7. Energy Flow in an Ecosystem

- **Food chain and food web**
- **The energy pyramid**
- **Bio-geo-chemical cycle : Carbon, oxygen and nitrogen cycles**

Looking back

1. What is meant by 'ecosystem'?
2. Which are the different types of ecosystems?
3. How do interactions take place between biotic and abiotic factors of an ecosystem?

Energy flow in an ecosystem

We have already learnt the classification of living organisms according to the mode of nutrition into producers, consumers, saprotrophs (saprophytes) and decomposers. Consider the various trophic levels of the ecosystem around you as given below.

Primary consumers (herbivores)
Ex. Grasshopper, squirrel, elephant, etc. They are directly dependent on autotrophs (producers).

Secondary consumers (carnivores)
Ex. Frog, owl, fox, etc.
These consumers use herbivores as their food.

Apex or top consumers (carnivores)
Ex. Tiger, lion, etc.
These consumers use herbivores and carnivores as their food. No other animals feed on top consumers.

Omnivores (mixed consumers)
Ex. Humans, bear, etc. Feed on herbivores, carnivores and producers.

Food chain and food web

Observe

Observe figure 7.1 and explain the relationship between the components.

Construct four chains like the one shown in figure 7.1.

Interactions go on continuously between producers, consumers and saprophytes. There is a definite sequence in these interactions which is called the food chain. Each chain consists of four, five or more links. An ecosystem consists of many food chains that are interconnected at various levels. Thus a food web is formed.

7.1 Food chain

Use your brain power !

Explain the food chains of various ecosystems which you have studied last year.

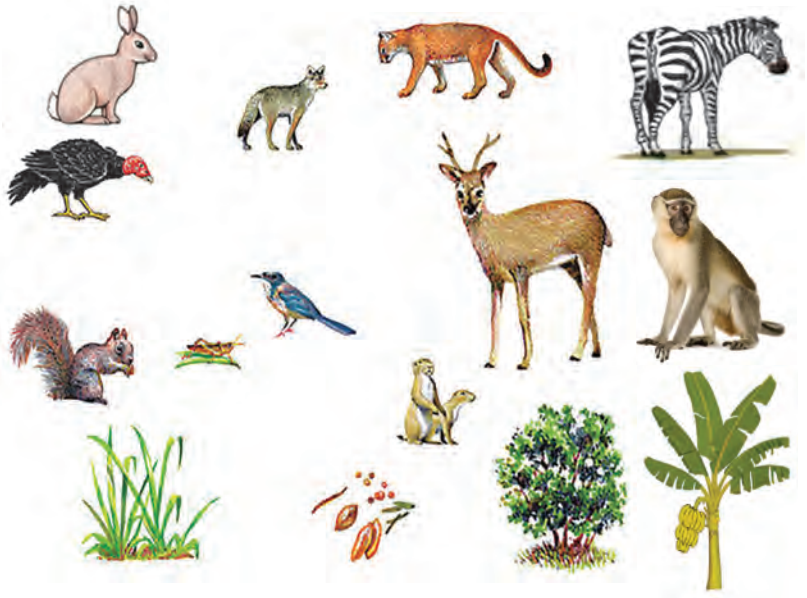
An organism may be the prey for many other organisms. For example, an insect feeds upon leaves of various plants but the same insect is the prey for different animals like frog, wall lizard, birds, etc. If this is to be shown in a figure, it will form an intricate web instead of a linear food chain. Such an intricate network is called a 'Food Web'. Generally, food-webs are found everywhere in nature.

Use your brain power !

Make a list of the various consumers of the ecosystems around you and classify them according to mode of nutrition.

Pictures of various organisms are given in fig. 7.2. Construct a foodweb from those pictures.

1. Is the number of consumers in a food web fixed?
2. What will be the effect on an ecosystem if only one type of organism in it forms the food for several different consumers in that ecosystem?
3. Why is balance or equilibrium necessary in a foodweb?



7.2 Various living organisans

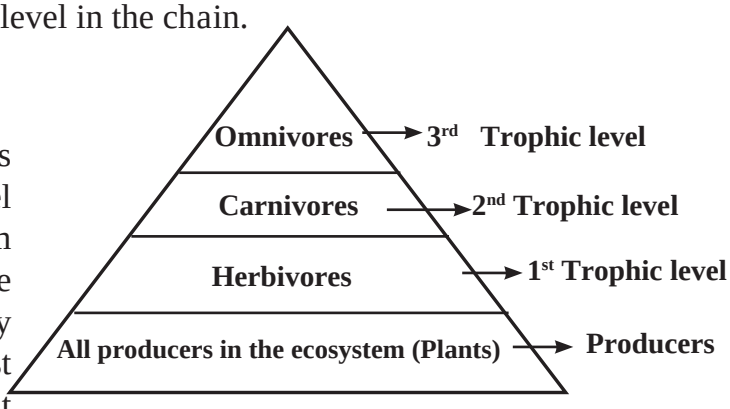
Research

Make some interesting observations while having a meal at home. Identify the trophic level of the various food items in your dish. Identify your own level in the chain.

The energy pyramid

Trophic level

Each level in the food chain is called a trophic level. A trophic level is the step at which the organism obtains its food in the chain. The amount of matter and energy gradually decreases from producers at lowest level to top consumers at the highest level.



7.3 Trophic levels

An introduction to scientists

Lindeman, In 1942 studied the food chain and energy flow through it. Charles Elton, a British scientist first proposed the concept of the Ecological Pyramid in 1927 after his study of the Tundra Ecosystem of the Beer islands in England. Hence, this pyramid is also called the Eltonian Pyramid.

Think about it

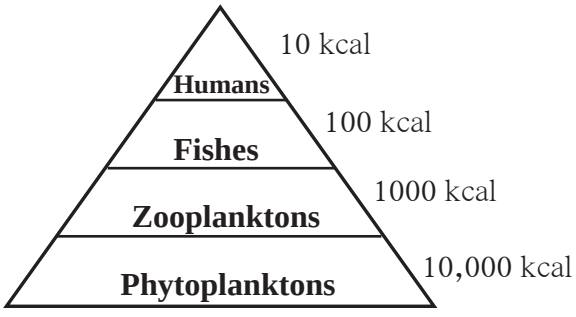
What happens to the energy during its transfer from producers to apex consumers? Does it remain trapped in the apex consumer? Does it remain in the body of apex consumer till its death?

Use your brain power !

What would happen if the energy remains trapped in the body of apex consumers even after their death? What will happen if there were no decomposers like microbes and fungi in nature?

Figure 7.4 shows the energy transfer that takes place at each trophic level. There are different levels of energy exchange in the food chain. The initial quantity of energy goes on decreasing at every level of energy exchange. Similarly, the number of organisms also decreases from the lowest level to the highest level. This pattern of energy exchange in an ecosystem is called a **'Pyramid of energy'**.

After the death of apex consumers, their energy becomes available to the decomposers. Fungi and other micro--organisms decompose the bodies of dead animals. They are called decomposers. In the process of obtaining food from the remains of organisms, decomposers convert them into simple carbon compounds. These substances easily mix with air, water and soil from where they are again absorbed by plants and incorporated into the food chain.



7.4 Pyramid of energy in an aquatic ecosystem

You can now see that due to the food web formed by the various modes of nutrition, energy and various nutrients circulate continuously in the ecosystem.

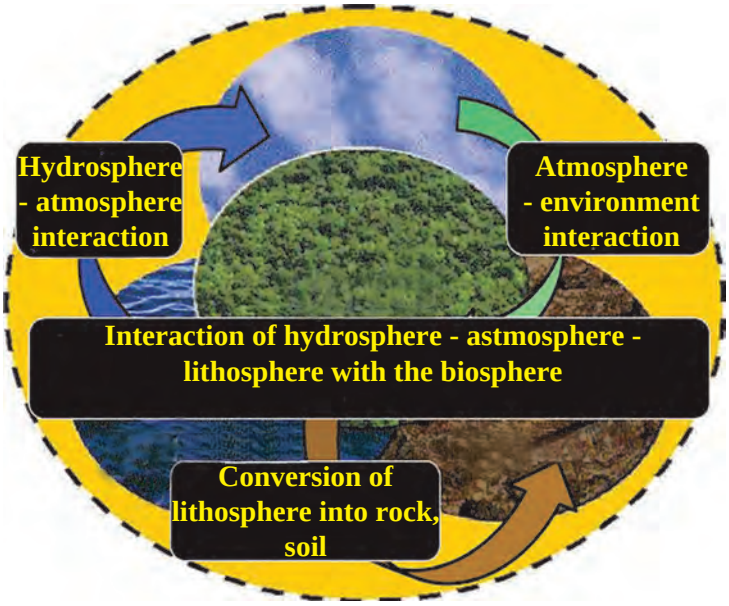
The sun is the most important source of energy in any ecosystem. Green plants of the ecosystem store some of the solar energy in the form of food. Before reaching the decomposers, this energy is passed on from one trophic level to the next. Decomposers dissipate some amount of energy in the form of heat. However, no part of the energy ever returns to the sun. Hence, such passage of energy is referred to as 'one way' transport.

Use your brain power !

Why are the numbers of tertiary consumers (apex carnivores) always less than those of other consumers?

Institutes at work

The Indian Institute of Ecology and Environment, Delhi, was established in 1980 and is involved mainly in research, training and arranging workshops and seminars. This institute has published the International Encyclopaedia of Ecology and Environment.



7.5 Bio-geo-chemical cycle

Bio-geo-chemical cycle

Though the energy flow in an ecosystem is one way, the flow of nutrients is cyclical. All organisms need nutrients for their growth. Study the various components in the figure given alongside and explain the bio-geo-chemical cycle in your own words.

The cyclical flow of nutrients within an ecosystem is called the bio-geo-chemical cycle.

Nutrients, necessary for the growth of organisms are continuously transferred from abiotic to biotic factors and biotic to abiotic factors within an ecosystem. This cycle operates continuously through the medium of the biosphere formed by the lithosphere, atmosphere and hydrosphere. The recycling of biological, geological and chemical sources of nutrients in this process is a complex process and depends upon the level of energy transfer in the ecosystem.

Types of bio-geo-chemical cycles

Gaseous cycle	Sedimentary cycle
* An accumulation of the main abiotic gaseous nutrient materials is found in the earth's atmosphere. * Includes nitrogen, oxygen, carbon dioxide, water vapour, etc.	* An accumulation of the main abiotic nutrient materials is found in soil, sediment and sedimentary rocks, etc. of the earth. * Includes soil components like iron, calcium, phosphorus, etc.

The gaseous cycle is a speedier cycle than the sedimentation cycle. For example, if CO_2 has accumulated in an area, it is quickly dispersed with the wind or absorbed by plants.

Climatic changes and human activities seriously affect the speed, intensity and equilibrium of these cycles Hence, various aspects of these cycles are extensively studied nowadays.

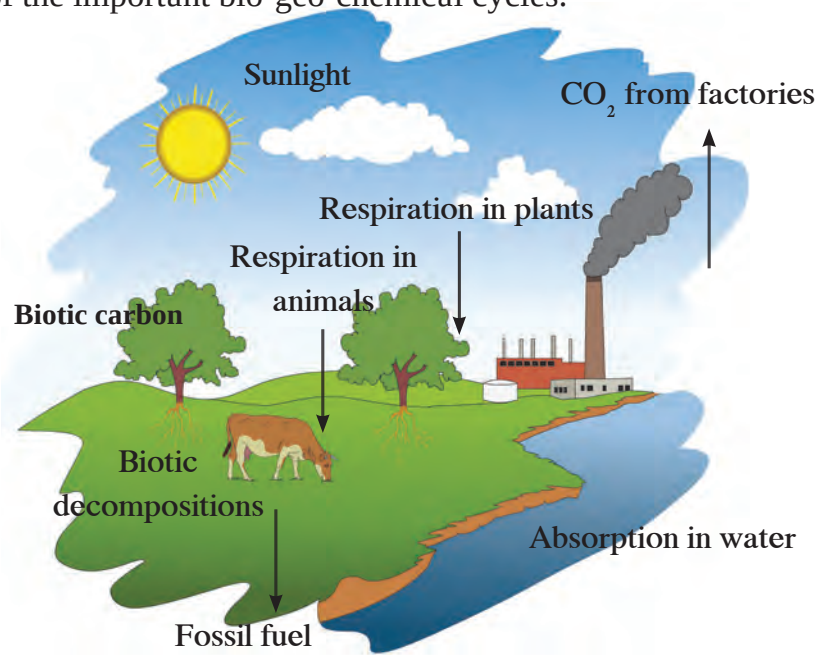
Do you know?

The cycle of gases and the sedimentary cycle cannot be completely separated from each other. For example, nitrogen is present in the form of a gas in the atmosphere and in the form of compounds like nitrogen oxide in the soil and sediments. Similarly, carbon occurs in abiotic form mainly in coal, granite, diamond, limestone, etc. in the earth's crust and in the form of carbon dioxide gas in the atmosphere. Generally, carbon is present in plants and animals for a much shorter duration than it is in coal.

The carbon cycle

The circulation and recycling of carbon from the atmosphere to living organisms and after their death back to the atomsphere is called the carbon cycle. Abiotic carbon atoms are circulated and recycled into biotic form mainly through photosynthesis and respiration. Hence, the carbon cycle is one of the important bio-geo-chemical cycles.

Plants convert carbon dioxide into carbohydrates by the process of photosynthesis. Similarly, they produce carbon compounds like proteins and fats, too. Herbivores feed upon plants. Carnivores feed upon herbivores. In this way, biotic carbon is transported from plants to herbivores, from herbivores to carnivores and from carnivores to apex consumers.



7.6 The carbon cycle

Main processes in the carbon cycle

$$6\,CO_2 + 12\,H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6\,H_2O + 6\,O_2\uparrow$$

$$C_6H_{12}O_6 + 6\,O_2 \xrightarrow{\text{Mitochondria}} 6\,CO_2\uparrow + 6\,H_2O + \text{Energy}$$

Eventally, after death, all types of consumer, are decomposed by decomposers like bacteria and fungi and carbon dioxide is released again into the atmosphere and is used again by living organism. In this way, carbon is continuously passed on from one living organism to another. After the death of living organisms, carbon goes to the atmosphere and is again taken up by living organisms.

Do you know?

Carbon dioxide is released into the atmosphere through abiotic processes like burning of fossil fuels and wood, forest fires and volcanic activity. Oxygen is released into the atmosphere by the biotic process of photosynthesis and CO_2 through respiration. The equilibrium of oxygen and carbon dioxide gases in the atmosphere is maitained by plants.

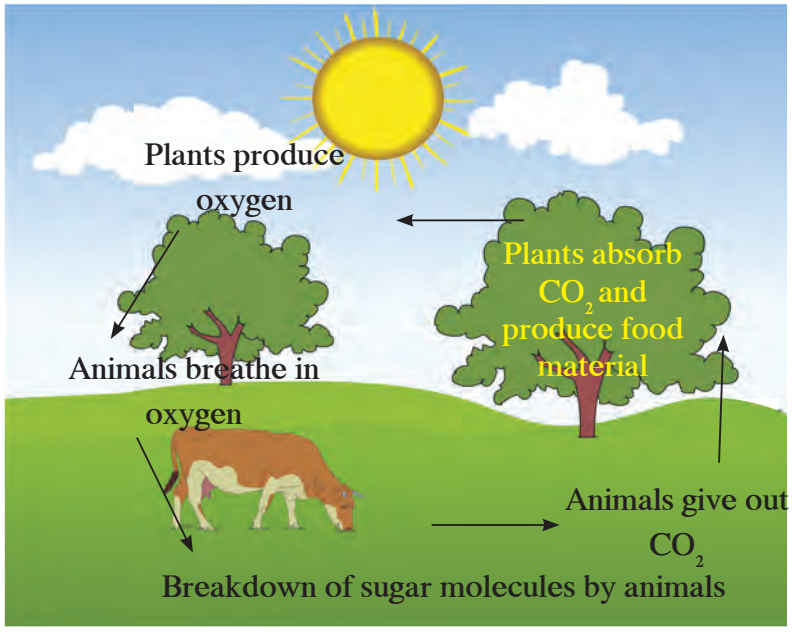
Think about it

1. The carbon cycle is very effective in the temperate region. Why is it so?
2. Even though the carbon content on earth is constant, why is there a rise in temperature due to carbon dioxide?
3. Identify the relationship between carbon in the air and the rise in atmospheric temperature.

The oxygen cycle

Oxygen forms 21% of the amosphere. It is also present in the hydrosphere and lithosphere. Circulation and recycling of oxygen within the biosphere is called the oxygen cycle. This cycle, too, includes both the biotic and abiotic components. Oxygen is continuously produced as well as used up in the atmosphere.

Oxygen is highly reactive and it readily reacts with other elements and compounds. As oxygen is found in various forms like molecular oxygen (O_2), water (H_2O), carbon dioxide (CO_2), inorganic compounds, etc. the oxygen cycle of the biosphere is extremely complex. Oxygen is released in the process of photosynthesis whereas it is used up in processes like respiration, combustion, decomposition, corrosion, rusting, etc.

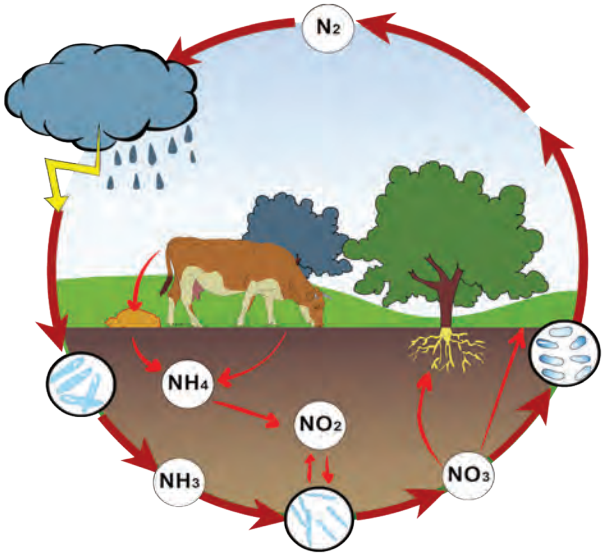


7.7 The oxygen cycle

Do you know?

Most micro-organisms use oxygen for respiration. Such microbes are called aerobes. Microbes which do not need oxygen are called anaerobes. Oxygen is important for the synthesis of proteins, carbohydrates and fats. It is also used in various chemical reactions. Ozone (O_3) is produced from oxygen through various atmospheric processes.

The nitrogen cycle



7.8 The nitrogen cycle

Can you recall?

1. What is meant by nitrogen fixation?
2. Which microbes bring about the process of nitrogen fixation?

Nitrogen forms 78% i.e. the maximum portion of the atmosphere. It is necessary for the maintenance of the cycle of nature. The circulation and recycling of nitrogen gas into the form of different compounds through various biotic and abiotic processes in nature is called the nitrogen cycle.

All organisms participate in the nitrogen cycle. It is an important component of proteins and nucleic acids. As compared to other elements, it is inactive and does not easily combine with other elements. Most organisms cannot use the free form of nitrogen.

Important processes of the nitrogen cycle

1. Nitrogen fixation: Conversion of nitrogen into nitrates and nitrites through atmospheric, industrial and biological processes.
2. Ammonification: Release of ammonia through decomposition of dead bodies and excretory wastes of organisms.
3. Nitrification: Conversion of ammonia into a nitrite and then nitrate.
4. Denitrification: Conversion of nitrogen compounds into gaseous nitrogen.

Surf the internet for information about processes in the oxygen cycle and carbon cycle similar to those of the nitrogen cycle.

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Exercises

1. **Complete the following table (Carefully study the carbon, oxygen and nitrogen cycles).**

Bio-geo-chemical cycles	Biotic processes	Abiotic processes
1. Carbon cycle 2. Oxygen cycle 3. Nitrogen cycle		

2. **Correct and rewrite the following statements and justify your corrections.**
   a. Carnivores occupy the second trophic level in the food chain.
   b. The flow of nutrients in an ecosystem is considered to be a 'one way' transport.
   c. Plants in an ecosystem are called primary consumers.

3. **Give reasons.**
   a. Energy flow through an ecosystem is 'one way'.
   b. Equilibrium is necessary in the various bio-geo-chemical cycles.
   c. Flow of nutrients through an ecosystem is cyclic.

4. **Explain the following cycles in your own words with suitable diagrams.**
   a. Carbon cycle.
   b. Nitrogen cycle.
   c. Oxygen cycle.

5. **What would you do to help maintain the equilibrium in the various bio-geo--chemical cycles? Explain in brief.**

6. **Explain in detail the inter-relationship between the food chain and food web.**

7. **State the different types of bio-geo-chemical cycles and explain the importance of those cycles.**

8. **Explain the following with suitable examples.**
   a. What type of changes occur in the amount of energy during its transfer from plants to apex consumers?
   b. What are the differences between flow of matter and of energy in an ecosystem? Why?

Activities :

1. Prepare a model based on any natural cycle and present it in a science exhibition.
2. Write a paragraph on 'Balance in an Ecosystem'.