Section 2.1 Summary

Food chains, food webs, and pyramids of numbers are models that show how energy passes from one organism to the next in an ecosystem.

- A food chain shows how energy that is stored in food passes from organism to organism.
- A food web shows a number of interconnected food chains. It gives a more accurate picture of what really happens in an ecosystem.
- A pyramid of numbers is a model that illustrates approximately how many organisms are at each level in a food chain.

Producers are necessary in all food chains. Producers use energy from the Sun to make their own food through a process called photosynthesis. Not all the energy that is stored in food passes directly to the next organism in a food chain. A lot of the energy is used to fuel daily activities, such as breathing and digesting food.

Key Terms

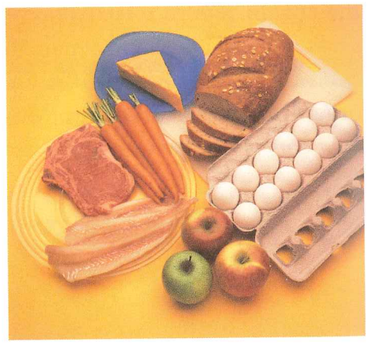
food chain
chlorophyll
photosynthesis
top consumer
cellular respiration
food web
pyramid of numbers
energy flow

Check Your Understanding

1. Use a Venn diagram to compare a pyramid of numbers with a food chain.

2. Why is all the energy in one level of a food pyramid *not* available to the organisms at higher levels of the pyramid? Explain.

3. Most humans eat foods from all levels of a food chain, such as the foods in the photograph shown here. Construct two different food chains based on foods you typically eat. Include four or more levels in at least one of your food chains. Use words and diagrams to describe your food chains.



Skill POWER

For tips on using Venn diagrams, turn to SkillPower 1.

4. **Apply** Suppose that you found hawks, field mice, and corn in the same ecosystem. What roles would each organism have in the food chain?

5. **Thinking Critically** Changes to the population of a species can affect other organisms in the ecosystem. Describe one situation in which changes in a food chain have had an impact on people. Explain your answer.

Section 2.2 Cycles of Matter

In section 2.1, you learned how plants absorb energy from the Sun and convert it into food energy. Animals eat the plants to obtain the stored energy. Eventually, the stored energy is converted into heat and lost to the abiotic environment. Plants must then trap more energy from the Sun to replace the lost energy.

Unlike energy, many types of matter are used over and over again by living systems. In other words, they are cycled through the environment. In this section, you will learn about two important cycles: the carbon cycle and the water cycle.

The Carbon Cycle

Plants use energy from the Sun to convert water and carbon dioxide into foods. These foods contain the carbon from the carbon dioxide. As one organism becomes food for the next organism in the food chain, the carbon-containing materials are passed along. When organisms use the food for energy, the carbon is converted back into carbon dioxide, and is available for plants to use again. Scientists use a model called the **carbon cycle** (Figure 2.11) to show how carbon is used over and over again in ecosystems.

Figure 2.11 The amount of carbon in the environment does not change. It is used over and over again by organisms. Some carbon is stored in the ground for millions of years in the form of coal, oil, and natural gas.

Not all the carbon in plants and animals is converted back into carbon dioxide immediately. When organisms in oceans and lakes die, their tissues often drift to the bottom and form a thick layer of carbon-containing materials. These materials are covered with sand and silt, and buried deeper and deeper. After millions of years, under a lot of pressure, the carbon-containing materials are converted into coal, oil, and natural gas. When people burn the coal, oil, and natural gas for fuel, the energy is released and the carbon is converted into carbon dioxide. These processes also contribute to the carbon cycle.

The Water Cycle

Carbon is not the only type of matter that is cycled through the environment. The **water cycle** is the continuous movement of water through the environment. There are four main processes in the water cycle:

1. **Evaporation** is the process in which liquid water changes into an invisible gas called water vapour. Water is always evaporating from streams, lakes, and ponds, as shown in Figure 2.12. Water is also evaporating from your skin.

Figure 2.12 Water evaporates from streams, lakes, ponds, and other bodies of water. It forms invisible water vapour. Although the water is constantly evaporating, the marsh will probably never be empty because rain will fill it up again.

2. **Transpiration** is the process in which water that is taken in through a plant's roots evaporates from the plant's leaves, stem, and flowers.

3. **Condensation** is the process in which water vapour in the air changes back to tiny droplets of liquid water when the air cools. The droplets of water are so small that they remain suspended in the air as clouds or fog.

4. **Precipitation** is the process in which the tiny droplets inside clouds combine to form large drops. These drops then fall to Earth as rain, sleet, snow, or hail.

READING Check

What is the difference between precipitation and evaporation?

The water cycle is shown in Figure 2.13. **Ground water** is water in the soil. The roots of plants can grow down to reach the ground water. People can reach the ground water by digging wells. **Run-off** is water that runs along the surface of the ground into lakes and rivers.

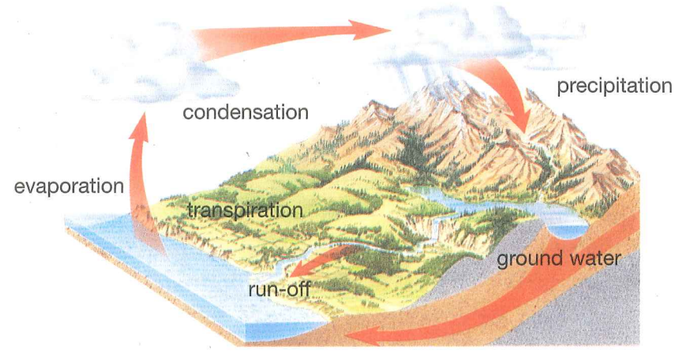


Figure 2.13 The water cycle includes evaporation, transpiration, condensation, and precipitation.

DidYouKnow?

The total amount of water on Earth has not changed for billions of years. A glass of water that you drink today might include some of the same water that cleaned and cooled a dinosaur's skin millions of years ago.

Find Out ACTIVITY 2-D

Modelling the Water Cycle

Water is the only substance that exists naturally on Earth in all three states: solid, liquid, and gas (water vapour). In this activity, you will see water changing from a liquid to a gas and then back again.

Safety Precautions

- Steam can cause severe burns. Take extra care when working with hot water and steam.
- Do this activity only under the supervision of your teacher or another adult.

Note: Your teacher may wish to do this activity as a class demonstration.

What You Need

kettle
cold water
ice
small saucepan
oven mitt or safety glove

What to Do

1. Fill the kettle half full with water. Plug in the kettle.
2. When the kettle has started to boil, place the ice in the saucepan. Put on the oven mitt. Take the saucepan by the handle, and hold it over the steam. **Observe** what happens on the bottom of the saucepan.

What Did You Find Out?

1. How does this activity model the water cycle in nature? Draw a labelled diagram, showing the water cycle you observed in this activity.
2. Which part of your model played a role that is similar to the role of the Sun?
3. Why did you put ice, rather than warm water, in the saucepan?

READING Check

How would you define the word "pollution"?

Pollution in the Environment

Water, carbon, and other substances constantly cycle through ecosystems. Unfortunately, some unwanted substances can enter these cycles. **Pollution** refers to any substance that is added to the environment so fast that it cannot be broken down, stored, or converted into a form that is not harmful. **Pollutants** are substances that cause pollution.

Many artificial substances that are harmful to organisms have entered ecosystems. In the past, PCBs (polychlorinated biphenyls) were commonly used for a variety of purposes, including paints and packaging materials. PCBs were never meant to enter the environment, but they have leaked into the water and ground. PCBs break down very slowly, so they remain in the ground and in water for years. Once in the ground and in water, they can cause harm to organisms.

DDT (dichloro-diphenyl-trichloroethane) is a pesticide that was commonly used across North America, including Canada. From the 1940s to 1960s, it was sprayed on crops and trees to kill harmful insects. DDT did control insect populations. It killed many insects that could destroy crops. It also killed disease-carrying mosquitoes and, thus, saved millions of human lives. Unfortunately, DDT is harmful to many living organisms — especially birds. DDT is now banned in Canada and many other countries but not everywhere in the world.

DidYouKnow?

A scientist named Rachel Carson (1907–1954) wrote the now famous book *Silent Spring*. In this book, she warned about the dangers of DDT. Her observations led to studies that showed that DDT caused the deaths of thousands of birds. Partly as a result of her writing, DDT was eventually banned in many countries, including Canada.

Bioaccumulation

Pollutants move from level to level in a food web. Pollutants are not broken down like food, however. If an organism consumes a pollutant, most of it remains in the tissues. Each animal in the food chain receives nearly all the pollutant that was consumed by the organisms below it. The build up of pollutants in organisms is called **bioaccumulation**.

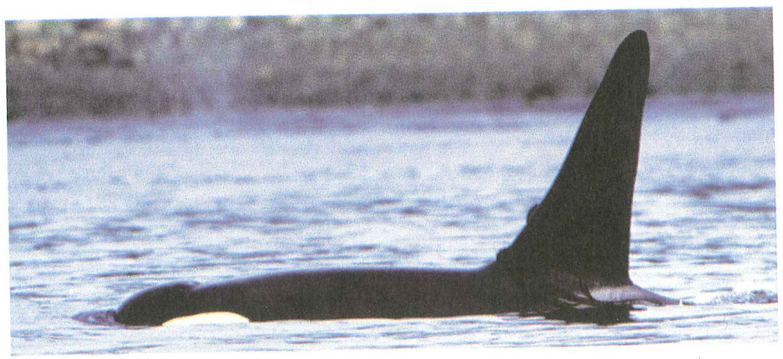


Figure 2.14 Killer whales in waters off southern British Columbia are becoming sick, and their population is getting smaller. One reason is the bioaccumulation of pollutants.

The killer whale in Figure 2.14 lives in the ocean off the coast of southern British Columbia. It is the top consumer in a food chain like the one in Figure 2.15. Pollutants in the water can enter the food chain at any level, but they often enter through organisms that are low on the food chain. For example, a pollutant may enter the food chain when it is absorbed by phytoplankton or zooplankton. The pollutant is passed along and concentrated in the tissues of the next organism in the food chain. Therefore, the amount of pollutant increases at each level in the food chain. As a result, the top consumer ends up with a very large amount of the pollutant in its body.

Many of the killer whales in British Columbia are becoming ill partly due to the bioaccumulation of pollutants, such as PCBs. The population of killer whales that spends most of its time near southern Vancouver Island, Vancouver, and northern Washington State is in the greatest danger. Pollutants in the food chain, as well as declining salmon populations (a source of food), are leading to the decline of the killer whales.

Human activities have caused harm to the environment. Now, however, people who are concerned about the environment are working to improve the habitats of killer whales and other endangered species. For example, populations of peregrine falcons, such as the one in Figure 2.16, were once in danger in British Columbia and throughout North America due to DDT. The birds that the falcons preyed on had eaten insects or seeds poisoned with DDT. The DDT made the falcons less successful at producing young. As a result, their populations began to decline. After DDT was banned in Canada, the populations of peregrine falcons slowly recovered.

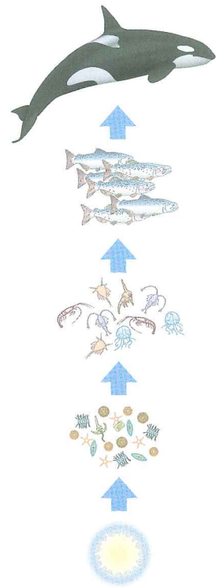


Figure 2.15 Killer whales are the top consumer in a food chain that usually includes phytoplankton, zooplankton, and salmon.

Figure 2.16 Peregrine falcons were once in danger, due to the bioaccumulation of DDT.

READING Check

In which link of the food chain, producers or consumers, do pollutants accumulate in the largest amounts? Explain your answer.

Section 2.2 Summary

Carbon cycles through the biotic and abiotic parts of an ecosystem. Carbon is found in carbon dioxide in the abiotic part of an ecosystem. In the biotic part of an ecosystem, carbon is in high-energy materials, such as sugar and starch.

Water cycles between the liquid, solid, and gaseous states. The water cycle has four main processes:

- Evaporation is the process in which liquid water changes into a gas.
- Transpiration is the process in which water evaporates from the leaves, stems, and flowers of plants.
- Condensation is the process in which water vapour changes into a liquid.
- Precipitation is the process in which tiny droplets of water inside clouds combine to form large drops that fall to Earth.

Pollution can also cycle through ecosystems. Pollutants are substances that cannot be broken down, stored, or recycled in the environment in a way that is not damaging. Bioaccumulation is the accumulation of pollutants in an organism after eating several polluted small organisms. The top consumers in food chains are affected most by bioaccumulation.

Key Terms

carbon cycle
water cycle
evaporation
transpiration
condensation
precipitation
ground water
run-off
pollution
pollutants
bioaccumulation

Check Your Understanding

1. In what forms do you find carbon in the carbon cycle?
2. Draw a diagram of the water cycle, showing the four main processes. Label and describe each process.
3. What are the similarities and differences between pollution and bioaccumulation?
4. **Apply** Pesticides are chemicals that are commonly used to control agricultural pests, such as insects. How might pesticides affect carnivores, which are higher up in food chains? Explain.
5. **Thinking Critically** What are the advantages of a human, or another omnivore, eating organisms that are lower rather than higher in the food chain?
6. **Thinking Critically** How do pollutants accumulate in food chains? Design a game that shows the process of bioaccumulation.

Section 2.3 Factors in Ecosystems that Limit Populations

Many species, such as rabbits, have an amazing capability to reproduce quickly. In any ecosystem, however, there are limits to the amount of food, water, living space, mates, nesting sites, and other resources that are available. Populations cannot continue growing larger forever. A population eventually reaches the largest number of individuals that an environment can support over a long period of time. This maximum number of individuals is called the **carrying capacity** of the ecosystem. Some common limiting factors are discussed on the following pages.

READING Check

How are limiting factors related to carrying capacity?

Limiting Factors

A **limiting factor** is any abiotic or biotic factor that controls the number of individuals in a population. In Figure 2.17, for example, you can see a distinct line across the mountainside. Trees do not grow above this line. The temperature is too cold for the trees to survive above this elevation, called the *tree line*. Temperature is one limiting factor for this population of trees. The strength of the winds and the thin soil may also limit the growth of these trees.

Figure 2.17 The growth of trees can be limited by temperature. The trees in this ecosystem will not grow above a certain elevation.