

Ecosystems of Communities, Biomes, and the Entire Planet

by
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When biologists study an *ecosystem*, they study interactions between living organisms (biota) and their nonliving (abiotic) environment. Abiotic portions of the environment are physical and chemical, such as: light, water, rocks, air, mineral-nutrients, temperature, wind, etc.

**An *ecosystem* contains
biotic (living) and abiotic (nonliving) components.**

If a biologist studies just the species (biota) living in a defined area, the biologist is studying a *biological community*. If the biologist also considers the abiotic portions of that defined area (such as, sunlight energy and/or mineral-nutrients), the biologist is studying an *ecosystem*.

An *ecosystem* can be very small (e.g., the biota and abiota of a small pond community) to very large (e.g., the biota and abiota of our entire planet).

**We refer to *communities* and *biomes* and the *biosphere*
as *ecosystems*
when we are studying both
their biotic and abiotic components.**

Note: Fourth-grade Life Science Standards for California Schools focus on ecosystems of biological communities (e.g., meadow, pond, etc.). Sixth-grade Life Science Standards focus on biome ecosystems (e.g., desert, chaparral, savanna, tropical forest, etc.).

Classification of Organisms in Ecosystems

When studying an ecosystem, biologists like to identify all of the organisms that they can find there, and determine their general ecological functions. Then they observe who eats whom to describe the flow of energy and matter through the ecosystem. Therefore, a biologist takes the following three steps in the initial study of an ecosystem:

First, a biologist looks at each organism, describes its basic structure, and determines which biological kingdom it belongs in.

A simple classification scheme used by many modern biologists is the five kingdoms (Table I). However biologists did not always recognize five kingdoms. Long ago, biologists thought all living things were either plants (which did not move) or animals (which did move). Eventually, biologists decided fungi were not plants because they were not green and did not photosynthesize, so biologists added a third kingdom. When microscopes were invented, biologists discovered single-celled animals and plants (microorganisms), and put them in a new kingdom. With more powerful microscopes, biologists discovered that some of the microorganisms were bacteria; these very tiny organisms now have their own kingdom. Biologists continue to reclassify life on Earth based on new discoveries and new understandings.

Second, a biologist determines the general ecological function of each organism.

Each organism in an ecosystem has a general ecological function – it either makes food or consumes food. Organisms that make food capture sunlight¹ and use the sunlight energy to build molecules of food (the sunlight energy is then stored in the food molecule as chemical energy) -- these organisms produce food (producers). Organisms that consume food use the chemical energy stored in the food molecules -- these organisms consume food (consumers). Consumers can be herbivores, carnivores, omnivores, scavengers, and/or decomposers.

Decomposers are a special type of consumer (bacteria and fungi) that absorbs, rather than eats, food (usually dead stuff) and releases mineral-nutrients (from the food) back into the soil. Plants can then take up these mineral-nutrients again. Table I shows the five biological kingdoms and their basic ecological functions (producer, consumer, and decomposer).

¹ An important exception is sea-vent ecosystems. Sea-vents occur in the dark, deep bottom of the ocean (no photosynthesis can take place down there). Sea-vent ecosystems are driven by chemical energy captured by chemosynthetic bacteria, which act as producers in the food web.

Table I. Five biological kingdoms of life on Earth and their functions in ecosystems. Note that viruses are not included in this table because they are not cells (they are free-ranging molecules), and life is usually defined as being cellular.

Kingdom	Description	Examples	Ecological Function
Animals	Multicellular organisms that eat food	Insect Cougar Starfish	Consumer
Plants	Multicellular organisms that make food	Flower Moss Tree	Producer
Fungi	Multicellular Consumers that absorb food	Mushroom Mold Yeast	Decomposer
Protists	Single-celled organisms that make food or eat food	Diatoms Algae & seaweed* Amoebas Protozoa	Producer Consumer
Bacteria	Tiny single-celled organisms that absorb food or make food	Blue-green bacteria Soil bacteria	Producer Decomposer

* Algae and seaweed are sometimes classified as plants because many species are multicellular.

Third, a biologist determines who eats whom to describe the flow of energy and matter through the ecosystem.

This flow of energy and matter through an ecosystem is called a food chain. The combination of several interconnected food chains in an ecosystem is called a food web.

Flow of Energy (Sunlight) in Ecosystems

The source of energy for almost all ecosystems on Earth is the sun². Sunlight enters an ecosystem when it is captured and stored as food by photosynthetic organisms: plants, algae, and blue-green bacteria.

The sunlight energy stored in the food is passed on to consumers that eat the plant, or eat an animal that has eaten the plant until all of the energy is eventually released as heat energy (by each organism) back into outer space.

**Energy in ecosystems comes to the Earth as sunlight
and then leaves the Earth as heat
– energy travels in a one-way flow.**

If no sunlight reached our planet, our ecosystem would not function. We are very dependent on the sun!

If no photosynthetic organisms were present to capture the sunlight, our ecosystem would not function. We are very dependent on plants, algae, and blue-green bacteria!

Energy flows through an ecosystem as chemical energy in food molecules. Figure 1 shows the flow of energy through a simple food chain.

² Note that sea vent ecosystems in the dark, deep bottom of the ocean are an exception; their ecosystems are driven by chemical energy captured by chemosynthetic bacteria. See website: http://www.jochemnet.de/fiu/OCB3043_42.html. This website provides information, photographs, maps, and diagrams documenting these unusual ecosystems.

Energy Flow through a Simple Ecosystem

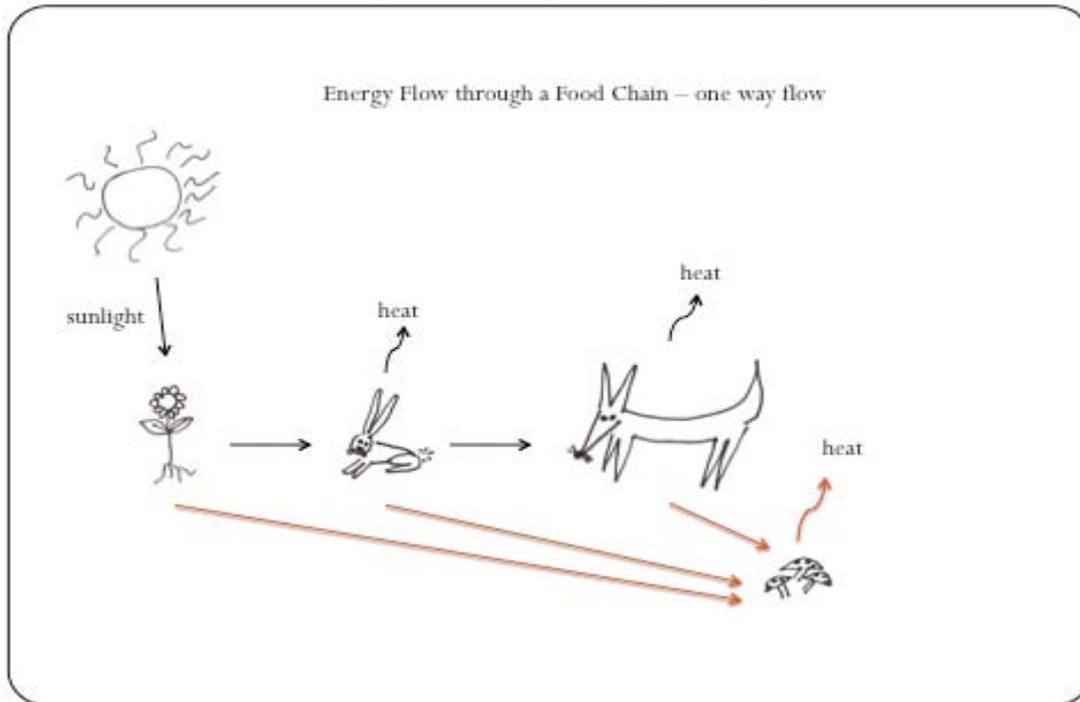


Figure I. Movement of energy through a simplified food chain of an ecosystem. Energy enters the ecosystem as sunlight, travels through the ecosystem as chemical energy in food molecules, and leaves the ecosystem as heat.

Another way to describe energy flow in a food chain of an ecosystem is with an energy pyramid, which indicates how much stored chemical energy (measured as biomass³) is present at each feeding level of that ecosystem. Because approximately 90%⁴ of the energy is lost as heat at each step in a food chain, every ecosystem has more producer biomass than herbivore biomass, and more herbivore biomass than carnivore biomass.

Sometimes, the producer biomass of an energy pyramid is all in one individual; for example, one oak tree can support several squirrels, which may support two hawks. Other times, the producer biomass of an energy pyramid is in many individuals; for example, a population of small plants can support several rabbits, which may support one coyote. Figure II shows the relative amount of energy (indicated as biomass) at each feeding level of a simple food chain.

³ The biomass of an organism is usually expressed as dry weight of an organism.

⁴ Note that energy loss before transfer to the next organism can be higher or lower than of 90%, depending upon the age and metabolism of the organism that is consumed.

Energy Pyramid of a Simple Ecosystem

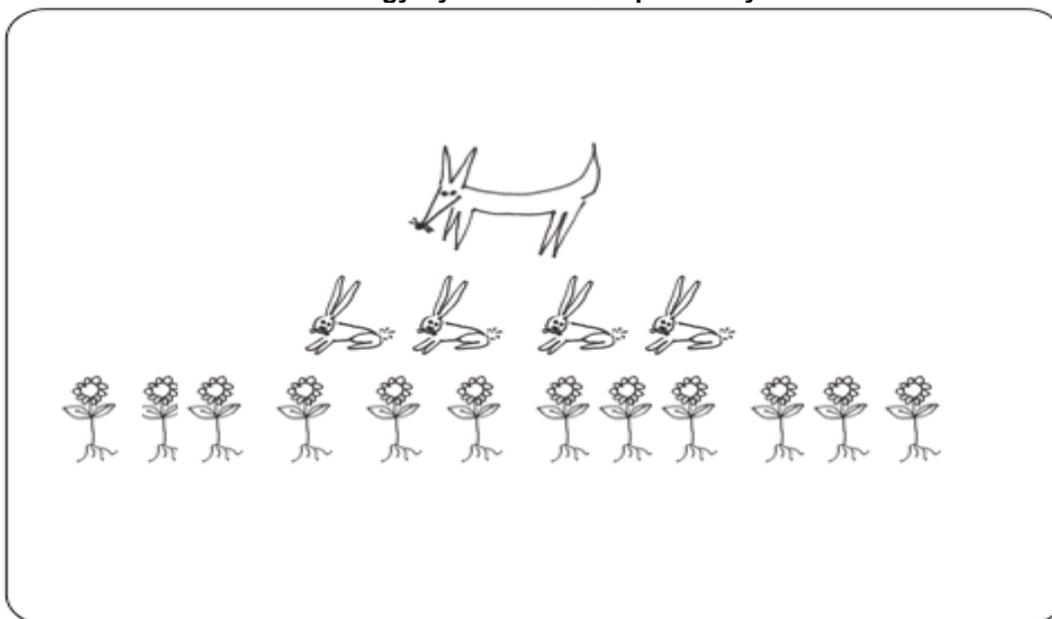


Figure II. Energy pyramid of simplified food chain of an ecosystem. In this hypothetical example, the energy pyramid represents the relative amount of stored chemical energy (measured as biomass) of each feeding level in a food chain, where one carnivore eats several herbivores, and each herbivore eats several producers.

Cycling of Matter (Atoms) in Ecosystems

All living organisms on Earth are made of molecules. Molecules never leave the Earth⁵; however, molecules do change form when they are broken and remade. What do not change form are the atoms⁶ in each molecule.

The source of atoms (matter) in ecosystems is the rocks, water, and air of Earth. Atoms are recycled (reused) over and over. In every ecosystem, atoms (such as: phosphorus, potassium, nitrogen, magnesium, carbon) cycle through the food chain and are used over and over again.

Atoms enter an ecosystem when they are taken up by plants in mineral-nutrient⁷ molecules and stored in food molecules. The atoms stored in the food molecules are passed on to consumers that eat the plant (or eat an animal that has eaten

⁵ Except when people send matter into outerspace in rockets.

⁶ Atoms only change form on Earth if they are split via natural radioactivity.

⁷ *Mineral-nutrients* are inorganic molecules and atoms that usually come from weathered rock and are taken up by the roots of plants. *Mineral-nutrients* act as fertilizer for plants (e.g., nitrate, phosphate, potassium). *Mineral nutrients* are not to be confused with *food nutrients*, which animals need. *Food nutrients* are organic molecules (such as: protein, fats, and carbohydrates).

the plant) until eventually the atoms are absorbed by decomposers (bacteria and fungi) and released back into the soil in mineral-nutrient molecules. Plants can then take up these mineral-nutrients again.

**Matter in ecosystems comes from the planet
and returns to the planet
– matter is recycled.**

If no decomposers were present on Earth, the recycling of matter would eventually stop. We are very dependent on decomposers! Figure III shows the recycling of matter through a simple food chain.

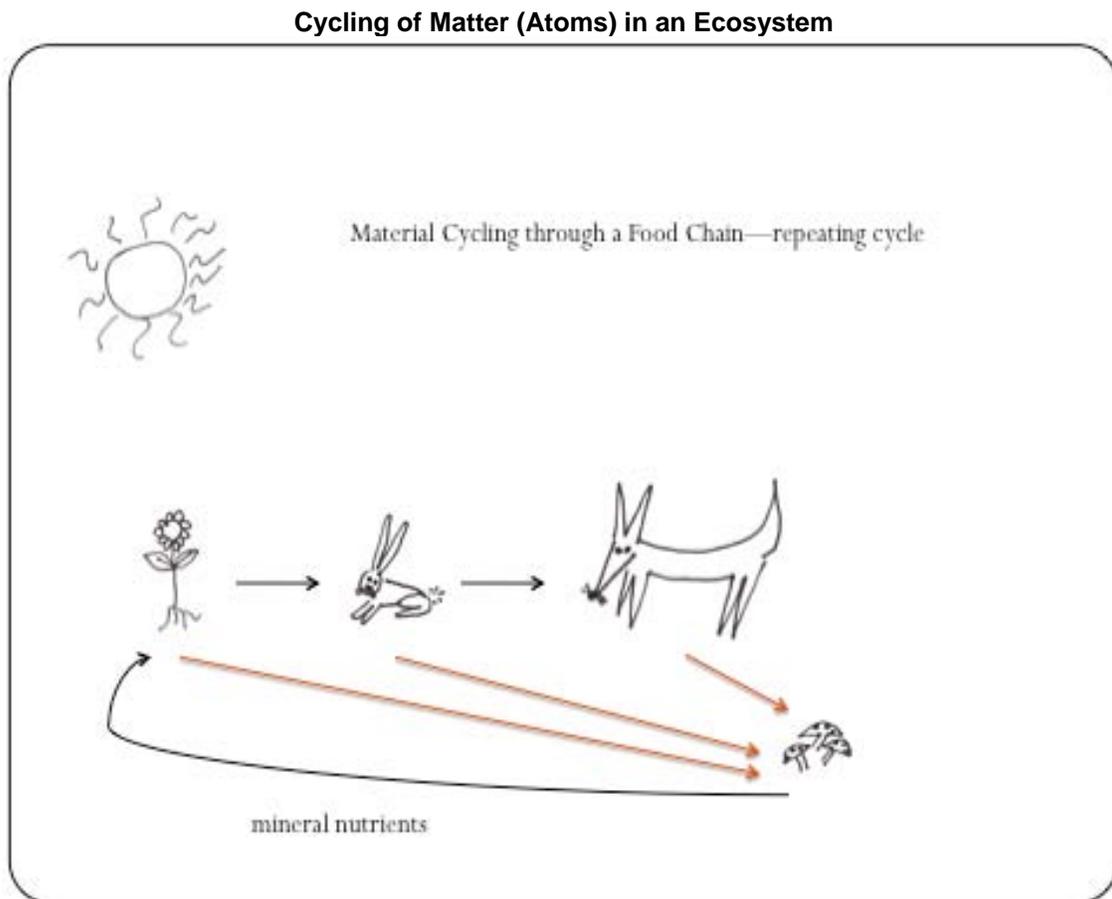


Figure III. Movement of matter (atoms) through a simplified food chain of an ecosystem. Atoms enter the ecosystem in mineral-nutrients (inorganic molecules), travel through the ecosystem in food molecules (organic molecules), and return to the soil in mineral-nutrients.