Energy Flows

Real World Ecosystems
Backgrounder
Grade Level: 5-8

Ecosystems are places where living **organisms** (any living or once-living things) interact with the non-living world around them. No matter where ecosystems are located and what organisms they contain, the basic rules for most ecosystems are the same: energy is transferred from the sun to plants, and from plants to various kinds of consumers before being released back to the environment as heat.

All living organisms on Earth require energy for life processes. For almost all organisms, this energy is supplied to cells in the form of a simple sugar called glucose. Glucose is a form of stored energy. Almost all cells in living organisms need glucose to maintain their life processes. They also need water, oxygen, nitrogen, and other substances.

Some organisms are able to make their own glucose, by combining water and carbon dioxide in a process that requires sunlight. The name of this process is photosynthesis**. Photosynthesis:** The chemical process during which green plants convert light energy, carbon dioxide, and water in the presence of chlorophyll into carbohydrates. Oxygen is produced as a by-product. Organisms that make their own glucose are called **autotrophic** because they essentially "feed themselves." (auto = self, trophic = eating or feeding). Most green plants are in this category. With little more than sunlight, water, and nutrients, plants can grow and reproduce. Plants are also called "**producers**", because they produce glucose, the energy molecule most other life forms d depend on.

Plants store their extra glucose in special molecules such as starch, cellulose, or convert it to other forms such as oils or fats, and proteins. Cellulose is the fibrous material you find in wood and plant stalks. Starch is most often found in seeds and grains. Oils and proteins are also found in seeds (think of peanut oil as an example). Cellulose, starch, sugar, fats and proteins are very important food molecules for another group of organisms called **consumers**. These are organisms that cannot make their own glucose, and must eat other organisms to get it. They digest and process these food molecules, converting them to glucose for use in their cells. These organisms are also called **heterotrophs** because to get their food energy, they must "eat others" (hetero = other and troph or trophic = eating or feeding).

The ultimate source of energy for living organisms is radiant energy from the sun. The Earth intercepts some of the sun's radiant energy but 34% is reflected back into space by Earth's atmosphere and surfaces. The energy that is absorbed within the biosphere has important consequences:

- 42% heats the land and atmosphere
- 23% results in **evaporation** (the process in which a liquid changes from that form to its gaseous form E.g. water may become steam when it evaporates) and **transpiration** (The process in which living plants draw water through their roots to their leaves and release water vapour into the atmosphere) as part of the water cycle
- 1% drives wind currents within the atmosphere

Earthworms: vital decomposers!
The recycling of nutrients within an ecosystem is the vital role filled by decomposers. One of the most important decomposers you will find is the common earthworm! Earthworms eat huge amounts of organic material – often as much as their own body weight per day. Earthworms provide a vital service by aerating and loosening soil to encourage plant growth and waste materials of the earthworms' digestion are rich in nutrients. The earthworm you most often see, the common garden worm, or night crawler (Lumbricus terrestris) was brought to North America in potted plants by Europeans. Almost all of the native North American earthworm species were killed off during the last ice age!

Of all the energy reaching the surface of the Earth, only 0.023% is actually captured by living organisms in the process of photosynthesis. Just think organisms on Earth depend on this very small amount of energy!

Of the energy captured by plants, a small amount may be passed to animals that eat plants (also called **herbivores**). A good example is a deer, which eats only plant material. The deer may be known as a consumer or heterotroph because it cannot make its own food, and must eat something else to get it. It is thought of as **primary consumer** because it receives its energy directly from producers.

A wolf is also a consumer, but gets its energy not from plants, but from deer or other prey. The wolf would be described as a **secondary consumer,** because its food energy comes to it through another consumer, in this case a herbivore. In nature, only some of the total energy available in deer gets transferred to predators like wolves. Most herbivores die of causes other than predators, and simply decompose. Their energy is passed to decomposers.

Let's say the wolf in our example is killed and eaten by a grizzly bear. The bear would be thought of as a **tertiary consumer** because at this point, the energy would now be in its third consumer. In reality, very few wolves are killed and eaten by anything, so are often called "top predators", or sometimes, "climax species". Grizzlies certainly are in this category. Their only natural enemies are humans.

The final transfer of energy occurs when either a producer or consumer dies and decomposes. Its remains are broken down by sometimes bacteria and sometimes **fungi** (Organisms that are primarily decomposers. Taking their nutrients from dead and decaying organisms. Some, such as Athlete's Foot, are parasitic) and a wide range of small organisms that feed on dead animal or plant matter. Members of this group are known as **decomposers**.
Decomposers are good at returning basic materials back to the ecosystem. They release oxygen, water, nitrogen, and other compounds to the air, water and soil. These materials can then be taken up by plants. Decomposers, like other organisms, release heat to the environment. You can see this in an active compost heap, where bacteria can cause the decomposing material to get very warm.

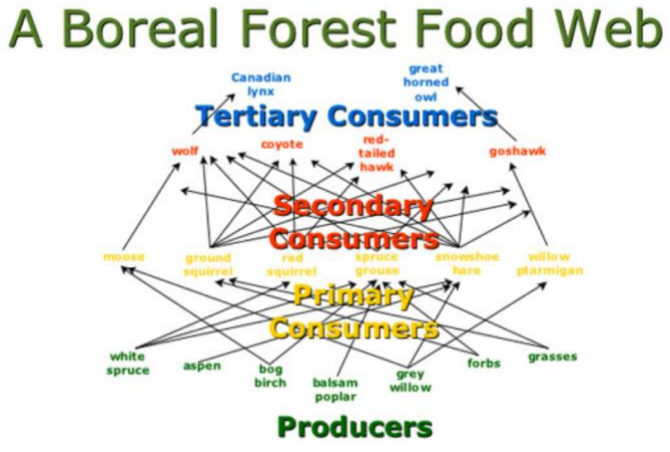
We think the transfers of energy from one set of organisms to another within an ecosystem as **trophic level** (the position of an organism in a food chain). Simple ecosystems may only have two, or even just one tropic level. Others, such as marine ecosystems, can have extremely complex pathways taken by energy involving six or more trophic levels. The table below shows the flow of energy through a possible system involving four trophic levels.

Cloning, Quaking Aspen in Boreal Forests
The "quaking: aspen (Populus tremuloides) is a dominant feature in many of Alberta's forests. Aspens are among the more important producers in the boreal forest ecosystem. It is the most widely-distributed tree species in North America and reproduces itself primarily by **cloning.** In the cloning process, a parent tree send sup suckers from an established root system, which can remain dormant for centuries. Professor Burt Barnes of the University of Michigan has identified aspen groves consisting of a single clone that has been growing since the last Ice Age. The groves are so extensive that it has been suggested they may actually be one of the largest

living organisms known. As fire or wind opens spaces in the forest canopy, sunlight will trigger the rapid growth of suckers and vertical stems, making the aspen one of the first plant species to repopulate a disturbed area. Aspen groves provide a critical habitat for many insect species and the birds that prey upon those insects. In addition, aspen bark and twigs are the major winter food source for elk and are the preferred food and supply of building material for the beaver. The most widespread economic use of aspect by humans is to provide pulp wood for the paper industry.

A food chain is the relationship between producers, consumers and decomposers within an ecosystem. A food chain is a way of recording how energy flows within an ecosystem. It simply describes a possible path taken by energy as it passes from organism to organism. The example we showed you above- of energy passing from plants to deer to wolves, then to grizzlies is an example of a food chain.

A food chain does not describe all the possible paths energy can take in an ecosystem. A **food web** does this. The diagram below shows how a food web might look. You can see that energy can take any of several different paths. Food chains can be incredibly complex, especially in ecosystems that have a lot of different species of producers and consumers. Understanding food chains and food webs is one of the first tasks undertaken by ecologists trying to learn how an ecosystem works. This tells the ecologist how the plants and animals are related to each other, and what could happen if some species is removed from the ecosystem.



At the next trophic level, you will observe many different secondary consumers using the same species of primary consumer as food. Higher trophic levels also follow the same pattern, so the actual energy flows into an ecosystem from a complex network of pathways referred to as a food web.

One very important thing to remember is that relatively little of the energy captured by one trophic level is passed on to the next. For example, only a small proportion of the total plant material (biomass) in a forest or meadow is eaten by herbivores. Similarly, only a few deer of the total population may be killed and eaten by wolves. You can assume that, on average, less than 10% of the energy or biomass is transferred from one trophic level to the next. Because of this, you can think of an ecosystem as a pyramid. This is a concept that helps ecologists explain how trophic levels depend on each other. The diagram shows this relationship.

Essentially, each trophic level represents a smaller amount of biomass. For example, one 100kg wolf may require a larger population of deer, something like 20,000 kg. To support this many deer will require many million kilograms of natural vegetation. This helps explain why some animals such as wolves and grizzlies require such large areas of wilderness. They are “top predator”, and the landscape must be able to produce enough plants and herbivores to support them.

Key Points

- Ecosystems are places where living organisms interact with the non-living world around them.
- Energy for organisms living in most ecosystems comes from the sun.
- Energy from the sun is captured by producers or autotrophs, and is passed to various kinds of consumers through a food chain.
- Energy and materials are returned to the ecosystems by decomposers.
- Organisms that must obtain their energy by eating other organisms for food are called heterotrophs.
- A food chain describes one possible path energy can take as it passes from one

organism to another through an ecosystem. A food web describes many of the possible path's energy takes going through an ecosystem.

- Biomass pyramids show that towards the top levels there is little energy available for the organism at higher levels. Whenever energy is transferred from one level to the next, some is lost.

Think About...

- What is the basic definition of an ecosystem? What are the main components of an ecosystem?
- The method by which an organism obtains carbon and energy allows us to classify living organisms into three groups, what are they?
- A herbivore is an animal that relies on plants as its source of food. Can you think of examples of a herbivore?
- An example of secondary consumer is a coyote when it eats a rabbit. Can you think of another example?
- Think about what the difference between a producer and consumer is. What is the importance of each in the food pyramid?
- In what ways are carnivores and detritovores similar to each other? In what ways are they different?
- Why do food pyramids of biomass get smaller towards the top?
- What do you think represents an ecosystem better, a food web or a food chain?