CHAPTER 3

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	

Lesson Summary

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?**

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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.

BUILD Vocabulary

biotic factor any living part of the environment with which an organism might interact

abiotic factor physical, or nonliving, factor that shapes an ecosystem

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.

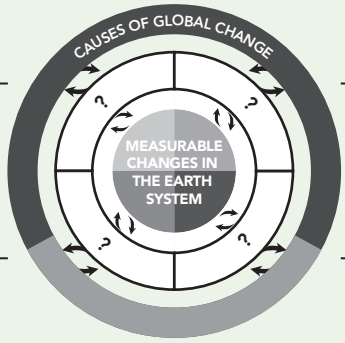
The outer ring, "Causes of Global Change," represents human and non-human causes of change in global systems.

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?

CHAPTER 3

LESSON 2

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?*

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

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.

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

BUILD Vocabulary

greenhouse effect the process in which certain gases (carbon dioxide, methane, and water vapor) trap sunlight energy in Earth's atmosphere as heat

Use Prior Knowledge A greenhouse is a enclosed glass or plastic structure used to grow plants. ☑ **How does knowing this help you understand the greenhouse effect?**

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.

READING TOOL

Connect to Visuals Examine Figure 3-9, Climate Zones, in your textbook. Identify the locations of the three main climate zones on Earth. ☑ **How does the angle of sunlight affect the climate of each of the climate zones?**

CHAPTER 3

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

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

Life on Land: Natural Biomes

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?**

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READING TOOL

Cause and Effect Abiotic factors cause aquatic ecosystems to have zones with different characteristics. As you read, note how each abiotic factor causes the characteristics of each zone to be different and how this affects the type of organisms that live in each zone. ☑ **Describe the differences in the abiotic factors of the open ocean photic zone compared to the open ocean aphotic zone.**

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.

BUILD Vocabulary

photic zone sunlit region near the surface of water

aphotic zone dark layer of the oceans below the photic zone where sunlight does not penetrate

plankton microscopic organisms that live in aquatic environments; includes both phytoplankton and zooplankton

wetland ecosystem in which water either covers the soil or is present at or near the surface for at least part of the year

estuary kind of wetland formed where a river meets the ocean

Prefixes The prefix *a-* can have multiple meanings, but in science terms, it often means "without," or "not." The word *aphotic* means "without light," which is the opposite the meaning of *photic*.

☑ **What other vocabulary word in this lesson is formed from a vocabulary word with the prefix *-a* added?**

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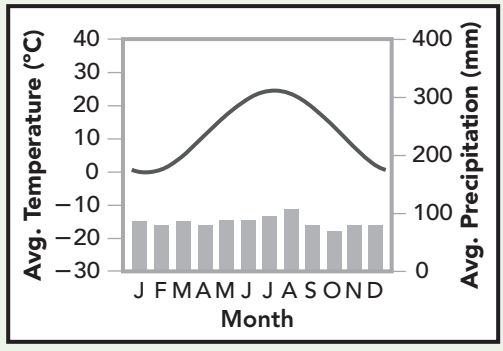
Estuaries

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?

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_____

2. Describe the annual temperature pattern in this place.

_____

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

_____

3 Chapter Review

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?