more predictable. Short-term changes in weather and long-term changes in climate determine whether food crops succeed or fail. Weather and climate also shape natural populations, communities, and ecosystems.

🔑 As you read, circle the answers to each Key Question. Underline any words you do not understand.

**BUILD Vocabulary**

**climate** average year-to-year conditions of temperature and precipitation in an area over a long period of time

**weather** day-to-day conditions of the atmosphere, including temperature, precipitation, and other factors

# The Global Climate System

🔍 **KEY QUESTION** _How is Earth's climate and average temperature determined?_

The global climate system is powered and shaped by the total amount of solar energy retained in the biosphere as heat. The global climate system is also shaped by the unequal distribution of that heat between the equator and the poles.

**Solar Energy and the Greenhouse Effect** Some of the sunlight that strikes Earth is reflected into space, and some is converted to heat. Some of this heat is trapped in the atmosphere. Earth's average temperature is determined by the balance between the amount of heat that stays in the atmosphere and the amount of heat that is lost to space. The amount of heat trapped in the atmosphere is mostly determined by three gases in the atmosphere: carbon dioxide, methane, and water vapor. These gases are called greenhouse gases, because they act like glass in a greenhouse. The greenhouse gases allow light to enter the atmosphere but trap heat. This is called the **greenhouse effect**. Both natural and human-related processes affect the amount of greenhouse gases in the atmosphere.

**Latitude and Solar Energy** The curvature and the tilt of Earth on its axis affect the angle that sunlight strikes the surface. There is more solar energy and therefore more heat near the equator, where the sun is directly overhead, than at the poles. This distribution of heat creates three main climate zones: tropical, temperate, and polar. The tropical zone, near the equator, has warm or hot temperatures all year. The temperate zone, further from the equator, has hot summers and cold winters. The polar zones have very cold winters and summers that are barely warm.

**Differential Heating and Global Winds** The unequal distribution of heat between the equator and the poles creates winds and ocean currents. Earth has winds because warm air rises and cool air sinks. Between the places where air sinks and the places where it rises, air travels over Earth's surface, creating winds. Earth's rotation causes winds to blow from west to east over the temperate zones, and from east to west over the tropics and poles.

# Ocean Currents

🔍 **KEY QUESTION** _What causes ocean currents?_

Ocean currents are driven and shaped by patterns of warming and cooling, by winds, and by the location of continents.

**Winds and Surface Currents** Winds blowing over the ocean create surface ocean currents. Currents flowing from the tropics to the temperate zones have a warming effect on nearby coastal areas. Currents flowing from cool regions toward the tropics have a cooling effect. These interactions between atmosphere and hydrosphere affect weather and climate in coastal areas.

**Deep Ocean Currents** Cold water near the poles sinks but can rise to the surface in places where winds push surface water away from a continent. One such upwelling occurs off the coast of Peru, creating the weather phenomenon called El Niño.

# Regional Climate

🔍 **KEY QUESTION** *What factors shape regional climate?*

Regional climates are shaped by latitude, the transport of heat and moisture by winds and ocean currents, and by geographic features such as mountain ranges, large bodies of water, and ocean currents. Temperature and precipitation can be very different on different sides of a mountain range.

# Changes in Climate

🔍 **KEY QUESTION** *What does climate change involve?*

Earth's climate has remained relatively stable during recorded human history. But global climate has changed dramatically over the much longer history of life. Climate change involves changes in temperature, clouds, winds, patterns and amounts of precipitation, and the frequency and severity of extreme weather events.

**Non-Human Causes of Climate Change** Several factors cause long-term changes in global climate. These factors include changes in solar energy and variations in Earth's orbit. Sudden events such as collisions with meteorites have had major effects on climate. The positions of Earth's continents change over millions of years because of plate tectonics, affecting winds and currents. Volcanic activity can change the amount of greenhouse gases in the atmosphere.

**Results of Past Changes in Global Climate** Non-human causes have produced both warm and cold periods over long periods of time. The most recent cold cycle caused the last major glacial period, which ended about 10,000 years ago. Changes in global climate can occur slowly enough that life on Earth can adapt and survive. At least five times in Earth's history, climate changes happened too fast for organisms to adapt, so many died. These episodes are known as mass extinctions.

## LESSON 3

# Biomes and Aquatic Ecosystems

**READING TOOL** **Organize Information** As you read your textbook, note the similarities and differences between the different land biomes and aquatic ecosystems. There will be more than 1 biome that fits into each feature, and each biome can be used more than once. Record your work in the table.

| Feature | Biome | Feature | Biome |
|---|---|---|---|
| Year-round precipitation | | Warm year-round | |
| Seasonal precipitation | | Warm summers, cool winters | |
| Low precipitation | | Cold year-round | |
| Nutrient-rich soil | | Nutrient-poor soil | |

# Lesson Summary

## Life on Land: Natural Biomes

🔍 As you read, circle the answers to each Key Question. Underline any words you do not understand.

🔍 **KEY QUESTION** *What abiotic and biotic factors characterize a biome?*

**Biomes** are regional climate communities on land. Biomes are described in terms of abiotic factors and biotic factors. A graph called a climate diagram summarizes the seasonal pattern of temperature and precipitation in a biome. The organisms living in a biome can vary, due to differing conditions such as elevation or soil.

Ecologists classify climate communities into roughly ten different biomes.

**Tropical Rain Forest** Tropical rain forests have more species than all other biomes combined. Tall trees form a dense leafy covering called a canopy high above the forest floor. In the shade below, shorter plants form a layer called the understory. Organic matter on the forest floor is reused so quickly that the soil is not very rich in nutrients.

**Tropical Dry Forest** Tropical dry forests grow where there are long periods without rain. Plants and animals are adapted to store water or to use less water.

**Tropical Grassland/Savanna/Shrubland** This biome receives less rain that a tropical dry forest but more than a desert. Grass is interspersed with small groves of trees and shrubs. Organisms are adapted as in a tropical dry forest.

**Desert** Deserts receive very little rain and often have extreme temperature changes between day and night. Animals get water from their food and are inactive during the hot daytime.

**Temperate Grassland** This biome includes plains and prairies dominated by grasses, and has fertile soils. Large animals graze on the grasses and small animals depend on camouflage and burrowing for protection from predators.

**Temperate Woodland and Shrubland** In this biome large areas of grasses are interspersed with trees, and includes shrubland called chaparral. Woody plants resist water loss and may be fire resistant. Animals use camouflage.

**Temperate Forest** Temperate forests have cold winters and warm summers. The fertile soil is rich in humus formed from decaying leaves and other organic matter. Animals may hibernate or migrate in winter.

**Northwestern Coniferous Forest** This biome has mild temperatures and abundant rain. Tall conifers such as giant redwoods grow here.

**Boreal Forest/Taiga** Dense forests of evergreen conifers at the northern edge of the temperate zone are called boreal forests or taiga. Winters are very cold, but summers are mild. Animals have extra insulation or migrate in winter.

**Tundra** The tundra is characterized by permafrost, a layer of permanently frozen subsoil. Tundra plants are small because it is hard for them to take root in the permafrost. Animals are adapted to limit heat loss or to migrate to avoid winters.

**Polar Regions** The polar regions are not one of the biomes, but they border the tundra and are cold all year. Plants are few. Animals include insects and marine mammals that have insulation to survive in the cold waters.

---

### BUILD Vocabulary

**biome** a group of ecosystems that share similar climates and typical organisms

**canopy** dense covering formed by the leafy tops of tall rain forest trees

**understory** layer in a rain forest found underneath the canopy formed by shorter trees and vines

**humus** material formed from decaying leaves and other organic matter

**taiga** biome with long cold winters and a few months of warm weather; dominated by coniferous evergreens; also called boreal forest

**permafrost** layer of permanently frozen subsoil found in the tundra

**Root Words** Break words into component parts to understand their meanings. For example, *permafrost* combines "permanent" and "frost" to indicate the word's meaning. ☑ What effect does the permafrost have on plants in the tundra?

_____

_____

_____

**Biomes Today** Biomes are useful for describing large regions with similar climate and types of organisms. However, there are not many natural communities left today. Humans have altered nearly 75 percent of all land outside the steepest mountains, the polar regions, and the deserts.

# Marine Ecosystems

🔍 **KEY QUESTION** *What factors shape aquatic ecosystems?*

Aquatic ecosystems are described primarily by salinity, depth, temperature, flow rate, and concentrations of dissolved nutrients. There are three main groups of aquatic ecosystems: marine ecosystems, freshwater ecosystems, and estuaries. Ecologists divide the ocean into zones based on depth and distance from shore. Water depth influences life because sunlight doesn't penetrate the water very far. Photosynthesis can occur in the sunlit region near the surface called the photic zone. Below the photic zone is the dark aphotic zone, where photosynthesis cannot occur. Aquatic food chains are based on plankton, which includes floating algae, or phytoplankton, and small animals called zooplankton. Phytoplankton require sunlight and only grow in the photic zone. Zooplankton may swim in or out of the photic zone.

**Intertidal Zone** Organisms in the intertidal zone are submerged in seawater at high tide and exposed to air and sunlight at low tide. Organisms experience extreme changes in temperature.

**Coastal Ocean** The coastal ocean extends from the low-tide mark to the outer edge of the continental shelf. The continental shelf is a relatively shallow part of the ocean surrounding the continents. Water here is lit by sunlight and often fed by nutrients in freshwater runoff from land. Kelp forests and coastal reefs flourish here.

**Open Ocean** More than 90% of the world's ocean lies past the edge of the continental shelf. Depths range from 500 meters along the continental slopes to more than 10,000 meters in deep ocean trenches. The open ocean is divided into photic and aphotic zones.

*Open Ocean Photic Zone* The sunlit top 100 meters of the open ocean supports small species of phytoplankton. Most photosynthesis on Earth occurs here, not in forests.

*Open Ocean Aphotic Zone* The permanently dark aphotic zone includes the deepest parts of the ocean. Deep ocean organisms are exposed to high pressure, cold temperatures, and total darkness. Deep-sea vents, where hot water boils from cracks in the ocean floor, support entire ecosystems based on chemical energy.

# Freshwater Ecosystems

🔍 **KEY QUESTION** *What are the major categories of freshwater ecosystems?*

Only three percent of Earth's surface water is fresh water, but that small percentage provides organisms with drinking water, food, and transportation. Freshwater ecosystems can be divided into three main categories: rivers and streams, lakes and ponds, and freshwater wetlands.

***Rivers and Streams*** Rivers, streams, creeks, and brooks often originate from underground water sources. A chain of rivers and streams may flow through several biomes.

***Lakes and Ponds*** Most life in lakes and ponds depends on plankton, algae, and plants. Water typically enters and leaves lakes and ponds through rivers and streams.

***Freshwater Wetlands*** A wetland is an ecosystem in which water either covers the soil or is present at or near the surface for at least part of a year. Freshwater wetlands include freshwater bogs, marshes, and swamps.

# Estuaries

🔍 **KEY QUESTION** *Why are estuaries so important?*

An estuary (ES tyoo ere e) is a wetland formed where a river meets the sea. Fresh water and salt water often mix here. Estuaries serve as spawning and nursery grounds for many ecologically and commercially important fish and shellfish. Salt marshes are temperate estuaries, and mangrove swamps are tropical estuaries.
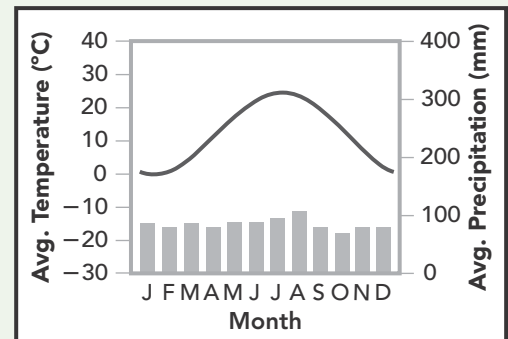
---

**Visual Reading Tool: Climate Diagram**

Use the climate diagram to answer the questions. The bar graph data shows the amount of precipitation, and the line graph shows the average temperature.

1. Describe the pattern of precipitation in this place. Is it seasonal or year-round?

_____

_____



2. Describe the annual temperature pattern in this place.

_____

3. What makes this chart a climate representation, and not one that shows the weather?

_____

## Review Vocabulary

*Choose the letter of the best answer.*

**1.** The gases in the atmosphere that trap heat produce

A. radiation.

B. solar energy.

C. the greenhouse effect.

D. the hydrosphere.

**2.** Nonliving factors of an environment are called

A. biotic.

B. bacteria.

C. abiotic.

D. plankton.

*Match the vocabulary term to its definition.*

**3.** _____ dense forests of coniferous boreal forests along the northern edge of the temperate zone

a. estuary

**4.** _____ a wetland formed where a river meets the sea

b. canopy

**5.** _____ a dense, leafy covering at the tops of tall trees in a rainforest

c. taiga

## Review Key Questions

*Provide evidence and details to support your answers.*

**6.** How do models help ecologists understand global systems?

_____

_____

**7.** What is climate and how does climate change affect ecosystems?

_____

_____

_____

**8.** What abiotic factors distinguish different biomes?

_____

_____

**9.** What factors describe aquatic ecosystems?

_____

_____