Energy and Matter Flow in Ecosystems

All organisms need a source of energy to survive. Energy is essential for metabolism, which is all of the chemical processes that build up or break down materials in an organism's body.

Predict Describe two ways that energy and matter flow in the tropical rain forest ecosystem shown in Figure 7.

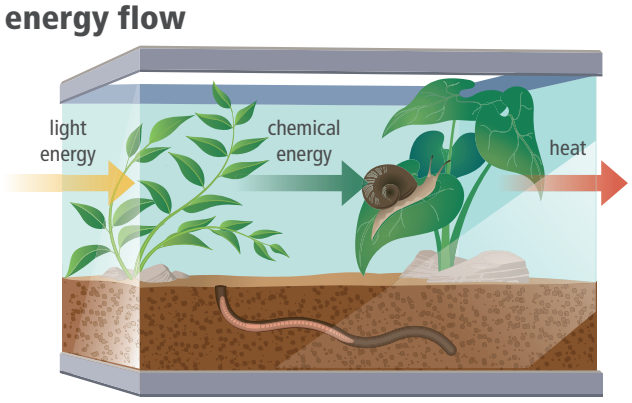
Plants get energy from sunlight, then organisms eat plants.

FIGURE 7: Tropical rain forest.

Energy in Ecosystems

A terrarium, as shown in Figure 8, is a simple way to model the flow of energy in an ecosystem. Life in an ecosystem requires an input of energy. The law of conservation of energy states that energy cannot be created or destroyed. Energy changes form as it flows within an ecosystem, but the amount of energy does not change.

FIGURE 8: Energy changes form as it flows through an ecosystem.



Explain How does energy flow in this terrarium in terms of photosynthesis and cellular respiration?

Energy and Matter

Explore Online

Energy and Matter Flow Through Organisms

The kingfisher and the fish shown in Figure 9 are components of an ecosystem. Each organism has a role in the transfer of energy and matter within that ecosystem. In addition to the kingfisher and the fish, plants, soil, and temperature also affect the flow of energy and matter. As in a terrarium, energy and matter change form as they cycle through this ecosystem, but they are not destroyed.

Model What is the relationship between energy and matter in the kingfisher? Make a model that shows how matter and energy cycle through this ecosystem.

FIGURE 9: A kingfisher dives underwater to catch a fish.

An ecosystem is a complex web of interconnected biotic and abiotic components. Changing one component in an ecosystem can affect many others. Imagine what would happen if a chemical spill occurred at the lake the kingfisher depended upon as a source of food. If the spill killed all the plants, this change would affect the insects that ate the plants, the fish that ate the insects, and the kingfisher that ate the fish. Thus one change can destabilize an entire ecosystem.

As part of the ecosystem, humans, like other species, rely on their environment for survival. If residents of a local town also eat fish from this ecosystem, these changes will negatively impact them. All species are affected by changes to the biotic and abiotic factors in an ecosystem.

Food Chains

Feeding relationships are a major component of the structure and dynamics of an ecosystem. Food chains and food webs are useful ways to model the complex structure of an ecosystem to better understand how energy is transferred between organisms. The simplest way to look at the transfer of food energy in an ecosystem is through a food chain, as shown in Figure 10. A food chain is a sequence that links species by their feeding relationships. This simple model follows the connection between one producer and a single chain of consumers within an ecosystem.

FIGURE 10: Food chains help scientists understand the transfer of energy in an ecosystem.

a Producer b Herbivore c Carnivore

Not all consumers are alike. Herbivores, such as desert cottontails, are organisms that eat only plants. Carnivores are organisms that eat only animals. Western diamondback rattlesnakes are carnivores that eat desert cottontails. Omnivores are organisms that eat both plants and animals. In a desert ecosystem, kangaroo rats are omnivores that eat both seeds and insects. Detritivores are organisms that eat detritus, or dead organic matter. Earthworms are detritivores that feed on decaying organic matter in soil.

Decomposers are organisms that break down organic matter into simpler compounds. These organisms include fungi, certain microbes in the soil, and earthworms. Decomposers are important to the stability of an ecosystem because they return vital nutrients back into the environment for other organisms to use.

Predict What might happen in an ecosystem if all the decomposers were suddenly removed?

FIGURE 11: Decomposers break down dead organic matter, including plants and animals.

Model Draw a food chain that includes organisms in the area where you live. Identify the producer and consumers, and describe the flow of energy in the food chain.

Walnuts → Squirrels → Hawks
Acorns "Nuts" Owls

Trophic Levels

8-4

Trophic levels, shown in Figure 12, are the levels of nourishment in a food chain. The first trophic level is occupied by the producer. The second level is occupied by the primary consumer, usually an herbivore. The third and fourth levels contain secondary and tertiary consumers, and so on, which can be omnivores or carnivores.

FIGURE 12: Each organism in a food chain occupies a different trophic level.

a Producer

b Primary consumer

c Secondary consumer

d Tertiary consumer

Explain Does energy transfer completely from one trophic level to another? Use evidence from this lesson to support your answer.

Energy flows up the food chain from the bottom trophic level to the top. Food chains are limited in length because energy is lost as heat at each trophic level. Organisms use the remaining energy to carry out life functions such as cellular respiration and growth. In this way, less and less energy is available for the next organism in the chain. Eventually, there is not enough energy to support another trophic level.

Collaborate Think about a typical meal you eat. With a partner, discuss what trophic level you occupy within that food chain.

Data Analysis

Population Size

A scientist sampled a small cross section of a grassland ecosystem. Her data for each trophic level are shown in the table.

Trophic Level	Producers	Primary Consumers	Secondary Consumers	Tertiary Consumers
Population Count	6,025,682	723,082	98,541	4

Analyze Answer the following questions in your Evidence Notebook:

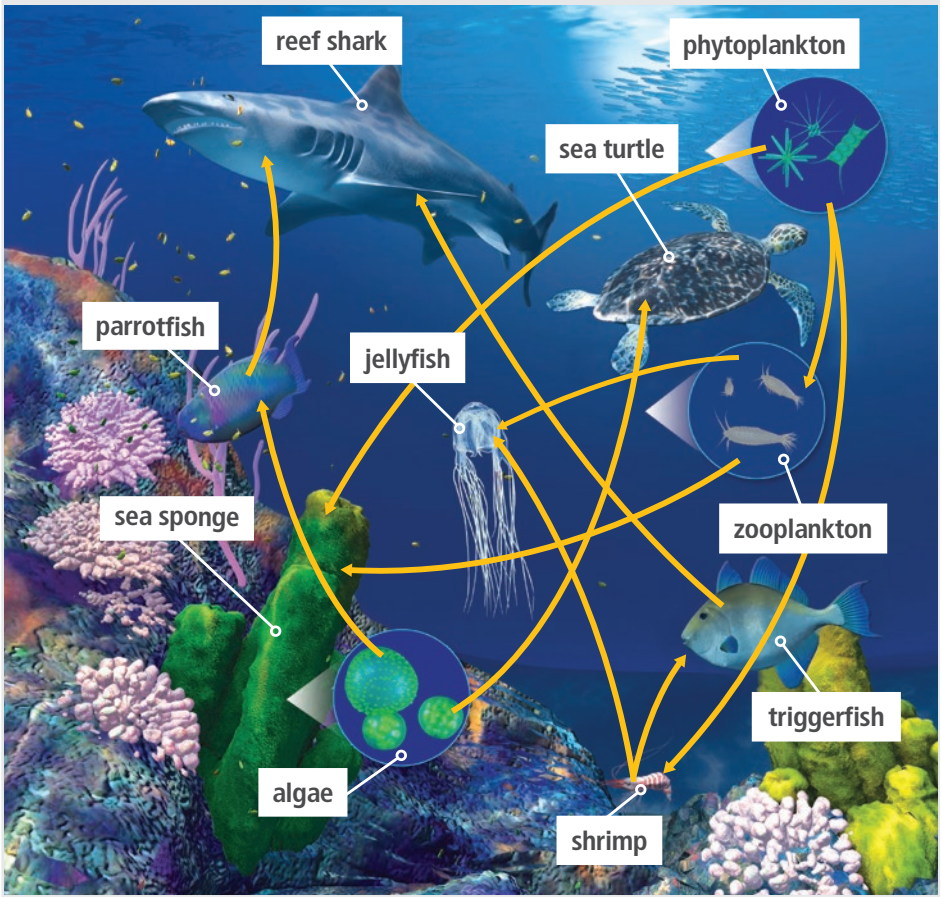
1. How does the population size change at each trophic level in this sample?
2. What is the relationship between trophic level and population size?
3. Predict what would happen if a quaternary consumer were added to this ecosystem.

Food Webs

Food chains are not isolated units but are linked together in food webs. Each organism in an ecosystem may feed on or be eaten by several other organisms and may be part of many different food chains.

Gather Evidence How would the food web be affected if the triggerfish were removed from the ecosystem? What about the algae?

FIGURE 13: A food web is made up of several different food chains.



Model Expand the food chain of the area where you live to make a food web.

A food web models the complex network of feeding relationships between trophic levels within an ecosystem. A food web represents the flow of energy within and sometimes beyond the ecosystem. The stability of any food web depends on the presence of producers, as they form the base of the food web. In the case of a marine ecosystem such as a coral reef, algae and phytoplankton are two of the producers that play this important role.

Explain Use the evidence you have gathered in this lesson to answer the following questions:

1. Scientists use both food chains and food webs to model energy and matter transfer in an ecosystem. Describe the pros and cons of using a food chain or a food web.
2. In the phytoplankton example from the beginning of the lesson, how will the decrease in phytoplankton affect the ecosystem's food web?