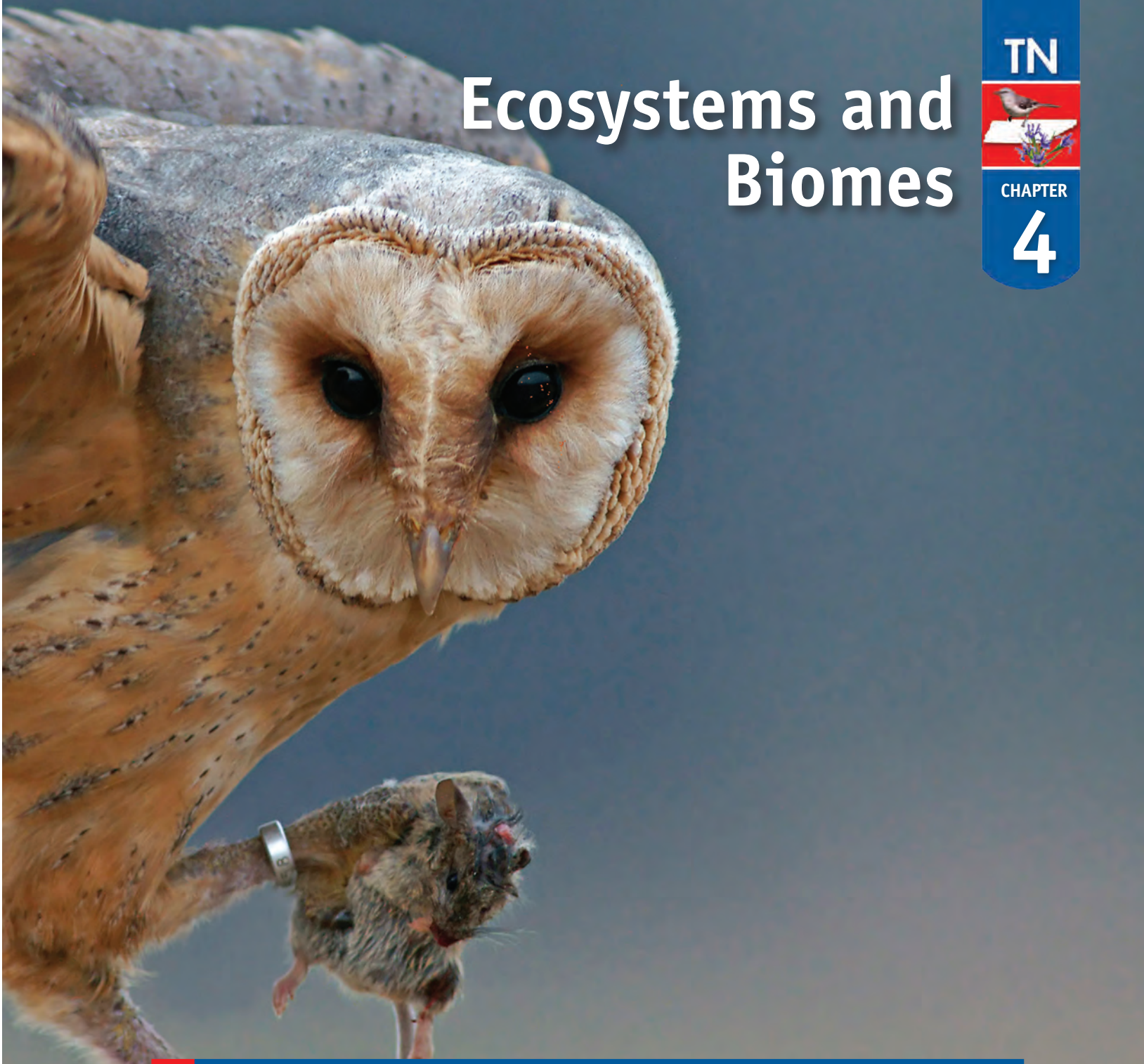
WHERE DOES FOOD COME FROM?

How do energy and matter move through ecosystems?

Flying around hunting for food, this barn owl spots a mouse for dinner. But what did the mouse eat? Perhaps it nibbled on seeds or a caterpillar. Then you might ask, where did the seeds and caterpillar get their food?

Develop Hypotheses **Where do living things get their food?**

Watch the **Untamed Science** video to learn more about ecosystems and biomes.



Ecosystems and Biomes

TN

CHAPTER 4

Tennessee Academic Standards for Science

6.LS2.3 Draw conclusions about the transfer of energy through a food web and energy pyramid in an ecosystem.
6.LS2.4 Using evidence from climate data, draw conclusions about the patterns of abiotic and biotic factors in different biomes, specifically the tundra, taiga, deciduous forest, desert, grasslands, rainforest, marine, and freshwater ecosystems.
6.LS2.6 Research the ways in which an ecosystem has changed over time in response to changes in physical conditions, population balances, human interactions, and natural catastrophes.
6.LS4.1 Explain how changes in biodiversity would impact ecosystem stability and natural resources.
6.ESS3.3 Assess the impacts of human activities on the biosphere including conservation, habitat management, species endangerment, and extinction.

CHAPTER 4

Getting Started

Check Your Understanding

1. **Background** Read the paragraph below and then answer the question.

One morning, Han walks to the park and sits by the pond. He has just studied **ecosystems** in class, and now, looking at the pond, he realizes he sees things in a new way. He notices a turtle sunning itself on a rock, and knows that the sun and rock are **abiotic factors,** while the turtle, and other living things, are **biotic factors.**

The community of organisms that live in a particular area, along with their nonliving environment, make up an **ecosystem.**

Abiotic factors are the nonliving parts of an organism's habitat.

Biotic factors are the living parts of an organism's habitat.

- Name one more biotic factor and one more abiotic factor that Han might see at the pond.

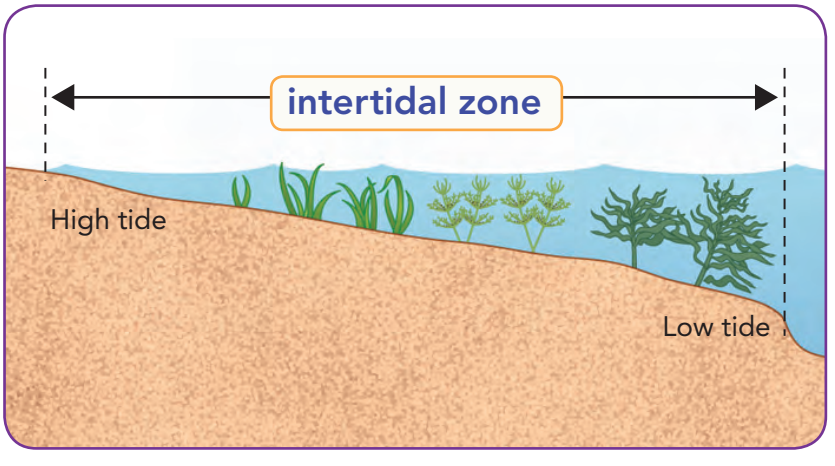
Vocabulary Skill

Prefixes Some words can be divided into parts. A root is the part of the word that carries the basic meaning. A prefix is a word part that is placed in front of the root to change the word's meaning. The prefixes below will help you understand some vocabulary in this chapter.

Prefix	Meaning	Example
inter-	between	intertidal, *adj.* ocean zone between the highest high-tide line and the lowest low-tide line

2. **Quick Check** **Circle the prefix in each boldface word below.**

- There was an **intermission** between the acts of the play.
- The **biosphere** is the area where life exists.



Chapter Preview

LESSON 1

- producer • consumer
- herbivore • carnivore • omnivore
- scavenger • decomposer
- food chain • food web
- energy pyramid • desertification

Relate Text and Visuals
Classify

LESSON 2

- biome • climate • desert
- rain forest • emergent layer
- canopy • understory • grassland
- savanna • deciduous tree
- boreal forest • coniferous tree
- tundra • permafrost

Compare and Contrast
Draw Conclusions

LESSON 3

- estuary
- intertidal zone
- neritic zone

Outline
Communicate

CCC: Energy and Matter

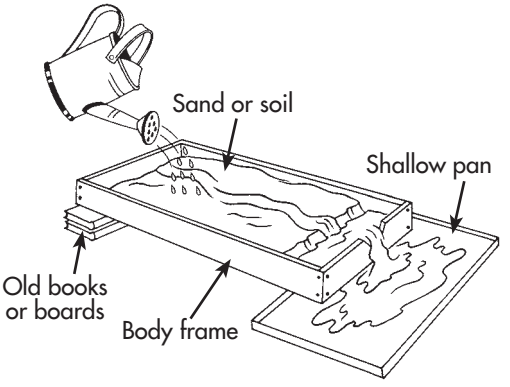
Inquiry **STEM Activity**

River Works

SEP: Developing and Using Models

Moving water on Earth's surface causes erosion and deposition of sediment. This process shapes various land features. The steepness of a hill and the amount of water running down it affect the speed and path of moving water. The materials the water flows over and around also affect its speed and path. These factors determine how land features are formed. Erosion caused by rivers can produce many features, including waterfalls, floodplains, meanders, and oxbow lakes. Deposition of sediments forms features such as deltas and alluvial fans.

In this activity, you will design, build, and test a river model that shows how water erosion and deposition lead to various land features. You will construct your river model on a stream table, as shown in the picture.



Identify the Problem

1. Suppose you want to build a home along a river. Why would it be useful to learn about how a river shapes the land? What problem will your design help solve, and how would it apply to site selection for a home?

Do Research

2. Examine the photos of the six land features produced by rivers: waterfalls, flood plains, meanders, oxbow lakes, deltas, and alluvial fans. On a separate sheet of paper, explain how moving water produces these features.

3. What variables in a working river model can affect the movement of sediment?

Go to the materials station(s). Examine the materials. Think about how each one may or may not be useful for your river model. Leave the materials where they are.

4. What are your design constraints?

Develop Possible Solutions

5. On a separate sheet of paper, describe ways you could use the materials to build a working river model. Identify at least two variables you could control in your model. Explain how the variables would affect the moving water. Then explain how this could form land features.

Choose One Solution

Answer the following questions on a separate sheet of paper.

6. List the material(s) you will use for your river model.

7. Draw your design and label all the parts. Describe how you will build your river model.

8. Describe how your model will show river erosion and deposition processes.

Inquiry **STEM Activity**

Design and Construct a Prototype

Have your teacher review and approve your design. Then, gather the materials you need to build your river model. Build a prototype, the first working version of your design. Wear goggles as you build and test your prototype. Measure the dimensions of your prototype, and note the placement of fixed features that you put into position. If you can, document your construction process by taking photos or recording video.

☑ **9.** On a separate sheet of paper, record the design details of your prototype. Include measurements and quantities for the materials you use.

☑ **10.** On a separate sheet of paper, draw a detailed diagram of your prototype under the heading Before the Test. Label the features and measurements.

Test the Prototype

Test your prototype. Produce a flow of water on the stream table across the land surface that you have designed. Observe what effects the moving water has on sediment. Identify any land features that the moving water produces.

☑ **11.** Answer yes or no to the following:

I could observe the water eroding sediment.	
I could observe the water depositing sediment.	
Moving water changed the land surface in my prototype.	

☑ **12.** Underline the features below that you built in your prototype. Circle the features that were formed by the moving water during your test.

Waterfall	Floodplain	Meander
Oxbow lake	Delta	Alluvial fan

☑ **13.** On a separate sheet of paper, draw a detailed diagram of your prototype under the heading After the Test. Label the features and measurements.

Communicate Results

☑ **14.** Collect the materials that document the design, construction, and testing of your prototype. Assemble a portfolio that includes the before and after diagrams of your river, your photographs or video of the process, and a record of your test results. Use at least one chart, graph, or data table to show your test results. Write a short summary of how your process and results could solve the problem of site selection for construction of a new home.

☑ **15.** Prepare a storyboard or computer slide show that shows how your river and land features changed over time. A storyboard is a series of sketches, similar to a comic strip, that shows a progression of steps over time. Number your sketches and display the storyboard in your class.

Evaluate and Redesign

☑ **16.** Evaluate your prototype using the following rubric. Check one answer for each question.

Does the prototype…	Very Much	Somewhat	Not At All
fit onto the stream table?			
show visible changes to the "land" from the movement of sediment?			
function without overflowing the stream table?			

☑ **17.** Compare your results with your classmates. Did your prototypes function in similar ways? Explain.

☑ **18.** What changes could you make to your prototype to make it more accurately show how rivers produce land features?

TN

LESSON 1

6.LS2.3, 6.LS4.1

Energy Flow in Ecosystems

UNLOCK THE BIG ?

- What Are the Energy Roles in an Ecosystem?
- How Does Energy Move Through an Ecosystem?
- How Do Human Activities Affect Ecosystems?

MY PLANET DIARY

I'll Have the Fish

Scientists have noticed something fishy going on with the wolves in British Columbia, Canada. During autumn, the wolves ignore their typical food of deer and moose and feast on salmon instead. Salmon are very nutritious and lack the big horns and hoofs that can injure or kill wolves. Plus, there are plenty of fish in a small area, making them easier to find and catch.

Many animals, including the wolves, depend upon the salmon's annual mating trip upstream. Losing this important food source to overfishing would hurt the populations of bears, wolves, birds, and many other animals.

DISCOVERY

Communicate **Discuss these questions with a classmate. Write your answers below.**

1. What are two reasons the wolves may eat fish in autumn instead of deer or moose?

2. What effect could overfishing salmon have on an ecosystem?

Lab zone® Do the Inquiry Warm-Up *Where Did Your Dinner Come From?*

Vocabulary

- producer
- consumer
- herbivore
- carnivore
- omnivore
- scavenger
- decomposer
- food chain
- food web
- energy pyramid
- desertification

Skills

Reading: Relate Text and Visuals

Inquiry: Classify

What Are the Energy Roles in an Ecosystem?

Do you play an instrument in your school band? If so, you know that each instrument has a role in a piece of music. Similar to instruments in a band, each organism has a role in the movement of energy through its ecosystem.

An organism's energy role is determined by how it obtains food and how it interacts with other organisms. **Each of the organisms in an ecosystem fills the energy role of producer, consumer, or decomposer.**

Producers Energy enters most ecosystems as sunlight. Some organisms, like the plants and algae shown in **Figure 1,** and some types of bacteria, capture the energy of sunlight and store it as food energy. These organisms use the sun's energy to turn water and carbon dioxide into food molecules in a process called photosynthesis.

An organism that can make its own food is a **producer.** Producers are the source of all the food in an ecosystem. In a few ecosystems, producers obtain energy from a source other than sunlight. One such ecosystem is found in rocks deep beneath the ground. Certain bacteria in this ecosystem produce their own food using the energy in hydrogen sulfide, a gas that is present in their environment.

FIGURE 1

Producers

Producers are organisms that can make their own food.

Identify **Complete the shopping list below to identify the producers that are part of your diet.**

- ○ wheat
- ○ corn
- ○ banana
- ○
- ○
- ○
- ○
- ○
- ○

FIGURE 2

What Happened Here?

While you were hiking, some hungry animals turned your campsite upside down.

Interpret Diagrams **In the table on the next page, check off the clues that relate to the organisms that were in the area. Using the clues, see if you can determine the order in which the organisms visited the campsite.**

Vocabulary Prefixes The prefix *omni-* means "all" or "every." How does this prefix help you understand what omnivores eat?

Consumers

Some members of an ecosystem, like the organisms listed in **Figure 2,** cannot make their own food. An organism that obtains energy by feeding on other organisms is a **consumer.**

Consumers are classified by what they eat. Consumers that eat only plants are **herbivores.** Some familiar herbivores are caterpillars, rabbits, and deer. Consumers that eat only animals are **carnivores.** Wolves, walruses, and snakes are some examples of carnivores. Consumers that eat both plants and animals are **omnivores.** Crows, bears, and humans are omnivores.

Some carnivores are scavengers. A **scavenger** is a carnivore that feeds on the bodies of dead organisms. Scavengers include catfish and vultures.

Clues	Bear	Mold	Rabbit	Wolf
Can easily reach the table top				
Grows on food and breaks it down				
Small enough to enter and exit tent				
Gets energy from meat				
Strong enough to open cooler				
Not a picky eater				
Gets energy from plants				

Decomposers If an ecosystem had only producers and consumers, the raw materials of life, such as carbon and nitrogen, would stay locked up in wastes and the bodies of dead organisms. However, there are organisms in ecosystems that prevent this from happening. **Decomposers** break down biotic wastes and dead organisms and return the raw materials to the ecosystem.

You can think of decomposers as nature's recyclers. While obtaining energy for their own needs, decomposers return simple molecules to the environment. These molecules can be used again by other organisms. Mushrooms, bacteria, and mold are common decomposers.

Lab zone® Do the Quick Lab *Observing Decomposition.*

Assess Your Understanding

1a. Describe An organism's energy role is determined by how it obtains _____ and how it _____ with other organisms.

b. Apply Concepts What is the main source of energy for all three energy roles? Why?

_____

_____

_____

_____

_____

_____

_____

got it?

○ **I get it!** Now I know that the energy roles in an ecosystem are _____

_____

_____

○ I need extra help with _____

_____

_____

_____

How Does Energy Move Through an Ecosystem?

As you have read, energy enters most ecosystems as sunlight and is converted into food by producers. This energy is transferred to the organisms that eat the producers, and then to other organisms that feed on the consumers. **Energy moves through an ecosystem when one organism eats another.** This movement of energy can be shown as food chains, food webs, and energy pyramids.

Food Chains

One way to show how energy moves in an ecosystem is with a food chain. A **food chain** is a series of events in which one organism eats another and obtains energy. You can follow one example of a food chain in **Figure 3.**

Food Webs

A food chain shows only one possible path along which energy can move through an ecosystem. Most producers and consumers are part of many food chains. A more realistic way to show the flow of energy through an ecosystem is with a food web. As shown in **Figure 4,** a **food web** consists of many overlapping food chains in an ecosystem.

Organisms may play more than one role in an ecosystem. Look at the crayfish in **Figure 4.** A crayfish is an omnivore that is a first-level consumer when it eats plants. But when a crayfish eats a snail, it is a second-level consumer.

Just as food chains overlap and connect, food webs interconnect as well. A gull might eat a fish at the ocean, but it might also eat a mouse at a landfill. The gull, then, is part of two food webs—an ocean food web and a land food web. All the world's food webs interconnect in what can be thought of as a global food web.

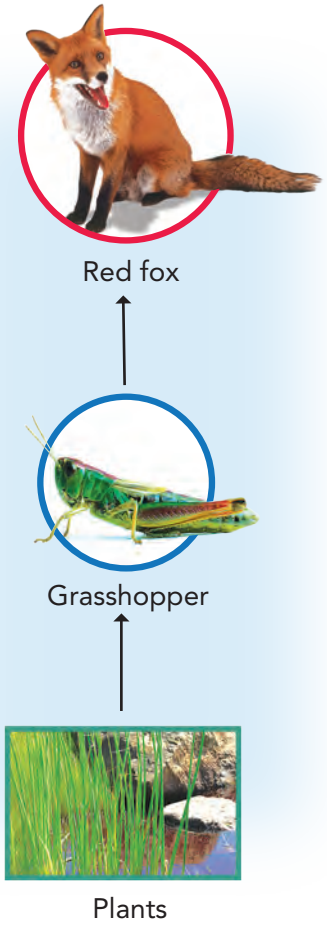
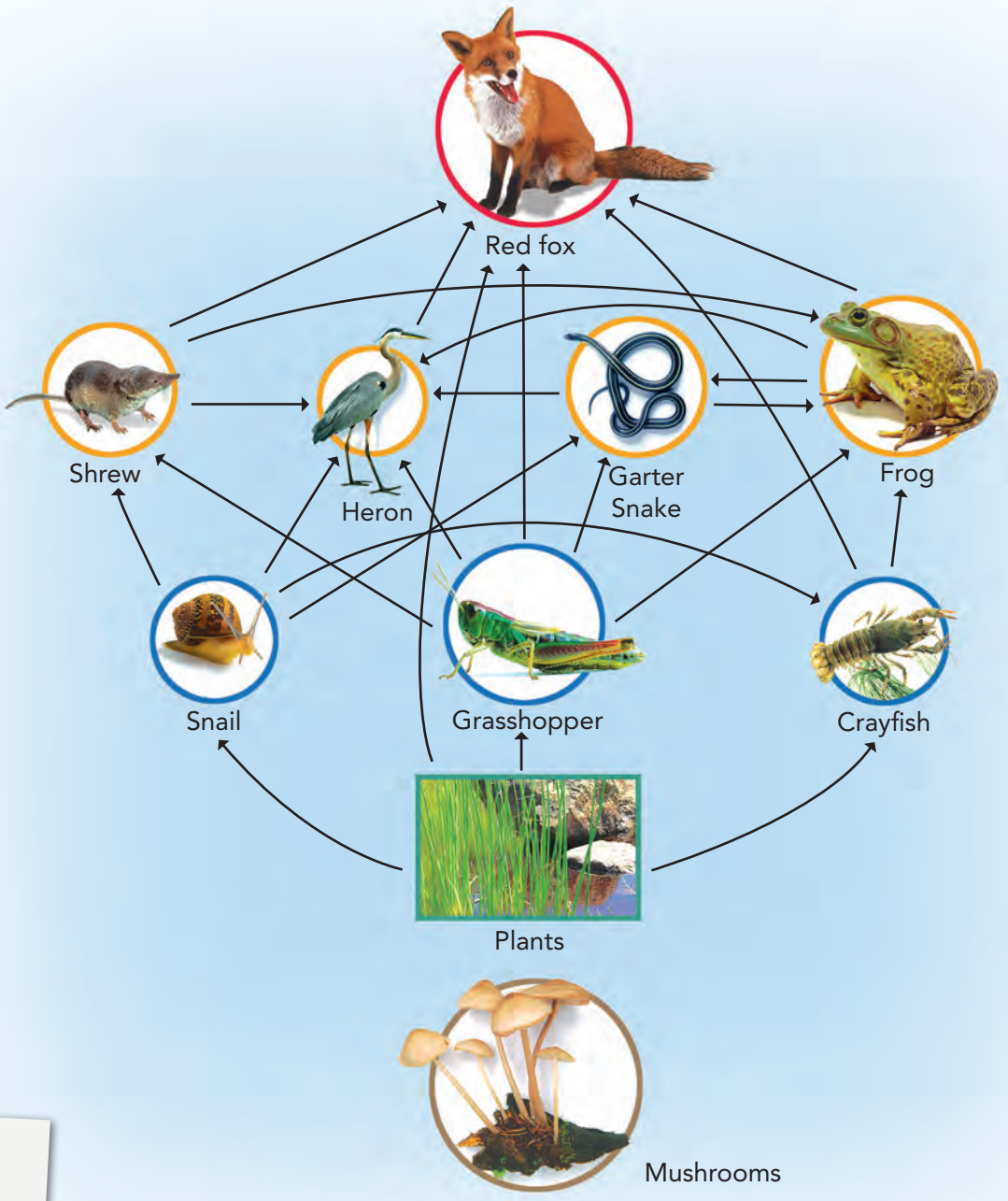


FIGURE 3
Food Chain
In this food chain, you can see how energy moves from plants, to a grasshopper, to the fox. The arrows show how energy moves up the food chain, from one organism to the next.

apply it!

Classify Using what you have learned about food chains, draw or describe a food chain from your local ecosystem. Show at least three organisms in your food chain. Name each organism and label it as a producer, consumer, or decomposer.



Third-level consumers eat the second-level consumers.

Second-level consumers eat the first-level consumers.

First-level consumers are organisms that feed directly on the producers.

Producers form the base of the food web. The first organism in a food chain is always a producer.

Decomposers consume the wastes and remains of other organisms.

FIGURE 4

Food Web

A food web consists of many interconnected food chains.

Complete the tasks.

1. **Interpret Diagrams** Pick two organisms from the food web. Draw arrows connecting them to the decomposers.

2. **Relate Text and Visuals** How can the fox be both a second-level and third-level consumer?

Energy Pyramids

When an organism in an ecosystem eats, it obtains energy. The organism uses some of this energy to move, grow, reproduce, and carry out other life activities. These activities produce heat, a form of energy, which is then released into the environment. When heat is released, the amount of energy that is available to the next consumer is reduced.

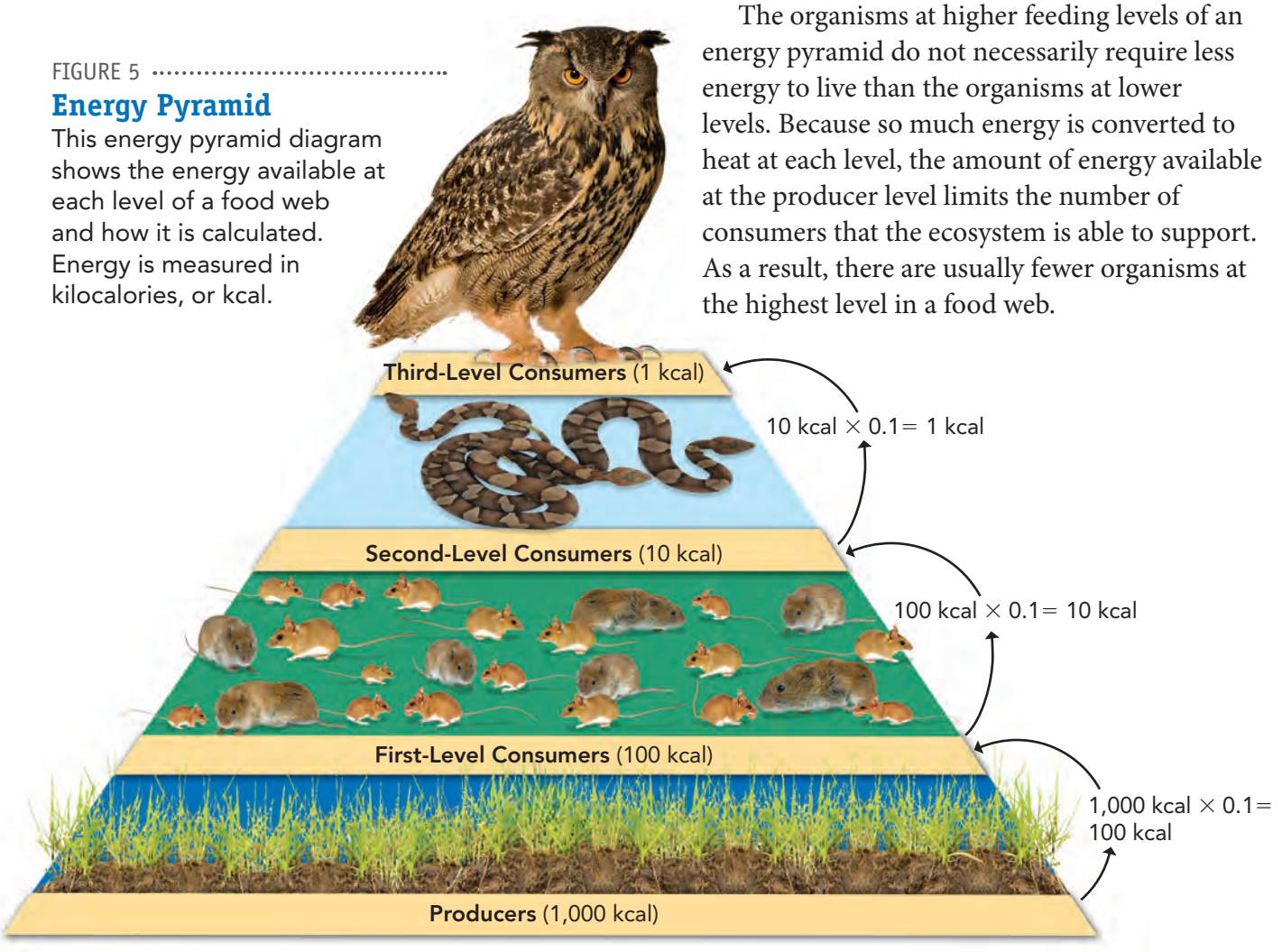
A diagram called an **energy pyramid** shows the amount of energy that moves from one feeding level to another in a food web. You can see an energy pyramid in **Figure 5.** **The most energy is available at the producer level of the pyramid. As energy moves up the pyramid, each level has less energy available than the level below.** An energy pyramid gets its name from the shape of the diagram—wider at the base and narrower at the top.

In general, only about 10 percent of the energy at one level of a food web is transferred to the next higher level. Most of the energy at each level is converted to heat. Since about 90 percent of the food energy is converted to heat at each step, there is not enough energy to support many feeding levels in an ecosystem.

The organisms at higher feeding levels of an energy pyramid do not necessarily require less energy to live than the organisms at lower levels. Because so much energy is converted to heat at each level, the amount of energy available at the producer level limits the number of consumers that the ecosystem is able to support. As a result, there are usually fewer organisms at the highest level in a food web.

Relate Text and Visuals
Look at the energy pyramid. Why is a pyramid the best shape to show how energy moves through an ecosystem?

FIGURE 5
Energy Pyramid
This energy pyramid diagram shows the energy available at each level of a food web and how it is calculated. Energy is measured in kilocalories, or kcal.

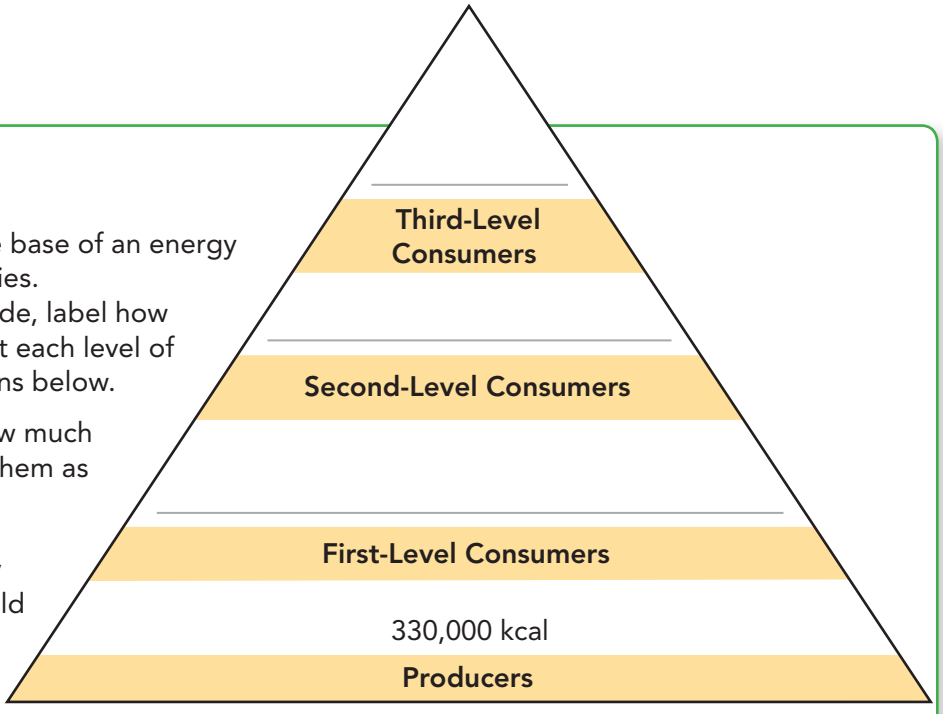


do the math!

Energy Pyramids

Suppose that the producers at the base of an energy pyramid contain 330,000 kilocalories.

Calculate Using **Figure 5** as a guide, label how much energy would be available at each level of the pyramid based on the questions below.



1. If mice ate all of the plants, how much energy would be available to them as first-level consumers?

2. If all of the mice were eaten by snakes, how much energy would the snakes receive?

3. If all of the snakes were eaten by the owl, how much energy would the owl receive?

4. CHALLENGE About how much energy would the owl use for its life processes or lose as heat? _____

5. CHALLENGE How much energy would be stored in the owl's body? _____

Lab zone® Do the Lab Investigation *Ecosystem Food Chains.*

Assess Your Understanding

2a. Define A food (web/chain) is a series of events in which one organism eats another and obtains energy. A food (web/chain) consists of many overlapping food (webs/chains).

b. Compare and Contrast Why is a food web a more realistic way of portraying an ecosystem than a food chain?

_____

_____

_____

c. Relate Cause and Effect Why are there usually fewer organisms at the top of an energy pyramid?

_____

_____

_____

_____

_____

_____

_____

got it?

○ **I get it!** Now I know that energy moves through an ecosystem when _____

_____

○ I need extra help with _____

_____

How Do Human Activities Affect Ecosystems?

Human activities can affect the environment. **Human activities may affect the balance in an ecosystem and thereby change the ecosystem.** Some examples of human activities include overusing resources and using technology in agriculture.

Agriculture Billions of people live on Earth, and they all need food. Many technologies have been developed to increase the amount of food produced. However, these technologies often have negative effects on the environment. For example, technologies that allow people to clear large tracts of forests for new farmland affect the amount of carbon dioxide in the atmosphere in two ways. First, the equipment used to remove the trees burns oil. Second, trees use carbon dioxide during photosynthesis. With fewer trees to take in carbon dioxide, more carbon dioxide remains in the atmosphere.

Farmers may use different types of chemicals to increase their crop yields. Insecticides kill insect pests that damage crops. Herbicides kill weeds. Both chemicals can enter the soil, where they can be absorbed by plant roots. They might also wash into streams and lakes, poisoning the organisms that live there. Farmers may also use chemicals called fertilizers, which put nutrients back into the soil. Like insecticides and herbicides, fertilizers may enter streams and lakes. Once there, the fertilizers may increase plant and algae growth. This overgrowth can kill animals living in the water.

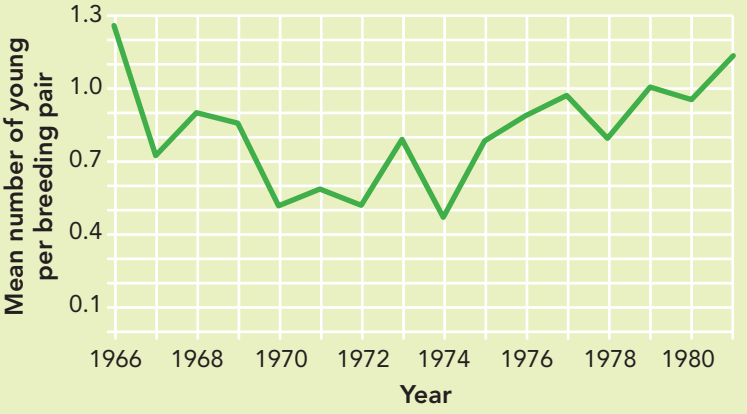
Relate Cause and Effect
Underline the effects of fertilizers on the environment.

do the math!

DDT in the Environment

DDT is an artificial insecticide that was commonly used in the mid-1900s. DDT washed into soil and eventually into streams and rivers. DDT was absorbed by plants and, as a result, entered the food supply of animals. DDT affected the ability of animals such as bald eagles to produce young.

Effect of DDT on Bald Eagle Reproduction



1 **Interpret Data** What is the relationship between DDT use and bald eagle reproduction?

2 **CHALLENGE** DDT was banned in 1972. In 1974, the mean number of young fell sharply. What might explain this decrease?

Overuse of Resources When humans overuse the resources in an ecosystem, the plants and animals living there can be affected. Marine ecosystems provide much of the world's food, especially fish. If people catch most of the fish in an ecosystem, the fish populations may not recover. It is estimated that about 70 percent of the world's fish species are overfished.

In the plains, people use grassland ecosystems to raise farm animals. These animals may eat the grasses more quickly than the grasses grow, or they may eat the grasses entirely so they do not grow back. Without the roots of grasses to hold the soil, winds can blow away fertile topsoil that supports plant growth. The grasslands may then become desert-like, as in **Figure 6**. The advance of desert-like conditions in an area once fertile is called **desertification.**

FIGURE 6

Overgrazing

Overusing resources can greatly change an ecosystem.

Relate Text and Visuals **Write a caption for each picture.**

Lab zone® *Do the Quick Lab Consequences of Human Activity.*

Assess Your Understanding

got it?

- ○ **I get it!** Now I know that human activities _____
- ○ I need extra help with _____

TN

LESSON 2

6.LS2.4

Biomes

UNLOCK THE BIG ?

What Are the Six Major Biomes?

MY PLANET DIARY

That's Super Cool!

Misconception: It is always fatal when body temperatures drop below freezing.

Fact: In the tundra, arctic ground squirrels hibernate up to eight months a year. During this time, a squirrel's body temperature drops below freezing! This is called supercooling and gives the squirrel the lowest body temperature of any mammal. Without waking, a squirrel will shiver for several hours every couple of weeks to increase its body temperature.

MISCONCEPTION

Answer the question below.

What do you think are the advantages of supercooling?

Lab zone® Do the Inquiry Warm-Up *How Much Rain Is That?*

What Are the Six Major Biomes?

Imagine that you are taking part in an around-the-world scientific expedition. On this expedition you will collect data on the typical climate and organisms of each of Earth's biomes. A **biome** is a group of ecosystems with similar climates and organisms.

The six major biomes are desert, rain forest, grassland, deciduous forest, boreal forest, and tundra. It is mostly the **climate**—the average annual temperature and amount of precipitation—in an area that determines its biome. Climate limits the species of plants that can grow in an area. In turn, the species of plants determine the kinds of animals that live there.

Vocabulary

- biome
- climate
- desert
- rain forest
- emergent layer
- canopy
- understory
- grassland
- savanna
- deciduous tree
- boreal forest
- coniferous tree
- tundra
- permafrost

Skills

Reading: Compare and Contrast

Inquiry: Draw Conclusions

Desert Biomes

The first stop on your expedition is a desert. You step off the bus into the searing heat. A **desert** is an area that receives less than 25 centimeters of rain per year. Some of the driest deserts may not receive any precipitation in a year! Deserts often undergo large shifts in temperature during the course of a day. A scorching hot desert like the Namib Desert in Africa cools rapidly each night when the sun goes down. Other deserts, such as the Gobi in central Asia, have a yearly average temperature that is below freezing.

Organisms that live in the desert, like the fennec in **Figure 1,** must be adapted to little or no rain and to extreme temperatures. For example, the stem of a saguaro cactus has folds that are similar to the pleats in an accordion. The stem expands to store water when it is raining. Gila monsters can spend weeks at a time in their cool underground burrows. Many other desert animals are most active at night when the temperatures are cooler.

FIGURE 1

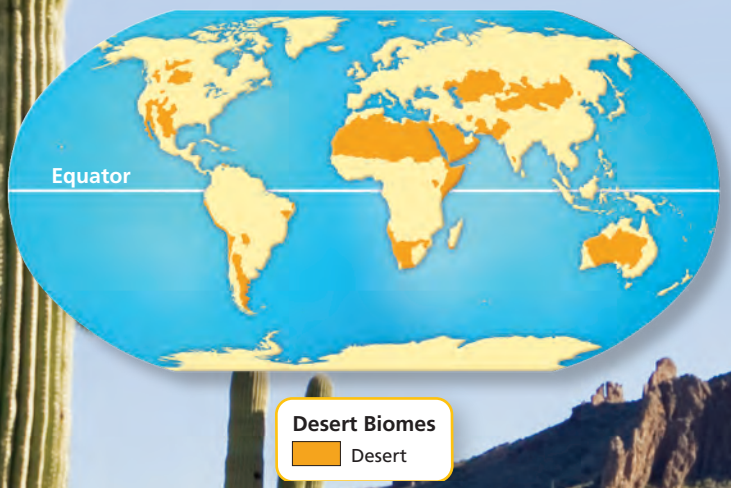
Desert

Organisms must be adapted to live in the desert.

Complete these tasks.

1. CHALLENGE How do you think the fennec's ears and fur are adaptations to the desert's extreme temperatures?

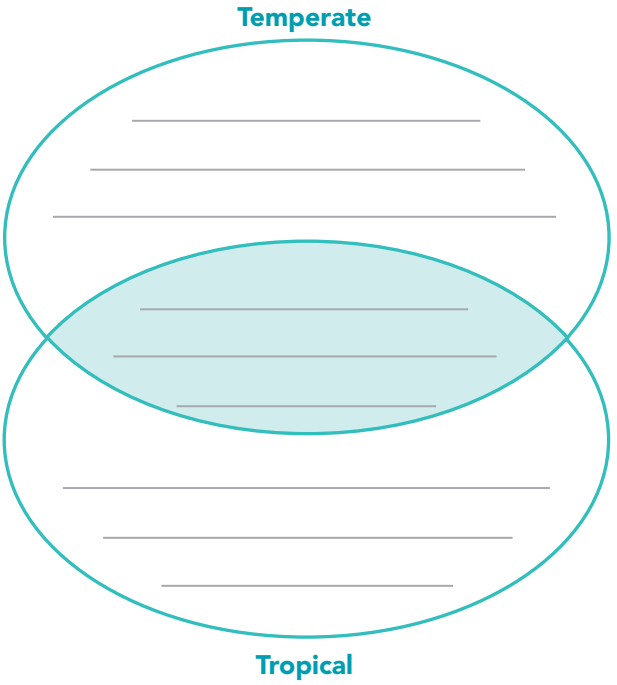
2. **List** Write five things you'll need to be well adapted to desert conditions. Pack carefully!



Supply List

- wide-brimmed hat
-
-
-
-
-

Compare and Contrast As you read about temperate and tropical rain forests, fill in the Venn diagram.



Rain-Forest Biomes

The second stop on your expedition is a rain forest. **Rain forests** are forests in which large amounts of rain fall year-round. This biome is living up to its name—it's pouring! After a short shower, the sun reappears. However, very little sunlight reaches the ground.

Plants are everywhere in the rain forest. Some plants, like the vines hanging from tree limbs, even grow on other plants! And animals are flying, creeping, and slithering all around you.

Temperate Rain Forests

You may think that a rain forest is a warm, humid "jungle" in the tropics. But there is another type of rain forest. The Pacific Northwest of the United States receives more than 300 centimeters of rain a year. Huge trees grow there, including redwoods, cedars, and firs. Many ecologists refer to this ecosystem as a temperate rain forest. The term *temperate* means "having moderate temperatures."

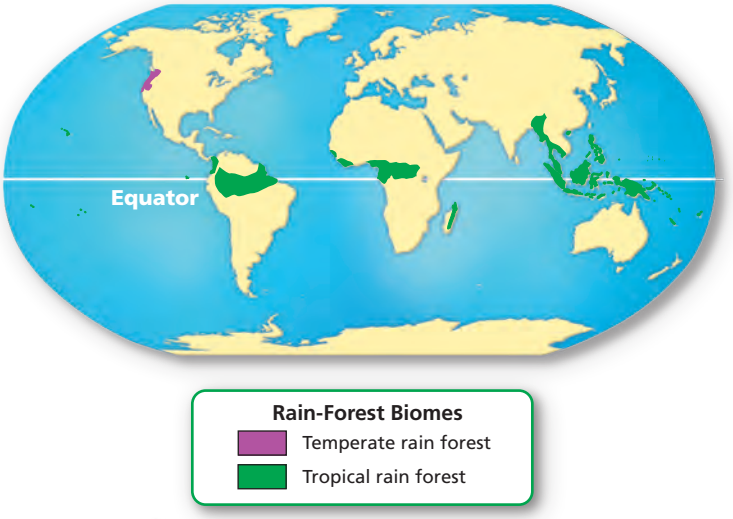


FIGURE 2

Temperate Rain Forests

The sugar pine is the tallest kind of pine tree, reaching heights of 53 to 61 meters. It also produces the largest pine cones. A sugar pine cone can reach a length of 30 to 56 centimeters. The sugar pine cone shown here is actual size!

Identify **What conditions do you think allow a tree to grow so tall?**

Tropical Rain Forests As you can see on the map, tropical rain forests are found in regions close to the equator. The climate is warm and humid all year long, and there is a lot of rain. Because of these climate conditions, an amazing variety of plants grow in tropical rain forests.

Trees in the rain forest form several distinct layers. The tallest layer of the rain forest which receives the most sunlight and can reach up to 70 meters, is the **emergent layer.** Underneath, trees up to 50 meters tall form a leafy roof called the **canopy.** Below the canopy, a layer of shorter trees and vines, around 15 meters high, form an **understory.** Understory plants grow well in the shade formed by the canopy. The forest floor is nearly dark, so only a few plants live there. Look at the tree layers in **Figure 3.**

The abundant plant life in tropical rain forests provides habitats for many species of animals. Ecologists estimate that millions of species of insects live in tropical rain forests. These insects serve as a source of food for many reptiles, birds, and mammals. Many of these animals, in turn, are food sources for other animals. Although tropical rain forests cover only a small part of the planet, they probably contain more species of plants and animals than all the other biomes combined.

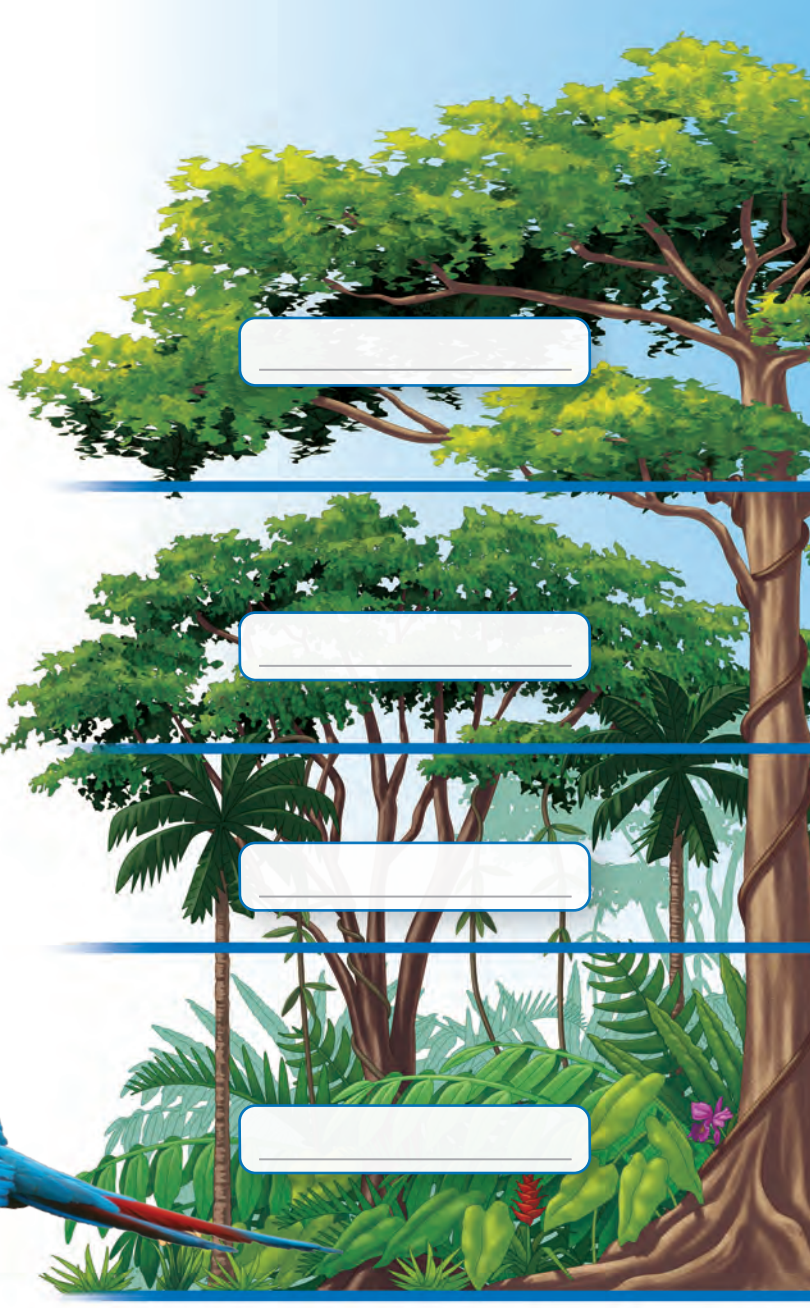


FIGURE 3

Tropical Rain Forests

On the edge of this tropical rain forest, an amazing variety of organisms can be found in the different layers.

Relate Text and Visuals **Based on your reading, label the four distinct layers of the tropical rain forest in the boxes above.**

FIGURE 4

Grasslands

The rhea, cassowary, and ostrich are grassland birds that live on different continents.

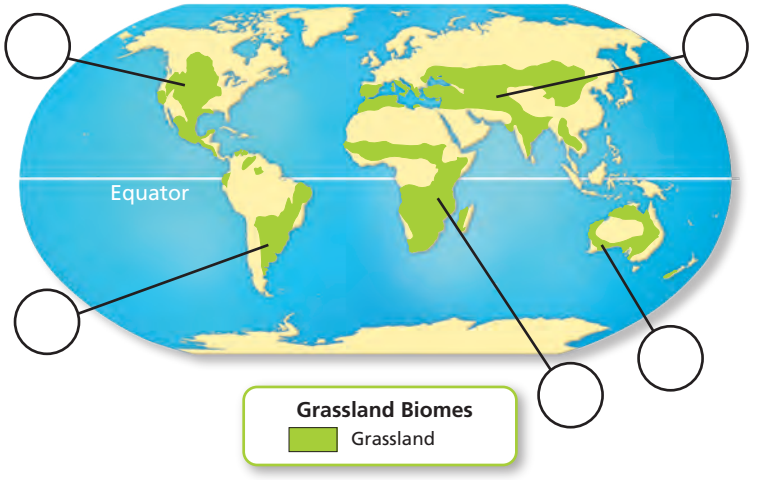
Interpret Maps **On the world map, identify the continents in which these three birds are located. List three characteristics that these grassland birds all share.**

Grassland Biomes

The third stop on the expedition is a grassy plain called a prairie. Temperatures are more comfortable here than they were in the desert. The breeze carries the scent of soil warmed by the sun. This rich soil supports grasses as tall as you. Startled by your approach, sparrows dart into hiding places among the waving grass stems.

Although the prairie receives more rain than a desert, you may notice only a few scattered areas of trees and shrubs. Ecologists classify prairies, which are generally found in the middle latitudes, as grasslands. A **grassland** is an area that is populated mostly by grasses and other nonwoody plants. Most grasslands receive 25 to 75 centimeters of rain each year. Fires and droughts are common in this biome. Grasslands that are located closer to the equator than prairies are known as savannas. A **savanna** receives as much as 120 centimeters of rain each year. Scattered shrubs and small trees grow on savannas, along with grass.

Grasslands are home to many of the largest animals on Earth—herbivores such as elephants, bison, antelopes, zebras, giraffes, kangaroos, and rhinoceroses. Grazing by these large herbivores maintains the grasslands. Their grazing keeps young trees and bushes from sprouting and competing with the grass for water and sunlight. You can see some grassland birds in **Figure 4.**



Deciduous Forest Biomes

Your trip to the fourth biome takes you to another forest. It is now late summer. Cool mornings here give way to warm days. Several members of the expedition are busy recording the numerous plant species. Others are looking through binoculars, trying to identify the songbirds.

You are now visiting a deciduous forest biome. Many of the trees in this forest are **deciduous trees** (dee SIJ oo us), trees that shed their leaves and grow new ones each year. Oaks and maples are examples of deciduous trees. Deciduous forests receive enough rain to support the growth of trees and other plants, at least 50 centimeters of rain per year. Temperatures can vary greatly during the year. The growing season usually lasts five to six months.

The variety of plants in a deciduous forest creates many different habitats. Many species of birds live in different parts of the forest, eating the insects and fruits in their specific areas. Mammals such as chipmunks and skunks live in deciduous forests. In a North American deciduous forest you might also see wood thrushes and white-tailed deer.

If you were to return to this biome in the winter, you would not see much wildlife. Many of the bird species migrate, or fly great distances, to warmer areas. Some of the mammals hibernate, or enter a state of greatly reduced body activity similar to sleep. Look at **Figure 5.** During the winter months, animals that hibernate get energy from fat stored in their bodies.

did you know?

How far would you be willing to migrate? The bobolink has one of the longest songbird migration routes. The birds travel south from southern Canada and the northern United States to northern Argentina. This migration route is approximately 20,000 kilometers round trip!

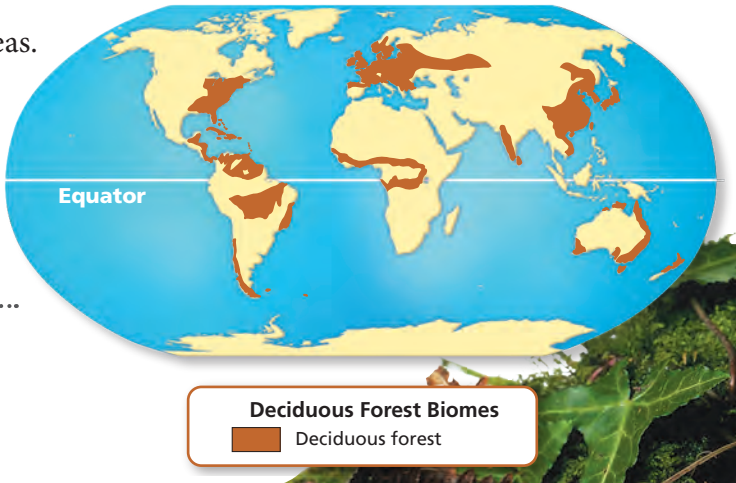


FIGURE 5

Deciduous Forest

Most of the trees in a deciduous forest have leaves that change color and drop to the forest floor each autumn. In the leaves, this dormouse hibernates through the winter.

Infer **Is hibernation an adaptation to life in a deciduous forest? Explain your answer.**

FIGURE 6

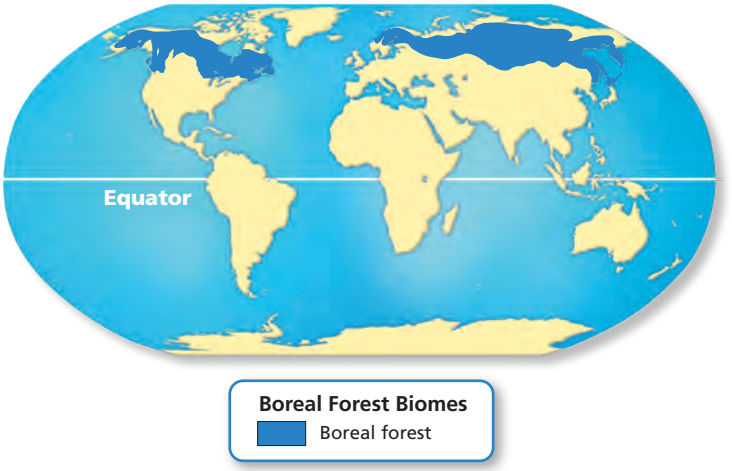
Boreal Forest

This lynx and snowshoe hare are adapted to life in the boreal forest.

1. Infer Choose the best answer. The feet of each animal are an adaptation to its

- ◯ food.
- ◯ climate.
- ◯ predators.
- ◯ all of the above

2. Explain Defend your answer.



Boreal Forest Biomes

Now the expedition heads north to a colder biome, the boreal forest. The term *boreal* means "northern," and **boreal forests** are dense forests found in upper regions of the Northern Hemisphere. The expedition leaders claim they can identify a boreal forest by its smell. When you arrive, you catch a whiff of the spruce and fir trees that blanket the hillsides. Feeling the chilly early fall air, you pull a jacket and hat out of your bag.

Boreal Forest Plants Most of the trees in the boreal forest are **coniferous trees** (koh NIF ur us), trees that produce their seeds in cones and have leaves shaped like needles. The boreal forest is sometimes referred to by its Russian name, the *taiga* (TY guh). Winters in these forests are very cold. The snow can reach heights well over your head! Even so, the summers are rainy and warm enough to melt all the snow.

Tree species in the boreal forest are well adapted to the cold climate. Since water is frozen for much of the year, trees must have adaptations that prevent water loss. Coniferous trees, such as firs and hemlocks, all have thick, waxy needles that prevent water from evaporating.

Boreal Forest Animals Many of the animals of the boreal forest eat the seeds produced by the coniferous trees. These animals include red squirrels, insects, and birds such as finches. Some herbivores, such as moose and beavers, eat tree bark and new shoots. The variety of herbivores in the boreal forest supports many predators, including lynx, otters, and great horned owls. **Figure 6** shows an herbivore and its predator.

Tundra Biomes

As you arrive at your last stop, the driving wind gives you an immediate feel for this biome. The **tundra** is extremely cold and dry. Expecting deep snow, many are surprised to learn that the tundra may receive no more precipitation than a desert.

Most of the soil in the tundra is frozen all year. This frozen soil is called **permafrost.** During the short summer, the top layer of soil thaws, but the underlying soil remains frozen. Because rainwater cannot soak into the permafrost, shallow ponds and marshy areas appear in the summer.

Tundra Plants

Mosses, grasses, and dwarf forms of a few trees can be found in the tundra. Most of the plant growth takes place during the long days of the short summer season. North of the Arctic Circle, the sun does not set during midsummer.

Tundra Animals

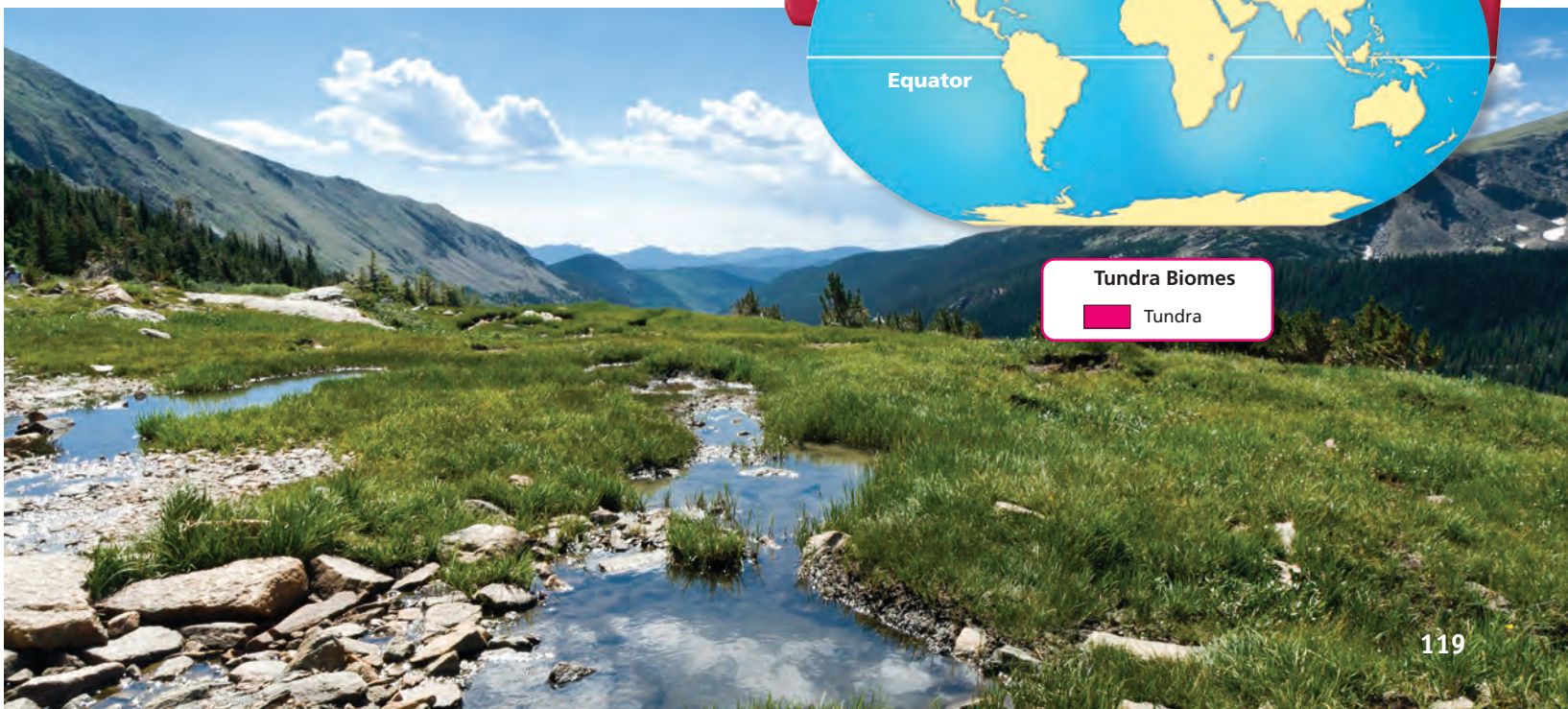
In summer, the insects are abundant. Insect-eating birds take advantage of the plentiful food by eating as much as they can. But when winter approaches, these birds migrate south. Mammals of the tundra include caribou, foxes, and wolves. The mammals that remain on the tundra during the winter grow thick fur coats. What can these animals find to eat on the tundra in winter? The caribou scrape snow away to find lichens. Wolves follow the caribou and look for weak members of the herd to prey upon.

FIGURE 7

Tundra

Although the ground is frozen for most of the year, mosses, grasses, and dwarf willow trees grow here.

Communicate Discuss with a partner why there are no tall trees on the tundra. Describe two factors that you think may influence tree growth.



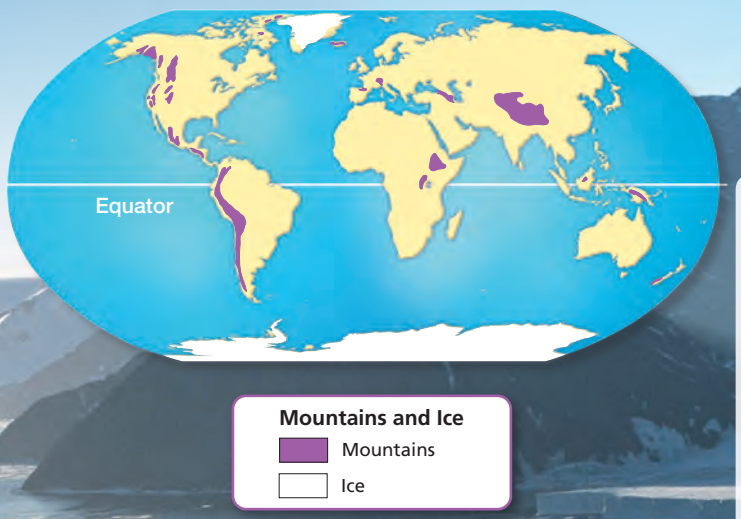


FIGURE 8

Mountains
Mountains are not part of any major biome.

Mountains and Ice

Some land areas are not classified as biomes. Recall that biomes are defined by abiotic factors such as climate and soil, and by biotic factors such as plant and animal life. Because the organisms that live in these areas vary, mountain ranges and land covered with thick ice sheets are not considered biomes.

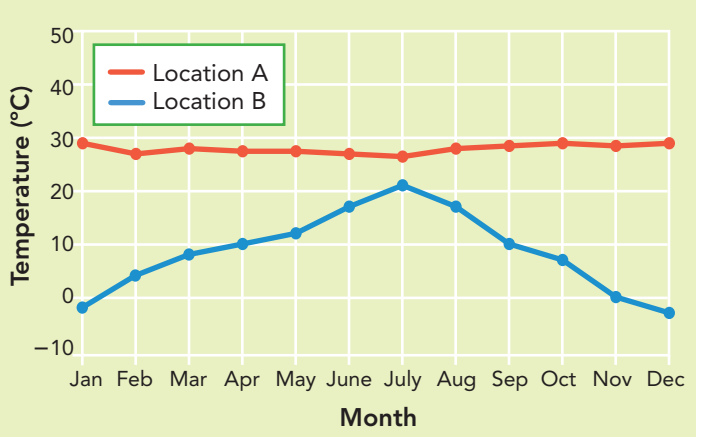
The climate of a mountain changes from its base to its summit. If you were to hike all the way up a tall mountain, you would pass through a series of biomes. At the base, you might find grasslands. As you climbed, you might pass through deciduous forest and then boreal forest. As you neared the top, your surroundings would resemble the cold, dry tundra.

Other places are covered year-round with thick ice sheets. Most of Greenland and Antarctica fall into this category. Organisms that are adapted to life on ice include leopard seals and polar bears.

do the math!

Biome Climates

An ecologist collected climate data from two locations. The graph shows the monthly average temperatures in the two locations. The total yearly precipitation in Location A is 250 centimeters. In Location B, the total yearly precipitation is 14 centimeters.



1 Read Graphs Provide a title for the graph. What variable is plotted on the horizontal axis? On the vertical axis?

2 Interpret Data Study the graph. How would you describe the temperature over the course of a year in Location A? In Location B?

3 Draw Conclusions Given the precipitation and temperature data for these locations, in which biome would you expect each to be located?

apply it!

1 Interpret Maps Using the colors shown in the biome maps throughout this lesson, color in the key above. Use the key to color in the areas on the map of North America.

2 Draw Conclusions Where are most of the boreal forests located? Why are there no boreal forests in the Southern Hemisphere?

3 Describe Mark the area in which you live with an *X* on the map. What is the climate like where you live? How do you think your climate affects which organisms live there?

Lab zone® Do the Quick Lab *Inferring Forest Climates.*

Assess Your Understanding

1a. Review _____ and _____ are the two main factors that determine an area's biome.

b. Infer What biome might you be in if you were standing on a bitterly cold, dry plain with only a few, short trees scattered around?

_____

got it?

○ **I get it!** Now I know that the six major biomes are _____

○ I need extra help with _____

TN

LESSON 3

6.LS2.4

Aquatic Ecosystems

UNLOCK THE BIG QUESTION

What Are the Two Major Aquatic Ecosystems?

MY PLANET DIARY

Underwater *Alvin*

Meet *Alvin*, an HOV (Human-Occupied Vehicle). Equipped with propulsion jets, cameras, and robotic arms, *Alvin* helps scientists gather data and discover ecosystems that exist deep in the ocean. Built in 1964, *Alvin* was one of the world's first deep-ocean submersibles and has made more than 4,500 dives. *Alvin* is credited with finding a lost hydrogen bomb, exploring the first known hydrothermal vents, and surveying the wreck of the *Titanic*.

TECHNOLOGY

Calculate Suppose that on each of the 4,500 dives *Alvin* has made, a new pilot and two new scientists were on board. How many scientists have seen the deep ocean through *Alvin's* windows? How many people, in total, traveled in *Alvin*?

Lab zone® Do the Inquiry Warm-Up *Where Does It Live?*

What Are the Two Major Aquatic Ecosystems?

Since almost three quarters of Earth's surface is covered with water, many living things make their homes in and near water. **There are two types of aquatic, or water-based, ecosystems: freshwater ecosystems and marine (or saltwater) ecosystems.** All aquatic ecosystems are affected by the same abiotic, or nonliving, factors: sunlight, temperature, oxygen, and salt content. Sunlight is an important factor in aquatic ecosystems because it is necessary for photosynthesis in the water just as it is on land. Half of all oxygen produced on Earth comes from floating algae called phytoplankton. Because water absorbs sunlight, there is only enough light for photosynthesis to occur near the surface or in shallow water.

Vocabulary

- estuary
- intertidal zone
- neritic zone

Skills

Reading: Outline

Inquiry: Communicate

Freshwater Ecosystems

No worldwide expedition would be complete without exploring Earth's waters. Even though most of Earth's surface is covered with water, only 3 percent of the volume is fresh water. Freshwater ecosystems include streams, rivers, ponds, and lakes. On this part of your expedition, you'll find that freshwater biomes provide habitats for a variety of organisms.

Streams and Rivers At the source of a mountain stream, the water flows slowly. Plants take root on the bottom, providing food for insects and homes for frogs. These consumers then provide food for larger consumers. Stream currents increase as streams come together to make larger streams, often called rivers. Animals here are adapted to strong currents. For example, trout have streamlined bodies to swim in the rushing water. As the current speeds up, it can become cloudy with sediment. Few plants or algae grow in this fast-moving water. Consumers such as snails feed on leaves and seeds that fall into the stream. At lower elevations, streams are warmer and often contain less oxygen, affecting the organisms that can live in them.

Ponds and Lakes Ponds and lakes are bodies of still, or standing, fresh water. Lakes are generally larger and deeper than ponds. Ponds are often shallow enough that sunlight can reach the bottom, allowing plants to grow there. In large ponds and most lakes, however, algae floating at the surface are the major producers. Many animals are adapted for life in still water. Dragonflies, snails, and frogs live along the shores of ponds. In the open water, sunfish feed on insects and algae close to the surface. Scavengers such as catfish live near the bottoms of ponds. Bacteria and other decomposers also feed on the remains of other organisms.

Outline As you read, make an outline on a separate sheet of paper that includes the different types of aquatic ecosystems. Use the red headings for the main ideas and the black headings for the supporting details.

FIGURE 1

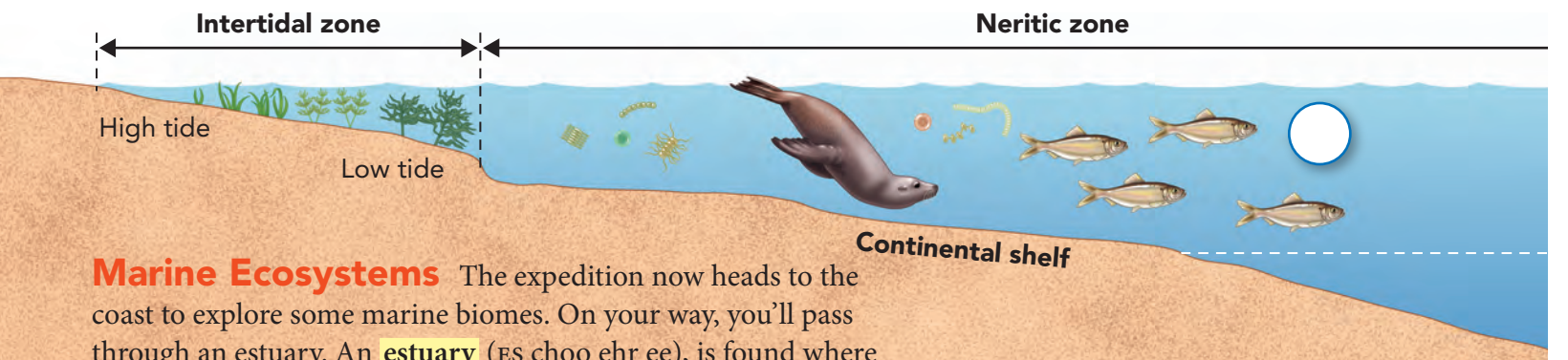
Freshwater Ecosystems

Water lilies live in ponds and lakes.

Answer the questions.

1. **Identify** What are two abiotic factors that can affect water lilies?

2. CHALLENGE What adaptations do fish have that allow them to live in water?



Marine Ecosystems The expedition now heads to the coast to explore some marine biomes. On your way, you'll pass through an estuary. An **estuary** (ES choo ehr ee), is found where the fresh water of a river meets the salt water of an ocean. Algae and plants provide food and shelter for animals, including crabs and fish. Many animals use the calm waters of estuaries for breeding grounds. Last, you explore the different ocean zones as described in **Figure 2.**

Ocean Zones

Zone	Location	Inhabitants
Intertidal zone	Located on the shore between the highest high-tide line and the lowest low-tide line	Organisms must be able to survive pounding waves and the sudden changes in water levels and temperature that occur with high and low tides. For example, barnacles and sea stars cling to the rocks while clams and crabs burrow in the sand.
Neritic zone	Region of shallow water found below the low-tide line and extending over the continental shelf	Sunlight passes through shallow water, allowing photosynthesis to occur. Many living things, such as algae and schools of fish, live here. Coral reefs can also be found here in warmer waters.
Surface zone, open ocean	Located beyond the neritic zone and extending from the water's surface to about 200 meters deep	Sunlight penetrates this zone, allowing photosynthesis to occur in floating phytoplankton and other algae. Tuna, swordfish, and some whales depend on the algae for food.
Deep zone, open ocean	Located beneath the surface zone to the ocean floor	Little, if any, sunlight passes through. Animals feed on the remains of organisms that sink down. Organisms, like the giant squid and anglerfish, are adapted to life in the dark.

FIGURE 2

Marine Ecosystems

The ocean is home to a number of different ecosystems.

Classify Using the clues, determine at which depth each organism belongs. In the circles in the ocean, write the letter for each organism in the correct zone.

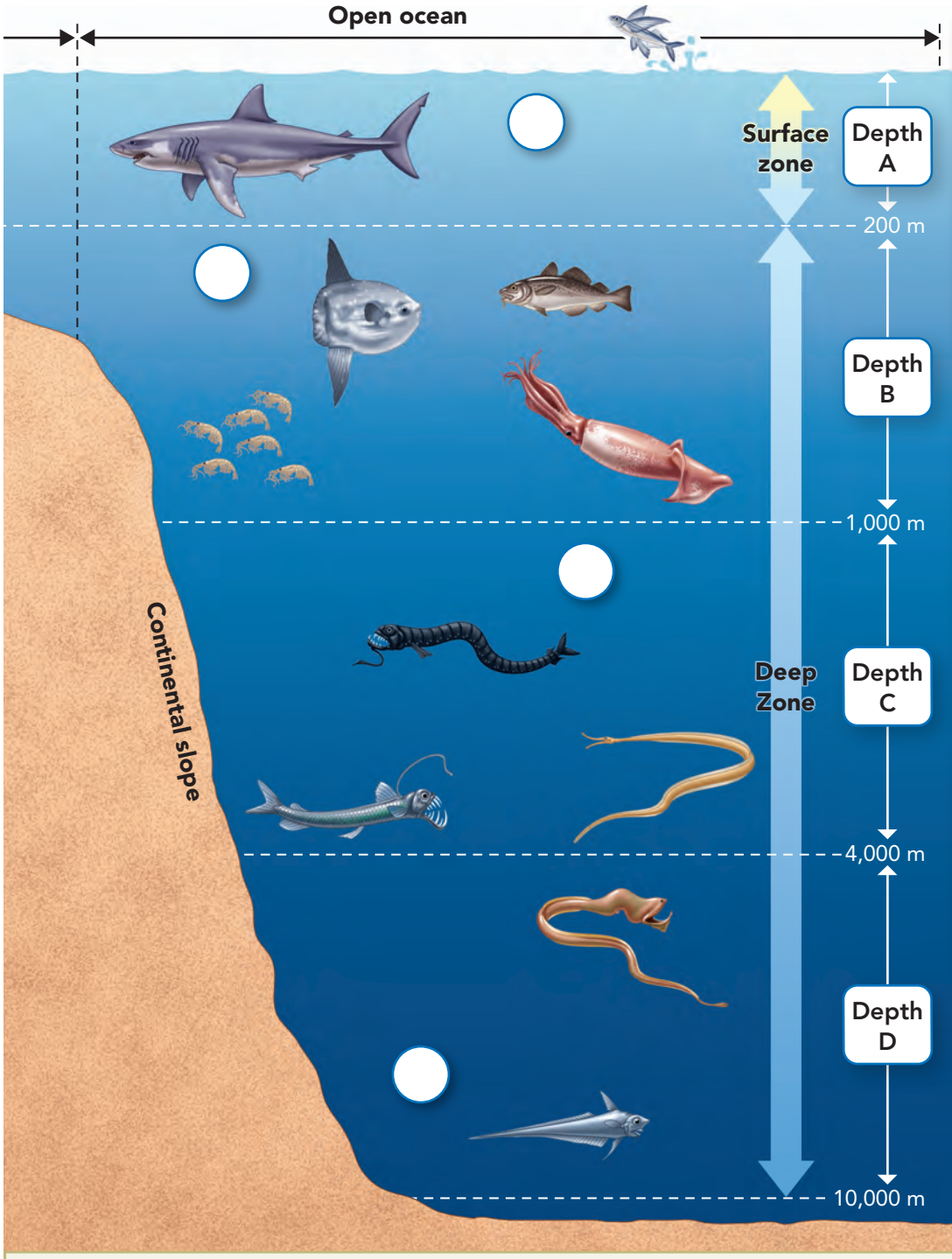
Anglerfish
Females have a lighted lure to help them attract prey in the dark.

Tripod Fish
This fish has three elongated fins to help it stand.

Yellowfin Tuna
Found in open waters and has been known to eat squid

Blue Whale
Feeds on shrimplike creatures at depths of more than 100 meters during the day

Swordfish
Often seen jumping out of the water to stun smaller fish



apply it!

While on a deep sea exploration, you discover a new marine organism on the ocean floor.

Communicate Draw or describe the new organism below. Identify the structures and adaptations it has to live in the deep zone.

Lab zone® Do the Quick Lab *Dissolved Oxygen.*

Assess Your Understanding

1a. List The four abiotic factors that affect all aquatic ecosystems are

b. Make Generalizations Why is sunlight important to all aquatic ecosystems?

got it?

- I get it! Now I know that the two major types of aquatic ecosystems are
- I need extra help with

CHAPTER 4

Study Guide

REVIEW THE BIG ?

Producers, _____, and _____ help to cycle energy through ecosystems.

LESSON 1 Energy Flow in Ecosystems

- Each of the organisms in an ecosystem fills the energy role of producer, consumer, or decomposer.
- Energy moves through an ecosystem when one organism eats another.
- The most energy is available at the producer level of the pyramid. As energy moves up the pyramid, each level has less energy available than the level below.

Vocabulary

- producer
- consumer
- herbivore
- carnivore
- omnivore
- scavenger
- decomposer
- food chain
- food web
- energy pyramid
- desertification

LESSON 2 Biomes

- The six major biomes are desert, rain forest, grassland, deciduous forest, boreal forest, and tundra.

Vocabulary

- biome
- climate
- desert
- rain forest
- emergent layer
- canopy
- understory
- grassland
- savanna
- deciduous tree
- boreal forest
- coniferous tree
- tundra
- permafrost

LESSON 3 Aquatic Ecosystems

- There are two types of aquatic, or water-based, ecosystems: freshwater ecosystems and marine (or saltwater) ecosystems.

Vocabulary

- estuary
- intertidal zone
- neritic zone

Review and Assessment

LESSON 1 Energy Flow in Ecosystems

1. A diagram that shows how much energy is available at each feeding level in an ecosystem is a(n)

a. food web. **b.** food chain.

c. water cycle. **d.** energy pyramid.

2. A(n) _____ is a consumer that eats only plants.

3. **Interpret Diagrams** Which organisms in the illustration are producers? Consumers?

4. **Compare and Contrast** How are food chains and food webs different?

5. **Write About It** Think about your own food web. Name the producers and consumers that make up your diet.

LESSON 2 Biomes

6. Little precipitation and extreme temperatures are main characteristics of which biome?

a. desert **b.** grassland

c. boreal forest **d.** deciduous forest

7. A _____ is a group of ecosystems with similar climates and organisms.

8. **Compare and Contrast** How are the tundra and desert similar? How are they different?

CHAPTER 4

Review and Assessment

LESSON 3 Aquatic Ecosystems

9. In which ocean zone would you find barnacles, sea stars, and other organisms tightly attached to rocks?

a. neritic zone **b.** intertidal zone

c. estuary ecosystem **d.** freshwater ecosystem

10. Coral reefs are found in the shallow, sunny waters of the _____

11. **Compare and Contrast** How are a pond and lake similar? How do they differ?

APPLY THE BIG Q How do energy and matter cycle through ecosystems?

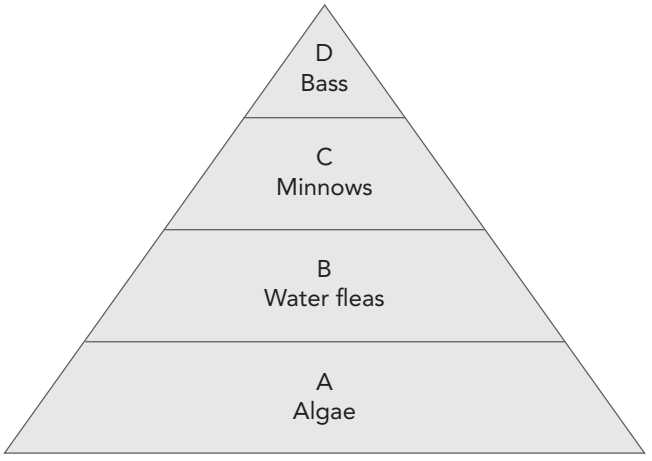
12. Many acres of the Amazon rain forest have been destroyed to create farmland. Describe how the amount of energy in the food web for this area might be affected. How might the carbon and oxygen cycle also be affected?

TNReady Prep

6.LS2.3, 6.LS2.4, 6.LS4.1

Read each question and choose the best answer.

1. At which level of this energy pyramid is the least energy available?



A Level A **B** Level B
C Level C **D** Level D

2. You are in an area in Maryland where the fresh water of the Chesapeake Bay meets the Atlantic Ocean. Which of the following terms describes where you are?

A tundra **B** estuary
C neritic zone **D** intertidal zone

3. Which pair of terms could apply to the same organism?

A carnivore and producer
B consumer and carnivore
C scavenger and herbivore
D producer and omnivore

4. The use of chemicals in agriculture, such as herbicides, insecticides, and fertilizer, can negatively impact the environment by

A putting nutrients back into soil.
B poisoning organisms in streams and rivers that the chemicals enter.
C destroying weeds that keep crops from growing.
D killing insects and pests that damage crops.

5. Moderate temperatures and rich soil are main characteristics of which biome?

A boreal forest
B deciduous forest
C grassland
D desert

Constructed Response

Write your answer to Question 6 on the lines below.

6. Describe the process of desertification and the impact it has on an ecosystem.

SCIENCE MATTERS

Everyday Science

A Lake Can't Last Forever

Much like living things, lakes change over time and even have life spans. Scientists call this change "lake succession". One way this occurs is through eutrophication.

Eutrophication refers to the addition of nutrients to bodies of water. It occurs naturally, but human activity can speed up the process. Nutrients—especially phosphorus and nitrogen—are necessary for algae and plants to grow in lakes. However, too many nutrients, such as those from fertilizers and sewage, can lead to excessive algae growth or "blooms."

These blooms often kill plant and animal life by upsetting the oxygen and carbon dioxide cycles. Decomposers, such as bacteria, feed off the algae, using up dissolved oxygen in the water in the process. This limits the amount and kinds of aquatic life that can live there.

Over many years, a lake becomes shallower when it fills with dying plant and animal matter. Material also builds up from outside the lake. The lake becomes a marsh that, over time, turns into dry land.

Research It With your classmates, analyze a body of water to determine its ability to support life. To study biotic factors, obtain and identify samples of organisms. Find information about how to count the kinds and numbers of invertebrates to judge pollution levels. Then look at abiotic factors. Use thermometers, probeware, and water chemistry kits to determine temperature, dissolved oxygen, and pH levels. Research information about how these factors affect the survival of organisms. Compile findings in a table and graph data. Pass records on to future classes to interpret and predict changes over time.

Trees: Environmental Factories

Some of the most important members of your community don't volunteer. They consume huge amounts of water and they make a mess. Despite these drawbacks, these long-standing community members do their share. Who are these individuals? They're trees!

Keeping it clean: Trees remove pollutants from the air. Some researchers have calculated the value of the environmental cleaning services that trees provide. One study valued the air-cleaning service that trees in the Chicago area provide at more than $9 million every year.

Keeping it cool: Trees provide shade and lower air temperature by the process of transpiration. Pollutants, like ozone and smog, form more easily when air temperatures are high, so by keeping the air cool, trees also keep it clean.

Acting locally and globally: Trees help fight global environmental problems such as climate change. Trees remove carbon dioxide from the air and store the carbon as they grow. Experts estimate that urban trees in the United States remove more than 700 million tons of carbon from the air every year.

Helping the local economy: Trees are also good for business. One study found that shoppers spend more money in urban areas where trees are planted than they do in similar areas that don't have trees!

Research It Examine a topographical map of the area where you live. Compare it to an aerial photograph from a library or local archive. Identify areas with a lot of trees, and areas that you think could benefit from more trees. Create a proposal to plant trees in one of the areas you identified. What kinds of trees will you plant? What do those trees need in order to grow well?

Schools, clubs, and civic groups all over the United States volunteer to plant trees in their communities. ▶