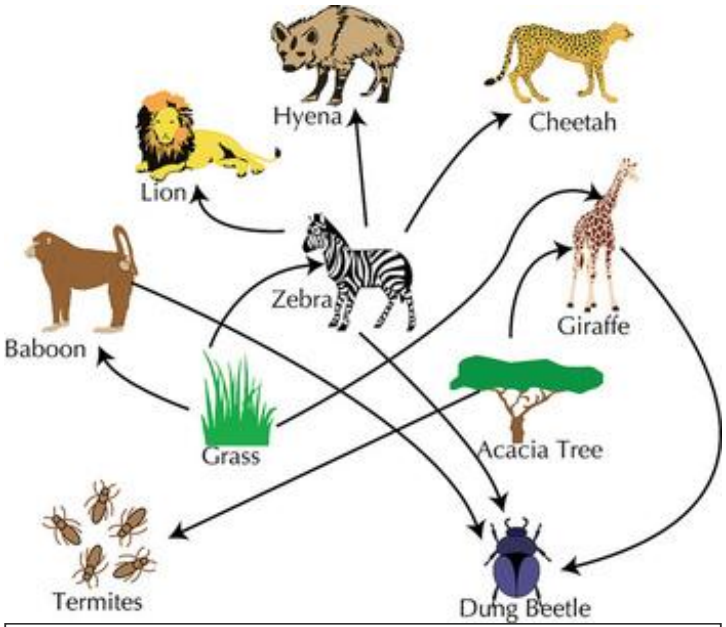
Flow of Energy in Ecosystems

Teacher Background

Flow of Energy in Ecosystems

Every ecosystem is complex. Many living and nonliving components are involved in the two most important processes: the flow of energy and cycling of matter. Different models have been developed to help us understand these processes. No single model captures all interactions within the ecosystem. Each model has its advantages and disadvantages.

Terrestrial producers are mostly plants, while aquatic producers include algae and small organisms in addition to plants. Consumers eat producers, other consumers, or both. Decomposers break down dead material, extracting energy and returning atoms back into the ecosystem to be used again. In terrestrial environments, decomposers recycle nutrients from dead plant or animal matter back to the soil while in aquatic environments, the matter is recycled back to the water.



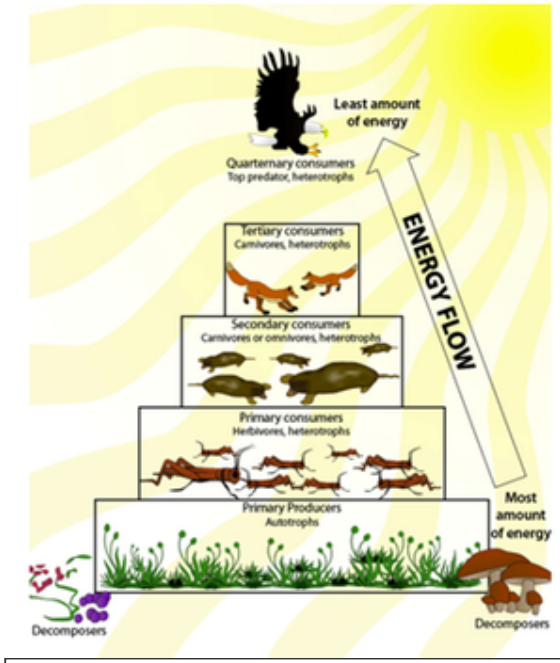
Food webs are one type of model. In a food web, arrows connect producers, consumers, and decomposers. The arrows show both energy flow and matter cycling.

Most food webs leave out the interactions with non-living components, such as air, soil, or water. This makes it difficult to trace atoms through the ecosystem. For example, plants take in carbon dioxide from the atmosphere for photosynthesis. Nitrogen-fixing bacteria on some plant roots provide nitrogen to the plant. Oxygen is released into the atmosphere by photosynthesis. Decomposers break down molecules that contain nitrogen and return the atoms back to the soil.

In contrast to matter, energy flows and is not recycled. The initial input of energy comes from the Sun in almost all ecosystems. Producers capture a fraction of the Sun's energy and store it in molecules. Consumers use some of the energy they take in to keep their body processes running and the rest for growth and reproduction. Ecological pyramids are a model that captures the amounts of energy contained in each level, as well as what level it came from and where it is going.

The advantage of pyramids over webs is that they can capture the abundance of organisms and energy contained in each level better than webs. The disadvantage of pyramids is that they frequently ignore the great variety of organisms at each level and provide only an average of energy transfer.

On average, only 10 percent of the energy contained in one level reaches the next higher level. The rest is lost to heat and maintaining body function. However, ecological efficiency varies



Food pyramids depict energy flow.

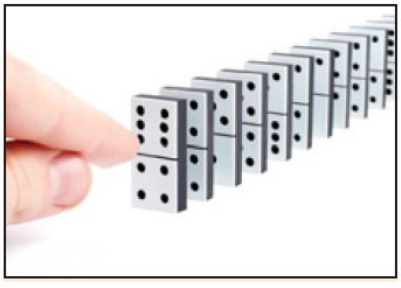
greatly. It is generally highest in plants and lowest in animals that can maintain a stable internal body temperature like mammals or birds. The number of organisms at each level and the total biomass can be determined. There are usually fewer large animals than small animals. Biomass may be a better indicator of energy contained in the level than abundance.

Flow of Energy in Ecosystems

Reflect

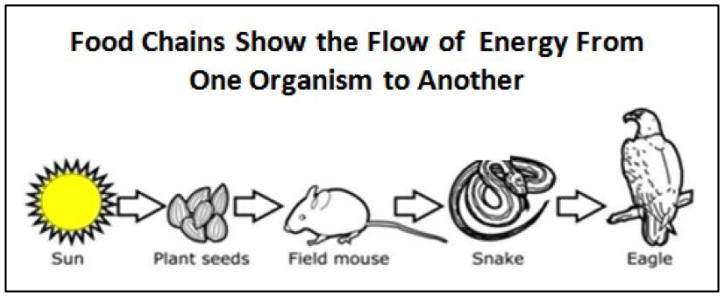
Animals, including humans, get their **energy** by eating other organisms. For example, you may have eaten an apple at breakfast that provided your body with energy later in the day. Where did the energy stored in the apple come from? We know that energy cannot be created or destroyed, so where does the source of energy in living systems begin, and how does it move through these systems?

energy – the ability to do work or cause change

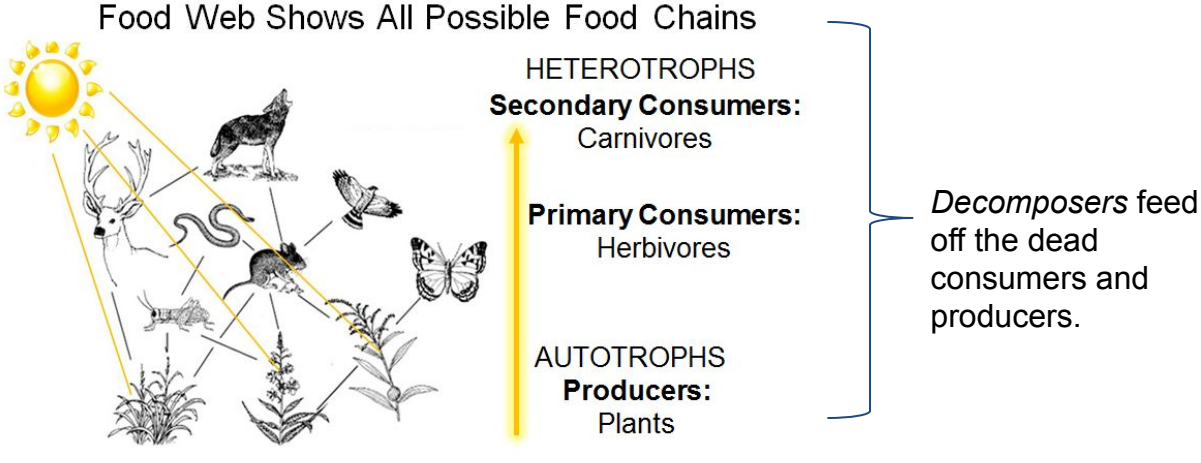


Energy flows through ecosystems.
When you push on the first of a series of lined-up dominoes, the energy from your push is transmitted from one domino to the next. Your push represents the energy that started the movement. This energy moves along the line as each domino topples into the next.

Energy also moves from a starting point through living systems in a one-way direction shown in a *food chain.* This movement is described as a flow of energy. The Sun is the major starting point for most of the living things on Earth.



Food webs are models that demonstrate how matter and energy are transferred between producers, consumers, and decomposers as the three groups interact within the connected food chains in an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Eventually, decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.



Trophic Levels in an Ecosystem

Energy flows in an ecosystem from one trophic level (feeding level) to the next. All organisms can also be classified as either autotrophs or heterotrophs.

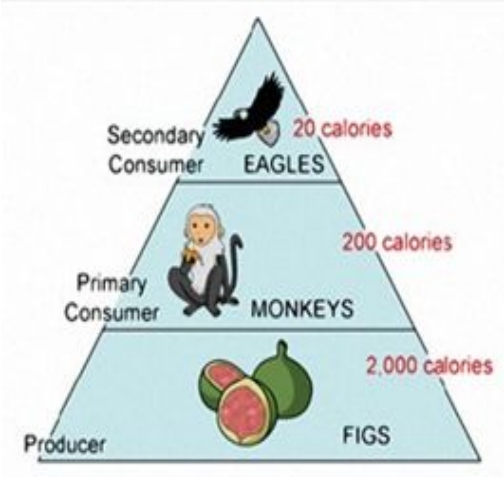
- **Autotrophs**
  - **Producers:** The first trophic level includes organisms that are called producers, or autotrophs, because they produce their own food. *Auto-* refers to "self," and *troph-* refers to "feeding," so autotrophs are self-feeders. Producers include plants, algae, and some bacteria that use photosynthesis to make their own food.
- **Heterotrophs**
  - **Consumers:** The second trophic level of organisms gets energy by eating other organisms. Consumers are further classified by the type of food eaten and by how many trophic levels of energy are involved.

Herbivore	Carnivore	Omnivore
• It only eats producers (the root word *herb* refers to plants). • They are also called *primary consumers*, because they are the first level in a food chain. • Examples are rabbits, squirrels, and cows.	• It only eats other animals (the root word *carn* refers to meat). • They can be *secondary consumers* (if they eat primary consumers) or *tertiary consumers* (if they eat secondary consumers). • Examples are snakes, hawks, and lions.	• It eats both plants and animals. • They can be primary consumers or secondary consumers, depending on what they choose to eat in a particular situation. • Examples are raccoons, brown bears, and humans.

  - **Decomposers:** Decomposers break down dead or decaying consumers and producers via chemical reactions and use the energy released from rearranging those molecules for growth and development. Decomposers can be fungi or bacteria.

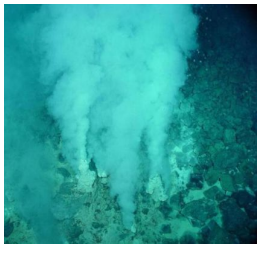
Flow of Energy in Ecosystems

Look Out!



Remember these important concepts about the flow of energy in ecosystems:

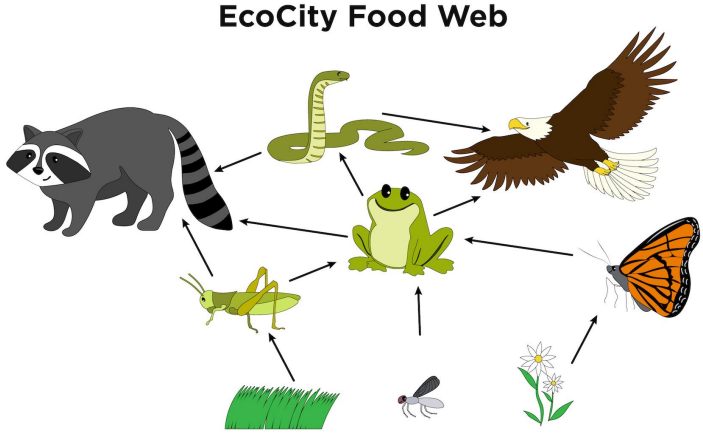
- Not all trophic levels of a food chain receive the same amount of energy. Only about 10% of the Sun's energy absorbed by plants is transferred to the consumers at the next trophic level. Where does 90% of the energy go? Some of it is used to fuel body processes such as growth, repair, and reproduction. Most of it is transferred to the atmosphere as heat. We can represent the energy flow of an ecosystem in an energy pyramid. The different levels of the pyramid represent the different groups of a food chain or food web. The producers are found at the bottom of the pyramid.The more levels there are in a pyramid, the less energy is available to the organism at the top.
- Energy moves through an ecosystem in a single direction. First it flows from the Sun to autotrophs, or *producers*. Then it flows from producers to *consumers*. Energy never flows backward from consumers to producers.
- When you draw a food chain, always begin with energy from the Sun to a producer. Don't forget that the arrows should point to the organism receiving the energy.
- A small percentage of organisms use sulfur compounds from volcanic sea vents deep in the ocean as their source of energy. Instead of using Sunlight in photosynthesis, these organisms use chemicals to aid in chemosynthesis. They make their own food, just like in photosynthesis.



Reflect

In terrestrial ecosystems, food webs involve organisms that live on land.

A food chain is useful for tracing energy flow, but it only tells part of the story. A *food web* shows the complexity of interactions between the different trophic levels. The terrestrial food web on the right shows several overlapping food chains. The producers are plants. Insects such as grasshoppers and butterflies are primary consumers that eat the plants. Frogs and raccoons are secondary consumers that eat insects, and snakes and eagles are tertiary consumers (also carnivores) that eat secondary consumers.



Flow of Energy in Ecosystems

What Do You Think?

Take a look at the terrestrial food web to the right. Identify each organism as one or more of the following:

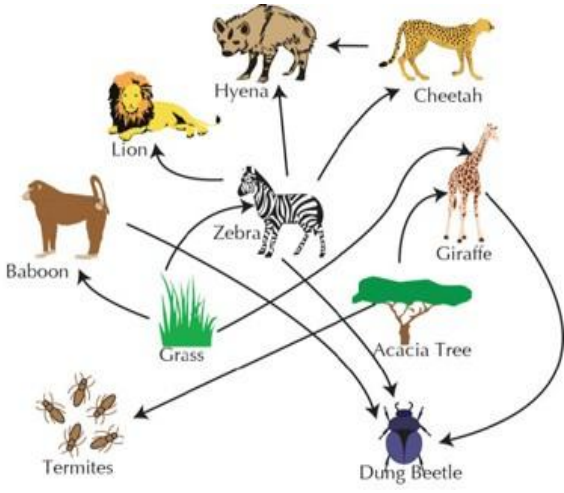
Producer (autotroph):

Primary consumer (heterotroph):

Secondary consumer (heterotroph):

Tertiary consumer (heterotroph):

Which organisms do you think would consume the dead plant and animal matter in this ecosystem?



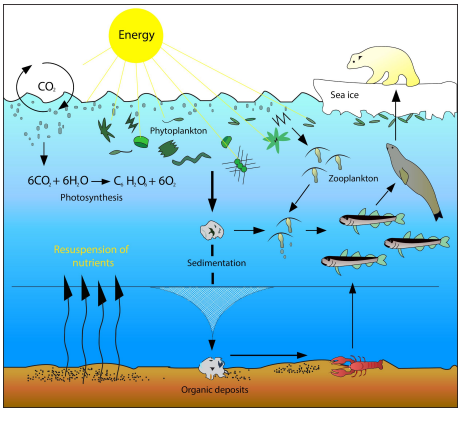
Look Out!

In aquatic ecosystems, food webs involve organisms that live in water.

Aquatic ecosystems make up the largest part of our *biosphere*, the part of Earth that is able to support life. *Aquatic ecosystems* include marine and freshwater ecosystems.

- *Marine ecosystems* are saltwater environments such as oceans, coral reefs, and salt marshes.
- *Freshwater ecosystems* are water environments with a very low salt content and include rivers, streams, and ponds. Like all ecosystems, aquatic ecosystems consist of food webs with producers and consumers.

Tiny aquatic plants called *phytoplankton* are the main producers in aquatic ecosystems. Algae are a common type of phytoplankton. Tiny aquatic animals called *zooplankton* and small animals without backbones called *invertebrates* are primary consumers that feed on phytoplankton. Fish and larger aquatic life eat these primary consumers and make up the higher consumer levels of the food chain.



Try Now

Study the images below. Identify the trophic levels shown in each image. Write “producer,” “primary consumer,” “secondary consumer,” or “tertiary consumer” next to the image in the right column of the table.

Image	Trophic Level
	Squirrel: Nut:
	Bear: Fish:
	Caterpillars: Leaf:
	Bird: Insect: Tree:

Explore

Name: _____ Date: _____

Food Webs

1. After discussing with your group, write your own definition of the terms below.

   a. Producer:

   b. Consumer:

   c. Decomposer:

2. Draw and label your food chain.

_____ Ecosystem Food Chain

3. Did you use all of the organisms in your ecosystem's food chain?

4. Is a food chain the most accurate model of an ecosystem? Why or why not?

Explore

5. Draw a diagram of the model you created that shows how energy flows through a food web. Use arrows to show the energy path flowing from one organism to another. Include a legend to provide details about color representation. For example: The green lines show energy flowing from producers.

Legend

- = From the Sun to producers
- = From producers to primary consumers
- = From primary consumers to secondary consumers
- = From secondary consumers to tertiary consumers
- = From tertiary consumers to quaternary consumers
- = From all organisms to decomposers

Explore

6. Reflect on the activity by answering the questions below.

    1. How do food chains and food webs differ?

    2. What do food webs model?

    3. How do consumers interact with producers in your system?

    4. Explain the role of decomposers in terrestrial and aquatic ecosystems.

    5. The quality, quantity, and reliability of the goods and ecosystem services provided by natural systems are directly affected by the health of those systems. Would you consider your ecosystem healthy? Justify your thinking.

    6. If humans extracted, harvested, transported, and/or consumed natural resources from your system, how would you expect the overall system health to be impacted?

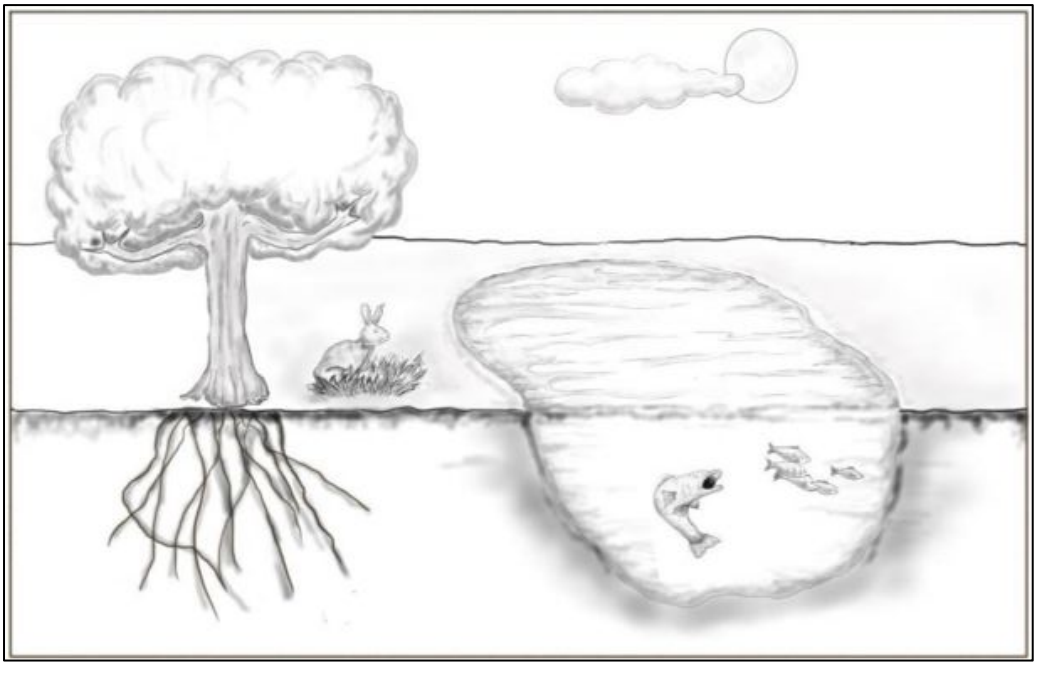
Explore

Name: _____ Date: _____

Cycling of Matter and Energy

Part I: Matter and Energy in the Ecosystem

1. Select four colors and fill out the color key below.
2. Draw arrows on the diagram to indicate which direction you think different matter and energy move through the ecosystem.



Color Key
= Water (H_2O)
= Oxygen (O_2)
= Carbon Dioxide (CO_2)
= Energy (E)

3. Fill out the table below to highlight what living and nonliving parts of the ecosystem each type of matter passed through.

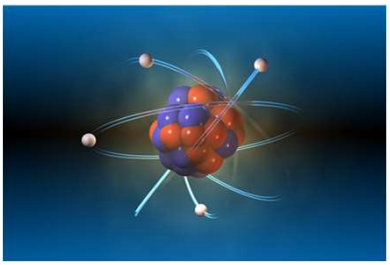
	Living Parts of Ecosystem	Nonliving Parts of Ecosystem
Water		
Oxygen		
Carbon Dioxide		

Flow of Energy in Ecosystems
Picture Vocabulary

Aquatic

Relating to water; living in or near water or taking place in water

Atom



The smallest particle of an element; made of electrons, protons, and neutrons

Consumers

An organism that must consume other organisms for nutrients

Decomposer

Organisms such as bacteria and fungi that break down the remains of dead plants and animals without need for internal digestion

Ecosystem

A system comprising all the biotic and abiotic factors in an area and all the interactions among them

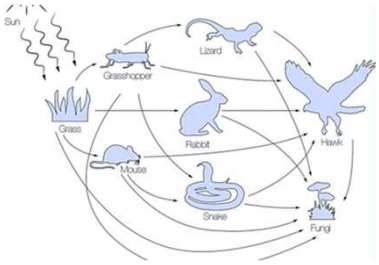
Energy

The ability of a system to do work; required for changes to happen within a system

Energy Transfer

Transfer of energy from the Sun through the different trophic levels of the biosphere

Food Web



Overlapping food chains with different pathways for the flow of food energy in an ecosystem

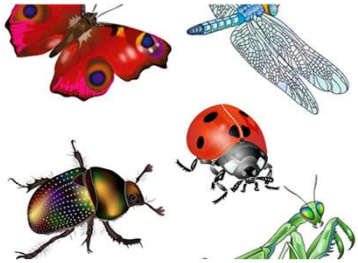
Matter Cycle

The movement of elements or molecules through a repeated sequence of events

Nutrients

Substances that provide nourishment essential for growth and the maintenance of life

Organism



A self-contained living thing

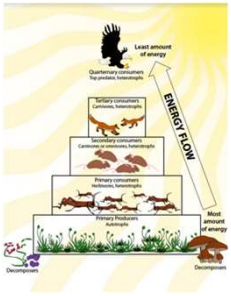
Producers

Organisms that transform energy from the Sun and use carbon dioxide and water to make food

Terrestrial

On or of Earth

Trophic Level



The position an organism occupies on the food web