2.1 Energy Flow in Ecosystems

In an ecosystem, energy flows from producers (plants) to primary consumers (herbivores) to secondary and tertiary consumers (carnivores). Food chains and food webs model this energy flow and these feeding relationships. Each step in a food chain is called a trophic level. Food pyramids model how energy is lost at each trophic level in an ecosystem.

This vast amount of leaf material forms part of the mass of all living organisms in the biosphere. To understand how much organic mass is produced in different parts of the biosphere, scientists estimate biomass. **Biomass** refers to the total mass of living plants, animals, fungi, and bacteria in a given area. Biomass can also refer to the mass of particular types of organic matter such as trees, plant crops, manures, and other organic materials that may be used to manufacture biofuels such as biogas. Estimates of biomass are usually expressed in grams or kilograms per square metre.

![Did You Know?](image)
The biomass of plants on Earth is over 100 times greater than the biomass of animals.

**Figure 2.2** Star fungi growing on leaf litter break down the dead leaves into usable nutrients.

**How Energy Flows in Ecosystems**

In section 1.2, you learned that organisms have special roles, or niches, in the ecosystems in which they live. They compete for food and other resources or may be part of a predator-prey relationship. Within its niche, every organism in an ecosystem interacts with that ecosystem in two ways: (1) the organism obtains food energy from the ecosystem, and (2) the organism contributes energy to the ecosystem. The flow of energy from an ecosystem to an organism and from one organism to another is called **energy flow**. You are part of this flow of energy when you eat the food energy stored in plants and animals (Figure 2.3).

Plants are called **producers** because they “produce” food in the form of carbohydrates during photosynthesis. Carbohydrates stored in plants become an energy source for other life forms. An insect such as a bee that feeds on a plant such as a sunflower is called a **consumer** (Figure 2.4A and Figure 2.4B). A consumer may also become an energy source if eaten by another consumer (Figure 2.4C).
Organisms continue to contribute to the energy flow in an ecosystem even after they die, in a process called decomposition. **Decomposition** is the breaking down of organic wastes and dead organisms. The action of living organisms such as bacteria to break down dead organic matter is called **biodegradation**. Organisms such as bacteria (Figure 2.5) and fungi are called decomposers. **Decomposers** change wastes and dead organisms into usable nutrients. The nutrients are then made available to other organisms in soil and water and link the biotic and abiotic components of an ecosystem.

**Energy Flow and Energy Loss in Ecosystems**

Scientists use different models to help them understand how energy flows through or is lost in an ecosystem. These models are food chains, food webs, and food pyramids. Each of these models reflects the feeding relationships of organisms within ecosystems.

**Food chains and food webs**

Food chains are models that show the flow of energy from plant to animal and from animal to animal (Figure 2.6). Each step in a food chain is called a **trophic level**. Trophic levels in a food chain show the feeding and niche relationships among organisms. Since plants and phytoplankton such as algae are the producers, they are at the first trophic level and are referred to as **primary producers**.

In Figure 2.6, you can see that **primary consumers** such as grasshoppers and zooplankton (microscopic aquatic animals) are in the second trophic level. They obtain their energy by eating primary producers. **Secondary consumers** such as frogs and crabs are in the third trophic level and obtain their energy by eating primary consumers. In the fourth trophic level are **tertiary consumers** such as hawks and sea otters that feed on secondary consumers to obtain energy.

When ecologists discuss the diet or behavior of organisms in a food chain, they often use the terms detritivores, herbivores, and carnivores. In terrestrial ecosystems, detritivores include small insects, earthworms, bacteria, and fungi (Figure 2.7).

**Detritivores** are consumers that obtain their energy and nutrients by eating the bodies of small dead animals, dead plant matter, and animal wastes. Detritivores feed at every trophic level (Figure 2.8) and make up their own important food chains. In fact, food chains based on dead plant and animal matter actually outnumber food chains based on living plants and animals. Detritivores such as earthworms and beetles are also an important energy source for consumers such as birds.
Herbivores, such as grasshoppers, are primary consumers that eat plants. Carnivores, such as spotted frogs, are secondary consumers that eat primary consumers. Carnivores also eat other secondary consumers and are often at the tertiary level of a food chain. Carnivores at this level are often referred to as top carnivores, top consumers, or top predators. Figure 2.9 and Figure 2.10 on the next page show more examples of herbivores and carnivores.

Many animals are part of more than one food chain and eat more than one kind of food in order to meet their energy requirements. For example, squirrels are primary consumers when they eat seeds or fruits. When they eat insects or young birds, squirrels are secondary or tertiary consumers. Consumers that eat both plants and animals are called omnivores. Interconnected food chains form a food web. Food webs are models of the feeding relationships within an ecosystem (Figure 2.11).
1. Fill in the blanks. See page 56.

In an ecosystem, _________________ flows from _________________ (plants) to _________________ (herbivores) to _________________ and _________________ (carnivores). Food _________ and food _________ model this energy flow and these feeding relationships. Each step in a food chain is called a ____________ level. Food _______________ model how _______________ is lost at each trophic level in an ________________.


a) **Biomass:**

___________________________________________________________________________

What units is biomass usually expressed in? __________________________________

b) **Energy flow:**

___________________________________________________________________________

How are you part of the energy flow? _____________________________________________

c) **Producers:**

___________________________________________________________________________

Name 3 producers. ________________  __________________  __________________

d) **Consumer:**

___________________________________________________________________________

Name 3 consumers. ________________  __________________  __________________

e) **Decomposition:**

___________________________________________________________________________

___________________________________________________________________________

f) **Biodegradation:**

___________________________________________________________________________

___________________________________________________________________________

g) **Decomposers:**

___________________________________________________________________________

___________________________________________________________________________

Name 2 decomposers: ___________________  __________________

3. Do reading check on page 59. Do # 1, 2, & 5. Write full sentences or no mark.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________
4. Refer to pages 60 to 62. Use the words in bold to fill in the blanks.
   a) ________________________: Primary consumers that eat plants.
   b) ________________________: Steps in a food chain that show feeding and niche
      relationships among organisms.
   c) ________________________: Consumers that eat both plant and animals.
   d) ________________________: Organisms in the third trophic level which obtain their energy
      by eating primary consumers.
   e) ________________________: Consumers that feed at every trophic level, obtaining their
      energy and nutrients by eating dead organic matter.
   f) ________________________: A model that shows the flow of energy from plant to animal
      and from animal to animal.
   g) ________________________: Organisms in the second trophic level which obtain their
      energy by eating primary producers.
   h) ________________________: A model of the feeding relationships within an ecosystem;
      formed from interconnected food chains.
   i) ________________________: Secondary consumers that eat primary consumers and often
      other secondary consumers. They are often at the tertiary level of the food chain.
   j) ________________________: Organisms in the first trophic level, such as plants and algae.
   k) ________________________: Organisms in the fourth trophic level which get their energy
      from eating secondary consumers.

5. Use the above terms to identify the trophic level, the producer or consumer level, and food
   chain niche (plant, herbivore, carnivore, or top carnivore). Refer to Figure 2.8 for help (pg 61).

<table>
<thead>
<tr>
<th>Organism</th>
<th>Trophic level</th>
<th>Producer or consumer</th>
<th>Niche in food chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>example: Krill</td>
<td>Second T.L.</td>
<td>Primary consumer</td>
<td>Herbivore</td>
</tr>
<tr>
<td>a) Grass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Grasshopper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Robin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Red tailed hawk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e) Caterpillar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) Algae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g) Sea otter</td>
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</tr>
<tr>
<td>h) Frog</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>i) Bear (page 62)</td>
<td></td>
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</tr>
</tbody>
</table>
6. Read the section on detrivores on page 61. Fill in the blanks below.
Detrivores are ______________ that obtain their energy and ______________ by eating
the bodies of dead ____________, dead _____________ matter, and animal _____________.
Detrivores feed at every _____________ level and make up their own important food
______________. Food chains based on _____________ plant and animal matter outnumber food
chains based on _____________ plants and animals.
Name four detrivores (see bottom page 60).

__________________  _________________  __________________

7. Colour the foodweb below. Do a nice job. Label the various animals in pen.
8. Refer to the food web on the previous page. Answer the following questions.

a) Notice the letters by each organism. What is the trophic and niche level of each letter, and give two examples:

<table>
<thead>
<tr>
<th>Letter</th>
<th>Trophic Level</th>
<th>Niche in food chain</th>
<th>Example 1</th>
<th>Example 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>B</td>
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<td></td>
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</tr>
<tr>
<td>C</td>
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<tr>
<td>D</td>
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<tr>
<td>E</td>
<td></td>
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</tr>
</tbody>
</table>

b) Make three different food chains using at least four organisms. Repeat as little as possible.

i) ______________ → ______________ → ______________ → ______________

ii) ______________ → ______________ → ______________ → ______________

iii) ______________ → ______________ → ______________ → ______________

c) What animals are the two top carnivores? ______________ ______________

d) Although not on the picture, where ultimately does all the energy come from that allows the food web to exist. Hint: Photosynthesis.

9. Build a food web like in # 7 and on page 62. (Bonus – find or draw good pictures of each organism. Print/cut it out and paste it in place: 1 mark per image)

Killer Whale

Eagle

Salmon

Octopus

Seagull

Herring

Shrimp

Clam

Phytoplankton

Zooplankton