CHAPTER 6

Functioning Ecosystem

As you must have learned in Chapter 5, an ecosystem is the basic functional unit in nature and consists of all living organisms functioning together with the non-living (physical) factors of the environment.

All ecosystems require a source of energy. The organisms in an ecosystem are linked together by their need for energy.

All the energy in ecosystems originates from the sun.

Autotrophs and Heterotrophs

Autotrophs are plants which can trap and use energy from sunlight for the process of photosynthesis to produce food.

They provide food for other organisms in the ecosystem; hence, they are called **producers**. All green plants and some bacteria are autotrophs (see page 49 of Chapter 4). Examples of terrestrial autotrophs include grasses, trees and shrubs, while aquatic examples include sea weeds, water hyacinths and phytoplankton.

Animals are heterotrophs (see Chapter 4). They cannot manufacture their own food. They get their food from plants and other animals.

Hence, they are called **consumers**. Consumers which feed directly on plants are herbivores, and are called **primary** consumers. Carnivores are animals which feed on other animalsâ€™ flesh. They are called **secondary** consumers. Another carnivore or omnivore in the case of man would be a **tertiary** consumer, and so on. Examples include grasshopper, goat, snail, fish, zoo-pankton and lion.

A third group of organisms in the ecosystem are called decomposers. They feed on dead organisms and the wastes of living organisms. They also recycle the materials used by plants. Examples include bacteria and fungi.

Food Chain and Food Web

A food chain is a way of illustrating the energy relationships among organisms in an ecosystem brought about by feeding.

Every food chain begins with a producer (i.e. a green plant) and occupies the first trophic level. Producers are fed upon by herbivores (primary consumers) which occupy the second trophic level. Herbivores in turn are fed on by carnivores (secondary consumer), which occupy the third trophic level.

Duckweeds (Producer) → Duckling (Primary) (consumer) → Snake (Secondary) (consumer) → Man (Tertiary) (consumer)

Fig 6.1 Food chain of a pond

In a pond, the producer might be the duck-weed growing on the surface of water, which is eaten by the duckling. A snake in turn could eat the duckling. And, finally, a man might feed on the snake.

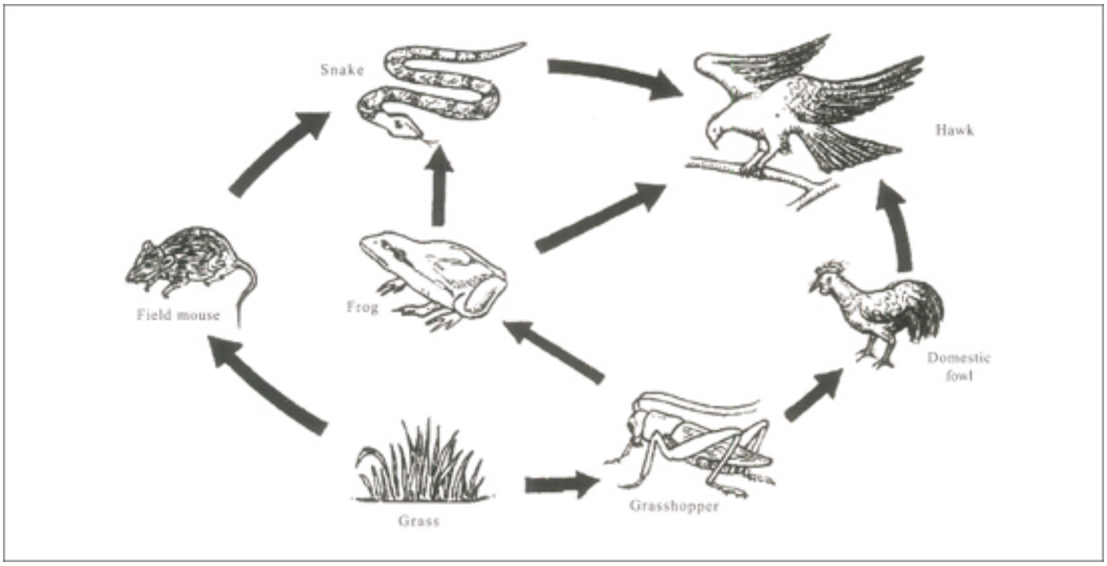

Fig 6.2 A food web in a farmland

The food chain just described is simpler than those found in most natural ecosystems. Many animals eat more than one type of food, and many plants are eaten by more than one herbivore. Thus, ecosystems usually contain overlapping food chains. Several interconnected food chains, such as those shown in *Fig. 6.2*, are called **food webs**. In this complex feeding relationship, the grass is eaten by both the grasshopper and field mouse. The grasshopper is eaten by the toad and the domestic fowl. The snake eats the toad, as well as the field mouse. The hawk eats the snake, the toad and the domestic fowl.

Energy flow

Each time energy is converted from one form to another, some fractions of the total amount of energy are lost. Of the energy that reaches the earth as sunlight, only a fraction is trapped for photosynthesis by green plants. Each time an organism is eaten, its energy is transformed into chemical energy that fuels the metabolism of the consumer. Much energy is lost as heat. Some of the energy is lost in the digestion of food. Animals also expend energy to capture their prey. Radiant energy from sunlight is converted to chemical energy stored in the food green plants synthesize.

Only about 10 percent of the energy an organism takes in is stored in the tissues of that organism. Therefore, when a mouse eats grass, it stores only 10 per cent of the energy available from the grass. When a snake eats a mouse, it stores only 10 per cent of the mouseâ€™s energy. When a hawk eats a snake, it stores only 10 per cent of the snakeâ€™s energy. The transfer of energy in a food chain is sometimes illustrated as an **energy pyramid** as shown in *Fig. 6.3*.

As you can see, the producers have most of the energy in the pyramid. The primary consumers have less energy, and the secondary consumers even lesser.

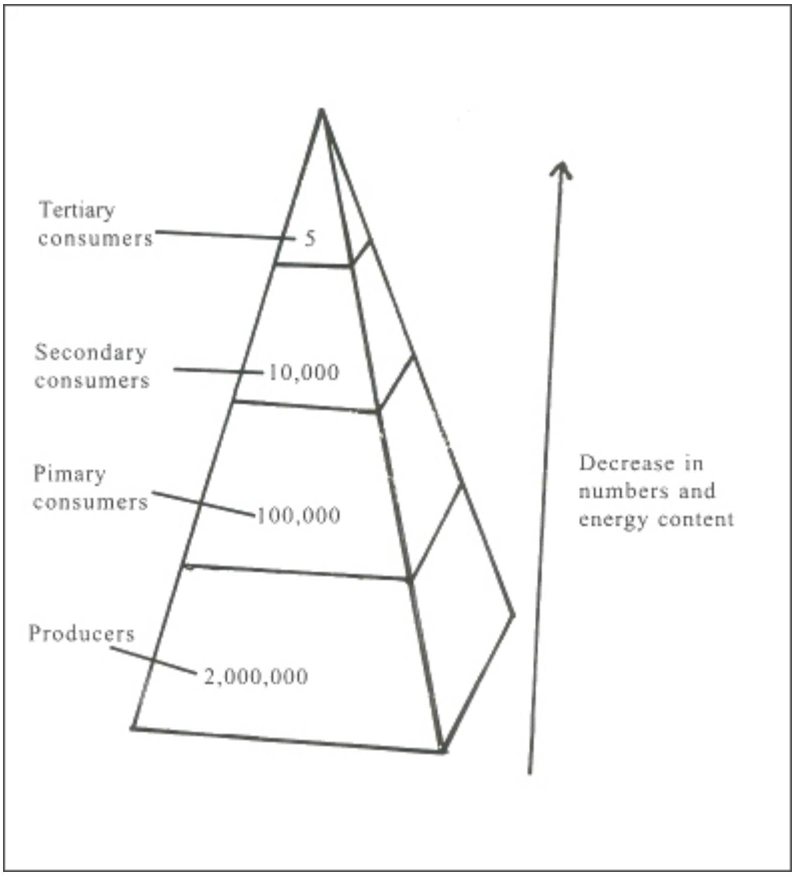

Fig 6.3 Pyramid of Energy/Number

The same pyramid can serve as a **pyramid of numbers**. The number of organisms in each level decreases as you move up the food chain. In most ecosystems, the producers are the most abundant. Usually, the consumers are less numerous than the producers because a primary consumer must eat many producers in order to obtain enough energy. At the top of the pyramid are the tertiary consumers which are the fewest in number.

Energy transformation in nature

Energy loss in the ecosystem

The energy from the sun passes through food chains. However, only a small proportion of the sunâ€™s energy gets into the bodies of the final consumers. The rest of the energy is lost as heat along the food chain. This progressive loss of energy at each level of a food chain puts a natural limit on the total weight of living matter that can exist at each level. In autotrophs, the loss in energy affects primary production because there is less of photosynthesis which ultimately affects the yield.

When the energy from the sun falls on grassland, about 20 per cent is reflected by the vegetation, 30 per cent is used in evaporating water from the leaves (transpiration), 40 per cent warms up the plants, the soil and the air, leaving only about 1 per cent to be used in photosynthesis for making new organic matter in the leaves of plants. This figure of 1 per cent will vary with the type of vegetation being considered and with climatic factors such as availability of water and the soil temperature. Sugarcane grown in ideal conditions can convert three per cent of the solar energy into photosynthetic products. Sugar beet at the height of its growth has about nine percent efficiency.

Tropical forests and swamps are more productive than grassland but it is difficult at the moment to effectively harvest and utilize their products. In order to allow plants to approach their maximum efficiency, they must be provided with sufficient water and mineral salts. This can be achieved by irrigation and the application of fertilizers. Other ways in which energy is lost apart from heat, include through clouds, vegetation, evaporation of water and the effects of winds.

Laws of Thermodynamics

The first law of thermodynamics states that energy is neither created nor destroyed but it is converted from one form to another. When one form of energy is converted into another, there is no net loss or gain. In other words, the total amount of energy resulting from a conversion is equal to the amount started off with. However, this does not mean that all energy is in the same form. The photosynthetic cells of a green plant can convert light energy from the sun into chemical energy in food. The latter can be converted into a variety of other forms of energy. In muscle tissues, chemical energy in food is converted into the mechanical energy of contraction. In luminescent organisms like the glow worm, it is converted into electrical energy, and so on.

The second law of thermodynamics states that when one form of energy is converted into another, a proportion of it is turned into heat. This law can be used to explain energy flow across trophic levels (see page 75). Only about 10 per cent of the energy an organism takes in is stored in the tissues of that organism. Of the rest, some is lost as heat, some is used up in the digestion of food, respiration and capture of prey, etc. This subsequent loss in energy puts a limit to the number of organisms found at each trophic level.

Nutrient Cycling in Nature

The energy in an ecosystem flows from one organism to another through food chains and webs. Once energy is used, it is lost to the ecosystem. Energy cannot be recycled. The chemical nutrients in an ecosystem, however, can be used over and over again.

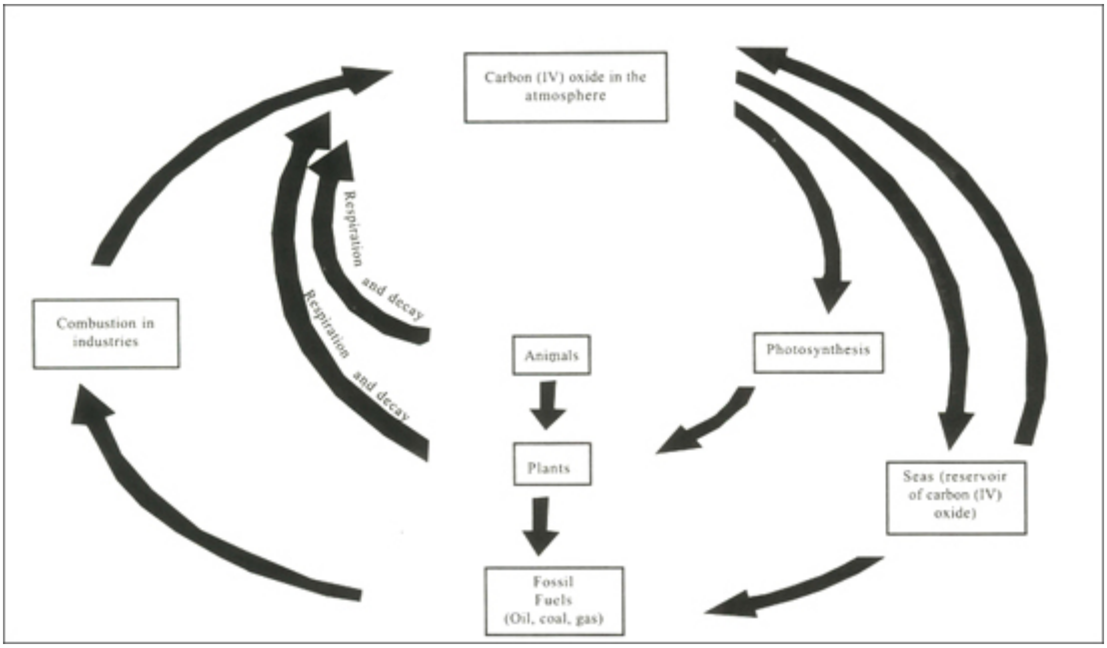

Fig 6.4 The carbon cycle

Several nutrients are especially important to the functioning of living things. Nutrients may alternate between time spent in the bodies of living things and time spent in the physical environment. The movement of these chemicals between living and non-living parts of the environment illustrates the close relationship of the environment and the living community.

The Carbon Cycle

The carbon cycle illustrates the way carbon(IV) oxide is taken out of the atmosphere by photosynthesis, and put back into it by respiration and decay. *(Fig. 6.4)*.

The air around us contains a small amount of carbon(IV) oxide. This is constantly being absorbed by green plants that use it for photosynthesis. Carbon(IV) oxide diffuses into the leaves, and is built up into sugar and other complex compounds. When the plant is eaten by an animal, sugar gets into the cells in the animalâ€™s body. Here, it is broken down into Carbon(IV) oxide and water to produce energy (process of respiration). As a result, Carbon(IV) oxide is put back into the atmosphere. When the animals and plants die, they decay. In this process, the bacteria and other microbes feed on them. The bacteria and other microbes respire too, and once again, carbon(IV) oxide is put back into the atmosphere. Carbon(IV) oxide is also released into the atmosphere when fuels such as coal, wood, petrol, kerosene are burned. When there is a little quantity of carbon(IV) oxide in the atmosphere, more is liberated from the seas. Conversely when there is too much carbon(IV) oxide in the atmosphere, more dissolve into the sea.

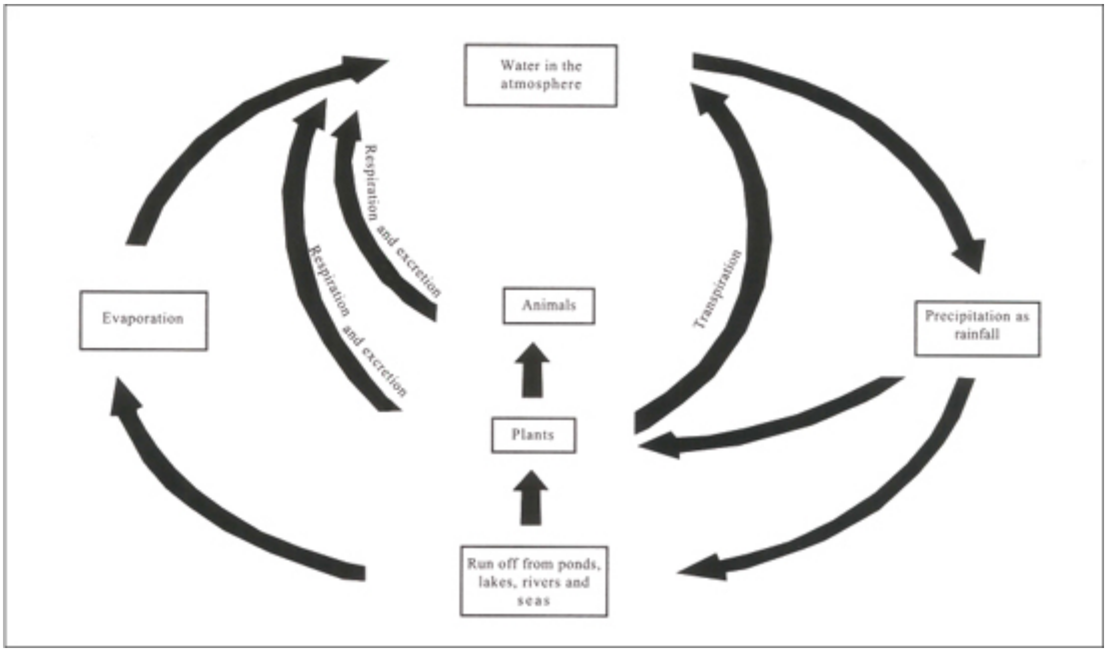

Fig 6.5 The Water Cycle

Importance of carbon

Carbon is very important in nature. This is because all living things are made up of various elements most of which is carbon. All food substances manufactured by plants are first formed from carbon compounds. Any substance that contains carbon is said to be organic, hence, all organisms are organic in nature.

The water cycle

When rain falls, some of it is absorbed by plants through their root hairs. After spending sometime in plants, water evaporates from them in the process of transpiration. A lot of the water is drunk by many animals and then released into the environs during respiration or excretion. Some rain falls directly into ponds or streams and some into rivers. Some of the water filters down through the soil and flows underground. Much of the underground water eventually flows into the oceans. Water returns to the atmosphere by evaporation. When water vapour accumulates in the atmosphere as clouds it may fall once again as rain.

Importance of Water

Water is the main component of plants and animals. It is the basic component of manâ€™s body tissue, comprising about 75 percent of it. It is essential for life and for all body chemical activities. It acts as a solvent for soluble food substances in digestion and as a medium of transport for nutrients. It constitutes a large part of the blood, aids excretion, regulates body temperature and maintains the osmotic content of body tissues. It is the basis for body secretions. Life cannot exist without water.

Decomposition in nature

Decomposers

When animals and plants in a habitat die, their bodies decay. This is because they are broken down by saprophytic bacteria and fungi which feed on them. These micro-organisms (microbes) are called **decomposers**. Apart from these **micro-decomposers**, we have **macro-decomposers** like snail, earthworm and mushroom. Other abiotic decomposers are fires in forests and savannas. As a result of their activities, simple substances such as carbon(IV) oxide, water, ammonia, hydrogen sulphide and mineral salts are released from the dead bodies. These can be used again by green plants i.e. producers.

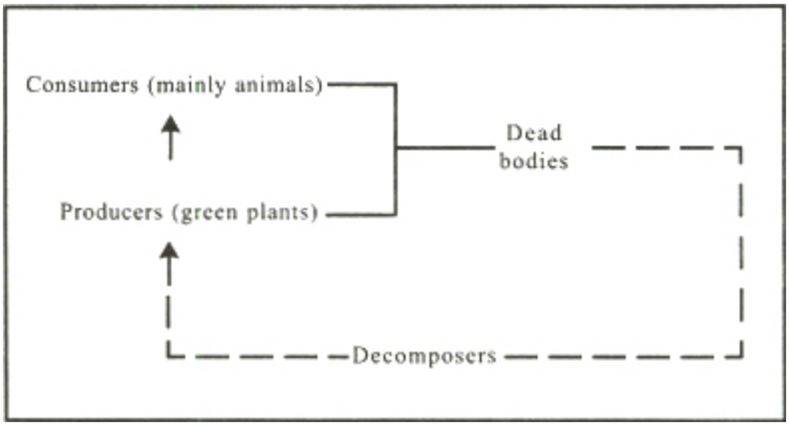

Fig. 6.6 Decomposers enable the materials in the bodies of the producers and consumers to be used again

Process of Decomposition

Decay does not occur all at once. It happens step by step. The decomposers first break the dead material down into liquid with the help of enzymes *(Fig. 6.6)*. They then absorb all the nutrients they need. As decay gets underway, the rotten materials may get warm, due to heat given out by the decomposers. It may also give out unpleasant smell due to gases like carbon(IV) oxide and hydrogen sulphide which are given off. Water or moisture and warmth usually accelerate the rate of decay.

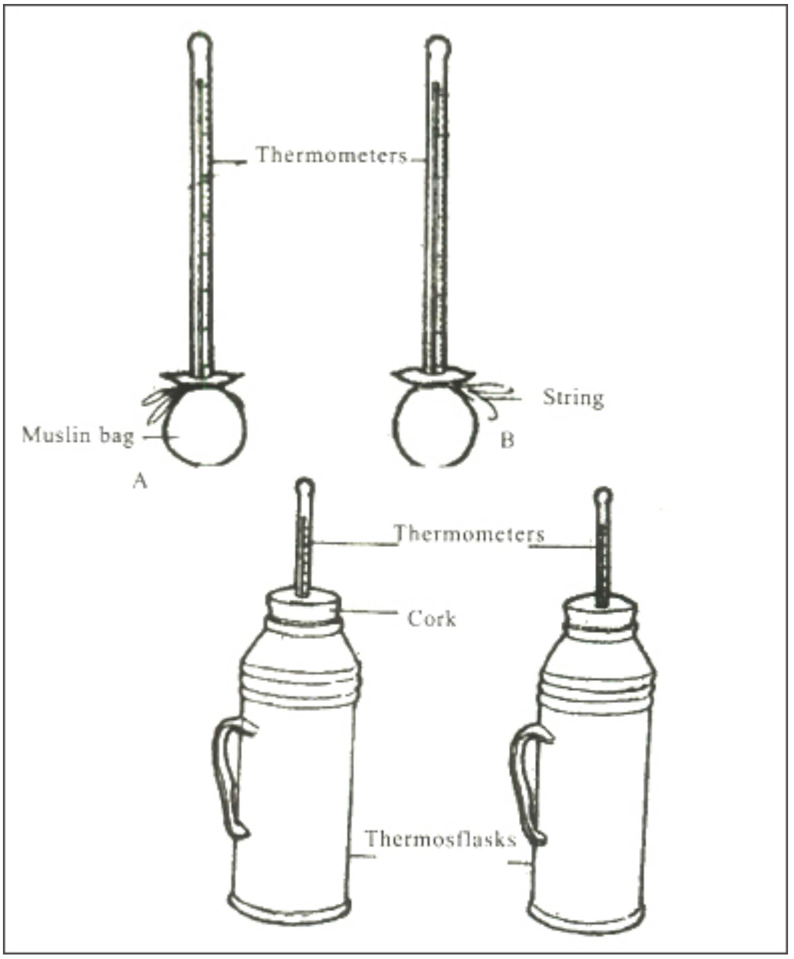

Fig. 6.7 Demonstrating that heat is given off during decomposition

Experiment 6.1 *To show that heat is given off during decomposition*

Method

1. Bring two thermos flasks, label them A and B.
2. Put some vegetable matter and moist loamy soil into a muslin bag. Insert a thermometer inside it and tie properly. Then, insert all in flask A.
3. Put some vegetable matter and moist baked soil into a muslin bag. Insert a thermometer inside it. Tie properly and insert all in flask B.
4. Allow the flasks to stand for some time and record the thermometer readings.

Observation

It will be observed that the temperature of flask A rose while that of B remained the same.

Inference: Heat is given off during decomposition.

Role of decomposers

When decomposers get to work on a dead body, they break its complex chemicals into simpler ones. Carbohydrates are broken down into carbon(IV) oxide and water and proteins into simple nitrogen salts. These simple substances can then be absorbed by plants, which build them up again into the complex material of their own bodies. So, decomposition puts back into the atmosphere and soil, the chemicals which plants took out of it. Decomposition is also useful in the making of cheese, yoghourt, and getting rid of sewage.

Suggested Practicals

1. Experiment to show that carbon(IV) oxide is released during decomposition.

(a) Label two gas jars A and B.

(b) Put some soil mixed with chopped vegetable matter in jar A.

(c) Put only chopped vegetable matter in jar B.

(d) Insert test tubes containing lime water into the gas jars and cover jars with lids.

(e) Leave the experiment to stand for about 24 hours. Then, observe the colour of the lime water and complete the table below.

Jar	Colour of lime water in test tube	Content of jar
A		
B		

2. Experiment to show the presence of water in expired air.

(a) Bring a glass plate and cobalt chloride paper.

(b) Breathe on the glass plate through your mouth and observe what happens.

(c) Quickly apply the blue-cobalt chloride paper to the glass plate and observe what happens.

(d) Write down what happened when you breathed on the glass plate.

(e) Record the colour change and explain.

Summary

1. The organisms in an ecosystem are either autotrophs or heterotrophs. They can also be classified as producers, consumers or decomposers.
2. These organisms interact with each other and with the environment.
3. The energy/food relationships between organisms in an ecosystem are illustrated by the food chain and food web.
4. There is a progressive loss of energy as we go along a food chain resulting in the pyramid of numbers and energy.
5. This progressive loss in energy puts a natural limit on the total weight of living matter that can exist at each trophic level.
6. From the thermodynamic stand point, energy can be changed into one form or another with the release of heat.
7. The chemical matters in an ecosystem can be used over and over

again. Some of these matters are carbon(IV) oxide, water, and nitrogen. Living things cannot exist without them.

8. When animals and plants die, their bodies decay. This decay (decomposition) is brought about by micro and macro decomposers such as bacteria, moulds, mushrooms, snails, earthworms and fire.
9. As a result of their activities, simple substances such as carbon(IV) oxide, water, hydrogen sulphide and mineral salts are released by the dead bodies, to be used again by green plants.
10. Heat is also given off during decomposition.

Objective Questions

1. Which of the following is not an important component in the carbon cycle?
   A. Green plants
   B. Root nodules
   C. Animals
   D. Organic remains of plants.
   E. Atmospheric carbon(IV) oxide.

2. The ultimate source of energy for food synthesis is
   A. green plants
   B. herbivores.
   C. decomposers
   D. solar energy.
   E. secondary consumers

3. Which of these is the correct sequence in the food relationship in a terrestrial community?
   A. grasshopper ➔ grass ➔ lizard ➔ hawk.
   B. grass ➔ grasshopper ➔ lizard ➔ hawk.
   C. grasshopper ➔ hawk ➔ grass ➔ lizard.
   D. lizard ➔ hawk ➔ grasshopper ➔ grass.
   E. grass ➔ lizard ➔ hawk ➔ grasshopper.

4. In a pyramid of numbers, the organisms with the greatest numbers are the
   A. primary consumers.
   B. tertiary consumers.
   C. producers.
   D. secondary consumers.
   E. scavengers.

5. All these are decomposers except
   A. mushroom.
   B. bacteria.
   C. *Rhizopus*
   D. earthworm.
   E. grass.

Essay Questions

1(a) Name four plants and four animals which you can find in a terrestrial habitat.

(b) Using some of the organisms, construct a food chain and a food web that may exist between them.

2(a) What is a decomposer? Describe the process of decomposition.

(b) What is the importance of decomposers?

3(a) State two importance of carbon, and four importance of water to living things

(b) Use a labelled diagram to explain fully the carbon cycle.

4. The following figures show the total number of organisms measured from grassland habitat during one year

Plant – 50

Herbivores – 10

Carnivores – 5

Explain why the number decreased at each step of the food chain.