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Energy Flow in Ecosystems

Guiding Questions

- What are the energy roles in an ecosystem?
- How is energy transferred between living and nonliving parts of an ecosystem?
- How is energy conserved in an ecosystem?

Connections

Literacy Integrate with Visuals

Math Analyze Proportional Relationships

MS-LS2-3

Vocabulary

producer
 consumer
 decomposer
 food chain
 food web
 energy pyramid

Academic Vocabulary

role


Vocabulary App

Practice vocabulary on a mobile device.

Quest CONNECTION

Think about how the energy roles played by organisms in the pond ecosystem are important to the stability of the system.

Connect It!

 Shade in one of the arrows to indicate the direction in which energy flows between the frog and the fly.

Analyze Systems Where do you think the plants in the image get the energy they need to grow and survive?

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Energy Roles in an Ecosystem

In gym class, have you ever been assigned to play a position like catcher or goalie for your class team? If so, you know what it's like to have a specific **role** in a system. Similar to positions in sports, every organism has a role in the movement of energy through its ecosystem.

Energy roles are based on the way organisms obtain food and interact with other organisms. In an ecosystem, organisms play the energy role of either a producer, consumer, or decomposer.

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

An organism that can make its own food is a **producer**. Producers become the source of food for other organisms in an ecosystem. In a few ecosystems, producers obtain energy from a source other than sunlight. Deep in the ocean, some bacteria convert chemical energy into food from hydrothermal vents in the ocean floor. They are the producers in these ecosystems that include worms, clams, and crabs.



INTERACTIVITY

Identify the sources of your dinner.

Academic Vocabulary

Have you heard the term *role* in other contexts? List some examples.

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Obtaining Energy

Figure 1 Many small pond organisms, like the fly, obtain energy from green plants. They, in turn, serve to provide energy for larger organisms, like the frog.





INTERACTIVITY

Model energy roles and energy flow in ecosystems.



INTERACTIVITY


Explore the roles living things play in ecosystems.



Write About It What are some producers, consumers, scavengers, and decomposers you have seen in your neighborhood?

Life and Death in an Alaskan Stream

Figure 2 Salmon migrate upstream to this forest environment after spending most of their lives at sea. As they travel, many of them become food for the ecosystem's carnivores.

Develop Models  Label the producers, consumers, decomposers, and scavengers in the image.

Consumers Organisms like the animals in **Figure 2** cannot produce their own food. A **consumer** obtains energy by feeding on other organisms.

Scientists classify consumers according to what they eat. As consumers eat, the food is broken down into molecules that help supply them energy.

Consumers that eat only animals are carnivores. Great white sharks, owls, and tigers are examples of carnivores. Some carnivores are scavengers. A scavenger is a carnivore that feeds on the bodies of dead organisms. Scavengers include hagfish and condors. Some carnivores will scavenge if they cannot find live animals to prey upon.

Herbivores are consumers that eat only plants and other photosynthetic organisms. Grasshoppers, rabbits, and cows are herbivores.

Consumers that eat both plants and animals are omnivores. Raccoons, pigs, and humans are omnivores.





HANDS-ON LAB

Investigate Observe how decomposers get energy.

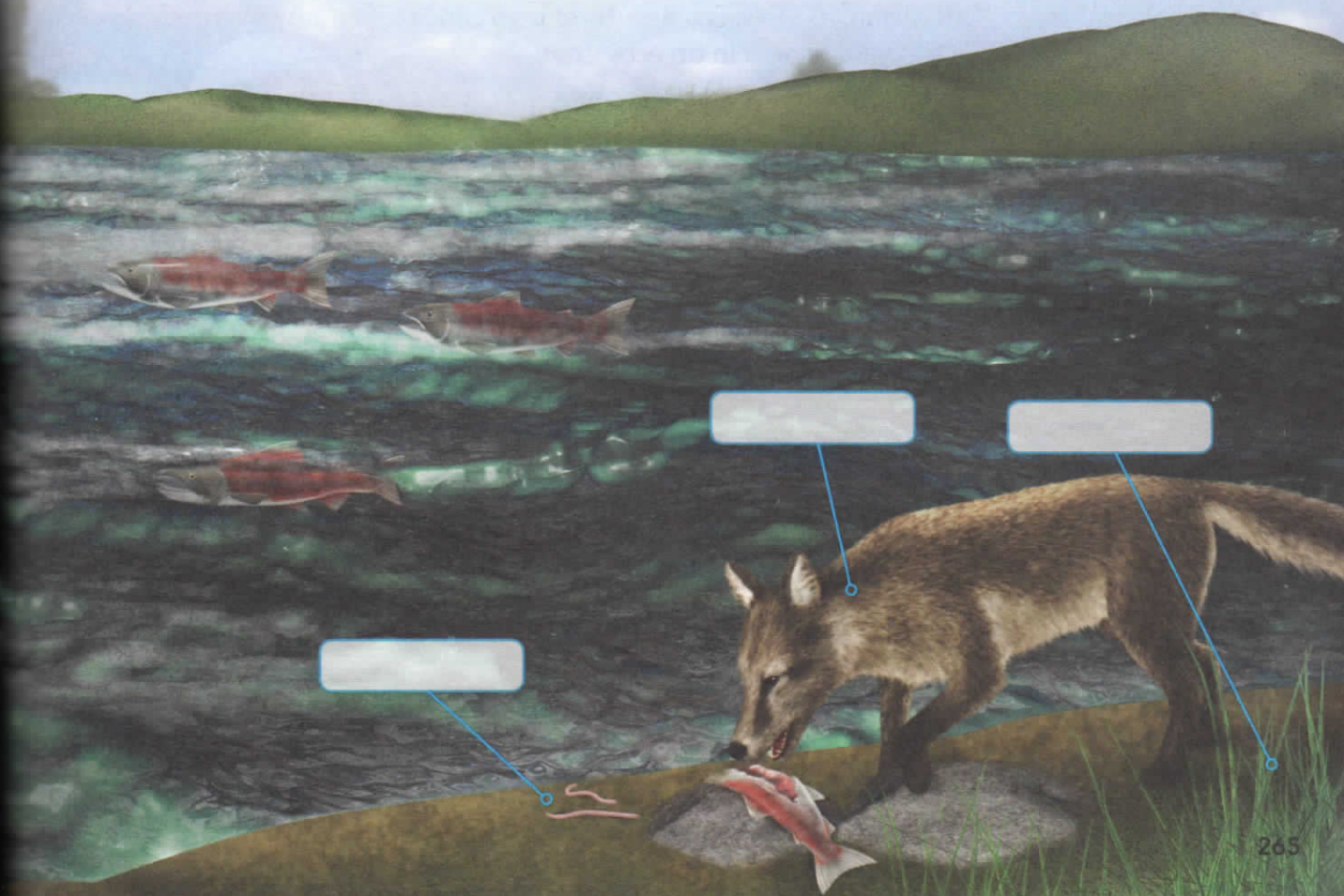
Decomposers If the only roles in an ecosystem were producer and consumer, then some of the matter that is essential for life, such as carbon and nitrogen, would remain in the waste products and remains of dead organisms. However, decomposers have a role in ecosystems to prevent this from happening. **Decomposers** break down biotic wastes and dead organisms, returning the raw materials to the ecosystem. For example, after adult salmon swim upstream and reproduce, they die. Their carcasses litter the riverbeds and banks. Bacteria in the soil help break down the carcasses, releasing their nutrients to trees, grasses, shrubs, and other producers that depend on them.

In a sense, decomposers are nature's recyclers. While obtaining energy for their own needs, decomposers also return matter in the form of simple molecules to the environment. These molecules can be used again by other organisms. Mushrooms, bacteria, and mold are common decomposers.

READING CHECK Integrate with Visuals In terms of their energy roles, what similarities do the bear, salmon, and coyote in **Figure 2** share?

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Food chain



Grizzly bear



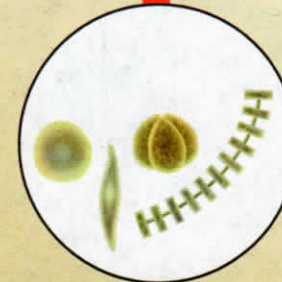
Salmon



Crustaceans



Zooplankton



Phytoplankton

Energy and Matter Transfer

Energy in most ecosystems comes from sunlight, and producers convert this energy into food through photosynthesis. The energy and matter are contained in atoms and molecules that are transferred to herbivores that eat the producers. Then they move on to carnivores feeding on the first, or primary, consumers. The energy and matter next move on through other meat-eating secondary consumers. This movement of energy and matter can be described through different models: food chains, food webs, and energy pyramids.

Food Chains A food chain is one way to show how energy and matter move through an ecosystem. A **food chain** is a series of events in which one organism eats another and obtains energy and nutrients. **Figure 3** illustrates one example of a food chain. The arrows indicate the movement of energy and matter as organisms are consumed up the food chain.

Food Webs Energy and matter move in one direction through a food chain, but they can also take different paths through the ecosystem. However, most producers and consumers are part of many overlapping food chains. For example, a salmon could be consumed by a shark in the ocean before it even has the chance to migrate upstream and encounter a bear. A more realistic way to show how energy and matter cycle 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. However, when a crayfish eats a snail, it is a second-level consumer.

Food Chain

Figure 3 The food chain tracing a path from the phytoplankton to the grizzly bear is a simple way of showing how energy and matter flow from one organism to the next in the Alaskan stream ecosystem shown in **Figure 2**.

Identify Limitations What are some limitations of modeling the flow of energy and matter in an ecosystem with a food chain?

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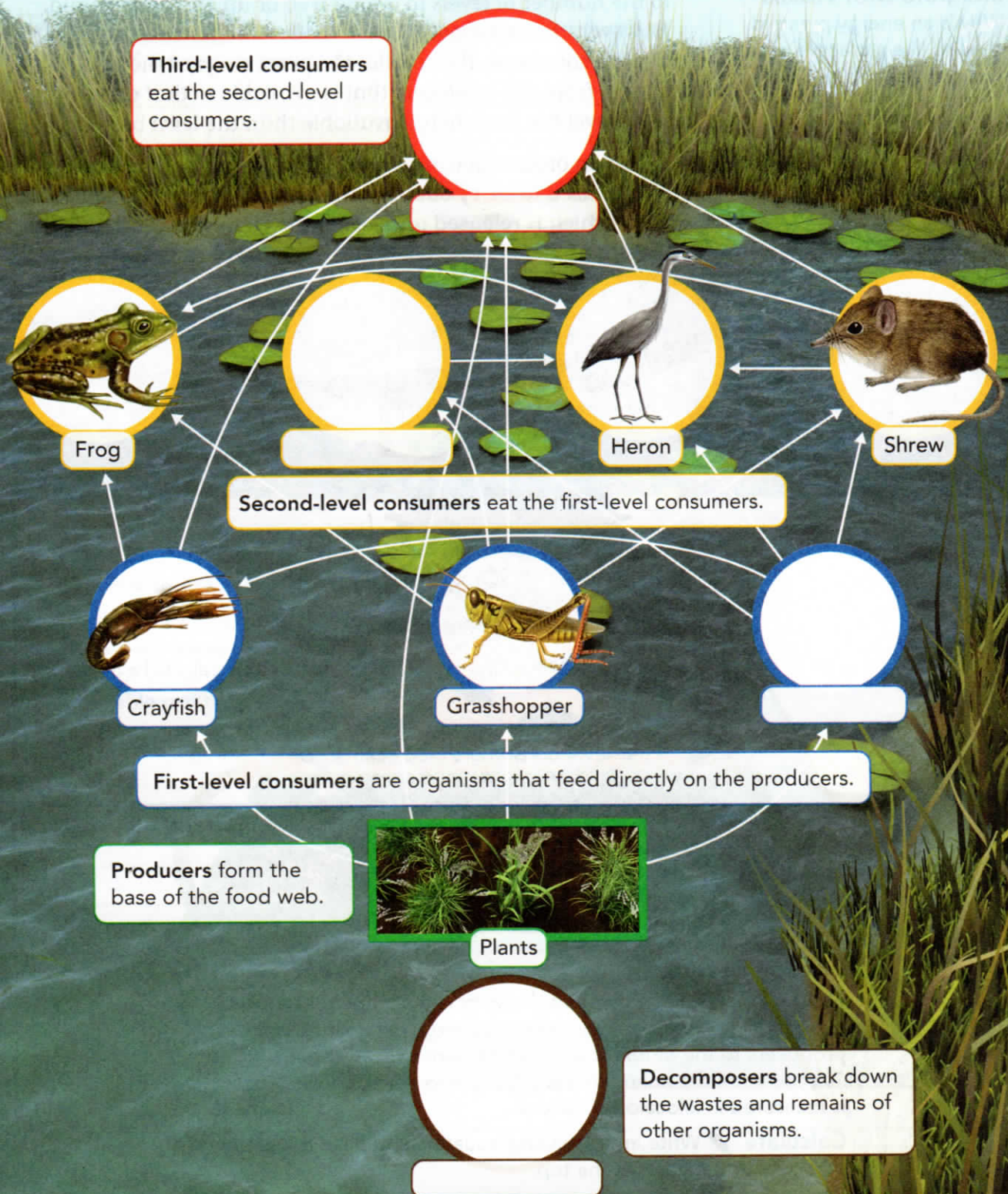
Model It !

Food Web

Figure 4 This food web depicts relationships among some of the organisms that live in a forest that has a small pond.

Develop Models Complete the food web by drawing and identifying the missing organisms listed below. Add arrows to the diagram to complete the web.

mushrooms red fox snail garter snake





VIRTUAL LAB

Investigate the food web of Chesapeake Bay.

Literacy Connection

Integrate with Visuals

Why is an energy pyramid shaped like a triangle with the point on top?

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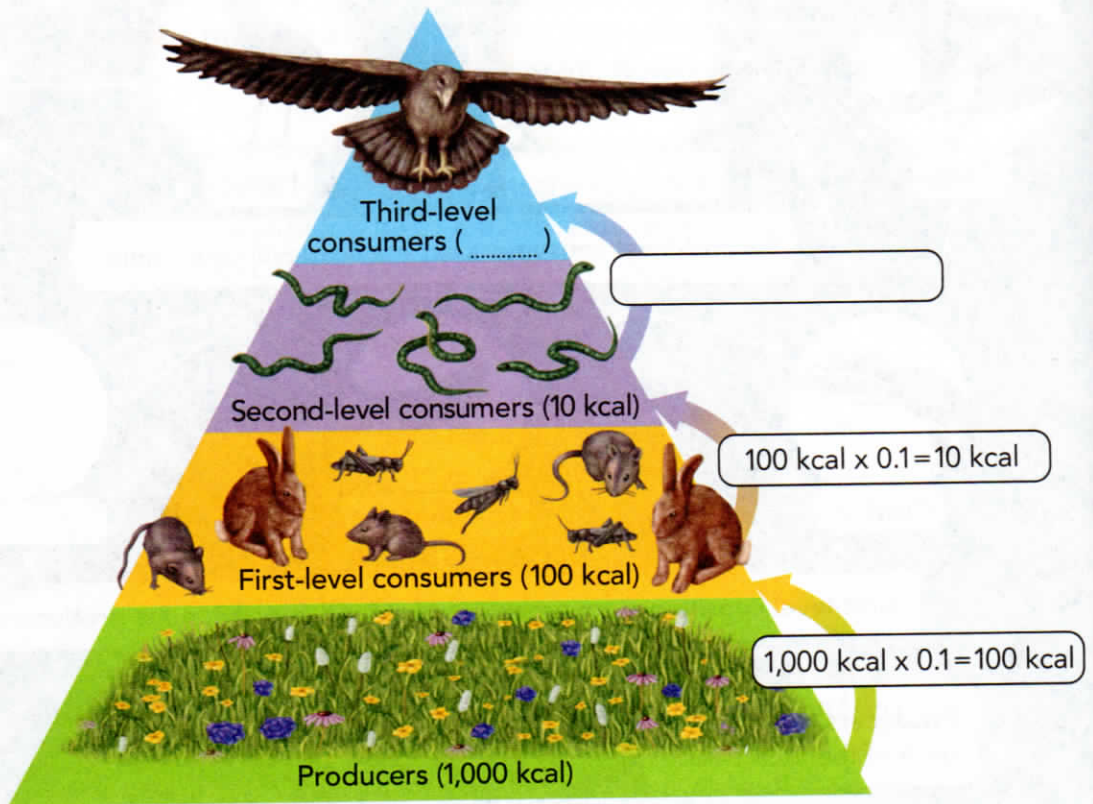
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Energy Pyramids A diagram called an **energy pyramid** shows the amount of energy that moves from one feeding level to another in a food web. Each step in a food chain or food web is represented by a level within an energy pyramid, as shown in **Figure 5**. Producers have the most available energy so they make up the first level, or base, of the pyramid. Energy moves up the pyramid from the producers, to the first-level consumers, to the second-level consumers and so on. There is no limit to the number of levels in a food web or an energy pyramid. However, the more levels that exist between a producer and a given consumer, the smaller the percentage of the original energy from the producers that is available to that consumer. Each level has less energy available than the level below.

When an organism consumes food it obtains energy and matter used to carry out life activities. These activities produce heat, which is released and lost to the environment, reducing the amount of energy available to the next level.



Energy Pyramid

Figure 5 This energy pyramid shows how the amount of available energy decreases as you move up an energy pyramid from the producers to the different levels of consumers. Only about 10 percent of the energy is transferred from level to level. Energy is measured in kilocalories, or kcal.

Calculate ✎ Write in the missing equation and fill in the energy that gets to the hawk at the top.

Energy Availability As you can see in **Figure 5**, only about 10 percent of the energy at one level of a food web is available to the next higher level. This greatly limits how many different levels a food chain can have, as well as the numbers of organisms that can be supported at higher levels. This is why it is typical for there to be fewer organisms as you move from one level of a pyramid or one “link” in a food chain up to the next level.

INTERACTIVITY

Model how altering a food web affects the flow of energy and matter in an ecosystem.

READING CHECK Summarize Text Why is energy reduced at each level of the energy pyramid?

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Math Toolbox

Relationships in an Energy Pyramid



In a small forest ecosystem, caterpillars eat plants. Carolina wrens eat the caterpillars, and black rat snakes eat the wrens. Suppose that the plants contain 550,000 kilocalories.

- Calculate** Complete the pyramid by calculating the energy available to each level.
- Analyze Proportional Relationships** How would the amount of energy in the pyramid change if the caterpillars ate only half of the available plants?

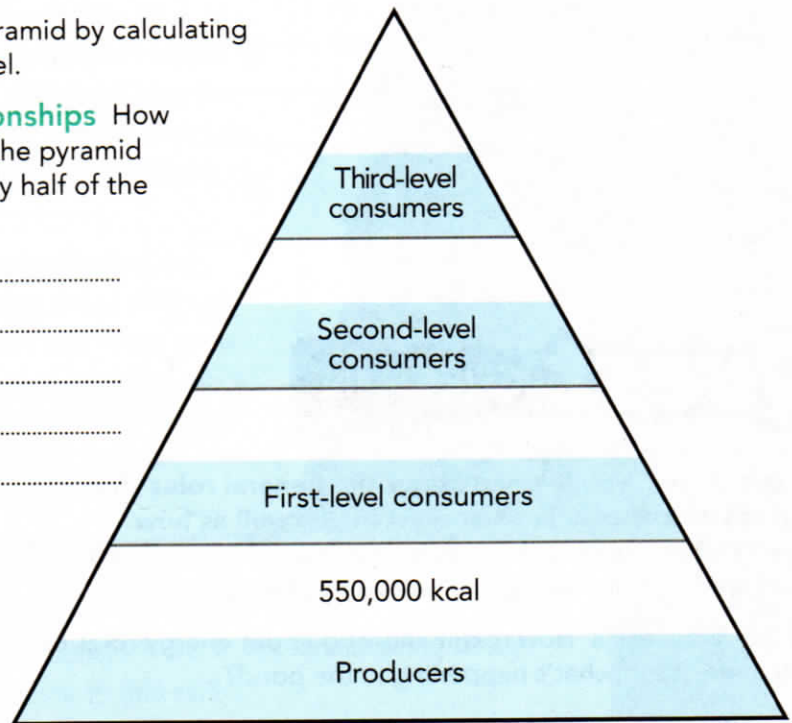
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✓ LESSON 2 Check

MS-LS2-3

1. Analyze Systems Which model best illustrates the flow of energy and matter in an ecosystem—a food chain or a food web? Explain.

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2. Evaluate Claims A student says an organism that is both a first-level and second-level consumer is an omnivore. Is that student correct? Explain.

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3. Apply Concepts Suppose a rancher wants to buy some grassland to raise cattle. What should she know about energy flow before she invests in the land or the cattle?

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4. Identify Patterns In Massachusetts, a team of scientists studying great white sharks estimates that a population of 15,000 seals supports fewer than 100 sharks during the summer. Why are there so few top-level consumers in this system?

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5. Cause and Effect Human activity can affect ecosystems by removing producers, consumers, and decomposers. What limiting factors may result from human actions, and what effects might they have on the flow of energy and matter in an ecosystem?

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Quest CHECK-IN

In this lesson, you learned about the general roles that organisms can play in an ecosystem, as well as how relationships among those roles can be modeled through food chains, food webs, and energy pyramids.

Apply Concepts How might knowing about energy roles help you understand what's happening in the pond?

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INTERACTIVITY

Nutrients and Aquatic Organisms

Go online to analyze what might happen to a pond ecosystem when nutrient levels are altered. Then discuss how the results of your analysis could help you solve the mystery.