3.3

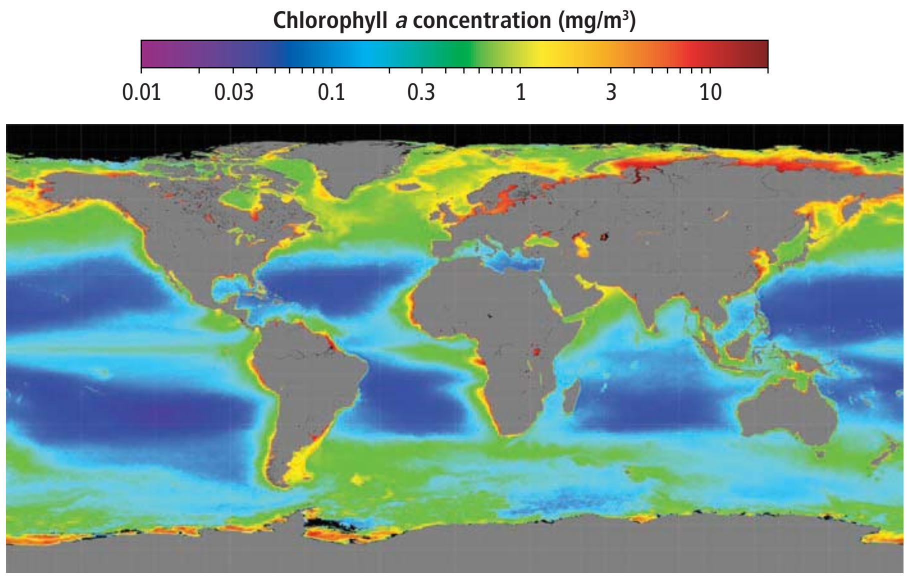
Modeling Matter and Energy in Ecosystems

This green sea turtle takes in energy and matter by eating sea grass.

CAN YOU EXPLAIN IT?

Phytoplankton are single-celled organisms that live in aquatic environments. Many species of marine animals feed on phytoplankton as their main food source. Phytoplankton are producers that use chlorophyll to carry out photosynthesis. Figure 1 shows a global map of the concentration of chlorophyll in the ocean. Greater chlorophyll concentrations correlate to larger populations of phytoplankton.

FIGURE 1: Global Concentration of Chlorophyll *a*



Gather Evidence As you explore the lesson, gather evidence to explain how energy and matter flow through ecosystems.

Phytoplankton produce nearly half of all oxygen in the atmosphere and use a large amount of carbon dioxide during photosynthesis. Scientists have discovered that the global population of phytoplankton has been decreasing.

Predict How might a decrease in the phytoplankton population affect the global flow of energy and matter?

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Introduction to Ecosystems

As its name suggests, an ecosystem is a system—it has boundaries, components, inputs, and outputs. Every living thing requires specific resources and conditions. The gray fox shown in Figure 2 requires certain types of food, shelter, temperatures, and other factors to survive. Gray foxes live in dens located in underground burrows, under rock crevices, or in caves. They eat plants, insects, and small mammals, such as mice and rabbits. Many types of internal and external parasites live on and in gray foxes, including ticks and tapeworms. Coyotes prey upon gray foxes, but the foxes can climb trees to escape.

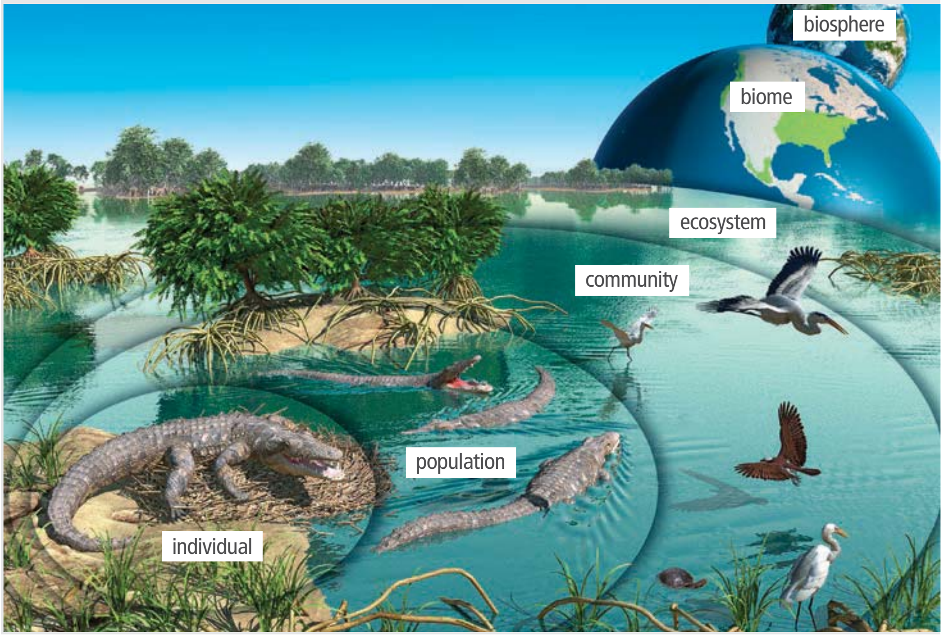
FIGURE 2: A gray fox emerges from its den.

Analyze What types of living and nonliving things does a gray fox's ecosystem include?

Ecosystem Structure

The Florida Everglades, illustrated in Figure 3, is an example of a complex ecosystem that can be difficult to study as a whole. To understand the complicated relationships that make up ecosystems, scientists break them down into smaller parts.

FIGURE 3: The Florida Everglades is an aquatic ecosystem that is found in the temperate deciduous forest biome.



Language Arts Connection Before they were listed as an endangered species, alligators in the Florida Everglades were hunted to near extinction. Use library and Internet resources to find information and write a report about how human activities have affected organisms, populations, and communities in the Florida Everglades ecosystem.

Ecologists can study ecosystems at different scales. They may study an individual alligator to learn more about factors that affect that species. They may also study an entire population of alligators. A population is a group of the same species that lives in the same area. Multiple populations of different species form a community. In the Everglades, an ecologist may study how a community of alligators, turtles, and birds in a certain area Interacts with one another.

An ecosystem includes all of the biotic, or living, and abiotic, or nonliving, components in a given area. Energy and matter cycle through these various components during processes such as photosynthesis, cellular respiration, and decomposition. Similar to other systems, an ecosystem also has feedback mechanisms that keep it in equilibrium and restore it to a balanced state when equilibrium is disrupted.

Explain What biotic and abiotic components are found in the ecosystem where you live, and how do they interact?

Biomes and Biodiversity

A biome is a major regional or global distribution of organisms adapted to living in that particular environment. Many different ecosystems make up a biome, and changes in one ecosystem may significantly affect the entire biome. At the largest scale, all life on Earth is part of the biosphere.

Biodiversity is a measure of the number of different species found within a specific area. An area with a high level of biodiversity, such as a tropical rain forest, has a large assortment of species living near one another. The amount of biodiversity found in an area depends on many factors, including moisture and temperature. The complex relationships in ecosystems mean that a change in one biotic or abiotic component can have many effects, both small and large, on a number of different species.

FIGURE 4: World Biomes


a Desert


b Tropical grassland


c Temperate grassland


d Tropical rain forest


e Temperate deciduous forest


f Temperate rain forest


g Taiga


h Tundra

There are many different types of biomes. Scientists categorize biomes in several ways, such as by the climate conditions and plant communities that thrive in them. This makes each biome's biodiversity different and unique. For the most part, the plants and animals that live in one biome are not found in any other biome. Although biomes can be categorized separately, they are still connected. Each of these broad biome types can be further divided into more specific zones. For example, a prairie is a type of temperate grassland. Frozen polar ice caps and high, snow- and ice-covered mountain peaks are not considered biomes because they lack specific plant communities.

Model Using your knowledge of photosynthesis, cellular respiration, and ecosystem structure, model how cutting down a tropical rain forest will affect surrounding biomes. Consider how the loss of the rain forest will affect the rate of photosynthesis in the area and how habitat loss will affect the rate of cellular respiration by animals in the forest. Then, model how the change in amounts of CO_2 and O_2 could affect surrounding ecosystems. What other ways might ecosystems be affected by such a loss?

Not all ecosystems are terrestrial, or land-based. About 71 percent of Earth's surface is covered with water, and it, too, is home to animal and plant life. These water-based ecosystems are called *aquatic ecosystems*. There are two main categories of aquatic ecosystems: salt water, or marine, and freshwater.

Collaborate Biodiversity tends to decrease the farther an ecosystem is located from the equator. Discuss this pattern of biodiversity in terms of different biomes and climate characteristics.

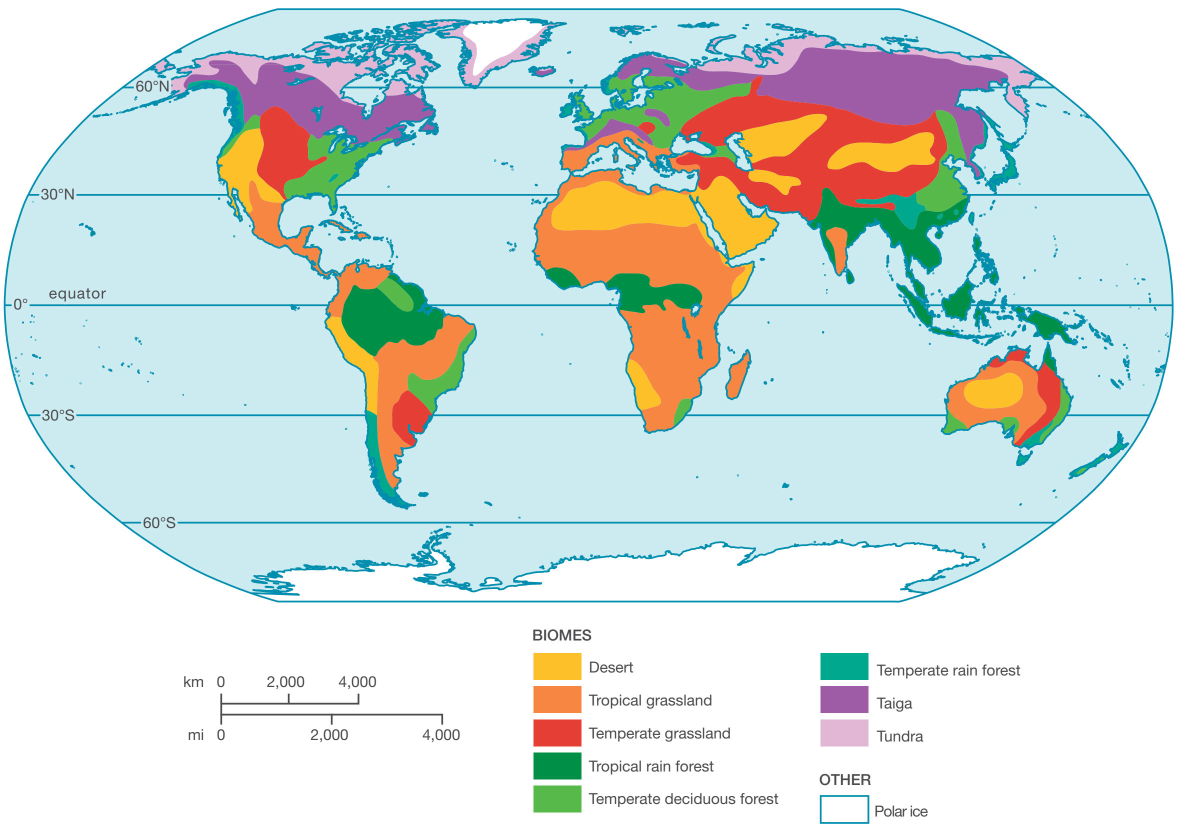
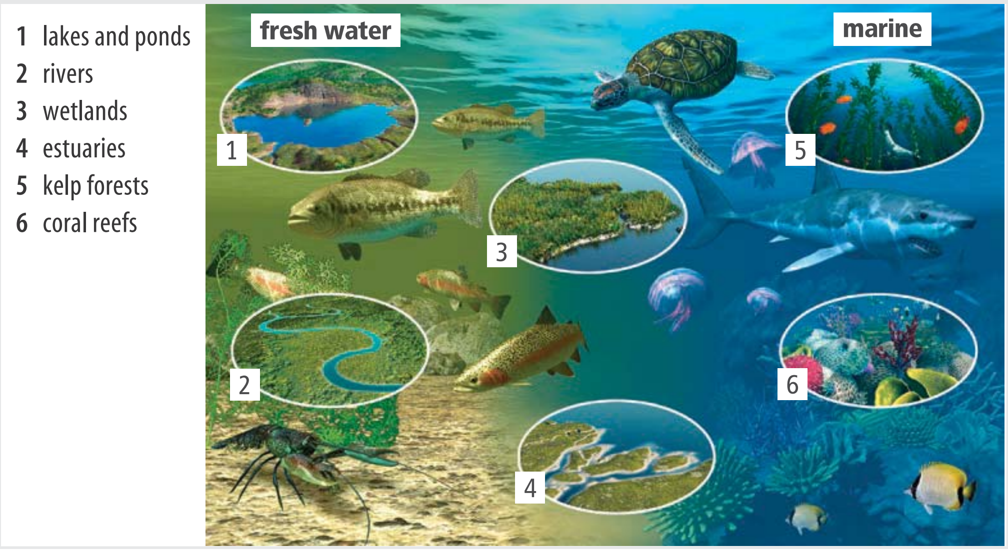


FIGURE 5: Like terrestrial ecosystems, aquatic ecosystems vary widely in size, location, and abiotic and biotic components.



Some types of aquatic ecosystems are shown in Figure 5. Marine ecosystems include the open ocean, coral reefs, kelp forests, and estuaries. Oceans spread from coastal shallows to the great depths of deep-sea vents. Most coral reefs grow within tropical zones. Kelp forests exist in cold, nutrient-rich waters. Estuaries occur where freshwater and salt water mix together.

Analyze How could rising ocean temperatures affect coral reef ecosystems?

Freshwater ecosystems include rivers, streams, lakes, ponds, and wetlands. Rivers and streams are flowing freshwater, while lakes and ponds are standing bodies of water. Wetlands are land that is saturated by surface water for at least part of the year.

Each of these ecosystems has unique groups of plants and animals that inhabit them. The plants and animals that live in these ecosystems are often highly specialized. Remember that aquatic plants utilize photosynthesis to convert sunlight into usable energy. They can only grow to water depths where sunlight can penetrate.

Cause and Effect

FIGURE 6: Discarded plastics pollute Bicaz Lake in Romania.

Analyzing Human Impacts

Human activities impact ecosystems, sometimes in severe ways. We produce wastes, such as plastics, that are a major source of pollution. Humans destroy habitats to build cities, grow crops, and mine resources. Most of these activities impair the air, water, soil, and biodiversity in ecosystems. How do you impact your ecosystem?

Explain Describe how changing a biotic or abiotic factor can influence an entire biome. Could changing biotic or abiotic factors be responsible for the decrease in phytoplankton populations introduced at the beginning of this lesson? Explain.

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.

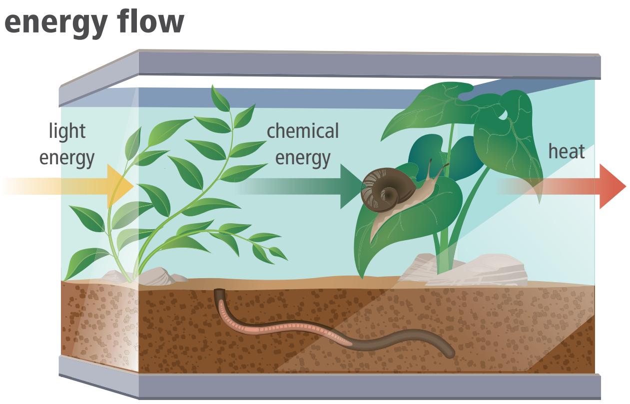
Predict Describe two ways that energy and matter flow in the tropical rain forest ecosystem shown in Figure 7.

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

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

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.

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.

Trophic Levels

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:

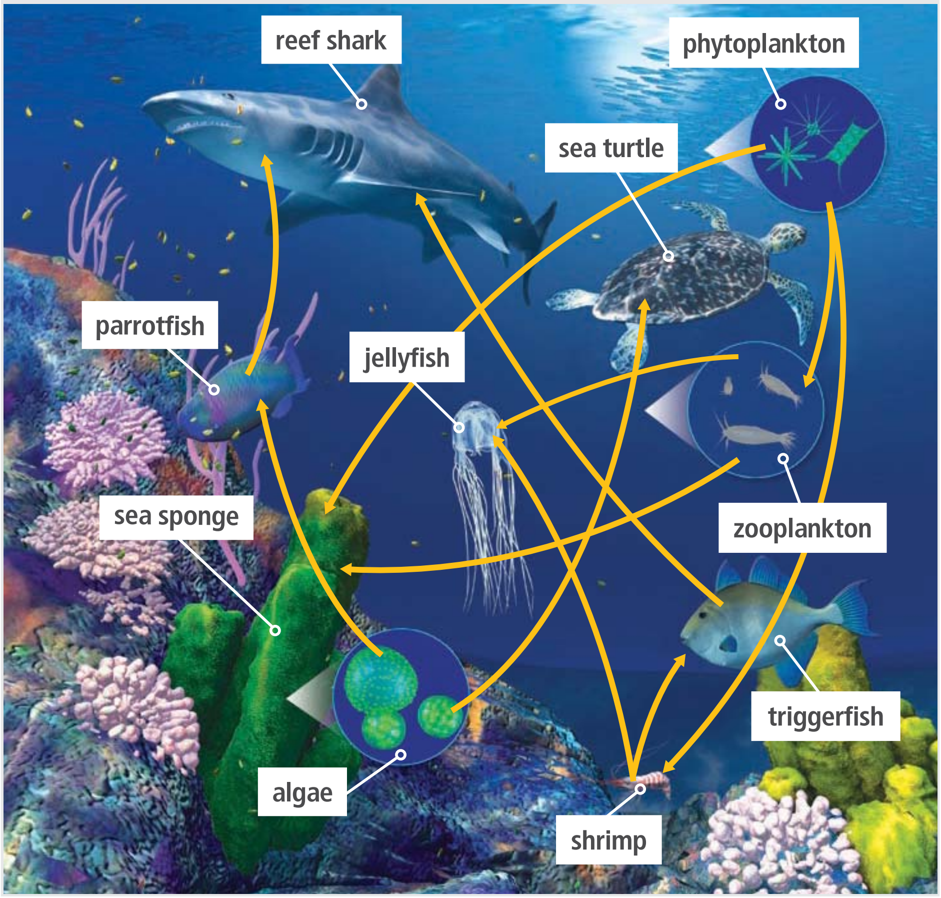
1. How does the population size change at each trophic level in this sample?
2. What is the relationship between trophic level and population size?
3. Predict what would happen if a quaternary consumer were added to this ecosystem.

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.

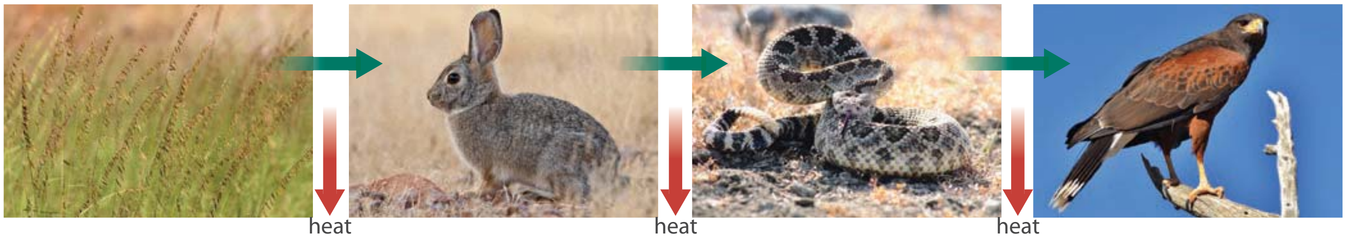
Explain Use the evidence you have gathered in this lesson to answer the following questions:

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?

Energy and Matter Distribution in Ecosystems

Ecosystems get their energy from sunlight. Producers use energy from sunlight to make food. Herbivores eat the plants but burn some energy in the process. The energy is given off as heat, which escapes into space. Carnivores then eat the herbivores but again, a portion of the energy is converted to heat, leaving it unavailable for use by the organism. Each level in the food chain obtains much less energy than the level below it. Fortunately, the sun provides a constant flow of energy into the system and allows life to continue.

FIGURE 14: Energy and matter transfer between trophic levels, but some energy is lost as heat.

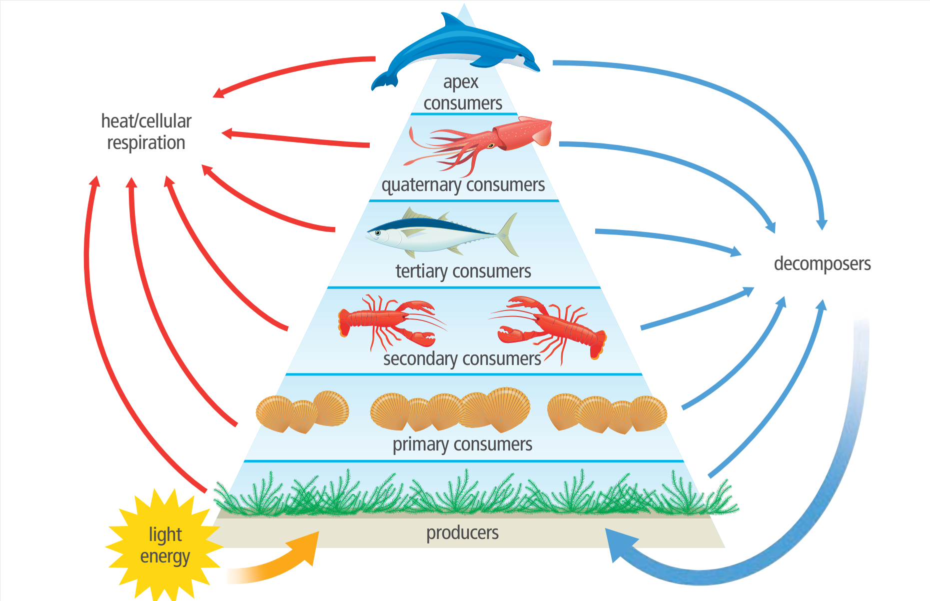


Reduction of Available Energy

When a consumer eats food, the energy it contains undergoes a transformation. Some energy is used for cellular respiration, which provides energy for movement and maintenance of the organism. Some is converted to new biomass, or growth. Of the remaining energy, some is released to the environment as heat, and the rest is excreted as waste, as illustrated in Figure 15. Although energy changes to different forms in this process, the total amount of energy remains unchanged or is conserved.

Analyze How does the amount of energy at each trophic level compare? Use evidence to support your reasoning.

FIGURE 15: As trophic level increases, the amount of available energy is reduced because some is converted to heat or excreted as waste.



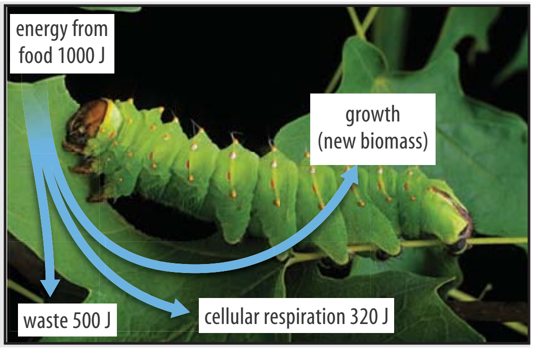
Data Analysis

Energy Calculations

SAMPLE PROBLEM

Energy can be measured using calories (cal), kilocalories (kcal), and joules (J). A caterpillar consumes 1000 J of energy from the plant it eats. However, the caterpillar cannot digest all the plant matter, so 500 J of energy are lost as bodily waste. Additionally, 320 J of energy are converted to heat or used for metabolism. What percentage of energy remains for the caterpillar to use for biomass, or growth?

FIGURE 16: A large amount of the energy a caterpillar consumes is converted to heat via cellular respiration or excreted as waste.



ANALYZE

To determine the amount of energy left for the caterpillar to use, subtract the amount converted to heat and excreted as waste from the total amount consumed:

$$1000\text{ J} - 500\text{ J} - 320\text{ J} = 180\text{ J}$$

The caterpillar has 180 J left over to convert into biomass.

SOLVE

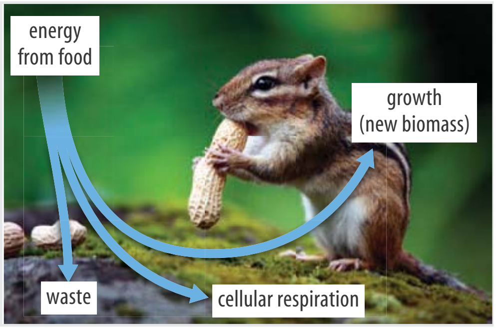
To determine the percentage of energy that is usable, divide the amount of available energy by the total amount of energy and multiply by 100 percent:

$$\frac{180\text{ J}}{1000\text{ J}} \times 100\% = 18\%$$

So 18 percent of the total energy consumed by the caterpillar is available for growth, and 82 percent of the energy is converted to other forms. Only a small percentage of the energy in the food was converted to new biomass.

PRACTICE PROBLEM

FIGURE 17: The energy a chipmunk consumes is also largely converted to heat or excreted as waste.



The chipmunk consumes 1000 J of energy from food, loses 177 J as waste, and loses 784 J to cellular respiration.

1. How many joules of energy are available to convert into new biomass?
2. What percentage of the total energy was available to become new growth?
3. What percentage of the total energy consumed was converted to unusable forms via cellular respiration, heat, and waste?
4. Make a model that supports the idea that energy is conserved. Use evidence from this example to support your claim.

Pyramid Models

The same pattern of energy and biomass distribution at the organism level also occurs at the ecosystem level. Biomass is a measure of the total dry mass of organisms in a given ecosystem at the time of measurement.

Pyramid models are useful for showing the productivity of an ecosystem and can illustrate the distribution of energy, biomass, and number of organisms. Productivity is the percentage of energy entering the ecosystem that is incorporated into biomass at a particular trophic level. Modeling ecosystem productivity with a pyramid allows scientists to compare the distribution of energy, biomass, or numbers of organisms between trophic levels.

Gather Evidence What information do scientists need in order to determine how much energy is converted into biomass at different trophic levels?

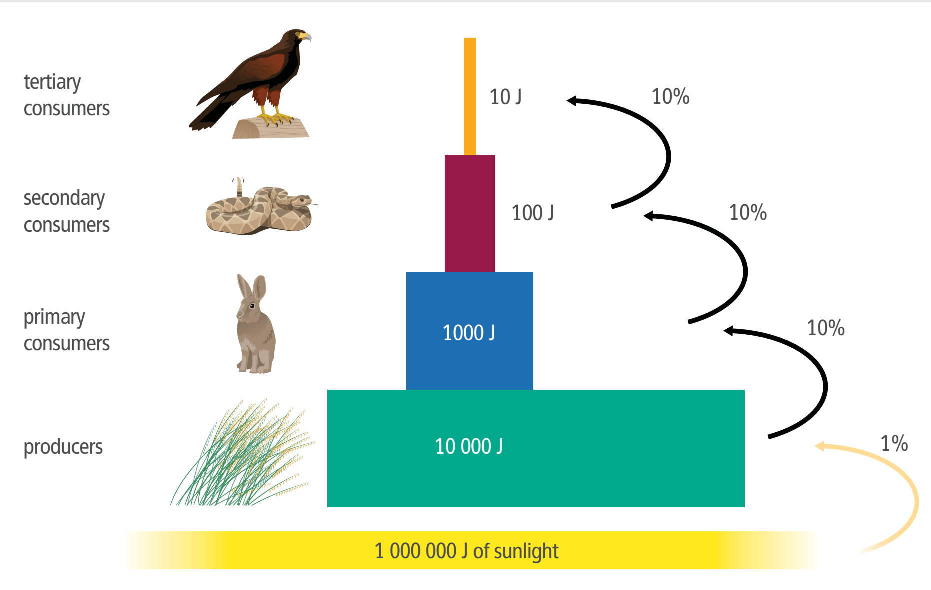
Energy Pyramids

Trophic efficiency is the percentage of energy transferred from one trophic level to the next. Remember that energy transfer from one organism to another is not efficient.

An energy pyramid models the transfer of energy beginning with producers and working up the food chain to the top-level consumer. The pyramid illustrates how available energy is distributed among trophic levels in an ecosystem. A typical energy pyramid has a very large section at the base for producers, and sections become progressively smaller above. Because energy is converted to heat lost to the environment at each level of the pyramid, the more levels there are in the ecosystem, the greater the loss of energy. The energy used by producers far exceeds the energy used by the consumers they support.

In the simplified energy pyramid shown in Figure 18, energy flows from one trophic level to the next. In this example, only 10 percent of energy produced is transferred to the next trophic level. Notice that only 0.1 percent of the energy in the producer level transfers to the tertiary consumer level.

FIGURE 18: An idealized energy pyramid of a grasslands ecosystem.



Data Analysis

According to this model, if the producer level contained 5000 J of energy, how many joules of energy would be present at the tertiary consumer level? Using this information, can you explain why the energy pyramid is shaped the way it is?

The simplified pyramid in Figure 18 shows a trophic efficiency of 10 percent for each link in the food chain. A simplified pyramid like this can help scientists make models and hypotheses. In reality, the energy transfer between trophic levels, or the trophic efficiency, can range from 5 to 20 percent, depending on the type of ecosystem.

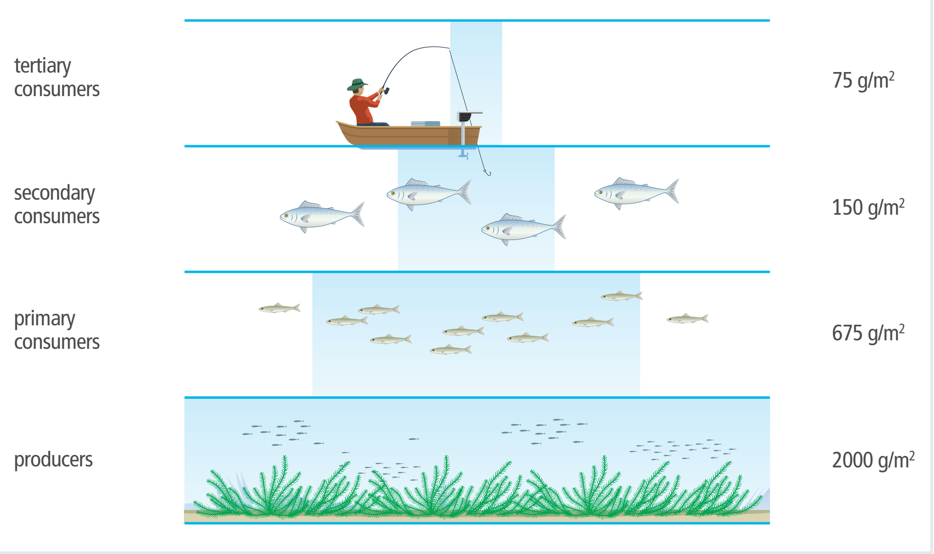
Producers convert only about 1 percent of the energy available from sunlight into usable energy. This is because not all of the sunlight hits the leaves of a plant, not all wavelengths of light are absorbed, and photosynthesis and cellular respiration in plants require large quantities of energy.

Gather Evidence Why is there a limit to the number of trophic levels in an ecosystem? Is energy conserved in an ecosystem?

Biomass Pyramid

A biomass pyramid, such as the one shown in Figure 19, compares the biomass at different trophic levels within an ecosystem. It illustrates the mass of producers needed to support primary consumers, the mass of primary consumers required to support secondary consumers, and so on. Biomass is measured as the total mass per unit of area. The biomass measurement includes living organisms and dead organic matter. As organisms die and decompose, the nutrients and matter in their bodies are cycled back through the biomass pyramid by decomposers.

FIGURE 19: A biomass pyramid depicts the total dry mass of organisms found at each trophic level. In this example the biomass is measured as g/m^2.



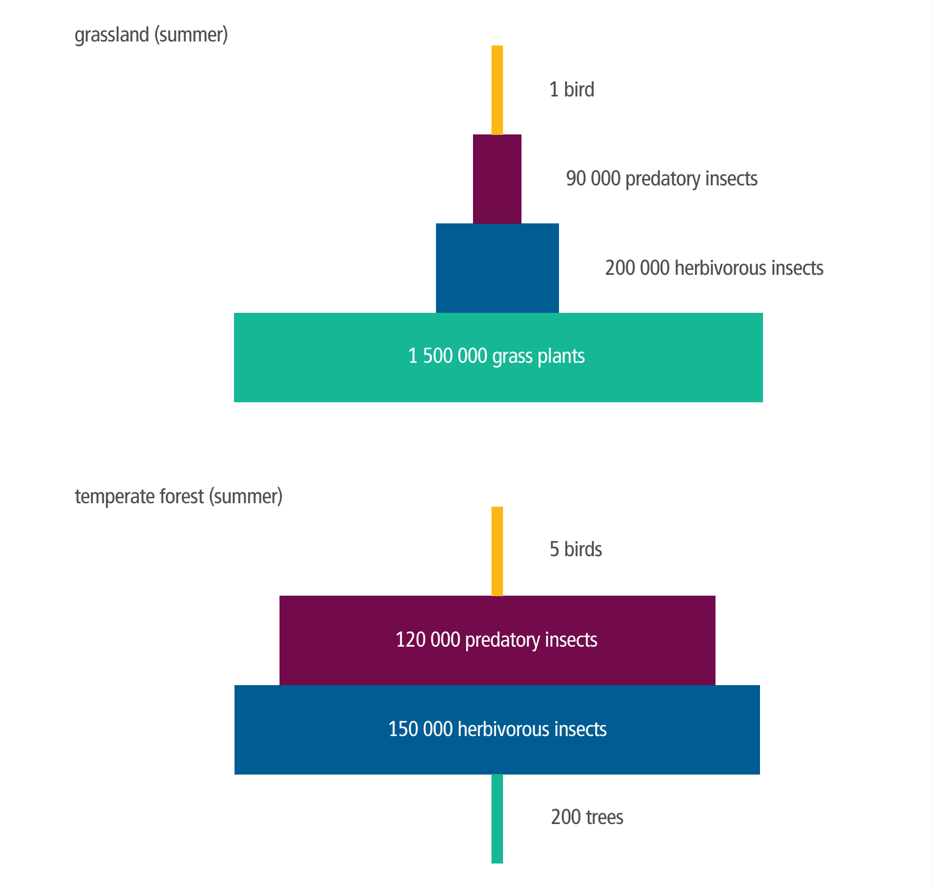
The amount of energy and biomass decreases in a biomass pyramid as you move up the trophic levels. In an energy pyramid, the percentage of energy transferred from one trophic level to the next is approximately the same at every level. In a biomass pyramid, the percentage of biomass transferred to the next trophic level depends on the types of organisms present in each trophic level and the level of consumption and the availability of that biomass for consumption. For example, leaf biomass is more available and useful for herbivores than wood.

Model Create a model that demonstrates the relationship between biomass and energy in an ecosystem.

Pyramid of Numbers

A pyramid of numbers shows how many individual organisms are present at each trophic level in an ecosystem. Two examples of a pyramid of numbers are shown in Figure 20. This type of pyramid is effective in showing the vast number of producers required to support even a few top-level consumers. Ecosystems vary in the number and types of organisms in each level. These organisms also vary in their rates of growth and reproduction, as well as in the amount of biomass each species needs to sustain life and growth. A trophic level that contains organisms that reproduce and grow rapidly often has less biomass at any given time than one in which reproduction and growth rates are slow. The size of the organisms also plays a role in the shape of the various pyramids. The larger the individual organism, the fewer that are needed to support the next trophic level.

FIGURE 20: A pyramid of numbers models how many organisms are at each trophic level.



Analyze According to the grassland pyramid, how many grass plants would be needed to support 12 birds?

Think about why a pyramid of numbers or a biomass pyramid might appear in an upside-down or diamond formation. A single tree in a rain forest would be greatly outnumbered by the primary and secondary consumers, such as insects and birds, that live on the tree. The upper layers of the pyramid of numbers would be larger than the bottom layer representing the single tree. If a secondary or tertiary consumer, such as a condor, were added to the top of the pyramid, a diamond shape would result.

Explain Compare and contrast the different ways to model energy and matter flow in an ecosystem. If you were a scientist studying an ecosystem, explain how you would use each type of pyramid and what information you could gain from each one.

Hands-on Activity

Biomagnification

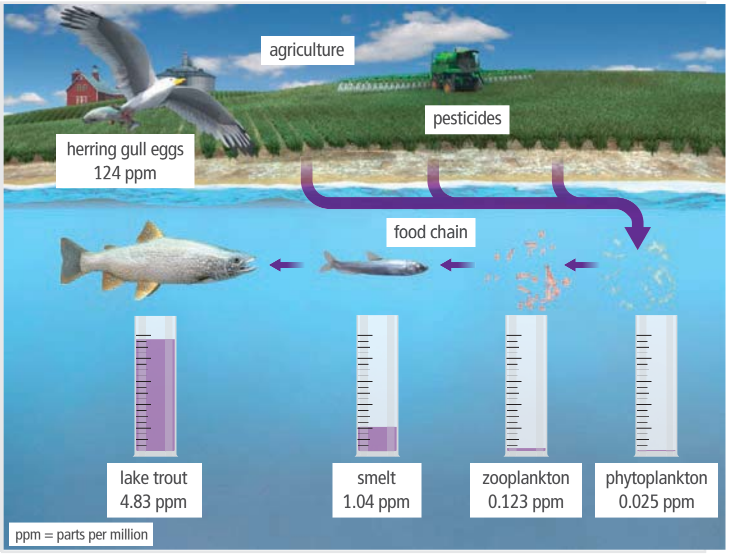
MATERIALS

- beads, large (16)
- beaker, 500 mL
- marker
- tape, masking
- paper cups (4 small, 2 medium, 1 large)
- pencil, sharpened
- salt

Predict How will the beads, or pollutants, transfer between the cups? How is this a model of biomagnification? How are contaminants magnified up the food chain?

Harmful chemicals enter aquatic ecosystems from the runoff of silt, pesticides, and fertilizers. These chemicals enter the food chain and build up in the bodies of organisms through a process known as biomagnification. Scientists study this process by measuring the amount of chemicals in each trophic level in parts per million.

FIGURE 21: Biomagnification in an aquatic ecosystem.



PROCEDURE

1. Label the small cups "Smelt," the medium cups "Trout," and the large cup "Gull." With just the pencil tip, punch one or two small holes in the bottom of each cup, and cover them with tape.
2. Fill each of the cups halfway with salt. Add four beads to each small cup.
3. Hold each of the small cups over the beaker and remove the tape. Allow the salt to flow through the holes into the beaker.
4. Pour the remaining contents of two small cups into one medium cup. Pour the contents of the other two small cups into the second medium cup. Repeat Step 3 with the medium-sized cups.
5. Pour the remaining contents of both medium cups into the large cup.

ANALYZE

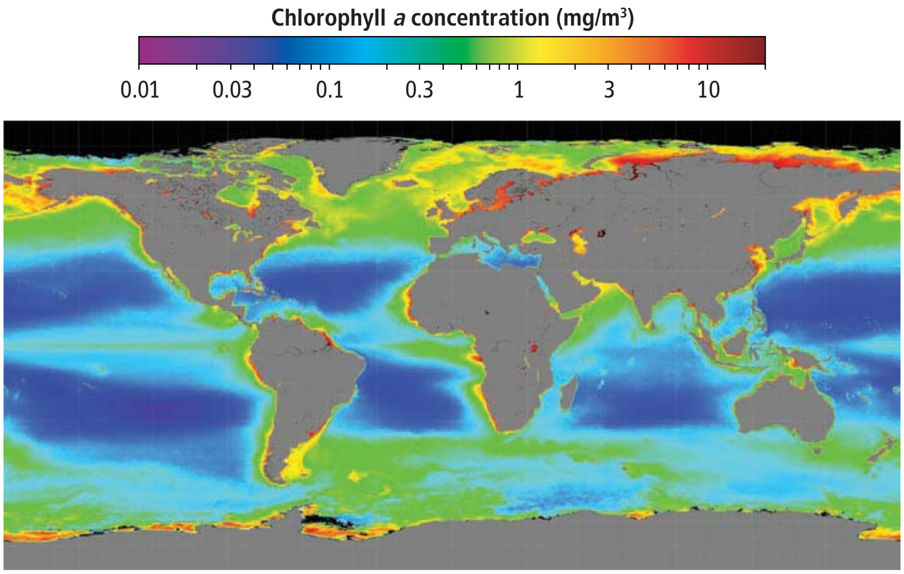
1. What pattern did you notice for the transfer of pollutants between trophic levels?
2. Why would tertiary consumers have the highest concentrations of toxins?
3. How are humans affected by biomagnification? Use evidence from this activity to explain why this is a concern.

WHAT DO ALLIGATORS EAT? | IS YOUR DIET ENERGY EFFICIENT? | AQUATIC PRIMARY PRODUCTIVITY | Go online to choose one of these other paths.

Lesson Self-Check

CAN YOU EXPLAIN IT?

FIGURE 22: Global Concentration of Chlorophyll *a*



Phytoplankton are tiny photosynthetic organisms that live in marine environments. They serve as the base for the aquatic ecosystem food web and are an integral part in the energy and matter flow in aquatic ecosystems. Through their role in the production of approximately half of Earth's oxygen, phytoplankton are important to terrestrial food webs and pyramids.

Explain Refer to your notes in your Evidence Notebook to explain how the flow of energy and matter through an ecosystem is modeled. Using this information, answer the following questions:

1. Explain the relationship between the phytoplankton population and chlorophyll concentration.
2. How can a decrease in the phytoplankton population affect life on Earth?
3. How might this change affect the flow of energy and matter in the biosphere?

CHECKPOINTS

Check Your Understanding

1. In a prairie ecosystem, which of the following populations has the most stored energy for use by other organisms?
   a. hawks
   b. buffalo
   c. prairie dogs
   d. prairie grasses

2. Which food chain correctly shows the direction that energy and matter flow through a forest ecosystem?
   a. fruit—insect—sparrow—hawk
   b. hawk—fruit—insect—sparrow
   c. insect—sparrow—hawk—fruit
   d. insect—hawk—fruit—sparrow

3. Which of the following terms are in the correct order, from smallest to largest?
   a. population, organism, community, ecosystem, biome, Earth, biosphere
   b. organism, community, population, ecosystem, biome, biosphere, Earth
   c. organism, population, community, ecosystem, biome, biosphere, Earth
   d. ecosystem, organism, population, community, biome, biosphere, Earth

4. Consider a pyramid model with a producer level, a primary consumer level, a secondary consumer level, and a tertiary consumer level. Which of the following statements are correct?
   a. The sun is the ultimate source of energy in an ecosystem.
   b. Matter cycles and is generally conserved within or among ecosystems.
   c. Energy flows through ecosystems, but only a certain amount of energy is transformed into biomass.
   d. Energy flows through ecosystems, but some is lost to the environment as heat.
   e. Matter and energy are completely conserved and transformed into biomass within an ecosystem.

5. What is the relationship between a food chain and trophic levels?
   a. A food chain demonstrates how the organisms at the highest trophic levels have the most energy.
   b. Food chains illustrate the flow of energy from one trophic level to the next.
   c. A food chain models the energy flow within a single trophic level.

6. A consumer eats 1500 J of food energy. The consumer uses 15 percent of the food energy for new biomass and the rest for cellular respiration and waste. Use this information to answer the following questions:
   a. How many joules of food energy were converted into new biomass?
   b. How many joules of food energy are converted to heat and excreted as waste?
   c. What percentage of the food energy was converted to heat and excreted as waste?

FIGURE 23: Desert

7. Why is a desert in North America, such as Arizona's Sonoran Desert (Figure 23), considered to be the same biome as a desert in Africa?

8. What biotic and abiotic factors influence the flow of matter and energy in different biomes?

9. Do you think it is possible for a biome to change from one type to another due to human activities? Explain a situation in which this might happen.

10. A student thinks that populations higher in a food chain are larger because they deplete the populations of organisms lower in the chain. Using evidence from this lesson, explain why this student's thinking is incorrect.

FIGURE 24: Rabbits are herbivorous and hawks are carnivorous.

a Primary Consumer

b Tertiary Consumer

11. Think about the trophic efficiency, or percentage of transferred energy between trophic levels, in an ecosystem. Why is an herbivorous diet more energy efficient than a carnivorous diet? Use the example of the rabbit and the hawk shown in Figure 24 to help explain your answer.

12. An aquatic ecosystem contains 10,000 freshwater shrimp, 1000 sunfish, 100 perch, 10 northern pike, and 1 osprey. Draw a pyramid of numbers that represents this ecosystem.

13. Describe how energy and matter flow, interact, and change forms throughout the Earth system.

14. In your Evidence Notebook, make a model that explains the relationship between river, estuary, and ocean ecosystems. How do matter and energy flow within and among these ecosystems?

MAKE YOUR OWN STUDY GUIDE

In your Evidence Notebook, design a study guide that supports the main ideas from this lesson:

Life in an ecosystem requires a source of energy. The flow of energy and matter in an ecosystem can be demonstrated by food chains, food webs, and pyramid models.

Remember to include the following information in your study guide:

- Use examples that model main ideas.
- Record explanations for the phenomena you investigated.
- Use evidence to support your explanations. Your support can include drawings, data, graphs, laboratory conclusions, and other evidence recorded throughout the lesson.

Consider how food chains, food webs, and pyramid models show the flow of energy and matter through trophic levels in an ecosystem.