2.5 Ecological Pyramids

Often, the pathway of energy through an ecosystem is illustrated by an **ecological pyramid**, also called a **food pyramid**. Ecologists use three basic types of pyramids: a pyramid of energy, a pyramid of numbers, and a pyramid of biomass.

Pyramid of Energy

A **pyramid of energy** is an ecological pyramid that uses blocks of different lengths to represent how much energy is available in each trophic level. The blocks are stacked one on top of the other, with producers on the bottom and carnivores on the top. The size of each layer represents the amount of energy present in that trophic level. Since the amount of energy available at each trophic level is less than the one below it, the diagram always has a pyramid shape (Figure 1); however, the size of the layers is not always proportional.

On average, only about 10 % of the energy present in one trophic level is passed on to the level above, as shown in Figure 1. Most of the energy at any level is used for basic life processes of the organisms at that level, such as movement, reproduction, and maintaining body temperature. Energy is also lost as heat at each trophic level, reducing the energy available to the next level even more. The low rate of energy transfer limits the number of trophic levels. Ecosystems rarely contain more than four levels because there is simply not enough energy in all the organisms at the top trophic level to support any more levels above them.

Did You KNOW?

Where Does the Energy Go?

The First Law of Thermodynamics states that energy cannot be created or destroyed but can only change from one form to another. The Second Law of Thermodynamics states that an energy transformation between two different forms is never 100 %. Some energy is always lost as heat in the process.

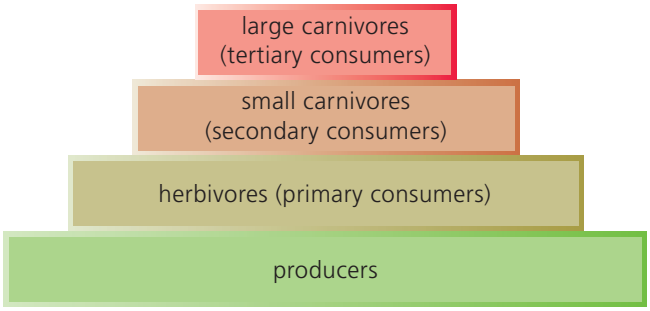

Figure 1 In a pyramid of energy, the amount of energy passing from one trophic level to the next is not always constant. The basic shape of the energy pyramid is constant however, and each level is always smaller than the one below it.

TRY THIS: The Energy You Eat

Skills Focus: recording, evaluating, analyzing, communicating

You can determine how much land was needed to produce the foods you eat.

Materials: notebook or graphic organizer

1. Record amounts of everything you eat in a 24-hour period. Determine how many kilojoules you ate from plant and from animal products, using an energy counter or by recording values from packaging.
2. To determine your annual energy intake, multiply your values by 365 days.
3. Determine how much land was needed by dividing the energy intake from plants by 8350 kJ/m^2 and dividing the energy intake from animals by 835 kJ/m^2.

A. Is it a more efficient use of land to eat plant or animal products? Explain.

B. What changes could people make to their diets in order to reduce the amount of land needed to make their food?

C. How might your average energy intake compare with people living in less developed regions of the world?

Pyramid of Numbers

A **pyramid of numbers** represents the actual number of organisms present in each trophic level. The shape of a pyramid of numbers varies widely depending on the physical size of the producers. For example, grasslands have very large numbers of small producers, while a forest of similar size might contain only a few large trees. A single tree might support thousands of small herbivores like insects. For a grassland community, a pyramid of numbers would have the typical shape (Figure 2). For a forest community, the producer level would likely be smaller than the herbivore layer above it (Figure 3). This distorted shape can be expected whenever a few large producers support large populations of small herbivores.

LEARNING TIP

Reinforce your understanding of pyramid of numbers and pyramid of biomass by examining Figures 2 to 4.

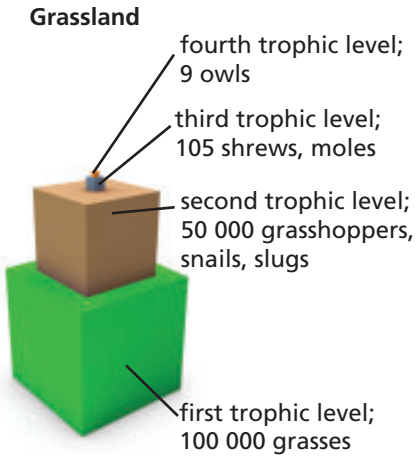

Figure 2 In a grassland community, there are fewer carnivores than herbivores and many more producers than herbivores.

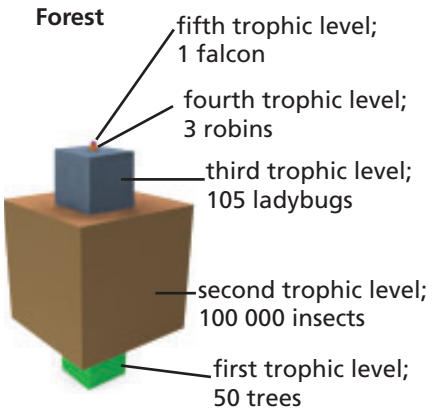

Figure 3 Pyramids of numbers are poor indicators of available energy. In a forest community, a single large organism such as a tree could be food for many small herbivores.

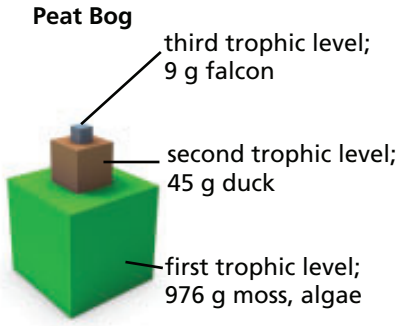

Figure 4 A typical pyramid of biomass

Pyramid of Biomass

Ecologists attempt to represent the total mass of the living things in each trophic level using a **pyramid of biomass**. These pyramids provide a snapshot in time of the mass at each trophic level in a community. In most communities, the pyramid of biomass has the standard pyramid shape (Figure 4), but sometimes the shape is inverted. This usually occurs in aquatic systems when a small biomass of producers, such as algae, supports a larger biomass of herbivores, such as fish. This is possible because the algae reproduce very quickly and are able to replace the biomass that is being consumed.

2.5 CHECK YOUR Understanding

1. Why are producers essential to a stable ecosystem?
2. List two factors that are responsible for the small percent of energy that passes from one trophic level to the next.
3. Why can more herbivores than carnivores live in equal-sized ecosystems?
4. On average, how much energy is available to organisms in the third trophic level if 5000 kJ were available at the first trophic level?
   A. 5 kJ
   B. 50 kJ
   C. 500 kJ
   D. 5000 kJ
5. Describe the effects of removing all of the herbivores from an ecosystem. Which organisms would be affected and how?
6. Explain why ecosystems usually contain only a few trophic levels.
7. Why do energy pyramids have the specific shape that they do?
8. Explain the similarities and differences between an ecological pyramid of energy, a pyramid of biomass, and a pyramid of numbers for a coniferous forest.
9. You have the option of choosing between a beef steak or a plate of beans and rice. Both meals provide you with 1000 kJ of energy. How will your choice affect the amount of energy required from the ecosystem?
10. Create a concept map that shows the path of energy in an ecosystem. Include the following terms in your diagram: herbivore, producer, carnivore, detrivore, trophic level, food web, food chain, and any additional terms you require.
11. Why does energy only flow in one general direction (from producer to consumer) in an ecosystem?
12. Which biome is most likely to have a pyramid of numbers that looks like Figure 5? Justify your answer.

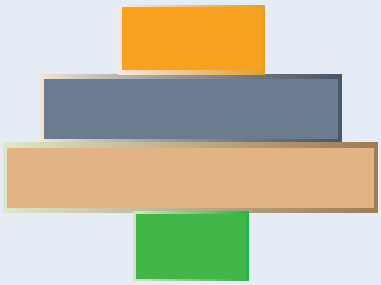

Figure 5

13. Draw two different energy pyramids for the food web in Figure 5 on page 36.
14. How might the shape of an energy pyramid differ throughout the year in a region that has a cold winter and a warm summer?
15. What types of organisms are able to make use of the energy that is not present in the top level of an energy pyramid?