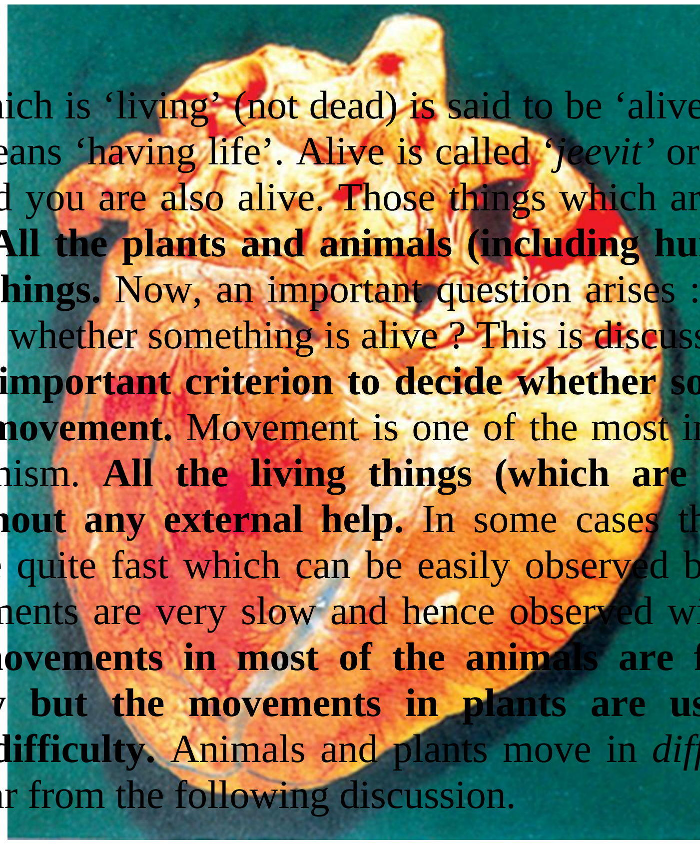
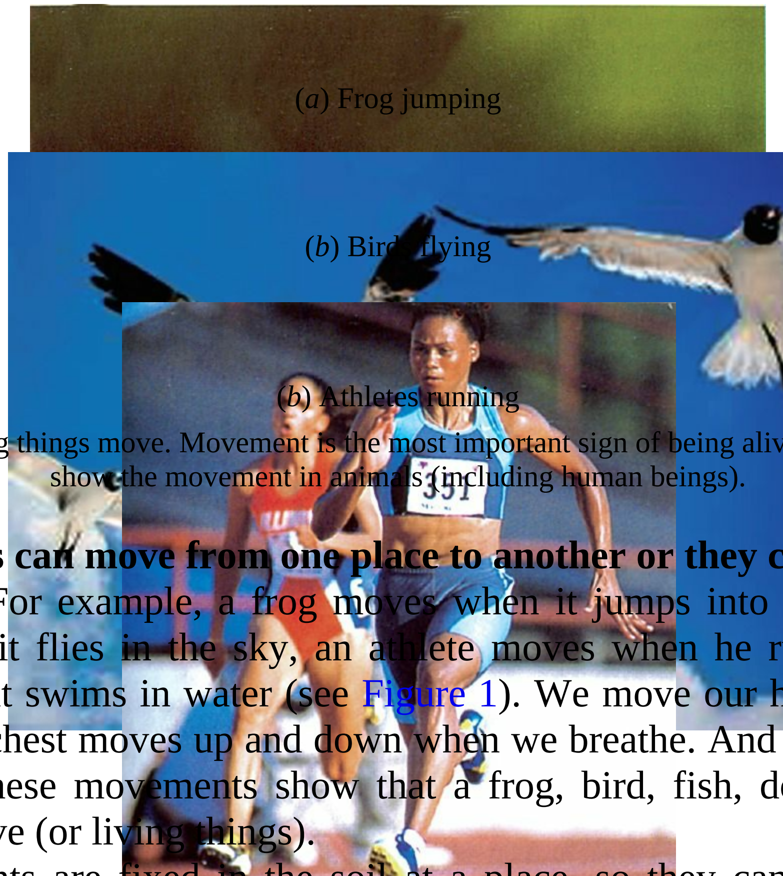
1

Life Processes



Something which is 'living' (not dead) is said to be 'alive'. In most simple terms, 'alive' means 'having life'. Alive is called '*jeevit*' or '*zinda*' in Hindi. We are alive and you are also alive. Those things which are alive are called 'living things'. **All the plants and animals (including human beings) are alive or living things.** Now, an important question arises : What criteria do we use to decide whether something is alive ? This is discussed below.

The most important criterion to decide whether something is alive (or not) is the movement. Movement is one of the most important signs of life in an organism. **All the living things (which are alive) move by themselves without any external help.** In some cases the movements of living things are quite fast which can be easily observed by us but in other cases the movements are very slow and hence observed with difficulty. For example, **the movements in most of the animals are fast and can be observed easily but the movements in plants are usually slow and observed with difficulty.** Animals and plants move in *different* ways. This will become clear from the following discussion.



(*a*) Frog jumping

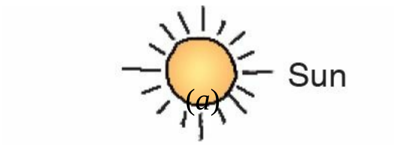
(*b*) Bird flying

(*b*) Athletes running

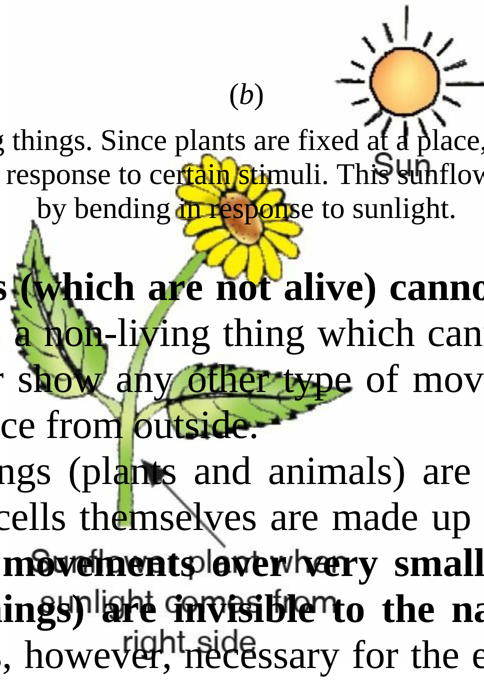
Figure 1. Living things move. Movement is the most important sign of being alive. These pictures show the movement in animals (including human beings).

Animals can move from one place to another or they can move their body parts. For example, a frog moves when it jumps into a pond, a bird moves when it flies in the sky, an athlete moves when he runs and a fish moves when it swims in water (see Figure 1). We move our hands when we clap and our chest moves up and down when we breathe. And a dog can wag its tail. All these movements show that a frog, bird, fish, dog and human beings are alive (or living things).

The plants are fixed in the soil at a place, so they cannot move like animals from place to place. **The plants can only move parts of their body such as leaves, flowers, shoots and roots.** The plant parts move *towards* a stimulus such as sunlight, gravity or water, etc. For example, the shoot, the leaves and flower of a sunflower plant move by bending towards the sun so as to face the sunlight (see Figure 2). The leaves of a *Mimosa pudica* plant (sensitive plant) move by folding up when touched with a finger. Plants also show movement by growing their roots and shoots bigger.



(*a*)



(*b*)

Figure 2. Plants are also living things. Since plants are fixed at a place, they can show movement only by bending their body parts in response to certain stimuli. This sunflower plant is showing movement by bending in response to sunlight.

Non-living things (which are not alive) cannot move by themselves. For example, a stone is a non-living thing which cannot move by itself from one place to another or show any other type of movement. We will have to move it by applying force from outside.

All the living things (plants and animals) are made up of tiny living units called cells. The cells themselves are made up of still smaller particles called molecules. **The movements over very small scale (as those in the molecules of living things) are invisible to the naked eye.** The invisible molecular movement is, however, necessary for the existence of life. In fact, viruses do not show any molecular movement in them (until they infect some cell) and this has created controversy about whether they are truly alive or not. In addition to movement, the living things also show some other characteristics. These are discussed below.

All the living things (which are alive) have some common characteristics (or features) which make them different from non-living things. **The characteristics of living things** are as follows :

(*i*) Living things can move by themselves.
(*ii*) Living things need food, air and water.
(*iii*) Living things can grow.
(*iv*) Living things can respond to changes around them. They are sensitive.
(*v*) Living things respire (release energy from food).
(*vi*) Living things excrete (get rid of waste materials from their body).
(*vii*) Living things can reproduce. They can have young ones.

What are Life Processes

All the organisms perform some basic functions to keep themselves alive. **The basic functions performed by living organisms to maintain their life on this earth are called life processes.** The basic life processes common to all the living organisms are : **Nutrition and Respiration; Transport and Excretion; Control and Coordination (Response to stimuli); Growth; Movement and Reproduction.** The process of nutrition involves the taking of food inside the body and converting it into smaller molecules which can be absorbed by the body. Respiration is the process which releases energy from the food absorbed by the body. Transport is the process in which a substance absorbed or made in one part of the body is moved to other parts of the body. Excretion is the process in which the waste materials produced in the cells of the body are removed from the body.

Control and coordination (or response to stimuli) is a process which helps the living organisms to survive in the changing environment around them. The process of growth involves the change from a small organism to a big organism (or an adult organism). In movement, the organism either moves from one place to another or moves its body parts while remaining at the same place. The process of reproduction involves the making of more organisms from the existing ones, so that organisms could live on this earth for ever.

Energy is Needed for the Life Processes

All the living organisms need energy to perform various life processes. They get this energy from food. **Food is a kind of fuel which provides energy to all the living organisms.** The living organisms use the chemical energy for carrying out various life processes. They get this chemical energy from food through chemical reactions. Actually, living organisms continuously need energy for their various life processes and other activities which they perform. For example, energy is required by an organism even during sleep. This is because when we are asleep, a number of biological processes keep on occurring in the body which require energy. Our heart beats non-stop even when we are asleep to pump blood throughout the body. And this beating of heart requires energy. Thus, the working of heart requires a continuous supply of energy.

The energy required by an organism comes from the food that the organism eats. Thus, food is the basic requirement of all the living organisms for obtaining energy. In this chapter we will first study the process of intake and utilisation of the food by an organism (called nutrition) and the liberation of energy from the food (called respiration). After that we will study the process of moving the digested food and other materials to the various parts of the body (called transport) and the removal of waste materials from the body (called excretion). Let us start with nutrition.

NUTRITION

Food is an organic substance. The simplest food is glucose. It is also called simple sugar. A more complex food is starch. Starch is made from glucose. The general name of substances like glucose (sugar) and starch is ‘carbohydrates’. Carbohydrates are the most common foods for getting energy. Fats and proteins are also foods. (A wider definition of food, however, also includes mineral salts, vitamins and water which are essential for the normal growth and development of an organism). The process of taking in food (consuming food) and utilising it is called nutrition. It is a process in which food is obtained in order to utilise it to provide energy for performing various metabolic activities of the organism. Actually, the term ‘nutrition’ comes from the word ‘nutrient’. A nutrient is an organic or inorganic substance required for the maintenance of life and survival of a living organism. In most simple terms, a nutrient can be said to be a particular type of food. **A nutrient can be defined as a substance which an organism obtains from its surroundings and uses it as a source of energy or for the biosynthesis of its body constituents (like tissues and organs).** For example, **carbohydrates and fats are the nutrients** which are used by an organism mainly as a source of energy whereas **proteins and mineral salts are nutrients** used by an organism for the biosynthesis of its body constituents like skin, blood, etc.

Figure 3. This is glucose powder. Glucose is the simplest food. It is very easily absorbed by our body.

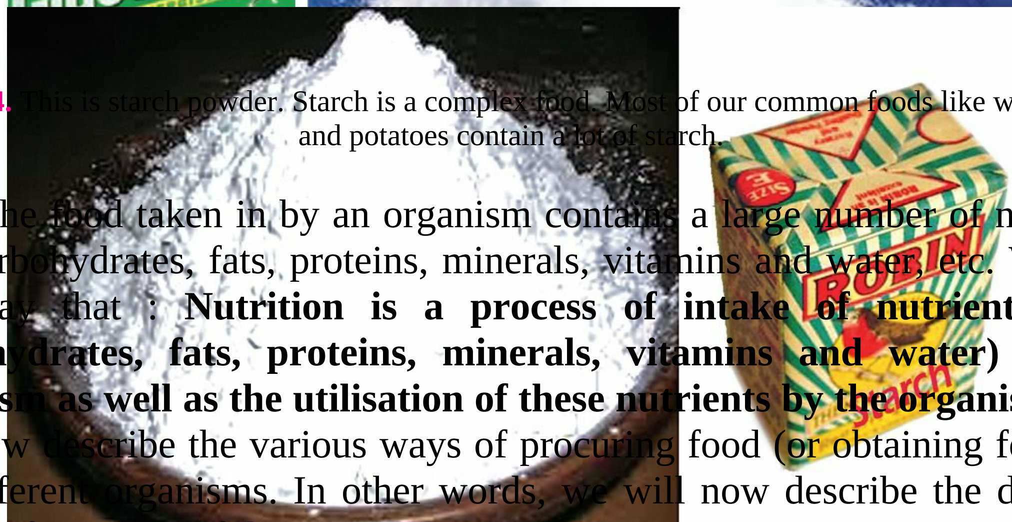


Figure 4. This is starch powder. Starch is a complex food. Most of our common foods like wheat, rice and potatoes contain a lot of starch.

The food taken in by an organism contains a large number of nutrients like carbohydrates, fats, proteins, minerals, vitamins and water, etc. We can now say that : **Nutrition is a process of intake of nutrients (like carbohydrates, fats, proteins, minerals, vitamins and water) by an organism as well as the utilisation of these nutrients by the organism.** We will now describe the various ways of procuring food (or obtaining food) by the different organisms. In other words, we will now describe the different modes of nutrition of the various organisms.

Modes of Nutrition

Modes of nutrition means methods of procuring food or obtaining food by an organism. All the organisms do not obtain their food in the same way. Different organisms have different methods of procuring food or obtaining food. In other words, organisms differ in their modes of nutrition. Depending on the mode (or method) of obtaining food, all the organisms can be classified into two groups: autotrophic and heterotrophic. Thus : **There are mainly two modes of nutrition :**

1. Autotrophic, and

2. Heterotrophic.

We will now discuss the autotrophic mode of nutrition and the heterotrophic mode of nutrition in detail, one by one.

1. Autotrophic Mode of Nutrition

The word 'auto' means 'self' and 'trophe' means 'nutrition'. Thus, autotrophic means 'self nutrition'. In autotrophic nutrition, the organism makes (or synthesizes) its own food from the inorganic raw materials like carbon dioxide and water present in the surroundings by using the sunlight energy. We can now say that : **Autotrophic nutrition is that mode of**

nutrition in which an organism makes (or synthesizes) its own food from the simple inorganic materials like carbon dioxide and water present in the surroundings (with the help of sunlight energy). Please note that food is an organic material (like glucose, etc.). This means that, in autotrophic nutrition, organic material (food) is made (or synthesized) from inorganic materials like carbon dioxide and water by utilizing the sunlight energy. **The green plants have an autotrophic mode of nutrition. The autotrophic bacteria also obtain their food by the autotrophic mode of nutrition** (though most bacteria are not autotrophic). The organisms having autotrophic mode of nutrition are called autotrophic organisms or just autotrophs.

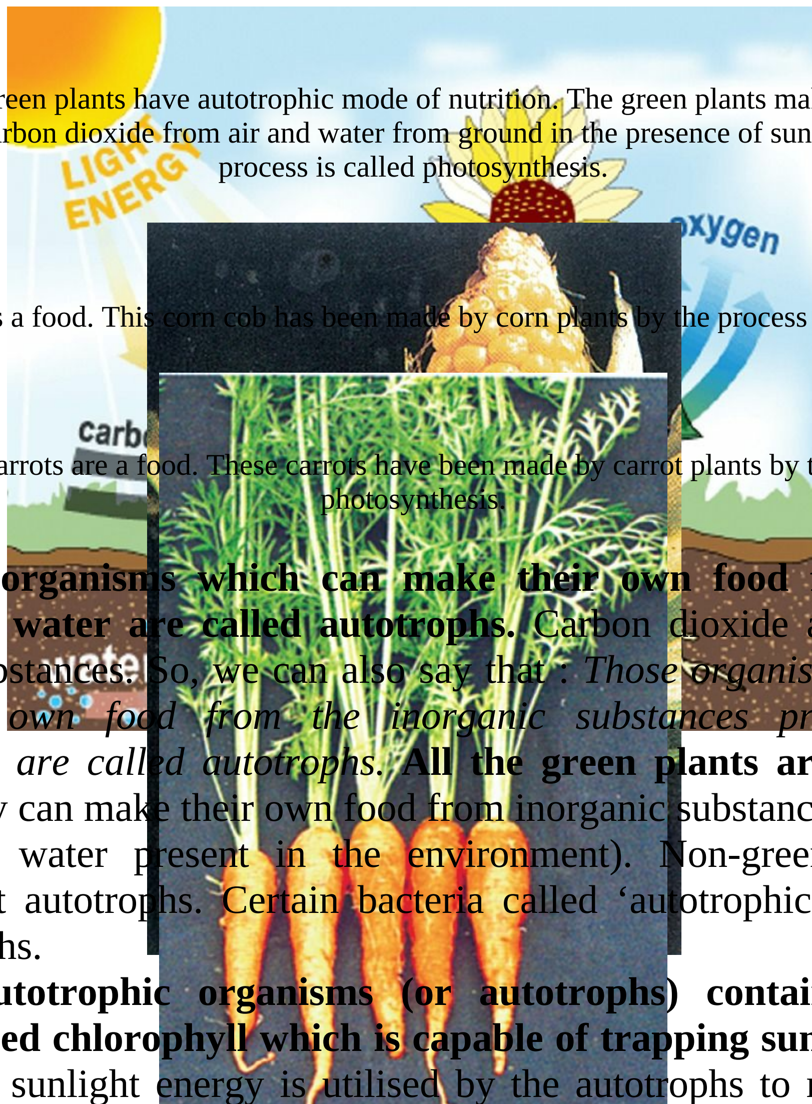


Figure 5. The green plants have autotrophic mode of nutrition. The green plants make their own food by combining carbon dioxide from air and water from ground in the presence of sunlight energy. This process is called photosynthesis.
Figure 6. Corn is a food. This corn cob has been made by corn plants by the process of photosynthesis.
Figure 7. Carrots are a food. These carrots have been made by carrot plants by the process of photosynthesis.

Those organisms which can make their own food from carbon dioxide and water are called autotrophs. Carbon dioxide and water are inorganic substances. So, we can also say that : *Those organisms which can make their own food from the inorganic substances present in the environment, are called autotrophs.* **All the green plants are autotrophs** (because they can make their own food from inorganic substances like carbon dioxide and water present in the environment). Non-green plants are, however, not autotrophs. Certain bacteria called 'autotrophic bacteria' are also autotrophs.

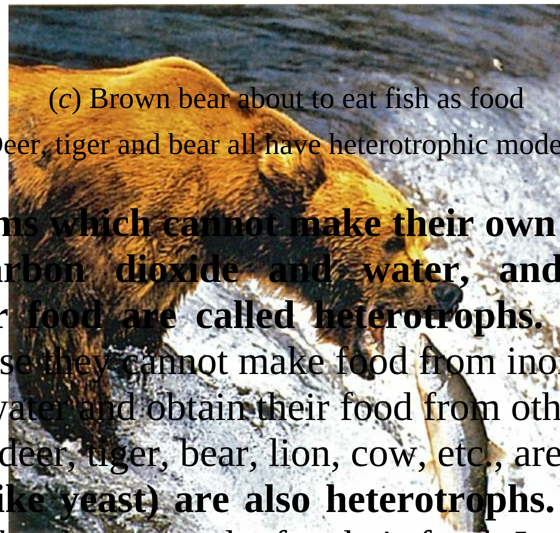
The autotrophic organisms (or autotrophs) contain the green pigment called chlorophyll which is capable of trapping sunlight energy. This trapped sunlight energy is utilised by the autotrophs to make food by combining inorganic materials like carbon dioxide and water present in the environment by the process of photosynthesis. Thus, autotrophs make their own food by photosynthesis. So, autotrophs are the producers of food. The food produced by autotrophs (green plants) is also used by human beings and many, many other animals.

2. Heterotrophic Mode of Nutrition

The word ‘heteros’ means ‘others’ and ‘trophe’ refers to ‘nutrition’. Thus, ‘heterotrophic’ means ‘nutrition obtained from others’. In heterotrophic nutrition, the organism cannot make (or synthesize) its own food from the inorganic raw materials like carbon dioxide and water, and uses the food made by autotrophic organisms directly or indirectly. We can now say that : **Heterotrophic nutrition is that mode of nutrition in which an organism cannot make (or synthesize) its own food from simple inorganic materials like carbon dioxide and water, and depends on other organisms for its food.** A heterotrophic organism is a consumer which derives its nutrition from other organisms. That is, a heterotrophic organism has to eat other organisms for its nutrition. **All the animals have a heterotrophic mode of nutrition. Most bacteria and fungi also have heterotrophic mode of nutrition.** The organisms having heterotrophic mode of nutrition are called heterotrophic organisms or just heterotrophs.

(*a*) Deer eating plant leaves as food

(*b*) Tiger eating deer as food



(*c*) Brown bear about to eat fish as food

Figure 8. Deer, tiger and bear all have heterotrophic mode of nutrition.

Those organisms which cannot make their own food from inorganic substances like carbon dioxide and water, and depend on other organisms for their food are called heterotrophs. All the **animals are heterotrophs** (because they cannot make food from inorganic substances like carbon dioxide and water and obtain their food from other plants or animals.). Thus, man, dog, cat, deer, tiger, bear, lion, cow, etc., are all heterotrophs. **The non-green plants (like yeast) are also heterotrophs.** Heterotrophs depend on autotrophs and other heterotrophs for their food. In other words, **animals are heterotrophs which depend on plants or other animals for their food.**

From the above discussion we conclude that green plants make their own food. Non-green plants and animals cannot make their own food. They obtain food from plants and other animals. We will now discuss the various types of the heterotrophic mode of nutrition.

Types of Heterotrophic Nutrition

A heterotrophic organism (or heterotroph) can obtain its food from other organisms in three ways. So, the heterotrophic mode of nutrition is of three types :

1. Saprotrophic nutrition,
2. Parasitic nutrition, and
3. Holozoic nutrition.

We will now discuss the three types of heterotrophic nutrition in detail, one by one. Let us start with the saprotrophic nutrition.

1. Saprotrophic Nutrition (or Saprophytic Nutrition)

Saprotrophic nutrition is that nutrition in which an organism obtains its food from decaying organic matter of dead plants, dead animals and rotten bread, etc. 'Sapro' means 'rotten', so a saprotrophic organism draws its food from rotting wood of dead and decaying trees, rotten leaves, dead animals and household wastes like rotten bread, etc. The organisms having saprotrophic mode of nutrition are called saprophytes. We can now say that : **Saprophytes are the organisms which obtain their food from dead plants (like rotten leaves), dead and decaying animal bodies, and other decaying organic matter (like rotten bread)**. Fungi (like bread moulds, mushrooms, yeast), and many bacteria are saprophytes. We know that fungi and bacteria are a kind of plants. So, we can also say that saprophytes are the plants which feed on dead and decaying organic matter. The saprophytes break down the complex organic molecules present in dead and decaying matter and convert them into simpler substances *outside* their body. These simpler substances are then absorbed by saprophytes as their food. Please note that saprotrophic nutrition is also known as saprophytic nutrition.

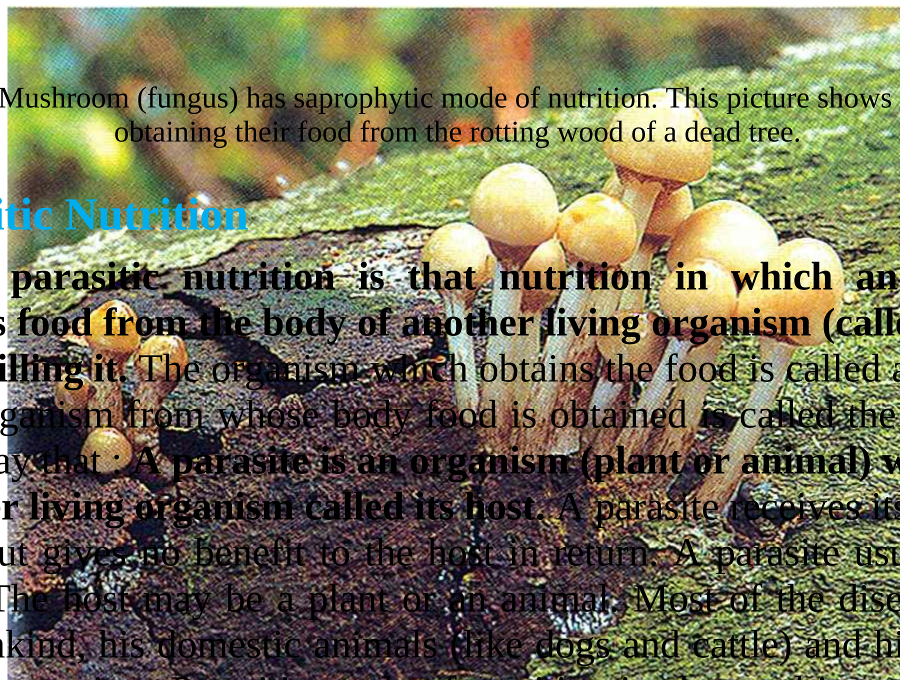


Figure 9. Mushroom (fungus) has saprophytic mode of nutrition. This picture shows mushrooms obtaining their food from the rotting wood of a dead tree.

2. Parasitic Nutrition

The parasitic nutrition is that nutrition in which an organism derives its food from the body of another living organism (called its host) without killing it. The organism which obtains the food is called a 'parasite', and the organism from whose body food is obtained is called the 'host'. We can now say that : **A parasite is an organism (plant or animal) which feeds on another living organism called its host**. A parasite receives its food from the host but gives no benefit to the host in return. A parasite usually harms the host. The host may be a plant or an animal. Most of the diseases which affect mankind, his domestic animals (like dogs and cattle) and his crops are caused by parasites. Parasitic mode of nutrition is observed in several fungi, bacteria, a few plants like *Cuscuta* (*amarbel*) and some animals like *Plasmodium* and roundworms. Thus, the micro-organism '*Plasmodium*' (which causes malaria disease) is a parasite. Roundworm which causes diseases in man and domestic animals (like dogs and cattle) is also a parasite. Roundworms live inside the body of man and his domestic animals. Several fungi and bacteria, and plants like *Cuscuta* (*amarbel*) are also parasites. Some other examples of parasites are ticks, lice, leeches and tapeworms.

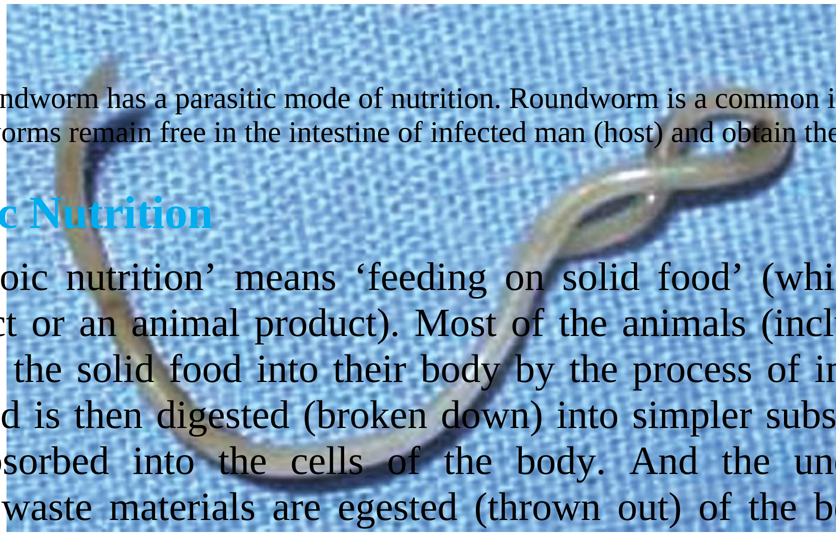


Figure 10. Roundworm has a parasitic mode of nutrition. Roundworm is a common intestinal parasite of man. Roundworms remain free in the intestine of infected man (host) and obtain their food from him.

3. Holozoic Nutrition

'Holozoic nutrition' means 'feeding on solid food' (which may be a plant product or an animal product). Most of the animals (including human beings) take the solid food into their body by the process of ingestion. The ingested food is then digested (broken down) into simpler substances which are then absorbed into the cells of the body. And the undigested and unabsorbed waste materials are egested (thrown out) of the body. We can now say that : **The holozoic nutrition is that nutrition in which an organism takes the complex organic food materials into its body by the process of ingestion, the ingested food is digested and then absorbed into the body cells of the organism.** The undigested and unabsorbed part of the food is thrown out of the body of the organism by the process of egestion. The human beings and most of the animals have a holozoic mode of nutrition. In other words, man, cat, dog, cattle, deer, tiger, lion, bear, giraffe, frog, fish and *Amoeba*, etc., have the holozoic mode of nutrition.

Figure 11. Giraffe has a holozoic mode of nutrition. This picture shows a giraffe eating the leaves from a tree.

NUTRITION IN PLANTS

Just like other organisms, plants also require food which can supply energy for their various metabolic activities. Though animals can move from one place to another in search of food, plants just stand still at one place and make their own food. Green plants are autotrophic and synthesize their own food by the process of photosynthesis. 'Photo' means 'light' and 'synthesis' means 'to build', thus 'photosynthesis' means 'building up by light'. The plants use the energy in sunlight to prepare food from carbon dioxide and water in the presence of chlorophyll. Chlorophyll is present in the green coloured bodies called 'chloroplasts' inside the plant cells. In fact, the leaves of a plant are green because they contain tiny green coloured organelles called chloroplasts (which contain chlorophyll). Keeping these points in mind, we can now define the process of photosynthesis as follows :

Figure 12. This is chlorophyll. It has been extracted from the green leaves of plants.

Figure 13. Chlorophyll is present in tiny organelles called chloroplasts inside the photosynthetic cells of leaves.

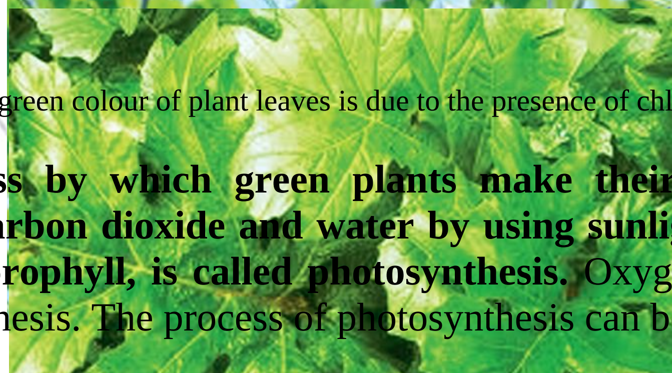


Figure 14. The green colour of plant leaves is due to the presence of chlorophyll in them.

The process by which green plants make their own food (like glucose) from carbon dioxide and water by using sunlight energy in the presence of chlorophyll, is called photosynthesis. Oxygen gas is released during photosynthesis. The process of photosynthesis can be represented as :

$$\underset{\substack{\text{Carbon dioxide}\\\text{(From air)}}}{6CO_2} + \underset{\substack{\text{Water}\\\text{(From soil)}}}{6H_2O} + \underset{\text{(From sun)}}{\text{Light energy}} \xrightarrow[\text{(Photosynthesis)}]{\text{Chlorophyll}} \underset{\substack{\text{Glucose}\\\text{(A food)}}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2}$$

The process of photosynthesis takes place in the green leaves of a plant. In other words, food is made in the green leaves of the plant. The green leaves of a plant make the food by combining carbon dioxide and water in the presence of sunlight and chlorophyll. This is shown clearly in Figure 15. The carbon dioxide gas required for making food is taken by the plant leaves from the air. This carbon dioxide enters the leaves through tiny pores in them called stomata. Water required for making food is taken from the soil. This water is transported to the leaves from the soil through the roots and stem. The sunlight provides energy required to carry out the chemical reactions involved in the preparation of food. The green pigment called chlorophyll present in green leaves helps in absorbing energy from sunlight. Oxygen gas is produced as a by-product during the preparation of food by photosynthesis. This oxygen gas goes into the air.

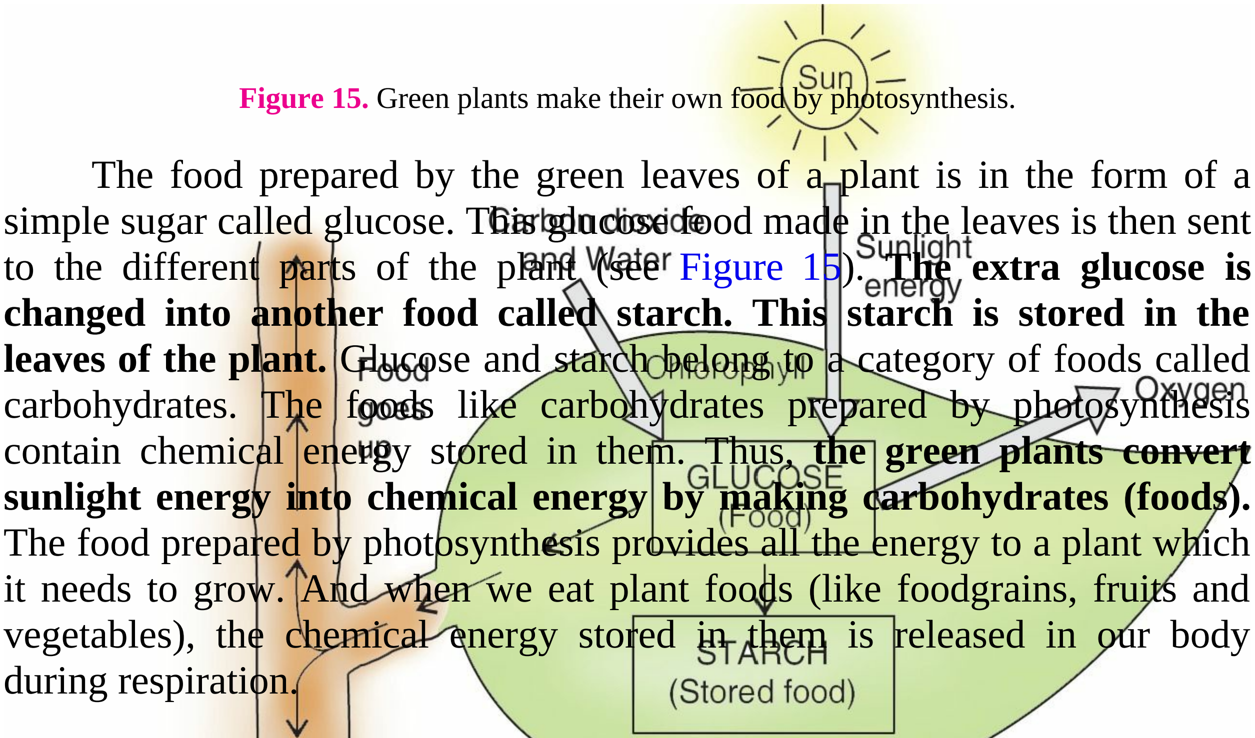


Figure 15. Green plants make their own food by photosynthesis.

The food prepared by the green leaves of a plant is in the form of a simple sugar called glucose. This glucose food made in the leaves is then sent to the different parts of the plant (see Figure 15). **The extra glucose is changed into another food called starch. This starch is stored in the leaves of the plant.** Glucose and starch belong to a category of foods called carbohydrates. The foods like carbohydrates prepared by photosynthesis contain chemical energy stored in them. Thus, **the green plants convert sunlight energy into chemical energy by making carbohydrates (foods).** The food prepared by photosynthesis provides all the energy to a plant which it needs to grow. And when we eat plant foods (like foodgrains, fruits and vegetables), the chemical energy stored in them is released in our body during respiration.

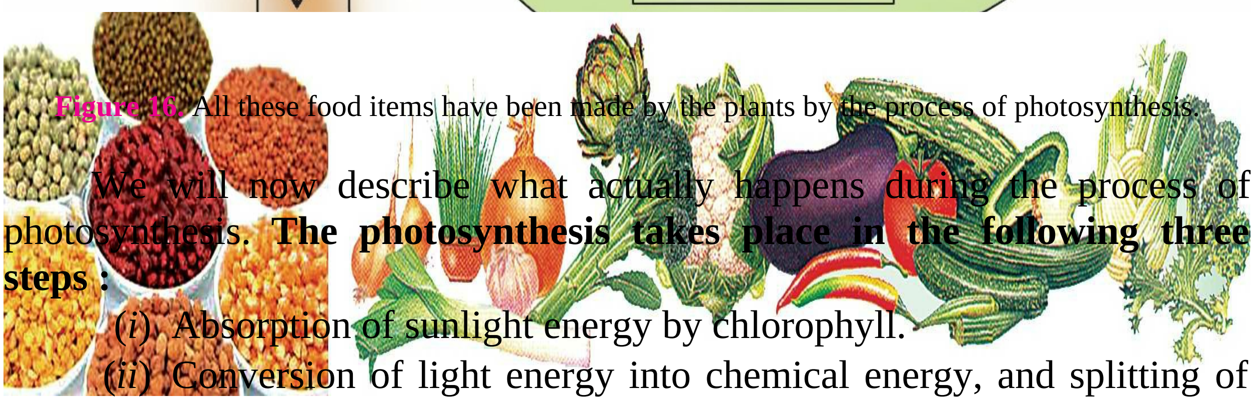


Figure 16. All these food items have been made by the plants by the process of photosynthesis.

We will now describe what actually happens during the process of photosynthesis. **The photosynthesis takes place in the following three steps :**

(*i*) Absorption of sunlight energy by chlorophyll.

(*ii*) Conversion of light energy into chemical energy, and splitting of water into hydrogen and oxygen by light energy.

(*iii*) Reduction of carbon dioxide by hydrogen to form carbohydrate like glucose by utilising the chemical energy (obtained by the transformation of light energy).

Please note that the three steps involved in photosynthesis need not take place one after the other immediately. They can take place at different times. For example, desert plants take up carbon dioxide at night and prepare an intermediate product which is acted upon by the sunlight energy absorbed by chlorophyll when the sun shines during the next day.

Conditions Necessary for Photosynthesis

It has been found by experiments that the presence of sunlight, chlorophyll, carbon dioxide and water is necessary for the process of photosynthesis. So, we can say that : The conditions necessary for photosynthesis to take place are :

1. Sunlight,
2. Chlorophyll,
3. Carbon dioxide, and
4. Water.

Please note that the conditions necessary for photosynthesis are also the conditions necessary for autotrophic nutrition. We will now describe some **experiments to show that sunlight, chlorophyll and carbon dioxide are necessary for photosynthesis by green plants.** These experiments will also show that leaves finally make 'starch' as food by photosynthesis.

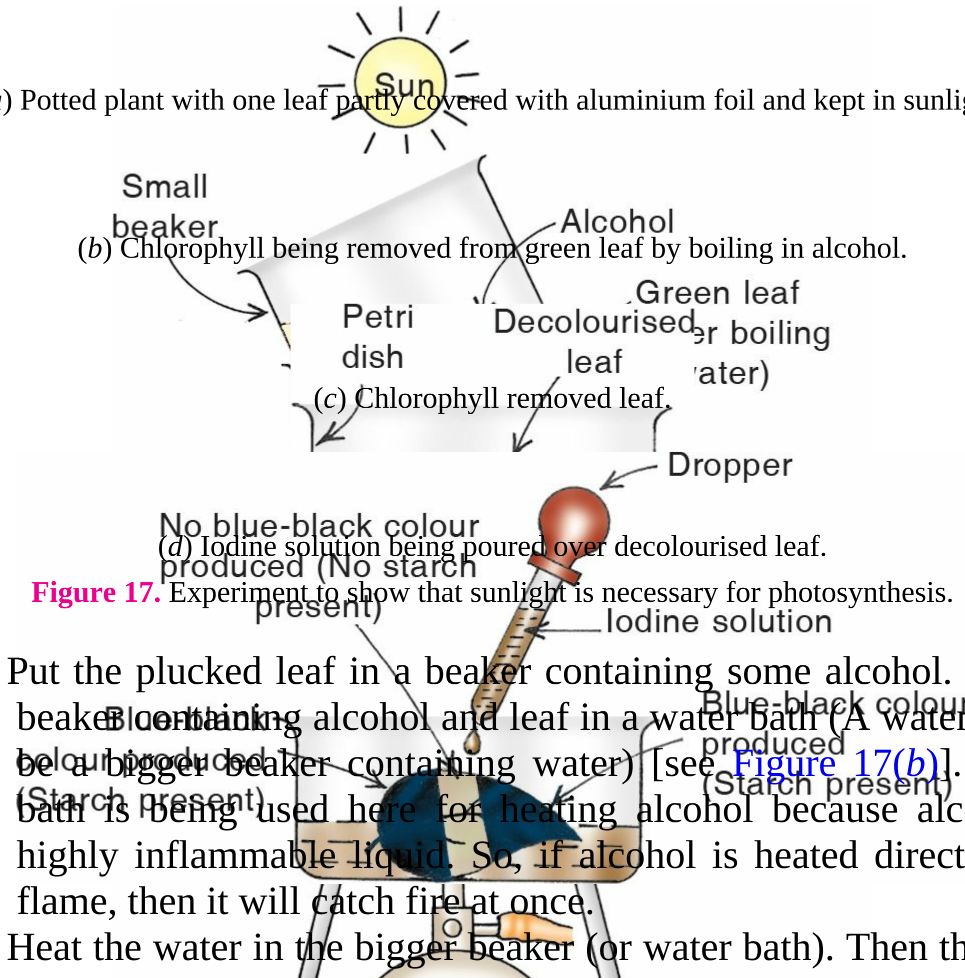
The experiments on photosynthesis depend on the fact that **green leaves make starch as food.** And that **starch gives a blue-black colour with iodine solution.** Now, ordinarily all the plants have starch in their green leaves, so before we can use a plant in a photosynthesis experiment, the initial starch present in its leaves must be removed. In other words, **we should destarch the leaves of a plant before using it in a photosynthesis experiment.** The green leaves of a plant are destarched by keeping this plant in a completely dark place in a room for at least three days.

When the plant is kept in a dark place, it cannot make more starch (food) by photosynthesis because there is no sunlight. So, the plant kept in dark place uses the starch already stored in its leaves during respiration. **The plant will use up all the starch stored in its leaves in about three days' time.** So, after about three days, the plant leaves will not have any starch left in them. And we say that the leaves have been destarched. This plant with destarched leaves can now be used in the photosynthesis experiments. Please note that we will be using a plant growing in a pot in these experiments. The 'plant growing in a pot' is called 'potted plant'. Let us describe the experiments now.

1. Experiment to Show that Sunlight is Necessary for Photosynthesis

1. We take a potted plant having green leaves and place it in a completely dark place for about three days to destarch its leaves. So, in the beginning of the experiment, the leaves do not have any starch in them.

2. Take a thin strip of aluminium foil (or black paper) and wrap it in the centre of one leaf on both the sides (while the leaf is still attached to the plant) [see Figure 17(*a*)]. The aluminium foil should be fixed tightly to the leaf by using paper clips so that sunlight may not enter it from the sides. The aluminium foil should cover only a small part of the leaf so that the remaining part of the leaf remains uncovered and exposed to sunlight [see Figure 17(*a*)]. We have covered the centre part of the leaf with aluminium foil so that sunlight may not fall on this covered part of the leaf.
3. Keep this potted plant (with partially covered leaf) in bright sunshine for three to four days [see Figure 17(*a*)].
4. Pluck the partially covered leaf from the plant and remove its aluminium foil. Immerse this leaf in boiling water for a few minutes. This will break down the cell membranes of leaf cells and make the leaf more permeable to iodine solution (so that it may reach the starch present inside the leaf cells). This leaf is now to be tested for the presence of starch. But before testing for starch, chlorophyll has to be removed from the leaf. This is because chlorophyll interferes in the test for starch due to its green colour.



(*a*) Potted plant with one leaf partly covered with aluminium foil and kept in sunlight.

(*b*) Chlorophyll being removed from green leaf by boiling in alcohol.

(*c*) Chlorophyll removed leaf.

(*d*) Iodine solution being poured over decolourised leaf.

Figure 17. Experiment to show that sunlight is necessary for photosynthesis.

5. Put the plucked leaf in a beaker containing some alcohol. Place the beaker containing alcohol and leaf in a water bath (A water bath can be a bigger beaker containing water) [see Figure 17(*b*)]. A water bath is being used here for heating alcohol because alcohol is a highly inflammable liquid. So, if alcohol is heated directly over a flame, then it will catch fire at once.
6. Heat the water in the bigger beaker (or water bath). Then the alcohol in the smaller beaker will also get heated and start boiling soon. This boiling alcohol will extract (or remove) chlorophyll from the green leaf.
7. Boil the green leaf in alcohol till all its green pigment 'chlorophyll' is removed. The leaf will now become almost colourless or pale (and the alcohol will turn green).
8. Remove the colourless leaf from alcohol and wash it thoroughly with hot water to soften it and remove any chlorophyll which may be sticking to it.
9. Place the colourless leaf in a petri-dish [see Figure 17(*c*)]. Drop iodine solution over the decolourised leaf with the help of a dropper. Observe the change in colour of leaf.
10. The middle part of leaf which was covered with aluminium foil does not turn blue-black on adding iodine solution showing that no starch is present in this middle part of the leaf [see Figure 17(*d*)]. This is because sunlight could not reach the covered 'middle part' of the

leaf due to which the covered 'middle part' of leaf could not do photosynthesis to make starch.

11. The uncovered part of leaf (on both sides of the aluminium foil) which was exposed to sunlight turns blue-black on adding iodine solution showing that starch is present in this part of leaf [see Figure 17(*d*)]. This means that the part of leaf which was exposed to sunlight could do photosynthesis to make starch.
12. Since the part of leaf which was covered and hidden from sunlight does not contain starch but the part of leaf which was exposed to sunlight contains starch, therefore, we conclude that **sunlight is necessary for photosynthesis (to make food like starch).**

From the above experiment, we actually get two conclusions. That :

(*i*) sunlight is necessary for the process of photosynthesis, and

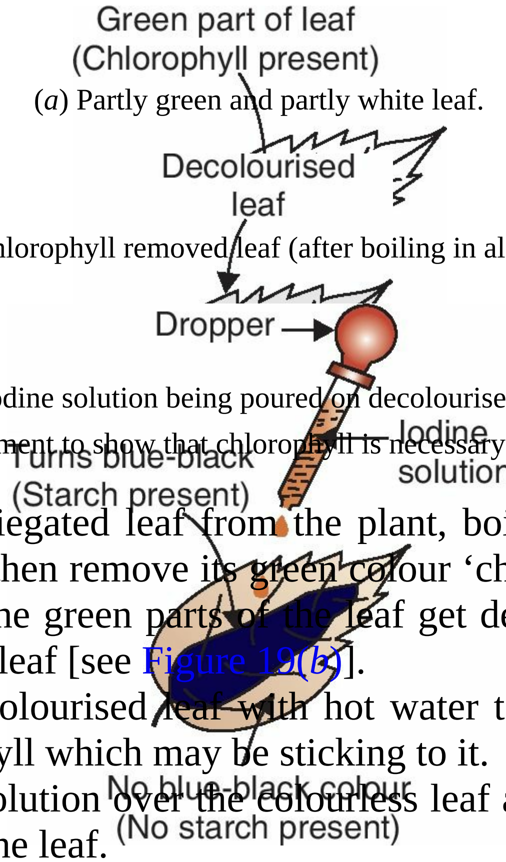
(*ii*) leaves make starch as food by photosynthesis.

Most of the common plants have leaves which are totally green (because all the parts of such leaves contain the green pigment called chlorophyll). But there are some plants whose leaves are partly green and partly white. The green part of such a leaf contains chlorophyll but the white part of such a leaf does not contain chlorophyll. **The leaves which are partly green and partly white are called 'variegated leaves'.** The plants such as croton and *Coleus* have variegated leaves which are partly green and partly white. We will use a plant having variegated leaves in the next experiment to show that chlorophyll is necessary for the process of photosynthesis in plants.

Figure 18. Variegated leaves.

2. Experiment to Show that Chlorophyll is Necessary for Photosynthesis

1. We take a potted plant like croton whose leaves are partly green and partly white [see Figure 19(*a*)]. The green part of the leaf has chlorophyll but the white part of the leaf does not have chlorophyll.
2. Place this plant in a completely dark place for about three days to destarch its leaves.
3. Take out the potted plant from the dark place and keep it in bright sunshine for three to four days.



(*a*) Partly green and partly white leaf.

(*b*) Chlorophyll removed leaf (after boiling in alcohol).

(*c*) Iodine solution being poured on decolourised leaf.

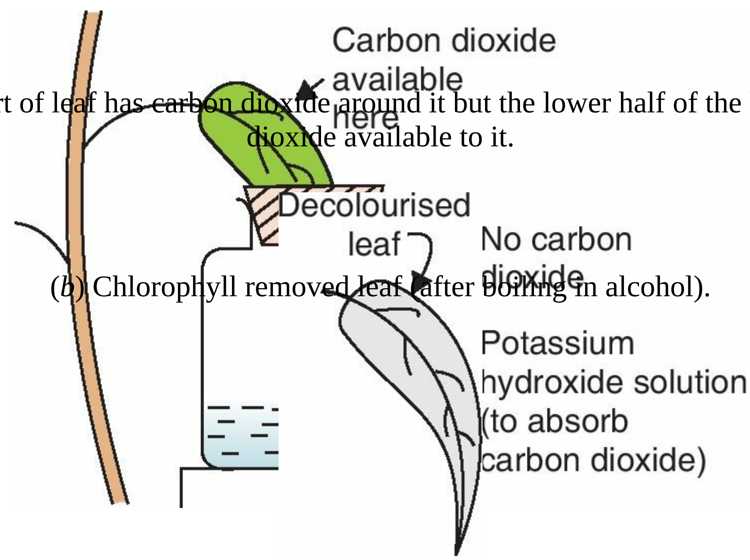
Figure 19. Experiment to show that chlorophyll is necessary for photosynthesis.

4. Pluck the variegated leaf from the plant, boil it in water for a few minutes and then remove its green colour ‘chlorophyll’ by boiling it in alcohol. The green parts of the leaf get decolourised. So, we get decolourised leaf [see Figure 19(*b*)].
5. Wash the decolourised leaf with hot water to soften it and remove any chlorophyll which may be sticking to it.
6. Pour iodine solution over the colourless leaf and observe the change in colour of the leaf.
7. We will find that the outer part of leaf that was originally white (without chlorophyll) does not turn blue-black on adding iodine solution showing that no starch is present in this outer part of the leaf [see Figure 19(*c*)]. From this observation we conclude that the photosynthesis to make starch does not take place without chlorophyll.
8. The inner part of leaf which was originally green (contained chlorophyll) turns blue-black on adding iodine solution showing that starch is present in this inner part of the leaf [see Figure 19(*c*)]. From this observation we conclude that the photosynthesis to make starch takes place in the presence of chlorophyll. In other words, **chlorophyll is necessary for the process of photosynthesis to take place.**

3. Experiment to Show that Carbon Dioxide is Necessary for Photosynthesis

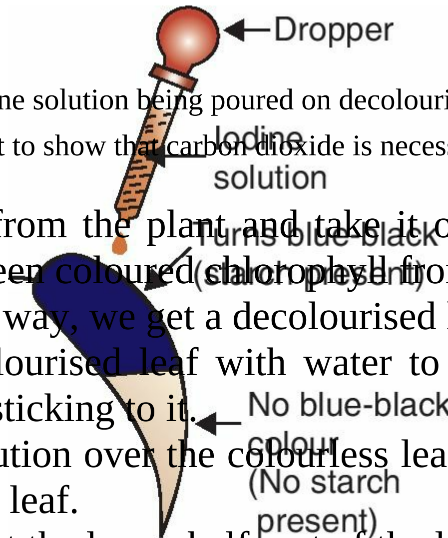
1. We take a potted plant having long and narrow leaves and place it in a completely dark place for about three days to destarch its leaves.

2. Take a glass bottle having a wide mouth and put some potassium hydroxide solution (KOH solution) in it. (This potassium hydroxide solution is to absorb the carbon dioxide gas from the air present in the glass bottle so that no carbon dioxide is left in the air inside the glass bottle).
3. Take a rubber cork which fits tightly into the mouth of the glass bottle and cut it into two halves.
4. Put a destarched leaf of the potted plant (while it is still attached to the plant), in-between the two halves of the cut cork and then fit the cork in the mouth of the glass bottle. The upper half of the leaf should remain outside the glass bottle and only the lower half of the leaf should be inside the glass bottle [as shown in Figure 20(*a*)].
5. The potted plant (with its one destarched leaf half inside the glass bottle containing potassium hydroxide solution) is kept in sunlight for 3 to 4 days. During this period, the upper half of the leaf (which is outside the glass bottle) gets carbon dioxide from the air but the lower half of the leaf (which is inside the glass bottle) does not get any carbon dioxide. This is because all the carbon dioxide of the air present in the glass bottle has been absorbed by potassium hydroxide solution. And no fresh air can come into the closed glass bottle.



(*a*) The upper part of leaf has carbon dioxide around it but the lower half of the leaf has no carbon dioxide available to it.

(*b*) Chlorophyll removed leaf (after boiling in alcohol).



(*c*) Iodine solution being poured on decolourised leaf.

Figure 20. Experiment to show that carbon dioxide is necessary for photosynthesis.

6. Pluck the leaf from the plant and take it out from the glass bottle. Remove the green coloured chlorophyll from the leaf by boiling it in alcohol. In this way, we get a decolourised leaf [see Figure 20(*b*)].
7. Wash the decolourised leaf with water to remove any chlorophyll which may be sticking to it.
8. Pour iodine solution over the colourless leaf and observe the change in colour of the leaf.
9. We will find that the lower half part of the leaf (which was inside the glass bottle having no carbon dioxide around it), does not turn blue-black on adding iodine solution showing that no starch is present in this lower half of the leaf [see Figure 20(*c*)]. From this observation we conclude that **the photosynthesis to make starch in the leaf does not take place without carbon dioxide.**
10. The upper half part of the leaf (which was outside the glass bottle, having carbon dioxide around it) turns blue-black on adding iodine solution showing that starch is present in this upper half of the leaf [see Figure 20(*c*)]. From this observation we conclude that photosynthesis (to make starch) takes place in the presence of carbon dioxide. In other words, **carbon dioxide is necessary for the process of photosynthesis to take place.**

Raw Materials for Photosynthesis

The preparation of carbohydrates (food) by plants by the process of photosynthesis requires two materials (or substances) : carbon dioxide, and water. Thus, the raw materials for photosynthesis are :

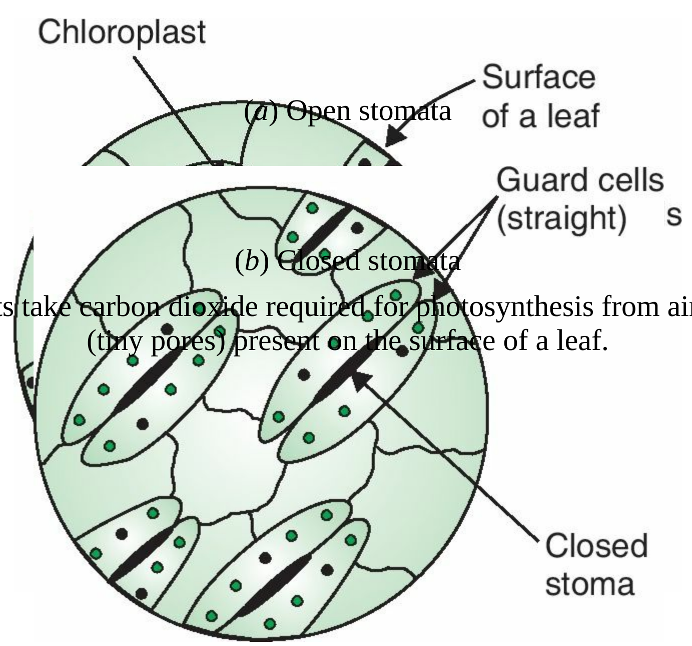
(*i*) Carbon dioxide, and

(*ii*) Water.

We will now describe how these two raw materials become available to plants for photosynthesis.

1. How the Plants Obtain Carbon Dioxide

There are a large number of tiny pores called stomata on the surface of the leaves of plants (The singular of *stomata* is *stoma*). **The green plants take carbon dioxide from air for photosynthesis.** The carbon dioxide gas enters the leaves of the plant through the stomata present on their surface [see Figure 21(*a*)]. Each stomatal pore (or stoma) is surrounded by a pair of guard cells. The opening and closing of stomatal pores is controlled by the guard cells. When water flows into the guard cells, they swell, become curved and cause the pore to open [see Figure 21(*a*)]. On the other hand, when the guard cells lose water, they shrink, become straight and close the stomatal pore [see Figure 21(*b*)]. A large amount of water is also lost from the cells of the plant leaves through open stomatal pores. So, when the plant does not need carbon dioxide and wants to conserve water, the stomatal pores are closed. The oxygen gas produced during photosynthesis also goes out through the stomatal pores of the leaves. Please note that in addition to leaves, the stomata are also present in the green stems (or shoots) of a plant. So, the green stems (or shoots) of a plant also carry out photosynthesis. It is clear from the above discussion that stomata allow the movement of gases in and out of plant cells. In other words, the gaseous exchange in plants takes place through the stomata in leaves (and other green parts). Please note that in most broad-leaved plants, the stomata occur only in the lower surface of the leaf but in narrow-leaved plants, the stomata are equally distributed on both the sides of the leaf. Another point to be noted is that the aquatic plants (or water plants) use the carbon dioxide gas dissolved in water for carrying out photosynthesis.



(*a*) Open stomata

(*b*) Closed stomata

Figure 21. The plants take carbon dioxide required for photosynthesis from air through the stomata (tiny pores) present on the surface of a leaf.

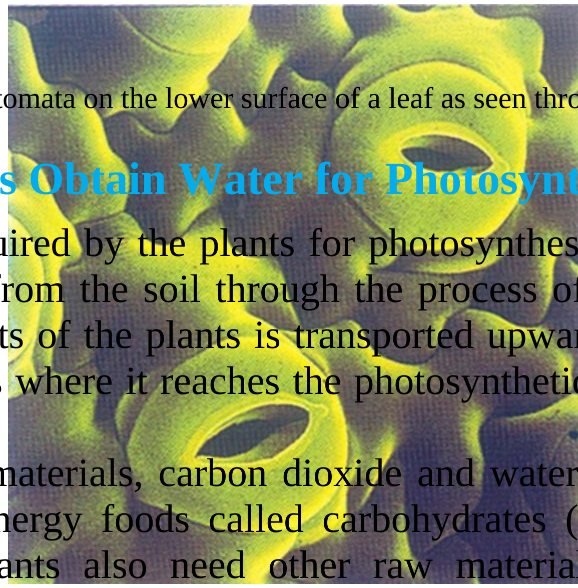


Figure 22. The stomata on the lower surface of a leaf as seen through a microscope.

2. How the Plants Obtain Water for Photosynthesis

The water required by the plants for photosynthesis is absorbed by the roots of the plants from the soil through the process of osmosis. The water absorbed by the roots of the plants is transported upward through the xylem vessels to the leaves where it reaches the photosynthetic cells and utilised in photosynthesis.

The two raw materials, carbon dioxide and water, are required by the plants to prepare energy foods called carbohydrates (such as glucose and starch). But the plants also need other raw materials such as nitrogen, phosphorus, iron and magnesium, etc., for building their body. **The plants take materials like nitrogen, phosphorus, iron and magnesium, etc., from the soil.** For example, nitrogen is an essential element used by the plants to make proteins and other compounds. The plants take up nitrogen from the soil in the form of inorganic salts called nitrates (or nitrites), or in the form of organic compounds which are produced by bacteria from the atmospheric nitrogen.

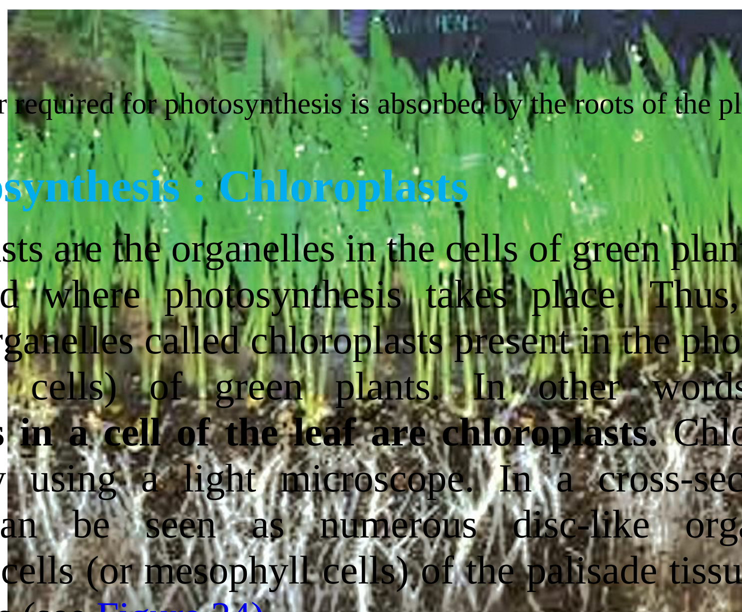


Figure 23. Water required for photosynthesis is absorbed by the roots of the plants from the soil.

Site of Photosynthesis : Chloroplasts

Chloroplasts are the organelles in the cells of green plants which contain chlorophyll and where photosynthesis takes place. Thus, photosynthesis occurs in the organelles called chloroplasts present in the photosynthetic cells (or mesophyll cells) of green plants. In other words, **the site of photosynthesis in a cell of the leaf are chloroplasts.** Chloroplasts can be seen easily by using a light microscope. In a cross-section of a leaf, chloroplasts can be seen as numerous disc-like organelles in the photosynthetic cells (or mesophyll cells) of the palisade tissue just below the upper epidermis (see Figure 24).

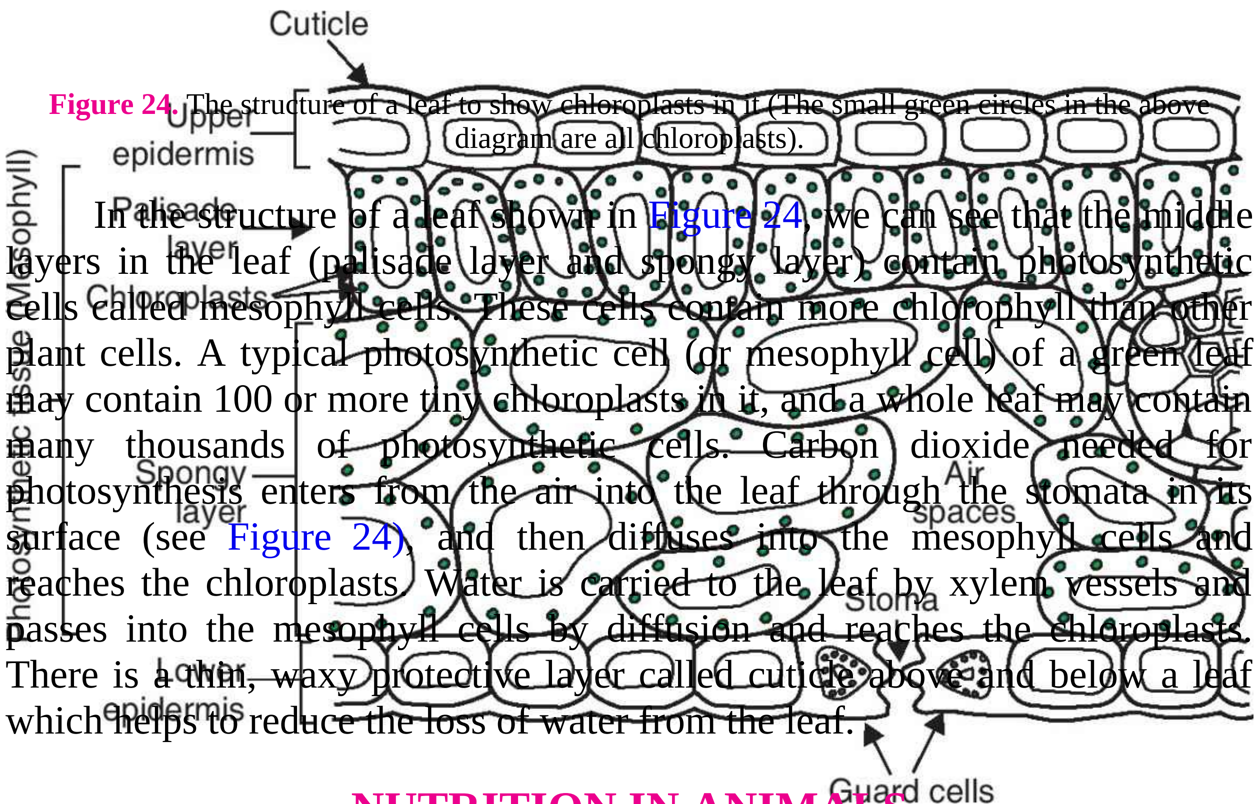


Figure 24. The structure of a leaf to show chloroplasts in it (The small green circles in the above diagram are all chloroplasts).

In the structure of a leaf shown in Figure 24, we can see that the middle layers in the leaf (palisade layer and spongy layer) contain photosynthetic cells called mesophyll cells. These cells contain more chlorophyll than other plant cells. A typical photosynthetic cell (or mesophyll cell) of a green leaf may contain 100 or more tiny chloroplasts in it, and a whole leaf may contain many thousands of photosynthetic cells. Carbon dioxide needed for photosynthesis enters from the air into the leaf through the stomata in its surface (see Figure 24), and then diffuses into the mesophyll cells and reaches the chloroplasts. Water is carried to the leaf by xylem vessels and passes into the mesophyll cells by diffusion and reaches the chloroplasts. There is a thin, waxy protective layer called cuticle above and below a leaf which helps to reduce the loss of water from the leaf.

NUTRITION IN ANIMALS

We have just studied the nutrition in plants. We have learnt that plants are autotrophic organisms which can manufacture their own food. So, plants don't have to look to others for getting their food. They are food producers themselves. But this is not so in the case of animals. Animals are heterotrophs and hence they depend on other organisms for their food. Thus, animals need an external source of food. We will now discuss how animals obtain their food.

Animals Obtain their Food from Plants or Other Animals

Since animals cannot make their own food, they depend on readymade food. This readymade food comes either from 'plants' or from 'other animals'. Thus, **animals obtain their food from plants or other animals (which they eat).** We (human beings) are also animals. We obtain the foods like wheat, rice, pulses (*dal*), fruits and vegetables from plants. And the foods like milk, curd, cheese and eggs are obtained from animals. Some people also eat meat, chicken and fish as food. These foods are also obtained from animals.

Many other animals obtain their food by eating the flesh of other animals. For example, the fish, birds, snakes and insects, all obtain their food from other animals. The big fish eats small fish; the birds eat worms and insects; the snake eats frogs and the insects eat dead bodies of animals. The non-green plants (which cannot make their own food by photosynthesis) also obtain their food from other plants and animals. Yeast plant is one such example. Even the plants can eat insects. For example, **the pitcher plant and the venus fly-trap are the two plants which eat insects.**

(*a*) A fly sitting on the leaf of venus fly-trap plant

(*b*) The leaf of venus fly-trap plant folds up capturing the fly (which is its prey)

Figure 25. Even some of the plants can eat insects. Venus fly-trap plant is one such plant.

All the animals can be divided into three groups on the basis of their food habits (or eating habits). These are :

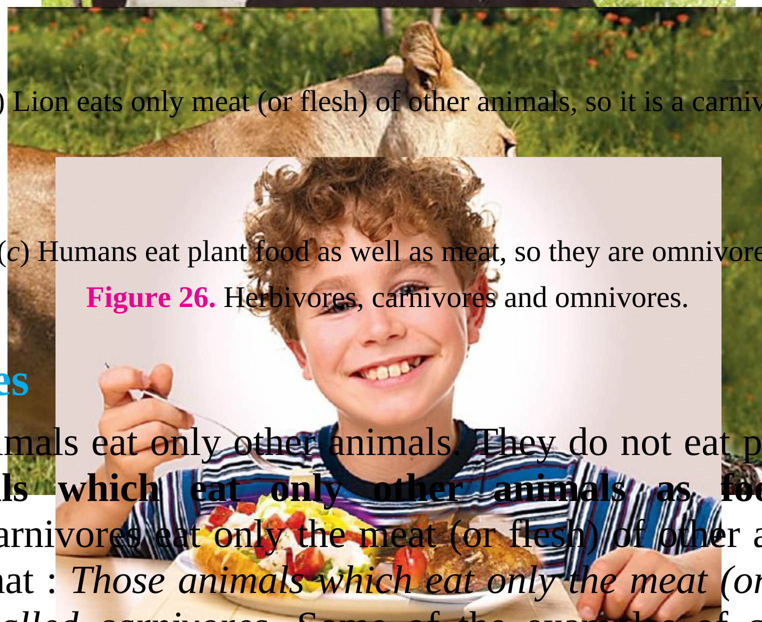
(*i*) **Herbivores,**
(*ii*) **Carnivores,** and
(*iii*) **Omnivores.**

We will now discuss herbivores, carnivores and omnivores in somewhat detail. Let us start with the herbivores.

1. Herbivores

Some animals eat only plants (or their products). **Those animals which eat only plants are called herbivores.** The herbivores may eat grasses, leaves, grains, fruits or the bark of trees. Some of the examples of herbivores are : Goat, Cow, Buffalo, Sheep, Horse, Deer, Camel, Ass, Ox, Elephant, Monkey, Squirrel, Rabbit, Grasshopper and Hippopotamus. Cow is called a herbivore because it eats only plants as food. Thus, **herbivores are plant eaters.** Herbivores are also called herbivorous animals.

(*a*) Cow eats only plant food (like grass), so it is a herbivore



(*b*) Lion eats only meat (or flesh) of other animals, so it is a carnivore

(*c*) Humans eat plant food as well as meat, so they are omnivores

Figure 26. Herbivores, carnivores and omnivores.

2. Carnivores

Some animals eat only other animals. They do not eat plant food at all. **Those animals which eat only other animals as food are called carnivores.** Carnivores eat only the meat (or flesh) of other animals. So, we can also say that : *Those animals which eat only the meat (or flesh) of other animals are called carnivores.* Some of the examples of carnivores are : Lion, Tiger, Frog, Vulture, Kingfisher, Lizard, Wolf, Snake and Hawk. Lion is called a carnivore because it eats only the meat (or flesh) of other animals like deer, rabbit, goat, etc. Thus, **carnivores are meat eaters.** Carnivores are also called carnivorous animals.

3. Omnivores

Some animals eat both, plants as well as other animals as food. **Those animals which eat both, plants and animals, are called omnivores.** In other words, the omnivores eat plant food as well as the meat (or flesh) of other animals. Some of the examples of omnivores are : Man (Human beings), Dog, Crow, Sparrow, Bear, Mynah, and Ant. Man is called an omnivore because he eats the plant food (such as grains, pulses, fruits and vegetables) as well as the meat of animals (such as goat, chicken and fish). Thus, **omnivores are plant eaters as well as meat eaters.** Omnivores are also called omnivorous animals.

All the living things on earth actually depend on the sun for their food. This has been shown clearly in Figure 27 given below :

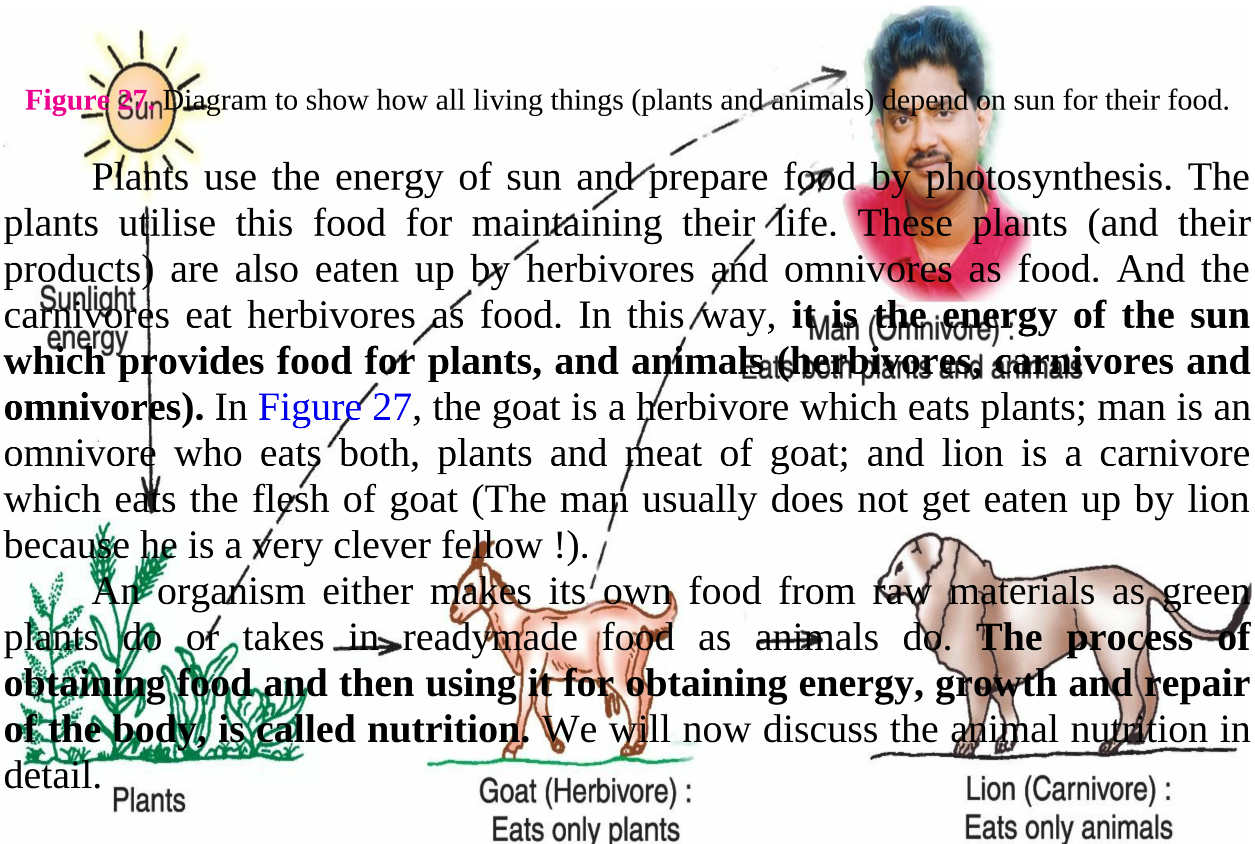


Figure 27. Diagram to show how all living things (plants and animals) depend on sun for their food.

Plants use the energy of sun and prepare food by photosynthesis. The plants utilise this food for maintaining their life. These plants (and their products) are also eaten up by herbivores and omnivores as food. And the carnivores eat herbivores as food. In this way, **it is the energy of the sun which provides food for plants, and animals (herbivores, carnivores and omnivores).** In Figure 27, the goat is a herbivore which eats plants; man is an omnivore who eats both, plants and meat of goat; and lion is a carnivore which eats the flesh of goat (The man usually does not get eaten up by lion because he is a very clever fellow !).

An organism either makes its own food from raw materials as green plants do or takes in readymade food as animals do. **The process of obtaining food and then using it for obtaining energy, growth and repair of the body, is called nutrition.** We will now discuss the animal nutrition in detail.

Different Steps in the Process of Nutrition in Animals

There are five main processes concerned with the use of food by animals. In other words, there are five steps in the process of nutrition in animals. These are : Ingestion, Digestion, Absorption, Assimilation and Egestion. All these steps are discussed below :

1. Ingestion

In order to provide the energy necessary for growth and carry on life’s activities, we must ‘eat food’ or ‘take food into the body’. **The process of taking food into the body is called ingestion.** In most simple terms, ingestion means ‘eating of food’ by the animal. When we put food into our mouth with hands, we are ingesting (the food).

2. Digestion

The food of most animals consists of large insoluble molecules which cannot be absorbed by the animal’s body in this form. So, before the food can be used by the animal for various functions like getting energy or for growth, it must be broken down into small, water soluble molecules which can be absorbed by the body. **The process in which the food containing large, insoluble molecules is broken down into small, water soluble molecules (which can be absorbed by the body) is called digestion.** In most simple terms, digestion is the dissolving of the solid food. Digestion makes the food soluble so that it can be utilised by the animal's body. Most animals use both, physical and chemical methods for digesting (breaking up) the large food molecules. Physical methods include chewing and grinding the food in mouth and chemical methods include the addition of digestive juices (enzymes) to food by the body itself.

Figure 28. Our food contains very big molecules of carbohydrates (like starch), fats and proteins which cannot be absorbed in the body as such. They must be broken down into small, water soluble molecules which can be absorbed by the body. This happens in the process of digestion.

3. Absorption

After digestion, the food molecules become small and soluble. The soluble food molecules can pass through the walls of our intestine and go into blood. **The process in which the digested food passes through the intestinal wall into blood stream is called absorption.**

4. Assimilation

Blood carries the absorbed food to all the parts of the body. The food then enters each and every cell of the body where it is used for producing energy and for making materials for the growth and repair of the body. **The process in which the absorbed food is taken in by body cells and used for energy, growth and repair, is called assimilation.**

5. Egestion

The whole food which we eat is not digested by our body. A part of the food which we eat remains undigested (or insoluble) which cannot be used by the body. This undigested part of the food is then removed from the body in the form of faeces when we go to toilet. **The process in which the undigested food is removed from the body is called egestion.**

Nutrition in Simple Animals

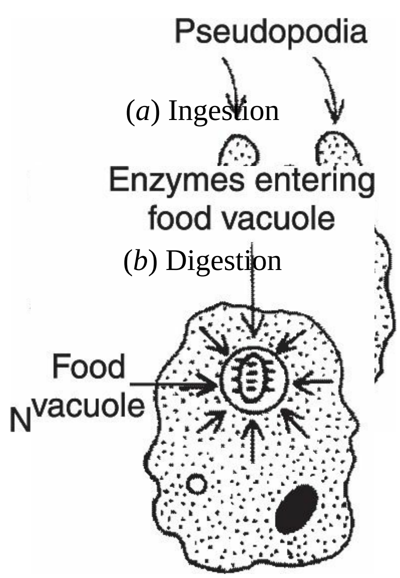
Amoeba and *Paramecium* are two very simple animals. The body of each one of them consists of a single cell only. They are called unicellular animals. **In unicellular animals, all the processes of nutrition are performed by the single cell.** This point will become more clear from the following example of the nutrition in *Amoeba*.

NUTRITION IN *AMOEBA*

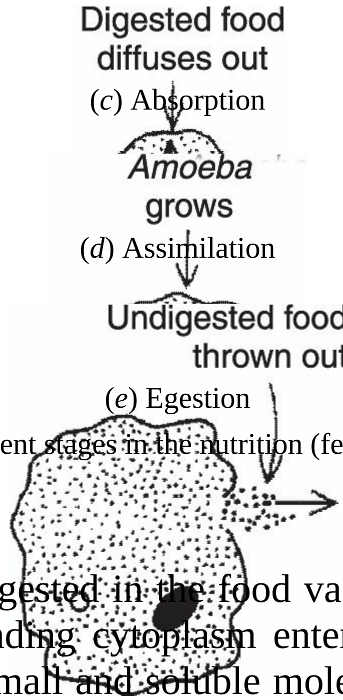
Amoeba is a unicellular animal. *Amoeba* eats tiny (microscopic) plants and animals as food which float in water in which it lives. The mode of nutrition in *Amoeba* is **holozoic.** The process of obtaining food by *Amoeba* is called **phagocytosis** ('Phagocytosis' means 'cell feeding'). The various steps involved in the nutrition of *Amoeba* are : ingestion, digestion, absorption, assimilation, and egestion. All the processes of nutrition are performed by the single cell of *Amoeba*. This is described below.

1. Ingestion

Amoeba has no mouth or a fixed place for the ingestion of food (intake of food). ***Amoeba* ingests food by using its pseudopodia.** When a food particle comes near *Amoeba*, then *Amoeba* ingests this food particle by forming temporary finger-like projections called pseudopodia around it [see Figure 29(*a*)]. The food is engulfed with a little surrounding water to form a food vacuole inside the *Amoeba*. This food vacuole can be considered to be a 'temporary stomach' of *Amoeba*.



(*a*) Ingestion
(*b*) Digestion



(*c*) Absorption

(*d*) Assimilation

(*e*) Egestion

Figure 29. Different stages in the nutrition (feeding) of *Amoeba*.

2. Digestion

In *Amoeba*, food is digested in the food vacuole by digestive enzymes. The enzymes from surrounding cytoplasm enter into the food vacuole and break down the food into small and soluble molecules by chemical reactions [see Figure 29(*b*)]. Thus, digestion in *Amoeba* takes place inside the food vacuole due to which the food dissolves (or food becomes soluble).

3. Absorption

The digested food present in the food vacuole of *Amoeba* is absorbed directly into the cytoplasm of *Amoeba* cell by diffusion [see Figure 29(*c*)]. Since *Amoeba* consists of only one small cell, it does not require blood system to carry the digested food. The digested food just spreads out from the food vacuole into the whole of *Amoeba* cell. After absorption of food, the food vacuole disappears.

4. Assimilation

A part of the food absorbed in *Amoeba* cell is used to obtain energy through respiration. The remaining part of absorbed food is used to make the parts of *Amoeba* cell which lead to the growth of *Amoeba*. Thus, on assimilating food *Amoeba* grows in size [see Figure 29(*d*)]. And then *Amoeba* can reproduce by dividing into two daughter cells.

5. Egestion

Amoeba has no fixed place (like anus) for removing the undigested part of food. When a considerable amount of undigested food collects inside

Amoeba, then its cell membrane suddenly ruptures at any place and the undigested food is thrown out of the body of *Amoeba* [see Figure 29(*e*)].

Paramecium is also a tiny unicellular animal which lives in water. ***Paramecium* uses its hair like structures called cilia to sweep the food particles from water and put them into its mouth** (see Figure 30). The *Paramecium* has thin, hair-like cilia all over its body. The cilia move back and forth rapidly in water. When the cilia present around the mouth region of *Paramecium* move back and forth, they sweep the food particles present in water into the mouth of *Paramecium* (see Figure 30). This is the first step in the nutrition of *Paramecium* which is called ingestion. Ingestion is followed by other steps such as digestion, absorption, assimilation and egestion (as explained in the case of *Amoeba*).

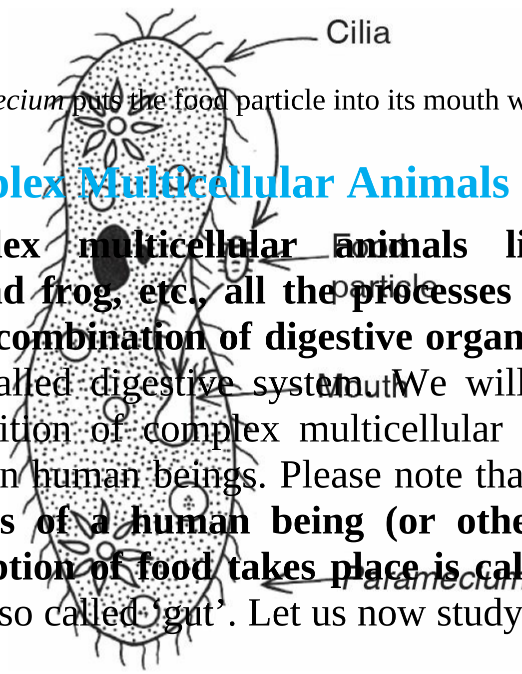


Figure 30. *Paramecium* puts the food particle into its mouth with the help of cilia.

Nutrition in Complex Multicellular Animals

In the complex multicellular animals like man (humans), grasshopper, fish and frog, etc., all the processes involved in nutrition are performed by a combination of digestive organs. This combination of digestive organs is called digestive system. We will now describe all the processes in the nutrition of complex multicellular animals by taking the example of nutrition in human beings. Please note that **a long tube running from mouth to anus of a human being (or other animals) in which digestion and absorption of food takes place is called alimentary canal**. Alimentary canal is also called 'gut'. Let us now study the nutrition in human beings.

NUTRITION IN HUMAN BEINGS
(Human Digestive System)

The nutrition in human beings (or man) takes place through human digestive system. The human digestive system consists of the alimentary canal and its associated glands. **The various organs of the human digestive system in sequence are : Mouth, Oesophagus (or Food pipe), Stomach, Small intestine and Large intestine. The glands which are associated with the human digestive system and form a part of the human digestive**

system are : Salivary glands, Liver and Pancreas. The human alimentary canal which runs from mouth to anus is about 9 metres long tube. The ducts of various glands open into the alimentary canal and pour the secretions of the digestive juices into the alimentary canal. The human digestive system is shown in Figure 32. We will now describe the various steps of nutrition in human beings (or man).

Figure 31. The digestion of food starts as soon as we put food in our mouth.

1. Ingestion

The human beings have a special organ for the ingestion of food. It is called mouth. So, in human beings, food is ingested through the mouth. The food is put into the mouth with the help of hands.

2. Digestion

In human beings, the digestion of food begins in the mouth itself. In fact, the digestion of food starts as soon as we put food in our mouth. This happens as follows : The mouth cavity (or buccal cavity) contains teeth, tongue, and salivary glands. The teeth cut the food into small pieces, chew and grind it. So, **the teeth help in physical digestion.** The salivary glands in our mouth produce saliva. Our tongue helps in mixing this saliva with food. Saliva is a watery liquid so it wets the food in our mouth. The wetted food can be swallowed more easily. Many times we have observed that when we see or eat a food which we really like, our mouth ‘waters’. This watering of mouth is due to the production of saliva by the salivary glands in the mouth. The **salivary glands help in chemical digestion by secreting enzymes.** The human saliva contains an enzyme called salivary amylase which digests the starch present in food into sugar. Thus, the digestion of starch (carbohydrate) begins in the mouth itself. Since the food remains in the mouth only for a short time, so the digestion of food remains incomplete in mouth.

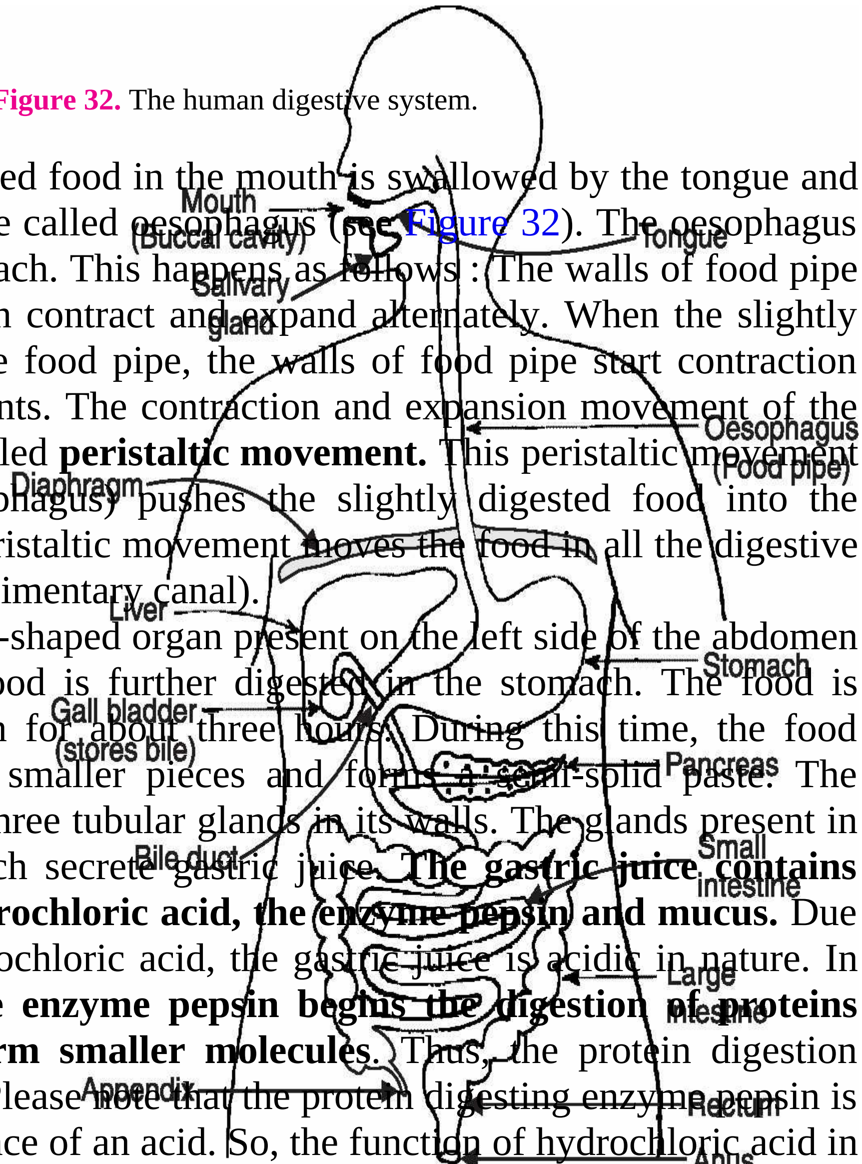


Figure 32. The human digestive system.

The slightly digested food in the mouth is swallowed by the tongue and goes down the food pipe called oesophagus (see Figure 32). The oesophagus carries food to the stomach. This happens as follows : The walls of food pipe have muscles which can contract and expand alternately. When the slightly digested food enters the food pipe, the walls of food pipe start contraction and expansion movements. The contraction and expansion movement of the walls of food pipe is called **peristaltic movement.** This peristaltic movement of food pipe (or oesophagus) pushes the slightly digested food into the stomach (In fact, the peristaltic movement moves the food in all the digestive organs throughout the alimentary canal).

The stomach is a J-shaped organ present on the left side of the abdomen (see Figure 32). The food is further digested in the stomach. The food is churned in the stomach for about three hours. During this time, the food breaks down into still smaller pieces and forms a semi-solid paste. The stomach wall contains three tubular glands in its walls. The glands present in the walls of the stomach secrete gastric juice. **The gastric juice contains three substances : hydrochloric acid, the enzyme pepsin and mucus.** Due to the presence of hydrochloric acid, the gastric juice is acidic in nature. In the acidic medium, **the enzyme pepsin begins the digestion of proteins present in food to form smaller molecules**. Thus, the protein digestion begins in the stomach. Please note that the protein digesting enzyme pepsin is active only in the presence of an acid. So, the function of hydrochloric acid in the stomach is to make the medium of gastric juice acidic so that the enzyme pepsin can digest the proteins properly. Another function of hydrochloric acid is that it kills any bacteria which may enter the stomach with food. The mucus helps to protect the stomach wall from its own secretions of hydrochloric acid. If mucus is not secreted, hydrochloric acid will cause the erosion of inner lining of stomach leading to the formation of ulcers in the stomach. The partially digested food then goes from the stomach into the small intestine. The exit of food from stomach is regulated by a ‘sphincter muscle’ which releases it in small amounts into the small intestine.

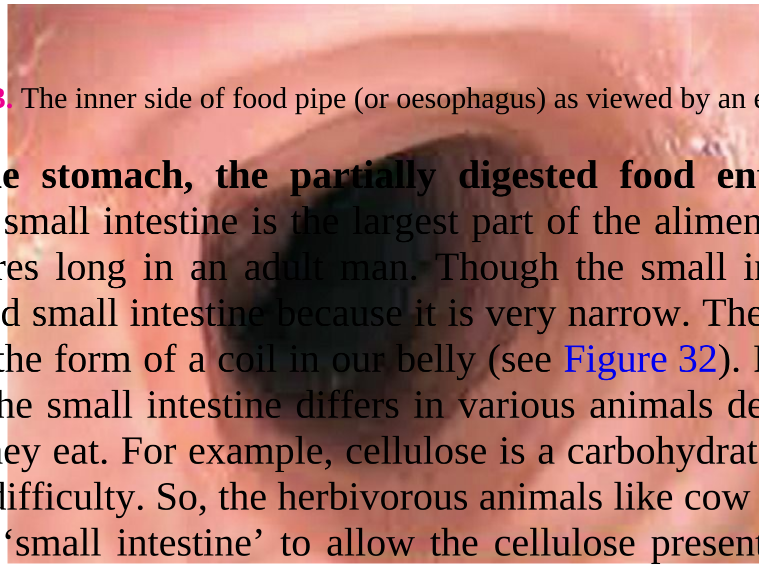


Figure 33. The inner side of food pipe (or oesophagus) as viewed by an endoscope.

From the stomach, the partially digested food enters the small intestine. The small intestine is the largest part of the alimentary canal. It is about 6.5 metres long in an adult man. Though the small intestine is very long, it is called small intestine because it is very narrow. The small intestine is arranged in the form of a coil in our belly (see Figure 32). Please note that the length of the small intestine differs in various animals depending on the type of food they eat. For example, cellulose is a carbohydrate food which is digested with difficulty. So, the herbivorous animals like cow which eat grass need a longer 'small intestine' to allow the cellulose present in grass to be digested completely. On the other hand, meat is a food which is easier to digest. So, the carnivorous animals like tigers which eat meat have a shorter 'small intestine'.

The small intestine in human beings is the site of complete digestion of food (like carbohydrates, proteins and fats). This happens as follows :

(*a*) The small intestine receives the secretions of two glands : liver and pancreas. Liver secretes bile. Bile is a greenish yellow liquid made in the liver which is normally stored in the gall bladder. Bile is alkaline, and contains salts which help to emulsify or break the fats (or lipids) present in the food. Thus, bile performs two functions : (*i*) makes the acidic food coming from the stomach *alkaline* so that pancreatic enzymes can act on it, and (*ii*) bile salts *break* the fats present in the food into small globules making it easy for the enzymes to act and digest them. Pancreas is a large gland which lies parallel to and beneath the stomach (see Figure 32). Pancreas secretes pancreatic juice which contains digestive enzymes like pancreatic amylase, trypsin and lipase. The enzyme amylase breaks down the starch, the enzyme trypsin digests the proteins and the enzyme lipase breaks down the emulsified fats.

Figure 34. The glands in the walls of the stomach secrete gastric juice containing hydrochloric acid, enzyme pepsin and mucus.

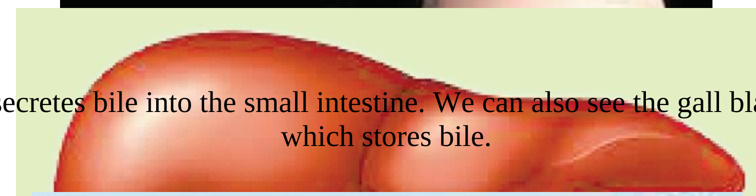


Figure 35. Liver secretes bile into the small intestine. We can also see the gall bladder in this picture which stores bile.

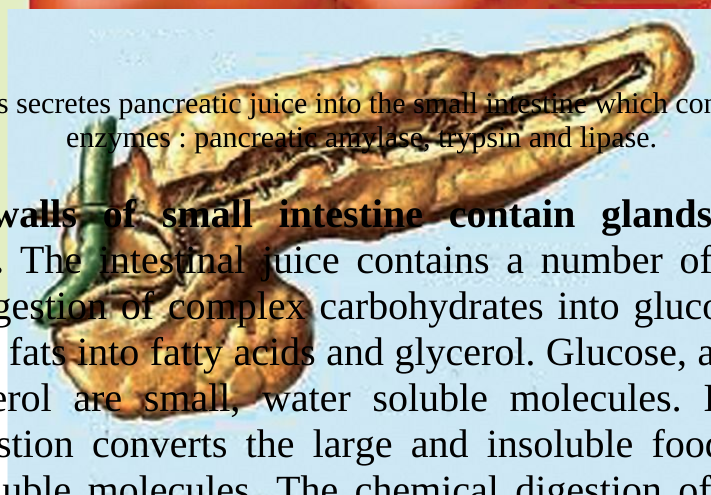


Figure 36. Pancreas secretes pancreatic juice into the small intestine which contains three digestive enzymes : pancreatic amylase, trypsin and lipase.

(*b*) The walls of small intestine contain glands which secrete intestinal juice. The intestinal juice contains a number of enzymes which complete the digestion of complex carbohydrates into glucose, proteins into amino acids and fats into fatty acids and glycerol. Glucose, amino acids, fatty acids and glycerol are small, water soluble molecules. In this way, the process of digestion converts the large and insoluble food molecules into small, water soluble molecules. The chemical digestion of food is brought about by biological catalysts called *enzymes.*

3. Absorption

After digestion, the molecules of food become so small that they can pass through the walls of the small intestine (which contain blood capillaries) and go into our blood. This is called absorption. **The small intestine is the main region for the absorption of digested food.** In fact, the small intestine is especially adapted for absorbing the digested food. The inner surface of small intestine has millions of tiny, finger-like projections called villi. The presence of villi gives the inner walls of the small intestine a very large surface area. And the large surface area of small intestine helps in the rapid absorption of digested food. The digested food which is absorbed through the walls of the small intestine, goes into our blood.

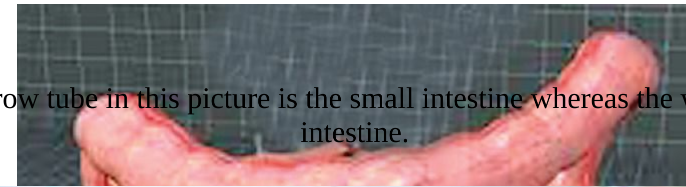


Figure 37. The narrow tube in this picture is the small intestine whereas the wider tube is the large intestine.

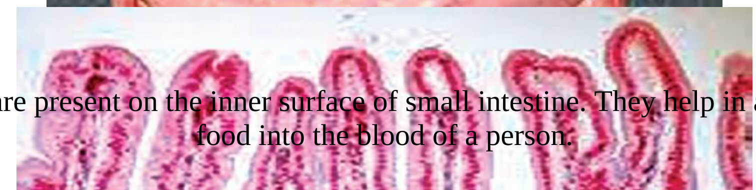


Figure 38. Villi are present on the inner surface of small intestine. They help in absorbing digested food into the blood of a person.

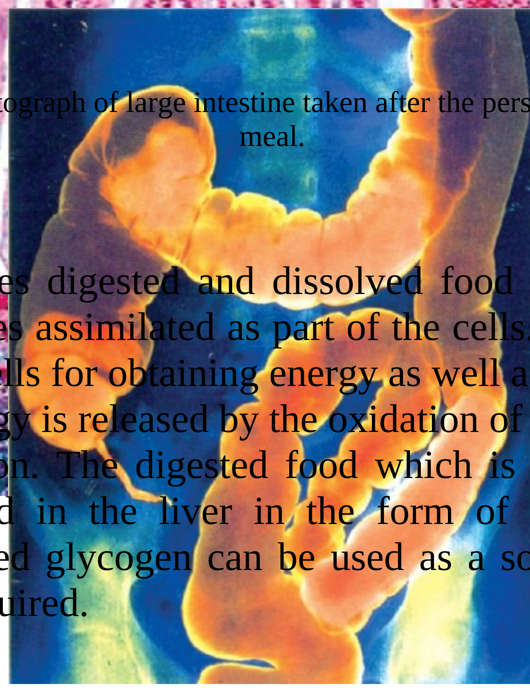


Figure 39. The X-ray photograph of large intestine taken after the person had been given a barium meal.

4. Assimilation

The blood carries digested and dissolved food to all the parts of the body where it becomes assimilated as part of the cells. This assimilated food is used by the body cells for obtaining energy as well as for growth and repair of the body. The energy is released by the oxidation of assimilated food in the cells during respiration. The digested food which is not used by our body immediately is stored in the liver in the form of a carbohydrate called ‘glycogen’. This stored glycogen can be used as a source of energy by the body as and when required.

5. Egestion

A part of the food which we eat cannot be digested by our body. This undigested food cannot be absorbed in the small intestine. So, the undigested food passes from the small intestine into a wider tube called large intestine (see Figure 32) (It is called large intestine because it is a quite wide tube). The walls of large intestine absorb most of the water from the undigested food (with the help of villi). Due to this, the undigested part of food becomes almost solid. The last part of the large intestine called ‘rectum’ stores this undigested food for some time. And when we go to the toilet, then this undigested food is passed out (or egested) from our body through anus as faeces or ‘stool’ (see Figure 32). The act of expelling the faeces is called **egestion** or **defecation.** The exit of faeces is controlled by the anal sphincter.

Let us solve one problem now.

Sample Problem. 1 mL of very dilute starch solution (1% starch solution) is taken in a test-tube and 1 mL of saliva is added to it. After keeping this mixture for half an hour, a few drops of dilute iodine solution are added to the test-tube. There is no change in colour on adding iodine solution. What does this tell you about the action of saliva on starch ?

Answer. When a mixture of dilute starch solution and saliva is kept in a test-tube for half an hour, it does not produce a blue-black colour with iodine solution showing that no starch is left in the test-tube. This tells us that the action of saliva has broken down starch into some other substance which does not give any colour with iodine solution. Actually, saliva contains an enzyme ‘amylase’ which converts starch into a sugar.

Dental Caries

The hard, outer covering of a tooth is called enamel (see Figure 40). Tooth enamel is the hardest material in our body. It is harder than even bones. The part of tooth below enamel is called dentine. Dentine is similar to bone. Inside the dentine is pulp cavity. The pulp cavity contains nerves and blood vessels. **The formation of small cavities (or holes) in the teeth due to the action of acid-forming bacteria and improper dental care is called dental caries.** This happens as follows.

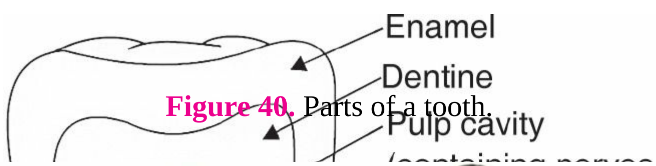


Figure 40. Parts of a tooth.

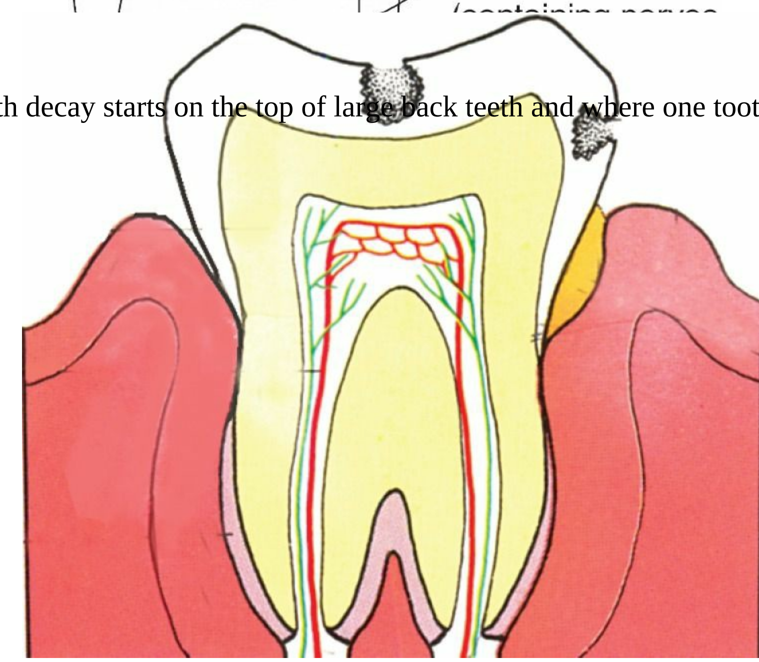


Figure 41. Tooth decay starts on the top of large back teeth and where one tooth touches another.

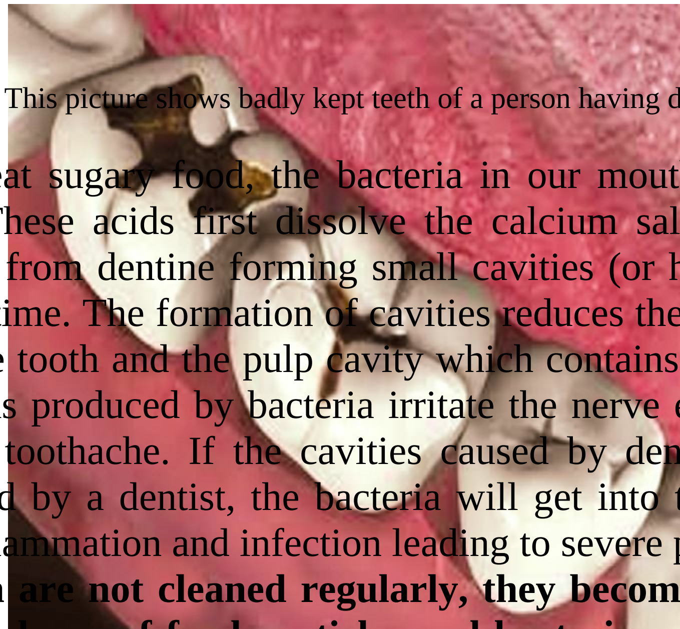


Figure 42. This picture shows badly kept teeth of a person having dental caries.

When we eat sugary food, the bacteria in our mouth act on sugar to produce acids. These acids first dissolve the calcium salts from the tooth enamel and then from dentine forming small cavities (or holes) in the tooth over a period of time. The formation of cavities reduces the distance between the outside of the tooth and the pulp cavity which contains nerves and blood vessels. The acids produced by bacteria irritate the nerve endings inside the tooth and cause toothache. If the cavities caused by dental decay are not cleaned and filled by a dentist, the bacteria will get into the pulp cavity of tooth causing inflammation and infection leading to severe pain.

If the teeth are not cleaned regularly, they become covered with a sticky, yellowish layer of food particles and bacteria cells called 'dental plaque'. Since plaque covers the teeth forming a layer over them, the alkaline saliva cannot reach the tooth surface to neutralise the acid formed by bacteria and hence tooth decay sets in. Brushing the teeth regularly, after eating food, removes the plaque before bacteria produces acids. This will prevent dental caries or tooth decay. Before we go further and discuss respiration, **please answer the following questions :**

Very Short Answer Type Questions

1. Which is the basic requirement of living organisms for obtaining energy ?
2. Which of the following type of energy is used by living organisms to perform vital life processes ? Kinetic energy, Chemical energy, Potential energy, Nuclear energy
3. Which of the following is an autotroph ? Green plant or Man
4. Name two inorganic substances which are used by autotrophs to make food.
5. What is the mode of nutrition in fungi ?
6. Name one organism each having saprophytic, parasitic and holozoic modes of nutrition.
7. Name the process by which plants make food.
8. In addition to carbon dioxide and water, state two other conditions necessary for the process of photosynthesis to take place.
9. Apart from sunlight and chlorophyll, what other things are required to make food by photosynthesis ?
10. (*a*) Name a gas used in photosynthesis.
    (*b*) Name a gas produced in photosynthesis.
11. The leaves of a plant first prepare food *A* by photosynthesis. Food *A* then gets converted into food *B*. What are *A* and *B* ?
12. Which substance is used to remove chlorophyll from a green leaf during photosynthesis experiments ?
13. Why do we boil the leaf in alcohol when we are testing it for starch ?
14. (*a*) Name the pigment in leaves which absorbs sunlight energy.
    (*b*) What is the colour of this pigment ?

15. Name the pigment which can absorb solar energy.

16. Name the organelle of plant cells in which photosynthesis occurs.

17. Apart from carbon dioxide and water, name four other raw materials which are needed by the plants.

18. Where is chlorophyll mainly present in a plant ?

19. What is the name of those cells in the leaf of a plant which control the opening and closing of stomata?

20. Name an animal whose process of obtaining food is called phagocytosis.

21. All the animals can be divided into three groups on the basis of their eating habits. Name the three groups.

22. What is the scientific name of the animals which are :

(*i*) only meat eaters ?

(*ii*) only plant eaters ?

(*iii*) both, plant and meat eaters ?

23. Name the green pigment present in the leaves of a plant.

24. Arrange the following processes involved in the nutrition in animals in the correct order (in which they take place) :

Assimilation, Egestion, Ingestion, Absorption, Digestion

25. How does *Amoeba* engulf the food particle ?

26. What substances enter into the food vacuole in *Amoeba* to break down the food ?

27. From which part of the body, undigested food is egested in *Amoeba* ?

28. Name a unicellular animal which uses cilia to move food particles into its mouth.

29. Name the enzyme present in human saliva. What type of food material is digested by this enzyme ?

30. Which of the organs perform the following functions in humans ?

(*i*) Absorption of food

(*ii*) Absorption of water

31. What moves the food in the digestive organs ?

32. What is the other name of food pipe ?

33. What substance is mixed with food in the mouth during chewing by the teeth ?

34. What is the name of tiny projections on the inner surface of small intestine which help in absorbing the digested food ?

35. In which part of the digestive system is water absorbed ?

36. What is the name of the opening in the human body through which undigested food is thrown out ?

37. Where is digested food absorbed into blood in human body ?

38. Name the biological catalysts which bring about chemical digestion of food.

39. Fill in the following blanks with suitable words :

(*a*) All green plants are………………

(*b*) All non-green plants and animals are …………..

(*c*) Heterotrophs depend on………….and other………………. for food.

(*d*) Green plants use………….,…………….and……………to make food.

(*e*) Iodine turns blue-black on reacting with……………………

Short Answer Type Questions

40. (*a*) What is chlorophyll ? What part does chlorophyll play in photosynthesis ?

(*b*) (*i*) Which simple food is prepared first in the process of photosynthesis ?

(*ii*) Name the food which gets stored in plant leaves.

41. (*a*) What criteria can be used to decide whether something is alive ?

(*b*) What is meant by life processes ? Name the basic life processes common to all living organisms which are essential for maintaining life.

42. (*a*) What are autotrophs ? Give one example of autotrophs.

(*b*) What are the conditions necessary for autotrophic nutrition ?

43. (*a*) What are heterotrophs ? Give one example of heterotrophs.

(*b*) What is the difference between autotrophic nutrition and heterotrophic nutrition ?

44. (*a*) Define a nutrient. Name four important nutrients present in our food.

(*b*) What are the various types of heterotrophic nutrition ?

45. (*a*) Photosynthesis converts energy X into energy Y. What are X and Y ?

(*b*) State the various steps involved in the process of photosynthesis.

46. (*a*) How do plants obtain food ?

(*b*) Why do plants need nitrogen ? How do plants obtain nitrogen ?

47. Define (*i*) saprophytic nutrition (*ii*) parasitic nutrition, and (*iii*) holozoic nutrition. Give one example of each type.

48. Define (*i*) saprophyte, and (*ii*) parasite. Name two saprophytes and two parasites.

49. (*a*) How does carbon dioxide from the air enter the leaves of a plant to be used in photosynthesis ?

(*b*) How does water from the soil reach the leaves of a plant to be used in photosynthesis ?

50. What substances are contained in gastric juice ? What are their functions ?

51. What substances are contained in pancreatic juice ? What are their functions ?

52. (*a*) What is the role of hydrochloric acid in our stomach ?

(*b*) What is the function of enzymes in the human digestive system ?

53. (*a*) Which part of the body secretes bile ? Where is bile stored ? What is the function of bile ?

(*b*) What is trypsin ? What is its function ?

54. What are the functions of liver and pancreas in the human digestive system ?

55. Match the organisms given in column I with the processes given in column II :

Column I	*Column II*
(*i*) Leech	(*a*) Holozoic nutrition
(*ii*) *Amoeba*	(*b*) Autotrophic nutrition
(*iii*) Mushroom	(*c*) Parasitic nutrition
(*iv*) Green plant	(*d*) Saprophytic nutrition

56. Name the following :

(*a*) The process in plants which converts light energy into chemical energy.

(*b*) Organisms that cannot prepare their own food.

(*c*) Organisms that can prepare their own food.

(*d*) The cell organelle where photosynthesis occurs.

(*e*) The cells which surround a stomatal pore.

(*f*) An enzyme secreted by gastric glands in stomach which acts on proteins.

57. Match the terms in column I with those in column II :

Column I	*Column II*
(*i*) Trypsin	(*a*) Liver
(*ii*) Amylase	(*b*) Gastric glands
(*iii*) Bile	(*c*) Pancreas
(*iv*) Pepsin	(*d*) Saliva

58. (*a*) What is common for *Cuscuta*, ticks and leeches ?

(*b*) Name the substances on which the following enzymes act in the human digestive system :

(*i*) Trypsin

(*ii*) Amylase

(*iii*) Pepsin
(*iv*) Lipase

(*c*) Why does absorption of digested food occur mainly in the small intestine ?

59. (*a*) Why is small intestine in herbivores longer than in carnivores ?
(*b*) What will happen if mucus is not secreted by the gastric glands ?
(*c*) What causes movement of food inside the alimentary canal ?

60. (*a*) How do guard cells regulate opening and closing of stomatal pores ?
(*b*) Two similar green plants are kept separately in oxygen free containers, one in dark and the other in continuous light. Which one will live longer ? Give reasons.

61. (*a*) What would happen if all the green plants disappear from the earth ?
(*b*) If a plant is releasing carbon dioxide and taking in oxygen during the day, does it mean that there is no photosynthesis occurring ? Justify your answer.

62. (*a*) Leaves of a healthy potted plant were coated with vaseline. Will this plant remain healthy for long ? Give reason for your answer.
(*b*) What will happen to the rate of photosynthesis in a plant under the following circumstances ?
(*i*) cloudy day in morning but bright sunshine in the afternoon
(*ii*) no rainfall in the area for a considerable time.
(*iii*) gathering of dust on the leaves

Long Answer Type Questions

63. (*a*) What is photosynthesis ?
(*b*) Write a chemical equation to show the process of photosynthesis in plants.
(*c*) Explain the mechanism of photosynthesis.

64. (*a*) Name the raw materials required for photosynthesis. How do plants obtain these raw materials ?
(*b*) What are the various conditions necessary for photosynthesis ?
(*c*) Name the various factors which affect the rate of photosynthesis in plants.

65. (*a*) Define nutrition. Why is nutrition necessary for an organism ?
(*b*) What are the different modes of nutrition ? Explain with one example of each mode of nutrition.
(*c*) Name the mode of nutrition in (*i*) roundworm, and (*ii*) *Plasmodium*.

66. (*a*) What are herbivores, carnivores and omnivores ? Give two examples of each.
(*b*) Classify the following into herbivores, carnivores and omnivores : Lion, Man, Dog, Goat, Crow, Elephant, Snake, Hawk, Rabbit, Deer
(*c*) Name the five steps which occur in the process of nutrition in animals.

67. (*a*) Describe the process of nutrition in *Amoeba*. Draw labelled diagrams to show the various steps in the nutrition in *Amoeba*.
(*b*) What is the mode of nutrition in *Amoeba* known as ?
(*c*) What is the process of obtaining food by *Amoeba* called ? What does it mean ?

68. (*a*) Draw a labelled diagram of the human digestive system. With the help of this diagram, describe the process of digestion of food in man (humans).
(*b*) Describe one way in which the small intestine is adapted for the absorption of digested food.
(*c*) What is the special name of the contraction and expansion movement which pushes the food further in our digestive tract (or alimentary canal) ?

69. (*a*) Describe the parts of our tooth with the help of a labelled diagram.
(*b*) What is meant by dental caries ? How are they caused ?
(*c*) What is dental plaque ? What harm can it do ? How can the formation of plaque be

prevented ?

70. (*a*) Name the main organs of the human digestive system. Also name the associated glands.
(*b*) How do carbohydrates, fats and proteins get digested in human beings ?

Multiple Choice Questions (MCQs)

71. Which of the following has the longest small intestine ?
(*a*) carnivore
(*b*) omnivore
(*c*) herbivore
(*d*) autotroph

72. The process of obtaining food by *Amoeba* is known as :
(*a*) dialysis
(*b*) cytokinesis
(*c*) phagocytosis
(*d*) amoebiasis

73. The organism having parasitic mode of nutrition is :
(*a*) *Penicillium*
(*b*) *Plasmodium*
(*c*) *Paramecium*
(*d*) Parrot

74. One of the following organisms has a saprophytic mode of nutrition. This organism is :
(*a*) mushroom
(*b*) malarial parasite
(*c*) leech
(*d*) lice

75. The length of small intestine in a human adult is about :
(*a*) 4.5 m
(*b*) 1.5 m
(*c*) 3.5 m
(*d*) 6.5 m

76. The process of digestion of food in humans begins in :
(*a*) stomach
(*b*) food pipe
(*c*) mouth
(*d*) small intestine

77. The process of digestion in humans is completed in :
(*a*) oesophagus
(*b*) small intestine
(*c*) stomach
(*d*) large intestine

78. In human digestive system, bile is secreted by :
(*a*) pancreas
(*b*) liver
(*c*) kidneys
(*d*) stomach

79. Two of the following organisms have a holozoic mode of nutrition. These organisms are :
(*a*) *Paramecium* and *Plasmodium*
(*b*) *Plasmodium* and Parakeet
(*c*) Parakeet and *Paramecium*
(*d*) *Paramecium* and Parasite

80. The autotrophic mode of nutrition requires :

(*a*) carbon dioxide and water
(*b*) chlorophyll
(*c*) sunlight
(*d*) all of the above

81. The correct order of steps occurring in nutrition in animals is :

(*a*) Ingestion $\longrightarrow$ Absorption $\longrightarrow$ Digestion $\longrightarrow$ Assimilation $\longrightarrow$ Egestion
(*b*) Ingestion $\longrightarrow$ Digestion $\longrightarrow$ Assimilation $\longrightarrow$ Absorption $\longrightarrow$ Egestion
(*c*) Ingestion $\longrightarrow$ Digestion $\longrightarrow$ Absorption $\longrightarrow$ Assimilation $\longrightarrow$ Egestion
(*d*) Ingestion $\longrightarrow$ Assimilation $\longrightarrow$ Digestion $\longrightarrow$ Absorption $\longrightarrow$ Egestion

82. In human digestive system, the enzymes pepsin and trypsin are secreted respectively by :

(*a*) pancreas and liver
(*b*) stomach and salivary glands
(*c*) pancreas and gall bladder
(*d*) stomach and pancreas

83. When carrying out the starch test on a leaf, why is it important to boil the leaf in alcohol ?

(*a*) to dissolve the waxy cuticle
(*b*) to make the cells more permeable to iodine solution
(*c*) to remove the chlorophyll
(*d*) to stop chemical reactions in the cells.

84. Pancreatic juice contains enzymes which digest :

(*a*) proteins and carbohydrates only
(*b*) proteins and fats only
(*c*) fats and carbohydrates only
(*d*) proteins, fats and carbohydrates

85. Which of the following is the correct statement regarding bile ?

(*a*) secreted by bile duct and stored in liver
(*b*) secreted by gall bladder and stored in liver
(*c*) secreted by liver and stored in bile duct
(*d*) secreted by liver and stored in gall bladder

86. Where are proteins first digested in the alimentary canal ?

(*a*) small intestine
(*b*) oesophagus
(*c*) mouth
(*d*) stomach

87. The inner lining of stomach is protected by one of the following from the harmful effect of hydrochloric acid. This is :

(*a*) pepsin
(*b*) mucus
(*c*) saliva
(*d*) bile

88. Which part of alimentary canal receives bile from the liver ?

(*a*) oesophagus
(*b*) small intestine
(*c*) stomach
(*d*) large intestine

89. Which of the following component of our food is digested by an enzyme which is present in saliva as well as in pancreatic juice ?

(*a*) proteins
(*b*) fat
(*c*) minerals
(*d*) carbohydrate

90. If the saliva is lacking in salivary amylase, then which of the following processes taking place in the buccal cavity will be affected ?

(*a*) proteins breaking down into amino acids
(*b*) starch breaking down into sugars
(*c*) fats breaking down into fatty acids and glycerol
(*d*) intestinal layer breaking down leading to ulcers

91. Which of the following are the correct functions of two components of pancreatic juice trypsin and lipase ?

(*a*) trypsin digests proteins and lipase carbohydrates
(*b*) trypsin digests emulsified fats and lipase proteins
(*c*) trypsin digests starch and lipase fats
(*d*) trypsin digests proteins and lipase emulsified fats

92. The oxygen liberated during photosynthesis by green plants comes from :

(*a*) glucose
(*b*) water
(*c*) carbon dioxide
(*d*) chlorophyll

93. Which of the following is an incorrect statement ?

(*a*) energy is essential for life processes
(*b*) organisms grow with time
(*c*) movement of molecules does not take place among cells
(*d*) organisms must repair and maintain their body

94. The internal energy (cellular energy) reserve in autotrophs is :

(*a*) proteins
(*b*) fatty acids
(*c*) glycogen
(*d*) starch

95. Which of the following events does not occur in photosynthesis ?

(*a*) conversion of light energy into chemical energy
(*b*) reduction of carbon dioxide to carbohydrates
(*c*) oxidation of carbon to carbon dioxide
(*d*) absorption of light energy by chlorophyll

96. The opening and closing of the stomatal pores depends upon :

(*a*) oxygen
(*b*) water in guard cells
(*c*) temperature
(*d*) concentration of CO_2 in stomata

97. Most of the plants absorb nitrogen in one of the following forms. This is :

(*a*) proteins
(*b*) nitrates and nitrites
(*c*) urea
(*d*) atmospheric nitrogen

98. The first enzyme to mix with food in the digestive tract is :

(*a*) pepsin

(*b*) cellulose
(*c*) amylase
(*d*) trypsin

99. Which of the following is the correct statement ?
(*a*) heterotrophs synthesise their own food
(*b*) heterotrophs utilize solar energy for photosynthesis
(*c*) heterotrophs do not synthesise their own food
(*d*) heterotrophs are capable of converting carbon dioxide and water into carbohydrates

100. In which of the following groups of organisms the food material is broken down outside the body and then absorbed ?
(*a*) Mushroom, Green plants, *Amoeba*
(*b*) Yeast, Mushroom, Bread mould
(*c*) *Paramecium*, *Amoeba*, *Cuscuta*
(*d*) *Cuscuta*, Lice, Tapeworm

101. Which of the following is the correct sequence of parts as they occur in the human alimentary canal ?
(*a*) Mouth $\longrightarrow$ Stomach $\longrightarrow$ Small intestine $\longrightarrow$ Oesophagus $\longrightarrow$ Large intestine
(*b*) Mouth $\longrightarrow$ Oesophagus $\longrightarrow$ Stomach $\longrightarrow$ Large intestine $\longrightarrow$ Small intestine
(*c*) Mouth $\longrightarrow$ Stomach $\longrightarrow$ Oesophagus $\longrightarrow$ Small intestine $\longrightarrow$ Large intestine
(*d*) Mouth $\longrightarrow$ Oesophagus $\longrightarrow$ Stomach $\longrightarrow$ Small intestine $\longrightarrow$ Large intestine

Questions Based on High Order Thinking Skills (HOTS)

102. When a person eats sugary food, then organisms A present in his mouth act on sugar to produce a substance B. The substance B first dissolves the calcium salts from the top part C of the tooth and then from its middle part D forming holes E. These holes ultimately reach the part F in the lower part of tooth which contains nerves and blood vessels. The substance B irritates the nerve endings inside the tooth causing toothache.
(*a*) What are (*i*) organisms A, and (*ii*) substance B ?
(*b*) What are (*i*) part C, and (*ii*) part D, of tooth known as ?
(*c*) By what name are the holes E in the tooth known ?
(*d*) Name the part F of the tooth.
(*e*) What will happen if organisms A reach part F of the tooth ?

103. If the teeth are not cleaned regularly, they become covered with a sticky yellowish layer W of food particles and bacteria. Since layer W covers the teeth, the alkaline liquid X secreted by glands Y inside the mouth cannot reach the teeth surface to neutralise the acid formed by the action of organisms Z on sugary food, and hence tooth decay sets in.
(*a*) What is W known as ?
(*b*) What is (*i*) X, and (*ii*) Y ?
(*c*) What are organisms Z ?
(*d*) State one way of removing layer W from the teeth.

104. When a person puts food in his mouth, then teeth cut it into small pieces, chew and grind it. The glands A in the mouth secrete a substance B which is mixed with the food by tongue. The substance B contains an enzyme C which starts the digestion of food in the mouth. The slightly digested food from the mouth goes down a tube D. The special type of movements E in the walls of tube D push the food into stomach for further digestion. The stomach wall secretes gastric juice containing three substance F, G and H. One of the functions of F is to kill bacteria which may enter the stomach with food. The substance G protects the inside layer of stomach from the damaging effect of substance F whereas substance H is an enzyme for digestion. The partially digested food then enters into small intestine for further digestion.

(*a*) What is (*i*) gland A (*ii*) substance B, and (*iii*) enzyme C ?

(*b*) Name the tube D.

(*c*) What is the movement E known as ?

(*d*) What are (*i*) F (*ii*) G, and (*iii*) H ?

105. The partially digested food coming from the stomach of a person enters a long and narrow organ A in his body. The organ A receives the secretions of two glands : liver and pancreas. Liver secretes a greenish-yellow liquid B which is normally stored in the organ C. Pancreas secretes pancreatic juice which contains three digestive enzymes D, E and F. The intestinal juice completes the process of digestion of food. The inner wall of organ A has millions of tiny finger-like projections G which help in the rapid absorption of digested food into blood stream. The undigested part of food then passes into wider tube H which absorbs most of the water from undigested food. The last part of tube H called I stores this undigested food (or waste) for some time. The undigested food is then passed out though opening J as faeces in the process known as K.

(*a*) Name the organ A.

(*b*) Name (*i*) liquid B, and (*ii*) organ C.

(*c*) What are the digestive enzymes D, E and F ?

(*d*) Name the projections G present on the inner wall of organ A.

(*e*) Name (*i*) tube H (*ii*) part I (*iii*) opening J, and (*iv*) process K.

106. A unicellular animal P having no fixed shape ingests a food particle by forming temporary finger-like projections Q. The food particle is engulfed with a little surrounding water to form a temporary stomach R inside it. The chemicals S from surrounding cytoplasm enter into R and break down food into small and soluble molecules by chemical reactions. The digested food is absorbed directly into cytoplasm by the process T. The undigested food is thrown out of the body by the rupture of a cell organelle U in a process called V.

(*a*) Name the unicellular animal P.

(*b*) What are (*i*) Q, and (*ii*) R ?

(*c*) Name (*i*) chemical S, and (*ii*) process T.

(*d*) Name (*i*) organelle U, and (*ii*) process V.

107. There are four organisms A, B, C and D. The organism A eats only the flesh of other animals as food. The organism B can eat grains, fruits and vegetables as well as meat and fish. The organism C can make the food itself from simple inorganic substances present in the environment by utilising sunlight energy. On the other hand, organism D eats only plants and their products as food.

(*a*) Which organism is (*i*) omnivore (*ii*) herbivore, and (*ii*) carnivore ?

(*b*) Which organism is an autotroph ?

(*c*) Which organism is/are heterotroph(s) ?

(*d*) Which organism can be a producer ?

(*e*) Which organism is/are consumer (s) ?

(*f*) Give one example each of organisms which could be like (*i*) A (*ii*) B (*iii*) C, and (*iv*) D

108. The organisms A, B and C can obtain their food in three different ways. Organism A derives its food from the body of another living organism which is called its D, without killing it. The organism B takes in the solid food by the process of ingestion, digests a part of this food and throws out undigested food in the process called E. The organism C obtains its food from dead and decaying plants.

(*a*) What is the mode of nutrition of (*i*) organism A (*ii*) organism B, and (*iii*) organism C ?
(*b*) What is the organism like D called ?
(*c*) Name the process E.
(*d*) Give one example each of organisms like (*i*) A (*ii*) B, and (*ii*) C.
(*e*) What is the general name of three modes of nutrition exhibited by organisms A, B and C ?

109. An organism A which cannot move from one place to another, makes a simple food B from the substances C and D available in the environment. This food is made in the presence of a green coloured substance E present in organs F in the presence of light energy in a process called G. Some of the simple food B also gets converted into a complex food H for storage purposes. The food H gives a blue-black colour with dilute iodine solution.
(*a*) What is (*i*) organism A (*ii*) food B, and (*iii*) food H ?
(*b*) What are C and D ?
(*c*) Name (*i*) green coloured substance E, and (*ii*) organ F.
(*d*) What is the process G ?

110. X is a wild animal which eats only the flesh of other animals whereas Y is a domestic animal which feeds mainly on green grass.
(*a*) What are animals like X known as ?
(*b*) What are animals like Y known as ?
(c) Which animal, X or Y, has a longer small intestine ? Why ?
(*d*) Name one animal which is like X.
(*e*) Name one animal which is like Y.

ANSWERS

1. Food **2.** Chemical energy **3.** Green plant **10.** (*a*) Carbon dioxide (*b*) Oxygen **11.** A is glucose ; B is starch **19.** Guard cells **20.** *Amoeba* **31.** Peristaltic movement **39.** (*a*) autotrophs (*b*) heterotrophs (*c*) plants ; animals (*d*) carbon dioxide, water, sunlight (*e*) starch **40.** (*b*) (*i*) Glucose (*ii*) Starch **45.** (*a*) X : Light energy ; Y : Chemical energy **55** (*i*) *c* (*ii*) *a* (*iii*) *d* (*iv*) *b* 56 (*a*) Photosynthesis (*b*) Heterotrophs (*c*) Autotrophs (*d*) Chloroplast (*e*) Guard cells (*f*) Pepsin **57.** (*i*) *c* (*ii*) *d* (*iii*) *a* (*iv*) *b* **58.** (*a*) Parasitic mode of nutrition (*b*) (*i*) Proteins (*ii*) Starch (*iii*) Proteins (*iv*) Fats (*c*) Due to the presence of a large number of villi **60.** (*b*) Plant kept in continuous light will live longer because it will be able to produce oxygen required for its respiration by the process of photosynthesis **61.** (*a*) Green plants are the source of food for all the organisms. If all the green plants disappear from the earth, then all the organisms (herbivores, carnivores and omnivores) will die due to starvation (*b*) When photosynthesis occurs during the day, the carbon dioxide released by plants by respiration is all used up and not released. Similarly, some of the oxygen produced during photosynthesis is used up in respiration. Since the plant here is releasing carbon dioxide and taking in oxygen even during the day, it means that no photosynthesis is taking place **62.** (*a*) This plant will not remain healthy for long because vaseline coating closes the stomatal pores on the leaves due to which (*i*) plant will not get oxygen for respiration (*ii*) plant will not get carbon dioxide for photosynthesis, and (*iii*) plant will not get water (and minerals) due to stoppage of transpiration (*b*) (*i*) Decreases in morning but increases in the afternoon (*ii*) Decreases (*iii*) Decreases **71.** (*c*) **72.** (c) **73.** (*b*) **74.** (*a*) **75.** (*d*) **76.** (*c*) **77.** (*b*) **78.** (*b*) **79.** (*c*) **80.** (*d*) **81.** (*c*) **82.** (*d*) **83.** (*c*) **84** (*d*) **85.** (*d*) **86.** (*d*) **87.** (*b*) **88.** (*b*) **89.** (*d*) **90.** (*b*) **91.** (*d*) **92.** (*b*) **93.** (*c*) **94.** (*d*) **95.** (*c*) **96.** (*b*) **97.** (*b*) **98.** (*c*) **99.** (*c*) **100.** (*b*) **101.** (*d*) **102.** (*a*) (*i*) Bacteria (*ii*) Acid (*b*) (*i*) Enamel (*ii*) Dentine (*c*) Dental caries (*d*) Pulp cavity (*e*) Inflammation and infection will occur leading to severe pain **103.** (*a*) Dental plaque (*b*) (*i*) Saliva (*ii*) Salivary glands (*c*) Bacteria (*d*) Brushing the teeth regularly after eating food **104.** (*a*) (*i*) Salivary gland (*ii*) Saliva (*iii*) Salivary amylase (*b*) Oesophagus (*c*) Peristaltic movement (*d*) (*i*) Hydrochloric acid (*ii*) Mucus (*iii*) Enzyme pepsin **105.** (*a*) Small intestine (*b*) (*i*) Bile (*ii*) Gall bladder (*c*) Pancreatic amylase, Trypsin and Lipase (*d*) Villi (*e*) (*i*) Large intestine (*ii*) Rectum (*iii*)

Anus (*iv*) Egestion **106.** (*a*) *Amoeba* (*b*) (*i*) Pseudopodia (*ii*) Food vacuole (*c*) (*i*) Enzymes (*ii*) Diffusion (*d*) (*i*) Cell membrane (*ii*) Egestion **107.** (*i*) B (*ii*) D (*iii*) A (*b*) C (*c*) A, B and D (*d*) C (*e*) A, B and D (*f*) (*i*) Lion (*ii*) Human (Man) (*iii*) Green plant (*iv*) Cow **108.** (*a*) (*i*) Parasitic (*ii*) Holozoic (*iii*) Saprophytic (*b*) Host (*c*) Egestion (*d*) (*i*) Tapeworm (*ii*) Man (*iii*) Mushroom (*e*) Heterotrophic nutrition **109.** (*a*) (*i*) Green plant (*ii*) Glucose (*iii*) Starch (*b*) Carbon dioxide and Water (*c*) (*i*) Chlorophyll (*ii*) Green leaf (*d*) Photosynthesis **110**. (*a*) Carnivores (*b*) Herbivores (*c*) Animal Y has a longer small intestine. The animal Y is a herbivore which eats grass (and other green plants). The grass contains a carbohydrate called cellulose which is digested with difficulty. A longer small intestine allows the cellulose present in grass to be digested completely. (*d*) Tiger (*e*) Cow

RESPIRATION

We have just studied that digested food is assimilated into the body of the living organisms. The assimilated food is used mainly for two purposes :

1. **Assimilated food is used as a fuel to get energy for various life processes,** and
2. **Assimilated food is used as a material for the growth and repair of the body.**

We will now describe how energy is released from the food which is absorbed and assimilated in the cells of the body. Please note that **food is the 'fuel' for energy production in cells**. Let us see how energy is actually obtained.

Most living things need oxygen (of air) to obtain energy from food. This oxygen reacts with the food molecules (like glucose) present in the body cells and burns them slowly to release energy. The energy thus released is stored in ATP molecules in the cells. The body can use this stored energy whenever it wants to do so.

The process of releasing energy from food is called respiration. When oxygen burns the food in the cells of the body to release energy, then carbon dioxide and water are produced as waste products which are to be eliminated from the body (see Figure 43). **The process of respiration involves taking in oxygen (of air) into the cells, using it for releasing energy by burning food, and then eliminating the waste products (carbon dioxide and water) from the body.** The process of respiration can be written in the form of a word equation as follows :

$$\text{Food} + \text{Oxygen} \longrightarrow \text{Carbon dioxide} + \text{Water} + \text{Energy}$$

The process of respiration which releases energy takes place inside the cells of the body. So, it is also known as cellular respiration. The process of cellular respiration is common to all the living organisms. It provides energy to the cells. There are two by-products of cellular respiration : carbon dioxide and water. Out of these only carbon dioxide is considered the real waste product of respiration because its accumulation in the body is harmful to the organism. Water produced during respiration is not harmful to the body. It is rather beneficial for the body. Please note that **respiration is essential for life because it provides energy for carrying out all the life processes which are necessary to keep the organisms alive.**

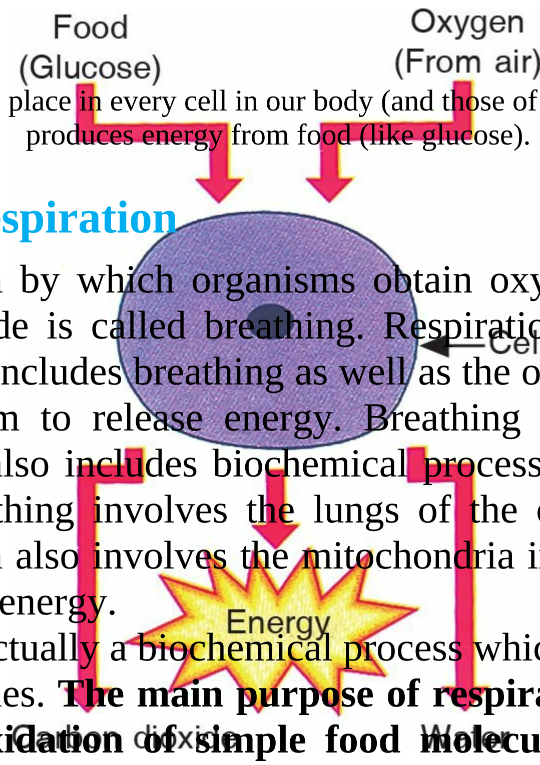


Figure 43. Respiration takes place in every cell in our body (and those of other organisms). Respiration produces energy from food (like glucose).

Breathing and Respiration

The mechanism by which organisms obtain oxygen from the air and release carbon dioxide is called breathing. Respiration is a more complex process. Respiration includes breathing as well as the oxidation of food in the cells of the organism to release energy. Breathing is a physical process whereas respiration also includes biochemical process of oxidation of food. The process of breathing involves the lungs of the organism whereas the process of respiration also involves the mitochondria in the cells where food is oxidised to release energy.

Respiration is actually a biochemical process which occurs in stages and requires many enzymes. **The main purpose of respiration is the release of energy from the oxidation of simple food molecules like glucose.** The energy released during respiration is used for carrying out the biological functions which are necessary for the maintenance of life and survival of an organism. Please note that **respiration is just opposite of photosynthesis.** This is because *photosynthesis makes food* (like glucose) by using carbon dioxide, water and sunlight energy, and releasing oxygen; whereas *respiration breaks food* (like glucose) by using oxygen, and releasing carbon dioxide, water and energy.

How Energy Released During Respiration is Stored

All the energy released during respiration is not used immediately by an organism (plant or animal). **The energy produced during respiration is stored in the form of ATP molecules in the cells of the body** and used by the organism as and when required. In order to understand this we should first know the meaning of ADP, ATP and inorganic phosphate. These are given below.

ADP is a substance called Adenosine Di-Phosphate. The molecules of ADP are present in a cell. ADP has low energy content. **ATP is a substance called Adenosine Tri-Phosphate.** It is also present inside a cell. ATP has a high energy content. Inorganic phosphate is a substance which contains a phosphate group made up of phosphorus and oxygen. Inorganic phosphates are also present in a cell. Inorganic phosphate can be represented by writing just 'Phosphate'. The inorganic phosphate can also be represented by the symbol P_i (where P stands for phosphate and i for inorganic). ADP contains two phosphate groups whereas ATP contains three phosphate groups in its molecule.

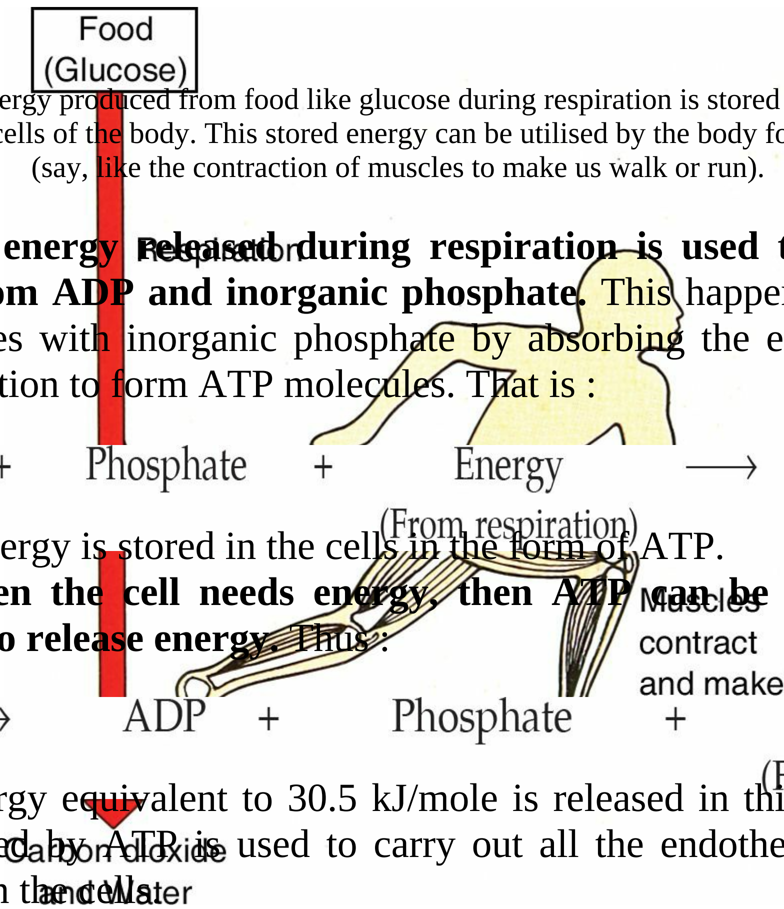


Figure 44. The energy produced from food like glucose during respiration is stored in the form of ATP molecules in the cells of the body. This stored energy can be utilised by the body for various purposes (say, like the contraction of muscles to make us walk or run).

(*i*) The energy released during respiration is used to make ATP molecules from ADP and inorganic phosphate. This happens as follows : ADP combines with inorganic phosphate by absorbing the energy released during respiration to form ATP molecules. That is :

ADP (Low energy) + Phosphate + Energy (From respiration) ⟶ ATP (High energy)

Thus, energy is stored in the cells in the form of ATP.

(*ii*) When the cell needs energy, then ATP can be broken down using water to release energy. Thus :

ATP ⟶ ADP + Phosphate + Energy (For use in cells)

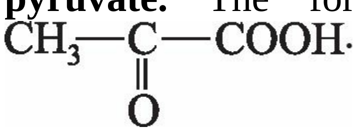
The energy equivalent to 30.5 kJ/mole is released in this process. The energy released by ATP is used to carry out all the endothermic reactions taking place in the cells.

Please note that ADP can be converted to ATP by absorbing energy produced during respiration, and ATP can be converted back to ADP releasing energy to be used by the cells, again and again. This ensures a continuous supply of energy to the organism.

Just as a battery can provide electrical energy for different purposes such as lighting, heating, running radio and computer, etc., in the same way, **the energy stored in ATP is used by the body cells for various purposes like contraction of muscles, conduction of nerve impulses, synthesis of proteins, and many other activities related to the functioning of cells**. In fact, ATP is known as the energy currency of cells.

An Important Discussion

In most of the cases, the organisms (plants and animals) carry out respiration by using oxygen (called aerobic respiration). There are, however, some organisms which carry out respiration without using oxygen (called anaerobic respiration). Before we describe aerobic respiration and anaerobic respiration, we should keep the following points in mind which will help us in understanding the two types of respiration.

1. **Glucose is $C_6H_{12}O_6$. It is a six carbon atom compound.** It is the simple food which is oxidised in the cells of organisms during respiration.
2. **The oxidation of glucose to pyruvic acid (or pyruvate) is called glycolysis.** It occurs in the cytoplasm of a cell and not in mitochondria. The oxidation of glucose to pyruvic acid does not require oxygen. One molecule of glucose on glycolysis produces two molecules of pyruvic acid (or pyruvate).
3. **Pyruvic acid is a three carbon atom compound. It is also called pyruvate.** The formula of pyruvic acid or pyruvate is  It is a ketonic carboxylic acid.
4. The fate of pyruvate formed during respiration depends on whether oxygen is present in the cells or not. If oxygen is present in the cells, then pyruvate is completely oxidised to carbon dioxide and water, and a lot of energy is produced (in the form of ATP). If, however, oxygen is not present in the cells (that is, in the absence of oxygen), pyruvate is converted to either 'ethanol and carbon dioxide' or 'lactic acid' depending on whether such a process is taking place in a plant cell or an animal cell. Much less energy is released in this case.

5. **Lactic acid is also a three carbon atom compound.** It is also called lactate. The formula of lactic acid or lactate is  It is a hydroxy carboxylic acid.

TYPES OF RESPIRATION

So far we have studied that respiration takes place in the presence of oxygen (of air). Respiration can, however, also take place in the absence of oxygen (of air), though it is very rare. This means that oxidation of food to obtain energy can occur in the *presence* of oxygen as well as in the *absence* of oxygen. Based on this, we have two types of respiration : **aerobic respiration** and **anaerobic respiration.**

1. Aerobic Respiration

The respiration which uses oxygen is called aerobic respiration. It is called aerobic respiration because it uses air which contains oxygen ('aerobic' means 'with air'). In aerobic respiration, the glucose food is completely broken down into carbon dioxide and water by oxidation. Aerobic respiration produces a considerable amount of energy for use by the organism which gets stored in the ATP molecules. The breaking down of glucose (food) during aerobic respiration (which is carried out by most of the organisms) can be represented as follows :

$$\underset{\text{(1 molecule)}}{\text{Glucose}} \xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \underset{\substack{\text{(Pyruvic acid)} \\ \text{(2 molecules)}}}{\text{Pyruvate}} \xrightarrow[\text{(in mitochondria)}]{\text{Oxygen (Kreb's cycle)}} \underset{\substack{\text{Carbon} \\ \text{dioxide}}}{6CO_2} + \underset{\text{Water}}{6H_2O} + \underset{\text{Energy}}{38\ \text{ATP}}$$

Please note that during aerobic respiration (shown above), 1 molecule of glucose (food) produces 38 energy-rich ATP molecules (Please do not worry about the name 'Kreb's cycle' written in the above equation. We will study this in higher classes). All the organisms which obtain energy by aerobic respiration, cannot live without oxygen (of air). This is because if there is no oxygen, they cannot get energy from the food which they eat. **Mitochondria are the sites of aerobic respiration in the cells** (see Figure 45). Thus, the breakdown of pyruvate to give carbon dioxide, water and energy takes place in mitochondria.

The energy released during aerobic respiration is used by the organism. **Most of the living organisms carry out aerobic respiration (by using oxygen of air).** For example, humans (man), dogs (see Figure 46), cats, lions, elephants, cows, buffaloes, goat, deer, birds, lizards, snakes, earthworms, frogs, fish, and insects (such as cockroach, grasshopper, houseflies, mosquitoes and ants, etc.) and most of the plants carry out aerobic respiration by using oxygen of air (to obtain energy)

Figure 45. The orange organelle in this picture is mitochondrion where aerobic respiration in a cell takes place.

Figure 46. The dog obtains energy from its food through aerobic respiration (by using oxygen of air).

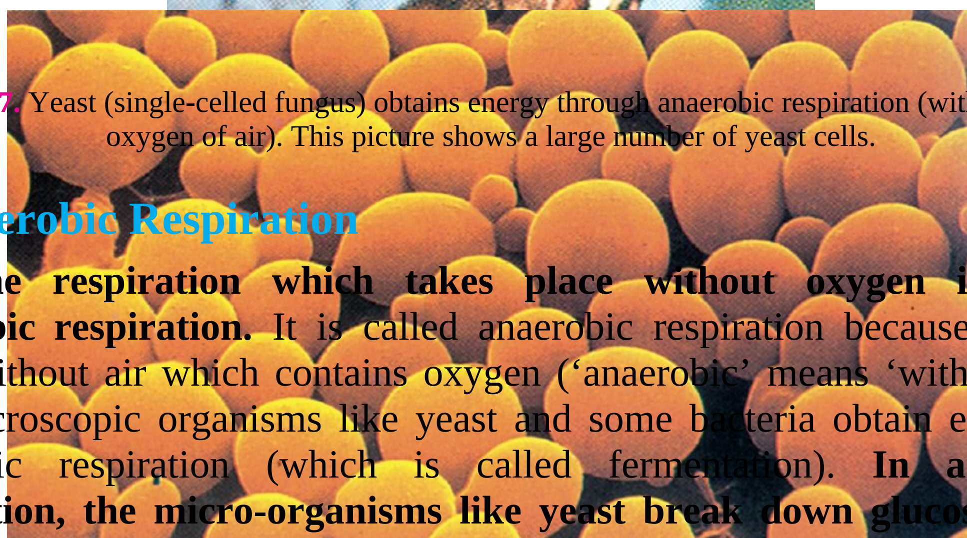


Figure 47. Yeast (single-celled fungus) obtains energy through anaerobic respiration (without using oxygen of air). This picture shows a large number of yeast cells.

2. Anaerobic Respiration

The respiration which takes place without oxygen is called anaerobic respiration. It is called anaerobic respiration because it takes place without air which contains oxygen ('anaerobic' means 'without air'). The microscopic organisms like yeast and some bacteria obtain energy by anaerobic respiration (which is called fermentation). **In anaerobic respiration, the micro-organisms like yeast break down glucose (food) into ethanol and carbon dioxide, and release energy.** This energy is then used by the micro-organisms. Anaerobic respiration produces much less energy which gets stored in the ATP molecules. The breaking down of glucose (food) during anaerobic respiration carried out by yeast (plants) can be represented as follows :

$$\underset{\text{(1 molecule)}}{\text{Glucose}} \xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \underset{\substack{\text{(Pyruvic acid)}\\ \text{(2 molecules)}}}{\text{Pyruvate}} \xrightarrow[\substack{\text{(Yeast)}\\ \text{(Fermentation)}}]{\text{In absence of oxygen}} \underset{\text{Ethanol}}{2C_2H_5OH} + \underset{\substack{\text{Carbon}\\ \text{dioxide}}}{2CO_2} + \underset{\text{Energy}}{2\text{ ATP}}$$

Please note that during anaerobic respiration (shown above), 1 molecule of glucose (food) produces only 2 energy-rich ATP molecules. A few organisms such as yeast plants and certain bacteria (called anaerobic bacteria) can obtain energy from food in the absence of oxygen by the process of anaerobic respiration. Please note that all the organisms which obtain energy by anaerobic respiration can live without oxygen (of air). For example, the single-celled, non-green plant called 'yeast' can live without oxygen because it obtains energy by the process of anaerobic respiration (see Figure 47). From this discussion we conclude that *all the cells do not use oxygen to produce energy*. Energy can be produced in cells even without oxygen. Please note that the whole process of anaerobic respiration takes place in the cytoplasm of cells.

We can carry out the fermentation of sugar by using the anaerobic respiration of yeast as follows : Take some sugar solution (or fruit juice) in a test-tube and add a little of yeast to it. Close the mouth of the test-tube with a cork and allow it to stand for some time. Now, open the cork and smell. A characteristic smell of ethanol (ethyl alcohol) is obtained from the test-tube. A gas is also evolved during this process. When this gas is passed through lime-water, the lime-water turns milky showing that it is carbon dioxide gas. This experiment tells us that the products of fermentation of sugar brought about by yeast are ethanol and carbon dioxide.

We (the human beings) obtain energy by aerobic respiration. But anaerobic respiration can sometimes take place in our muscles (or the muscles of other animals). For example, **anaerobic respiration takes place in our muscles during vigorous physical exercise when oxygen gets used up faster in the muscle cells than can be supplied by the blood.** When anaerobic respiration takes place in human muscles (or animal muscles), then glucose (food) is converted into lactic acid with the release of a small amount of energy. The breaking down of glucose (food) during anaerobic respiration in muscles can be represented as follows :

$$\underset{\text{(1 molecule)}}{\text{Glucose}} \xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \underset{\substack{\text{(Pyruvic acid)} \\ \text{(2 molecules)}}}{\text{Pyruvate}} \xrightarrow[\text{(muscle tissue)}]{\text{In absence of oxygen}} \text{2 Lactic acid} + \underset{\text{Energy}}{\text{2ATP}}$$

The sudden build up of lactic acid in our muscles during vigorous physical activity can cause muscular 'cramps'. (The painful contractions of muscles are called cramps). Let us discuss this in a little more detail. During heavy physical exercise (or any other heavy physical activity), most of the energy in our muscles in produced by aerobic respiration. Anaerobic respiration in muscles provides only some extra energy which is needed under the conditions of heavy physical activity (like running very fast or running for a long time) (see the people running a long distance race in Figure 48). The anaerobic respiration by muscles brings about partial breakdown of glucose (food) to form lactic acid. This lactic acid accumulates in the muscles. **The accumulation of lactic acid in the muscles causes**

muscle cramps. Thus, muscle cramps occur due to the accumulation of lactic acid in muscles when the muscles respire anaerobically (without oxygen) while doing hard physical exercise. **We can get relief from cramps in muscles caused by heavy exercise by taking a hot water bath or a massage.** Hot water bath (or massage) *improves* the circulation of blood in the muscles. Due to improved blood flow, the supply of oxygen to the muscles increases. This oxygen breaks down lactic acid accumulated in muscles into carbon dioxide and water, and hence gives us relief from cramps. The anaerobic respiration does not take place only in the muscles of human beings, it also takes place in the muscles of other animals such as lion, tiger, cheetah, deer, and many other animals when they run very fast and require much more energy than normal. This means that even the animals like lion, tiger, cheetah and deer, etc., can get leg cramps due to the accumulation of lactic acid in leg muscles if they run very fast for a considerable time. Please note that :

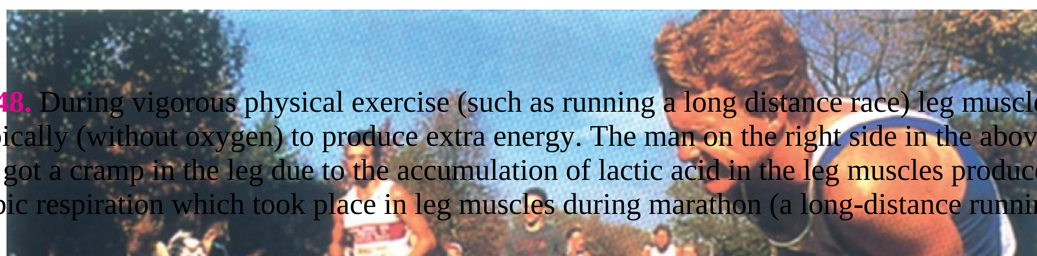


Figure 48. During vigorous physical exercise (such as running a long distance race) leg muscles respire anaerobically (without oxygen) to produce extra energy. The man on the right side in the above picture has just got a cramp in the leg due to the accumulation of lactic acid in the leg muscles produced by the anaerobic respiration which took place in leg muscles during marathon (a long-distance running race).

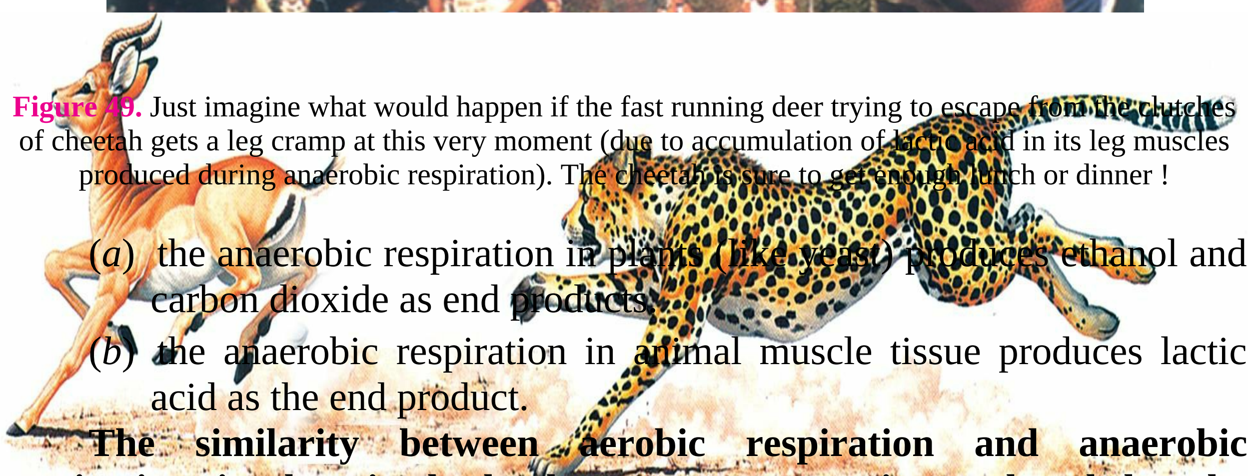


Figure 49. Just imagine what would happen if the fast running deer trying to escape from the clutches of cheetah gets a leg cramp at this very moment (due to accumulation of lactic acid in its leg muscles produced during anaerobic respiration). The cheetah is sure to get enough lunch or dinner !

(*a*) the anaerobic respiration in plants (like yeast) produces ethanol and carbon dioxide as end products.

(*b*) the anaerobic respiration in animal muscle tissue produces lactic acid as the end product.

The similarity between aerobic respiration and anaerobic respiration is that in both the cases, energy is produced by the breakdown of food like glucose. The main differences between aerobic respiration and anaerobic respiration are given below.

Differences between Aerobic and Anaerobic Respiration

Aerobic respiration	*Anaerobic respiration*

1. Aerobic respiration takes place in the *presence* of oxygen.	1. Anaerobic respiration takes place in the *absence* of oxygen.
2. Complete breakdown of food occurs in aerobic respiration.	2. Partial breakdown of food occurs in anaerobic respiration.
3. The end products in aerobic respiration are carbon dioxide and water.	3. The end products in anaerobic respiration may be ethanol and carbon dioxide (as in yeast plants), or lactic acid (as in animal muscles).
4. Aerobic respiration produces a considerable amount of energy.	4. Much less energy is produced in anaerobic respiration.

Let us answer one question now.

Sample Problem. The breakdown of pyruvate to give carbon dioxide, water and energy takes place in :

(*a*) cytoplasm
(*b*) mitochondria
(*c*) chloroplast
(*d*) nucleus

(NCERT Book Question)

Answer. (*b*) mitochondria

RESPIRATION IN PLANTS

Like animals, plants also need energy. The plants get this energy by the process of respiration. Plants also use oxygen of air for respiration and release carbon dioxide. Thus, the respiration in plants also involves the exchange of oxygen and carbon dioxide. So, *oxygen and carbon dioxide are called respiratory gases.* **The respiration in plants differs from that in animals in three respects :**

1. All the parts of a plant (like root, stem and leaves) perform respiration individually. On the other hand, an animal performs respiration as a single unit.
2. During respiration in plants, there is a little transport of respiratory gases from one part of the plant to the other. On the other hand, respiratory gases are usually transported over long distances inside an animal during respiration.
3. The respiration in plants occurs at a slow rate. On the other hand, the respiration in animals occurs at a much faster rate.

Plants get Oxygen by Diffusion

Plants have a branching shape, so they have quite a large surface area in comparison to their volume. Therefore, diffusion alone can supply all the cells of the plants with as much oxygen as they need for respiration. Diffusion occurs in the roots, stems and leaves of plants.

1. Respiration in Roots

Air is present in-between the particles of soil. The roots of a plant take the oxygen required for respiration from the air present in-between the soil particles by the process of diffusion. The extensions of the epidermal cells of a root are called root hair. The root hair are in contact with the air in the soil. Oxygen (from air in the soil particles) diffuses into root hairs and reaches all the other cells of the root for respiration. Carbon dioxide gas produced in the cells of the root during respiration moves out through the same root hairs by the process of diffusion. Thus, the respiration in roots occurs by the diffusion of respiratory gases (oxygen and carbon dioxide) through the root hairs (see Figure 50). It has been found that the land plants die if their roots remain waterlogged for a considerable time. This is because too much water expels all the air from in-between the soil particles. Due to this, oxygen is not available to the roots for aerobic respiration. Under these conditions, the roots will respire anaerobically, producing alcohol. This may kill the plant.

In order to understand the respiration in stems of plants we should remember that the soft stems of small, herbaceous plants have *stomata* in them whereas the hard and woody stems of large plants and trees have *lenticels* in them. Lenticel is a small area of bark in a woody stem where the cells are loosely packed allowing the gaseous exchange to take place between the air and the living cells of the stem.

2. Respiration in Stems

The stems of herbaceous plants (or herbs) have stomata. So, the exchange of respiratory gases in the stems of herbaceous plants takes place through stomata. The oxygen from air diffuses into the stem of a herbaceous plant through stomata and reaches all the cells for respiration. The carbon dioxide gas produced during respiration diffuses out into the air through the same stomata. The hard and woody stems of big plants or trees do not have stomata. In woody stems, the bark (outer covering of stem) has lenticels for gaseous exchange (see Figure 51). The oxygen from air diffuses into the stem of a woody plant through lenticels and reaches all the inner cells of the stem for respiration. The carbon dioxide gas produced in the cells of the stem during respiration diffuses out into the air through the same lenticels.

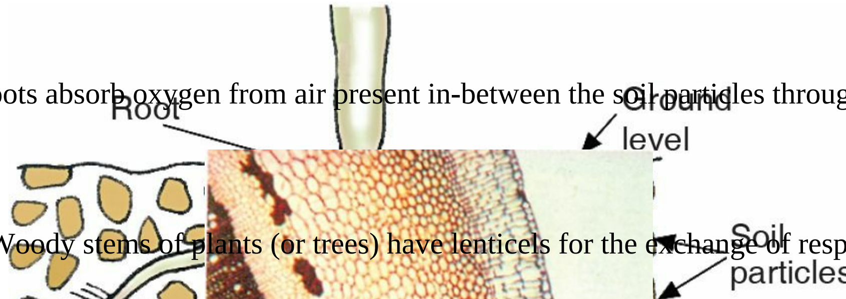


Figure 50. Roots absorb oxygen from air present in-between the soil particles through the root hair.

Figure 51. Woody stems of plants (or trees) have lenticels for the exchange of respiratory gases.

Figure 52. The exchange of respiratory gases in leaves takes place through tiny pores called stomata.

3. Respiration in Leaves

The leaves of a plant have tiny pores called stomata (see Figure 52). The exchange of respiratory gases in the leaves takes place by the process of diffusion through stomata. Oxygen from air diffuses into a leaf through stomata and reaches all the cells where it is used in respiration. The carbon dioxide produced during respiration diffuses out from the leaf into the air through the same stomata.

It should be noted that **respiration in leaves occurs during the day time as well as at night.** On the other hand, **photosynthesis occurs only during the day time** (no photosynthesis occurs at night). Due to this, **the net gaseous exchange in the leaves of a plant is as follows :**

(*i*) During day time, when photosynthesis occurs, oxygen is produced. The leaves use some of this oxygen for respiration and the rest of oxygen diffuses out into air. Again, during day time, carbon dioxide produced by respiration is all used up in photosynthesis by leaves. Even more carbon dioxide is taken in from air. Thus, **the net gas exchange in leaves during day time is : O_2 diffuses out ; CO_2 diffuses in.**

(*ii*) At night time, when no photosynthesis occurs and hence no oxygen is produced, oxygen from air diffuses into leaves to carry out respiration. And carbon dioxide produced by respiration diffuses out into air. So, **the net gas exchange in leaves at night is : O_2 diffuses in; CO_2 diffuses out.**

RESPIRATION IN ANIMALS

Different animals have different modes of respiration. For example :

(*i*) In simple unicellular animals like *Amoeba*, respiration takes place by the simple diffusion of gases through the cell membrane.

Most of the animals have, however, specific organs for respiration.

(*ii*) The animals like earthworms which live in the soil use their skin to absorb oxygen from air and remove carbon dioxide. So, the respiratory organ in the earthworm is the skin.

(*iii*) The aquatic animals like fish, prawns and mussels have gills as the respiratory organs which extract oxygen dissolved in water and take away carbon dioxide from the body.

(*iv*) In the insects like grasshopper, cockroach, housefly and a mosquito, the tiny holes called spiracles on their body and the air tubes called tracheae are the respiratory organs (see Figure 53).

(*v*) The respiratory organs of the land animals such as man (humans), birds, lizard, dog, and frog, etc., are the lungs. (Frogs, however, breathe both by lungs and skin).

(*a*) This is a grasshopper. It is an insect.

(*b*) We can see the tiny holes called spiracles on the body of grasshopper in this magnified picture

(*c*) This picture shows a bigger air tube called trachea in the body of a grasshopper dividing into smaller air tubes called tracheoles

Figure 53. Grasshopper (an insect) breathes and respires through tiny holes called spiracles, air tubes called tracheae and their branches called tracheoles.

Once the air (containing oxygen) enters the skin or lungs, blood absorbs the oxygen and transports it to various tissues of the animal. Blood also picks up the carbon dioxide from the tissues and brings it back to the skin or lungs for throwing it out into the air. Please note that **all the respiratory organs (whether skin, gills, trachea or lungs) have three common features** :

1. All the respiratory organs have a large surface area to get enough

oxygen.

2. All the respiratory organs have thin walls for easy diffusion and exchange of respiratory gases.
3. All the respiratory organs like skin, gills and lungs have a rich blood supply for transporting respiratory gases (only in the tracheal system of respiration, air reaches the cells directly).

The animals which live in water (aquatic animals) use the oxygen dissolved in water to carry out respiration. Since the amount of dissolved oxygen in water is low as compared to the amount of oxygen in the air, therefore, **the rate of breathing in aquatic animals in much faster than in terrestrial animals** (or land animals). A faster rate of breathing provides *more* oxygen to the aquatic animal. The terrestrial animals (or land animals) use the oxygen of air or atmosphere for breathing and respiration. Thus, a terrestrial animal has an advantage over an aquatic animal in regard to obtaining oxygen for respiration that it is surrounded by an oxygen-rich atmosphere from where it can take any amount of oxygen. We will now describe the process of respiration in *Amoeba*, earthworm, fish and human beings.

Respiration In *Amoeba*

Amoeba is a single-celled animal. ***Amoeba* depends on simple diffusion of gases for breathing.** The diffusion of gases takes place through the thin cell membrane of *Amoeba*. In other words, the exchange of gases in *Amoeba* takes place through its cell membrane. Let us discuss this in somewhat detail. *Amoeba* lives in water. This water has oxygen gas dissolved in it. The oxygen from water diffuses into the body of *Amoeba* through its cell membrane (see Figure 54). Since the *Amoeba* is very small in size, so the oxygen spreads quickly into the whole body of *Amoeba*. This oxygen is used for respiration (energy release) inside the *Amoeba* cell. The process of respiration produces carbon dioxide gas continuously. This carbon dioxide gas diffuses out through the membrane of *Amoeba* into the surrounding water (see Figure 54). Thus, the breathing surface (or respiratory surface) of *Amoeba* is its cell surface membrane. In addition to *Amoeba*, other simple animals like *Paramecium* and *Planaria* also depend on the simple diffusion of gases for breathing and respiration. Thus, ***Amoeba, Paramecium* and *Planaria* all breathe through their cell membranes.**

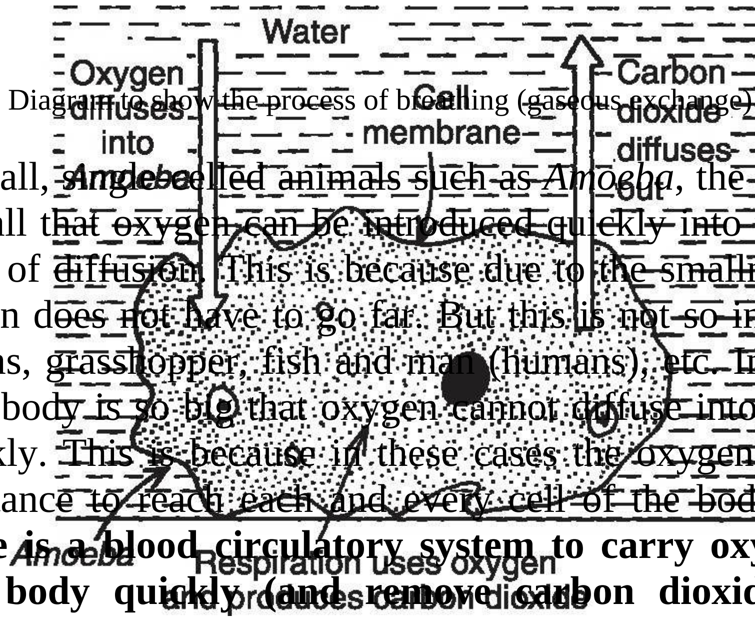


Figure 54. Diagram to show the process of breathing (gaseous exchange) in *Amoeba*.

In the small, single-celled animals such as *Amoeba*, the volume of their body is so small that oxygen can be introduced quickly into the whole body by the process of diffusion. This is because due to the smallness of *Amoeba* cell, the oxygen does not have to go far. But this is not so in larger animals like earthworms, grasshopper, fish and man (humans), etc. In large animals, the volume of body is so big that oxygen cannot diffuse into all the cells of the body quickly. This is because in these cases the oxygen has to travel a very large distance to reach each and every cell of the body. So, **in large animals, there is a blood circulatory system to carry oxygen to all the parts of the body quickly (and remove carbon dioxide).** The blood contains respiratory pigments which take up oxygen from air and carry it to the body cells. This will become more clear from the following example.

Diffusion is insufficient to meet the oxygen requirements of large multicellular organisms like humans because the volume of human body is so big that oxygen cannot diffuse into all the cells of the human body quickly. This is because oxygen will have to travel large distances inside the human body to reach each and every cell of the body. Diffusion being a very slow process will take a lot of time to make oxygen available to all the body cells. For example, it has been estimated that if diffusion were to provide oxygen in our body, then it would take about 3 years for a molecule of oxygen from our lungs to reach our toes by the process of diffusion. On the other hand, the blood circulatory system in humans carries oxygen to all the parts of the body quickly (and removes carbon dioxide). Actually, **human blood contains a respiratory pigment called haemoglobin which carries the oxygen from the lungs to all the body cells very efficiently.** Haemoglobin is present in red blood corpuscles. We will now discuss the process of breathing and respiration in some large animals like earthworm, fish and humans.

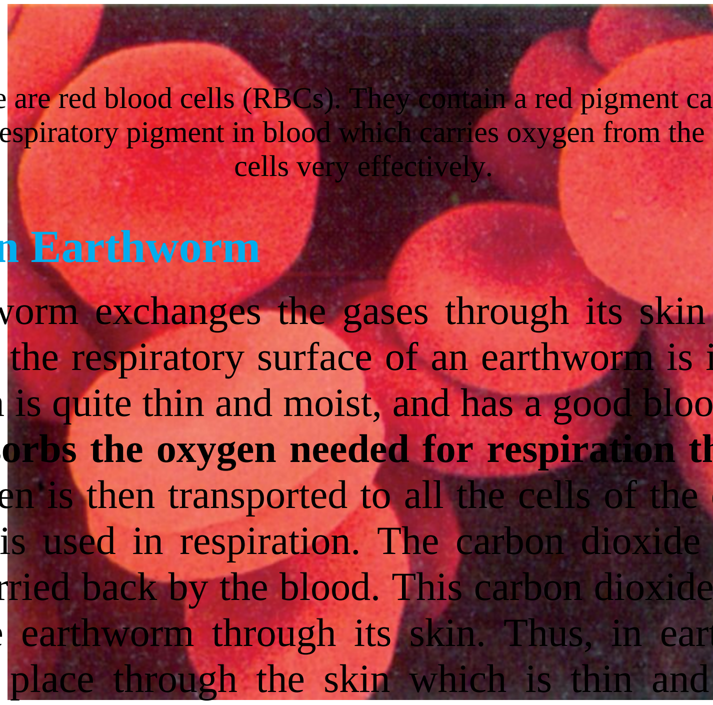


Figure 55. These are red blood cells (RBCs). They contain a red pigment called haemoglobin. Haemoglobin is a respiratory pigment in blood which carries oxygen from the lungs to all the body cells very effectively.

Respiration in Earthworm

The earthworm exchanges the gases through its skin (see Figure 56). This means that the respiratory surface of an earthworm is its skin. The skin of an earthworm is quite thin and moist, and has a good blood supply. So, **the earthworm absorbs the oxygen needed for respiration through its moist skin.** This oxygen is then transported to all the cells of the earthworm by its blood where it is used in respiration. The carbon dioxide produced during respiration is carried back by the blood. This carbon dioxide is expelled from the body of the earthworm through its skin. Thus, in earthworm, gaseous exchange takes place through the skin which is thin and moist. Just like earthworms, the leeches also absorb the oxygen needed for respiration through their skin (see Figure 57). And carbon dioxide produced inside the leeches (during respiration) also goes out through the skin.

Figure 56. The gas exchange in an earthworm takes place through its thin and moist skin.

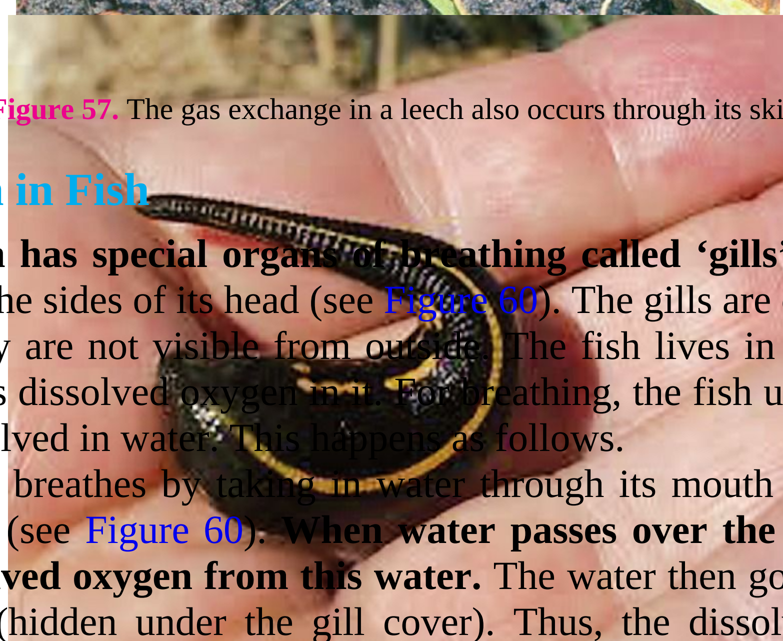


Figure 57. The gas exchange in a leech also occurs through its skin.

Respiration in Fish

The fish has special organs of breathing called 'gills'. The fish has gills on both the sides of its head (see Figure 60). The gills are covered by gill covers so they are not visible from outside. The fish lives in water and this water contains dissolved oxygen in it. For breathing, the fish uses the oxygen which is dissolved in water. This happens as follows.

The fish breathes by taking in water through its mouth and sending it over the gills (see Figure 60). **When water passes over the gills, the gills extract dissolved oxygen from this water.** The water then goes out through the gill slits (hidden under the gill cover). Thus, the dissolved oxygen is extracted from water by the fish when it flows over the gills. The extracted oxygen is absorbed by the blood and carried to all the parts of the fish. The carbon dioxide produced by respiration is brought back by the blood into the gills for expelling into the surrounding water. The fish has no lungs like us, the gaseous exchange in fish takes place in the gills. So, the respiratory surface of a fish is the surface of its gills. It is a common observation that when a fish is taken out from water it dies soon (even though there is a lot of oxygen in the air around it). This is because a fish does not have lungs to utilise the oxygen of air for breathing and respiration. The fish has gills which can extract only dissolved oxygen from water and provide it to fish. Gills cannot take in the oxygen from air on land. Since fish does not get oxygen for breathing when taken out of water, it dies. In addition to fish, many other aquatic animals like prawns and mussels also have special organs called 'gills' for breathing and respiration.

Figure 58. Fish in water.

Figure 59. Gill of fish.

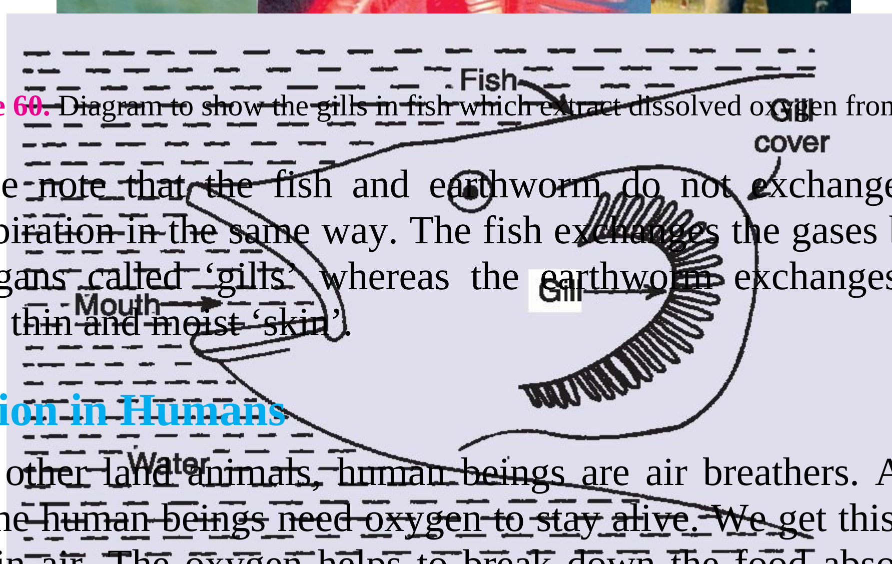


Figure 60. Diagram to show the gills in fish which extract dissolved oxygen from water.

Please note that the fish and earthworm do not exchange the gases during respiration in the same way. The fish exchanges the gases by using its special organs called 'gills' whereas the earthworm exchanges the gases through its thin and moist 'skin'.

Respiration in Humans

Like other land animals, human beings are air breathers. Air contains oxygen. The human beings need oxygen to stay alive. We get this oxygen by breathing in air. The oxygen helps to break down the food absorbed in the body to release energy. This energy is used for maintaining our life. **The process by which energy is released from food in our body is called respiration.** Carbon dioxide and water are the two by-products of respiration. The process of respiration takes place inside the cells of our body. It involves our respiratory system. **The function of respiratory system is to breathe in oxygen for respiration (producing energy from food), and to breathe out carbon dioxide produced by respiration.** The breathing organs of human beings are lungs (see Figure 61). It is in the lungs that the gases are exchanged between the blood and air. **The gases exchanged between blood and air are oxygen and carbon dioxide.** We will now describe the human respiratory system in detail. Before we go further and describe the human respiratory system in detail, it is necessary to learn the process of breathing which is an important part of respiration. This is discussed below.

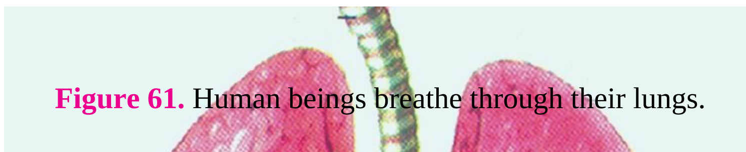


Figure 61. Human beings breathe through their lungs.

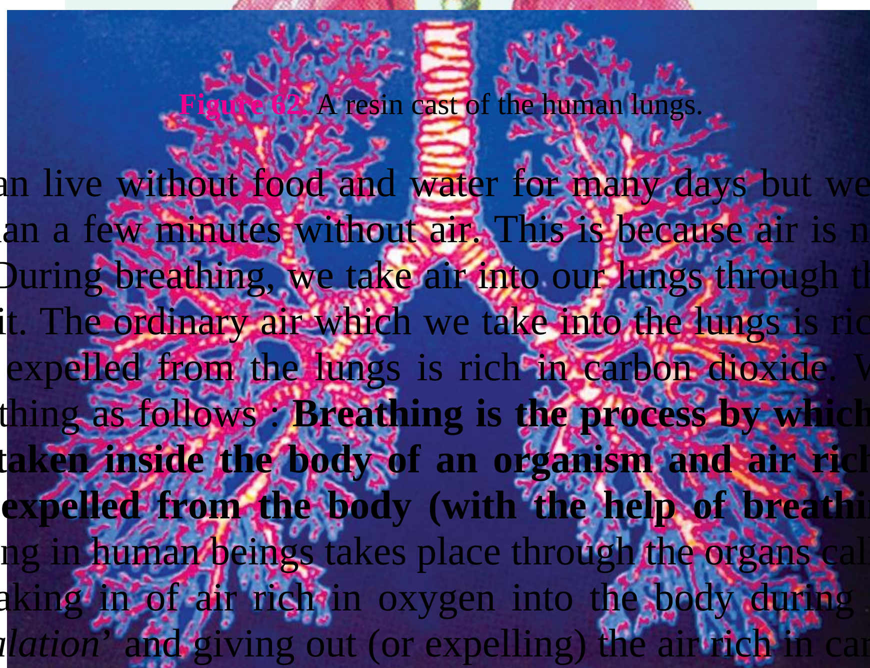


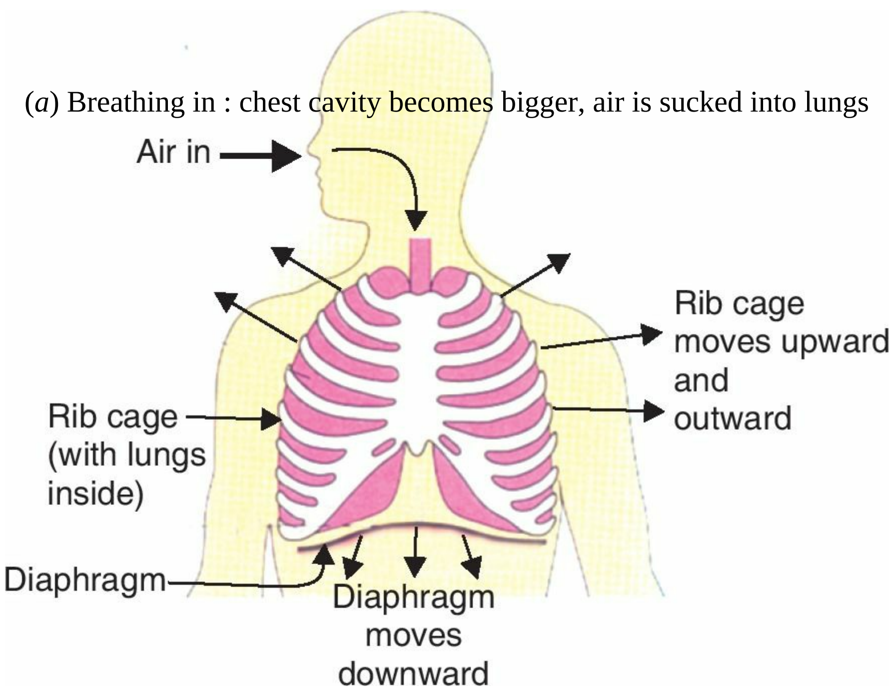
Figure 62. A resin cast of the human lungs.

We can live without food and water for many days but we cannot live for more than a few minutes without air. This is because air is necessary for breathing. During breathing, we take air into our lungs through the nose, and then expel it. The ordinary air which we take into the lungs is rich in oxygen but the air expelled from the lungs is rich in carbon dioxide. We can now define breathing as follows : **Breathing is the process by which air rich in oxygen is taken inside the body of an organism and air rich in carbon dioxide is expelled from the body (with the help of breathing organs).** The breathing in human beings takes place through the organs called lungs.

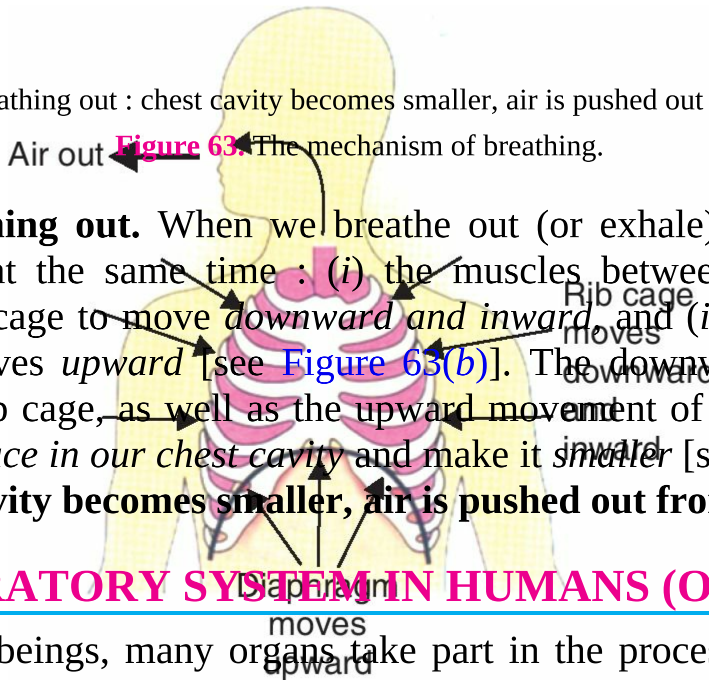
The taking in of air rich in oxygen into the body during breathing is called '*inhalation*' and giving out (or expelling) the air rich in carbon dioxide is called '*exhalation*'. Both, inhalation and exhalation take place regularly during breathing. **A breath means 'one inhalation plus one exhalation'.** We know that air contains oxygen. So, when we breathe in air, it is actually the oxygen gas present in air which is utilised by our body (to break down food and produce energy). Thus, we '*breathe in*' *air to supply oxygen to the cells of our body* (*for the breakdown of food to release energy*), *and we 'breathe out' to remove waste product carbon dioxide from our body* (*which is produced during the breakdown of food in the cells*). Breathing is a continuous process which goes on all the time throughout our life.

We will now learn the mechanism of breathing. That is, we will now learn how air from outside is sucked into our lungs during *inhaling* (breathing in), and how air from our lungs is pushed out during *exhaling* (breathing out). The process of breathing takes place in our lungs. Lungs are connected to our nostrils (holes in the nose) through nasal passage (or nasal cavity) and windpipe. When we inhale air, it enters our nostrils, passes through nasal passage and windpipe, and reaches our lungs. Our two lungs hang in an airtight space in our body called 'chest cavity'. Around the sides of the chest cavity is the **rib cage** with sheets of muscles between the ribs. The rib cage encloses the lungs in it [see Figure 63(*a*)]. At the bottom of the chest cavity is a curved sheet of muscle called diaphragm [see Figure 63(*a*)]. Diaphragm forms the floor of chest cavity. **Breathing involves the movements of the rib cage and the diaphragm**. This happens as follows :

(*a*) Breathing in. When we breathe in (or inhale), then two things happen at the same time : (*i*) the muscles between the ribs contract causing the rib cage to move *upward and outward*, and (*ii*) the diaphragm contracts and moves *downward* [see Figure 63(*a*)]. The upward and outward movement of rib cage, as well as the downward movement of diaphragm, both *increase the space in the chest cavity* and make it *larger* [see Figure 63(*a*)]. **As the chest cavity becomes larger, air is sucked in from outside into the lungs**. The lungs get filled up with air and expand.



(*a*) Breathing in : chest cavity becomes bigger, air is sucked into lungs



(*b*) Breathing out : chest cavity becomes smaller, air is pushed out of lungs

Figure 63. The mechanism of breathing.

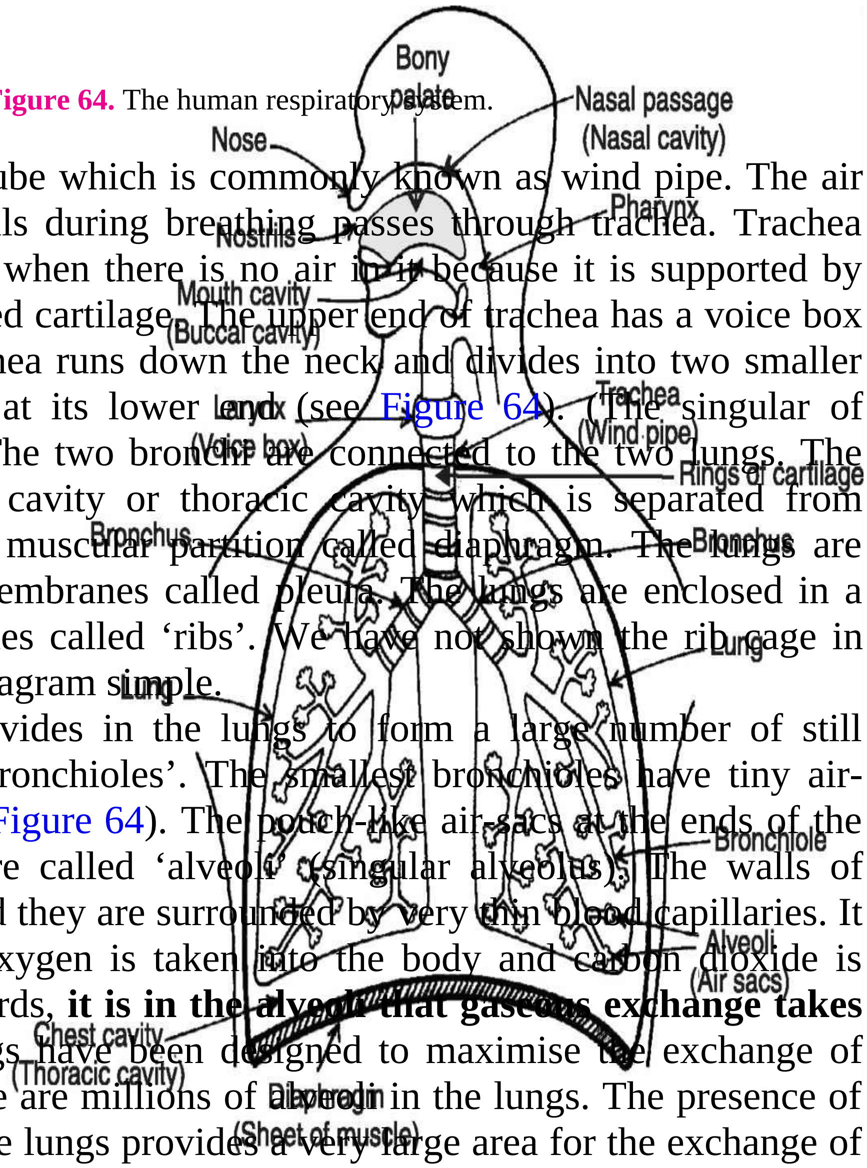
(*b*) Breathing out. When we breathe out (or exhale), even then two things happen at the same time : (*i*) the muscles between the ribs relax causing the rib cage to move *downward and inward*, and (*ii*) the diaphragm relaxes and moves *upward* [see Figure 63(*b*)]. The downward and inward movement of rib cage, as well as the upward movement of diaphragm, both *decrease the space in our chest cavity* and make it *smaller* [see Figure 63(*b*)]. **As the chest cavity becomes smaller, air is pushed out from the lungs.**

RESPIRATORY SYSTEM IN HUMANS (OR MAN)

In human beings, many organs take part in the process of respiration. We call them organs of respiratory system. **The main organs of human respiratory system are : Nose, Nasal passage (or Nasal cavity), Trachea, Bronchi, Lungs and Diaphragm.** The human respiratory system is shown in Figure 64.

The human respiratory system begins from the nose. Our nose has two holes in it which are called nostrils (see Figure 64). There is a passage in the nose behind the nostrils which is called nasal passage (or nasal cavity). **The air for respiration is drawn into our body through the nostrils present in the nose.** This air then goes into nasal passage. The nasal passage is separated from the mouth cavity (buccal cavity or oral cavity) by a hard, bony palate so that we can breathe in air even when we are eating food (and the mouth cavity is filled with food). The nasal passage is lined with fine hair and mucus (Mucus is secreted by the glands inside the nasal passage). When air passes through the nasal passage, the dust particles and other impurities present in it are trapped by nasal hair and mucus so that clean air goes into the lungs. The part of throat between the mouth and wind pipe is called pharynx. From the nasal passage, air enters into pharynx and then goes into the wind pipe (or trachea) (see Figure 64).

Figure 64. The human respiratory system.



The trachea is a tube which is commonly known as wind pipe. The air coming from the nostrils during breathing passes through trachea. Trachea does not collapse even when there is no air in it because it is supported by rings of soft bones called cartilage. The upper end of trachea has a voice box called larynx. The trachea runs down the neck and divides into two smaller tubes called 'bronchi' at its lower end (see Figure 64). (The singular of bronchi is bronchus). The two bronchi are connected to the two lungs. The lungs lie in the chest cavity or thoracic cavity which is separated from abdominal cavity by a muscular partition called diaphragm. The lungs are covered by two thin membranes called pleura. The lungs are enclosed in a 'rib cage' made of bones called 'ribs'. We have not shown the rib cage in Figure 64 to keep the diagram simple.

Each bronchus divides in the lungs to form a large number of still smaller tubes called 'bronchioles'. The smallest bronchioles have tiny air-sacs at their ends (see Figure 64). The pouch-like air-sacs at the ends of the smallest bronchioles are called 'alveoli' (singular alveolus). The walls of alveoli are very thin and they are surrounded by very thin blood capillaries. It is in the alveoli that oxygen is taken into the body and carbon dioxide is eliminated. In other words, **it is in the alveoli that gaseous exchange takes place**. The human lungs have been designed to maximise the exchange of gases as follows : There are millions of alveoli in the lungs. The presence of millions of alveoli in the lungs provides a very large area for the exchange of gases. And the availability of large surface area maximises the exchange of gases. For example, if all alveoli from the two human lungs are unfolded, they would give an area of about 80 square metres (which is nearly the size of a tennis court !). The diaphragm is a sheet of muscle below the lungs (see Figure 64). It helps in 'breathing in' and 'breathing out'. The muscles of chest also help in breathing in and breathing out.

Figure 65. This picture shows where in the body our lungs are.

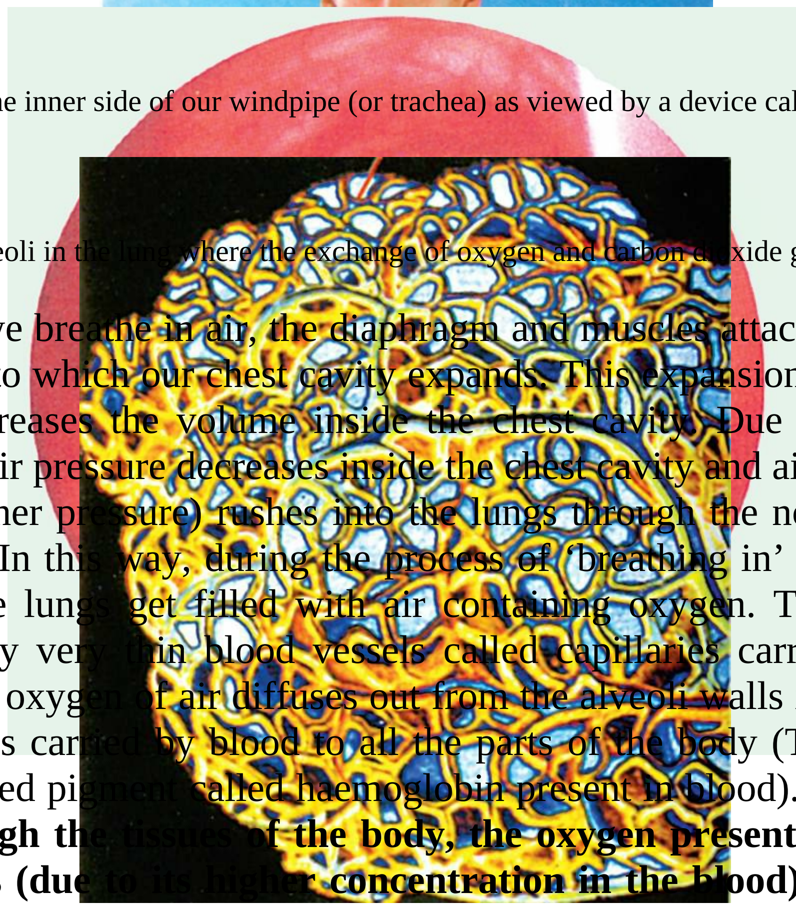


Figure 66. The inner side of our windpipe (or trachea) as viewed by a device called endoscope.

Figure 67. Alveoli in the lung where the exchange of oxygen and carbon dioxide gases takes place.

When we breathe in air, the diaphragm and muscles attached to the ribs contract due to which our chest cavity expands. This expansion movement of the chest increases the volume inside the chest cavity. Due to increase in volume, the air pressure decreases inside the chest cavity and air from outside (being at higher pressure) rushes into the lungs through the nostrils, trachea and bronchi. In this way, during the process of 'breathing in' the air sacs or alveoli of the lungs get filled with air containing oxygen. The alveoli are surrounded by very thin blood vessels called capillaries carrying blood in them. So, the oxygen of air diffuses out from the alveoli walls into the blood. The oxygen is carried by blood to all the parts of the body (This oxygen is carried by a red pigment called haemoglobin present in blood). **As the blood passes through the tissues of the body, the oxygen present in it diffuses into the cells (due to its higher concentration in the blood).** This oxygen combines with the digested food (glucose) present in the cells to release energy. Carbon dioxide gas is produced as a waste product during respiration in the cells of the body tissues. **This carbon dioxide diffuses into the blood (due to its higher concentration in body tissues).** Blood carries the carbon dioxide back to the lungs where it diffuses into the alveoli. When we breathe out air, the diaphragm and the muscles attached to the ribs relax due to which our chest cavity contracts and becomes smaller. This contraction movement of the chest pushes out carbon dioxide from the alveoli of the lungs into the trachea, nostrils and then out of the body into air. In this way the process of gaseous exchange is completed in the human respiratory system.

Please note that during the breathing cycle, when air is taken in (or inhaled) and let out (or exhaled), the lungs always contain a certain *residual volume* of air so that there is sufficient time 'for the oxygen to be absorbed' into the blood and 'for the carbon dioxide to be released' from the blood.

Another point to be noted is that carbon dioxide is more soluble in water (than oxygen), so it is mostly transported in the dissolved form in our blood.

Experiment to Show That Carbon Dioxide is Produced During Respiration

We know that carbon dioxide gas turns lime-water milky. The fact that carbon dioxide is produced during respiration can be shown by demonstrating the effect of inhaled air and exhaled air on lime-water. The apparatus to demonstrate the effect of inhaled air and exhaled air on lime-water is shown in Figure 68. The apparatus consists of two boiling tubes *A* and *B* fitted with two-holed corks. The boiling tubes *A* and *B* are connected through a special type of glass tube *C*. The left arm of glass tube *C* is short which goes in the boiling tube *A*. The right arm of glass tube *C* is long and dips in lime-water in boiling tube *B* (see Figure 68). The boiling tube *A* has another bent glass tube *D* whose longer side dips in lime-water contained in it. The boiling tube *B* has also another short, bent tube *E* in it which does not dip in lime-water.

To perform the experiment, we put the top end of the tube *C* in mouth and 'breathe in' and 'breathe out' gently. When we breathe in, then the inhaled air (fresh air) enters the glass tube *D* and passes through the lime-water in boiling tube *A*. And when we breathe out, then the exhaled air (coming from our lungs) passes through the lime-water in boiling tube *B*. We continue to breathe in and breathe out for about five minutes. We will find that the lime-water in boiling tube *A* (in which inhaled air is passed) turns milky only slightly but the lime-water in boiling tube *B* (in which exhaled air is passed) turns milky appreciably. This shows that **less carbon dioxide is present in inhaled air but much more carbon dioxide is present in exhaled air.** From this observation we conclude that **carbon dioxide is produced during respiration (which comes out in exhaled air).**

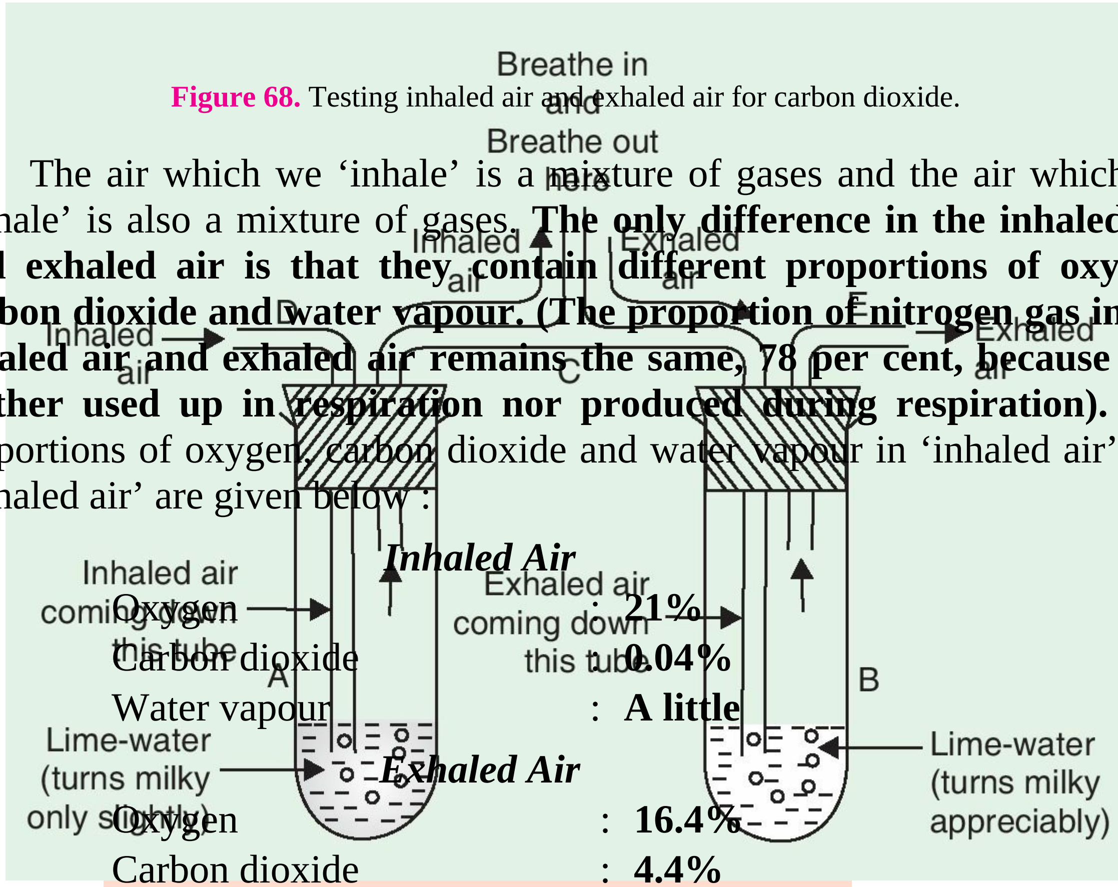


Figure 68. Testing inhaled air and exhaled air for carbon dioxide.

The air which we 'inhale' is a mixture of gases and the air which we 'exhale' is also a mixture of gases. **The only difference in the inhaled air and exhaled air is that they contain different proportions of oxygen, carbon dioxide and water vapour. (The proportion of nitrogen gas in the inhaled air and exhaled air remains the same, 78 per cent, because it is neither used up in respiration nor produced during respiration).** The proportions of oxygen, carbon dioxide and water vapour in 'inhaled air' and 'exhaled air' are given below :

Inhaled Air

Oxygen	:	**21%**
Carbon dioxide	:	**0.04%**
Water vapour	:	**A little**

Exhaled Air

Oxygen	:	**16.4%**
Carbon dioxide	:	**4.4%**
Water vapour	:	**A lot**

We can see from the above figures that the air which we inhale contains a greater proportion (21 per cent) of oxygen. Now, some of the oxygen of inhaled air is used up in breaking down glucose food during respiration, so the exhaled air which comes out after the process of respiration contains a lower proportion (16.4 per cent) of oxygen. The air which we inhale contains a lower proportion (0.04 per cent) of carbon dioxide. Now, during respiration, when oxygen breaks down glucose food, then a lot of carbon dioxide is produced, so the exhaled air which comes out after respiration contains a much higher proportion (4.4 per cent) of carbon dioxide. Again, the air which we inhale contains only a little of water vapour. Now, when glucose food is broken down by oxygen during respiration, then water is also produced (alongwith carbon dioxide). So, the exhaled air contains a lot more water vapour than inhaled air.

Rate of Breathing

The process of breathing pumps in oxygen into our body (and removes carbon dioxide). Breathing occurs involuntarily (on its own) but the rate of breathing is controlled by the respiratory system of brain. **The average breathing rate in an adult man at rest is about 15 to 18 times per minute.** This breathing rate increases with increased physical activity. For example, if we do some physical exercise (like sit-up exercise), then our breathing rate goes up considerably. This is because when we do some physical exercise, then our body needs more energy. And to produce more energy through respiration, our body requires more oxygen gas. **Rapid breathing supplies more oxygen to body cells for producing more energy required for doing physical exercise.** Thus, we breathe faster after exercise so as to produce more energy to compensate the loss of energy suffered by our body in doing exercise.

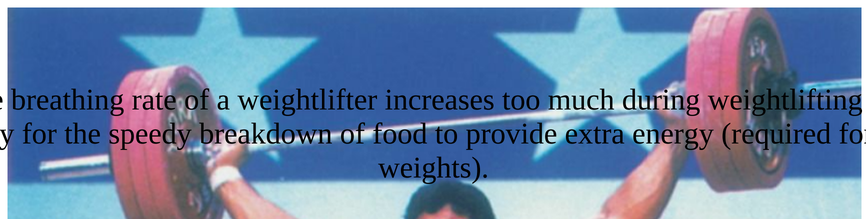


Figure 69. The breathing rate of a weightlifter increases too much during weightlifting so as to supply oxygen rapidly for the speedy breakdown of food to provide extra energy (required for lifting heavy weights).

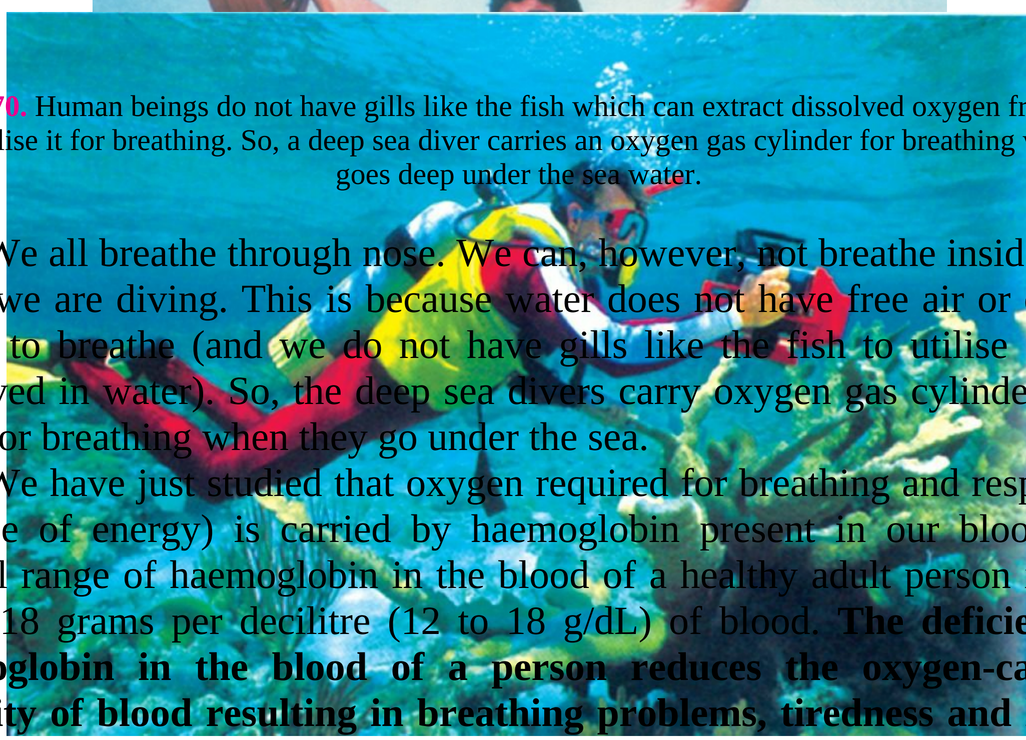


Figure 70. Human beings do not have gills like the fish which can extract dissolved oxygen from water and utilise it for breathing. So, a deep sea diver carries an oxygen gas cylinder for breathing when he goes deep under the sea water.

We all breathe through nose. We can, however, not breathe inside water when we are diving. This is because water does not have free air or oxygen for us to breathe (and we do not have gills like the fish to utilise oxygen dissolved in water). So, the deep sea divers carry oxygen gas cylinders with them for breathing when they go under the sea.

We have just studied that oxygen required for breathing and respiration (release of energy) is carried by haemoglobin present in our blood. The normal range of haemoglobin in the blood of a healthy adult person is from 12 to 18 grams per decilitre (12 to 18 g/dL) of blood. **The deficiency of haemoglobin in the blood of a person reduces the oxygen-carrying capacity of blood resulting in breathing problems, tiredness and lack of energy.** The person looks pale and loses weight.

Many times we have heard of **carbon monoxide poisoning.** This happens as follows. Carbon monoxide gas (CO) is formed whenever a fuel burns in an insufficient supply of air. For example, if coal (or charcoal) is burned in a closed space (like a room with closed doors and windows), then a lot of carbon monoxide is formed. Carbon monoxide is also produced when petrol burns in a car engine. Now, we know that haemoglobin present in our blood carries oxygen to all the parts of our body. Haemoglobin has more affinity (or attraction) for carbon monoxide than oxygen, So, if carbon monoxide gas is inhaled by a person, then this **carbon monoxide binds very strongly with haemoglobin in the blood and prevents it from carrying oxygen to the brain and other parts of the body.** Due to lack of oxygen, the person cannot breathe properly. If carbon monoxide is inhaled for a long time, then the person becomes unconscious and can even die due to oxygen starvation.

The persons having breathing problems (or respiratory problems) are given oxygen masks to facilitate breathing. In serious cases, the patient is put on a machine called 'ventilator' in which a tube is inserted directly into the trachea (or wind pipe) of the patient to help him in breathing comfortably. Before we go further and describe the transport of materials in plants and animals, **please answer the following questions :**

Very Short Answer Type Questions

1. Do all cells use oxygen to produce energy ?
2. Name one substance which is produced in anaerobic respiration by an organism but not in aerobic respiration.
3. Name one organism which can live without oxygen.
4. In which type of respiration, aerobic or anaerobic, more energy is released ?
5. Name the substance whose build up in the muscles during vigorous physical exercise may cause cramps.
6. Which part of roots is involved in the exchange of respiratory gases ?
7. Name the process by which plant parts like roots, stems, and leaves get oxygen required for respiration.
8. Name the pores in a leaf through which respiratory exchange of gases takes place.
9. Name the areas in a woody stem through which respiratory exchange of gases takes place.
10. What is the name of the extensions of the epidermal cells of a root which help in respiration ?
11. Out of photosynthesis and respiration in plants, which process occurs :
(*a*) all the time ?
(*b*) only at daytime ?
12. Name the organs of breathing in fish.
13. Name an animal which absorbs oxygen through its moist skin.
14. Name an animal which depends on simple diffusion of gases for breathing.
15. Name two animals which breathe through gills.
16. The trachea divides into two tubes at its lower end. What is the name of these tubes ?
17. Where does the blood absorb oxygen in the human body ?
18. Name the red pigment which carries oxygen in blood.
19. Which gases are exchanged in your lungs ?
20. Where in the lungs does gas exchange take place ?

21. What is the name of tiny air-sacs at the end of smallest bronchioles in the lungs ?
22. What is the other name of wind-pipe ?
23. What organs are attached to the two bronchi ?
24. In the lungs :
(*a*) what substance is taken into the body ?
(*b*) what substance is removed from the body ?
25. State whether the following statements are true or false :
(*a*) During respiration, the plants take CO_2 and release O_2.
(*b*) Energy can be produced in cells without oxygen.
(*c*) Fish and earthworm exchange gases during respiration in the same way.
26. Fill in the following blanks with suitable words :
(*a*) The organs of respiration in man are the……………..
(*b*) The actual exchange of gases takes place in the……………of the lungs.
(*c*) ………………in the lungs provide a very large surface area for gaseous exchange.
(*d*) Yeast undergoes……………..respiration whereas *Amoeba* undergoes……………… respiration.
(*e*) Gills are the breathing organs in…………….

Short Answer Type Questions

27. Explain why, a land plant may die if its roots remain waterlogged for a long time.
28. What are the differences between aerobic and anaerobic respiration ? Name some organisms that use anaerobic mode of respiration.
29. Name the final product/products obtained in the anaerobic respiration, if it takes place :
(*a*) in a plant (like yeast).
(*b*) in an animal tissue (like muscles).
30. What type of respiration takes place in human muscles during vigorous physical exercise ? Give reason for your answer.
31. Name the type of respiration in which the end products are :
(*a*) C_2H_5OH and CO_2
(*b*) CO_2 and H_2O
(*c*) Lactic acid
Give one example of each case where such a respiration can occur.
32. Define breathing. State the differences between breathing and respiration.
33. What are the different ways in which glucose is oxidised to provide energy in various organisms ? Give one example of each.
34. Explain why, when air is taken in and let out during breathing, the lungs always contain a residual volume of air.
35. Explain why, it is dangerous to inhale air containing carbon monoxide.
36. Describe the process of respiration in *Amoeba*. State whether it is anaerobic respiration or aerobic respiration.
37. State the three common features of all the respiratory organs like skin, gills and lungs.
38. Describe the process of respiration in fish.
39. What would be the consequences of deficiency of haemoglobin in our bodies ?
40. Describe the process of respiration in the following parts of a plant :
(*a*) Root
(*b*) Stem
(*c*) Leaves
41. (*a*) What is meant by aquatic animals and terrestrial animals ?
(*b*) From where do the aquatic animals and terrestrial animals obtain oxygen for breathing

and respiration ?

42. Why do fishes die when taken out of water ?

43. Why is the rate of breathing in aquatic organisms much faster than in terrestrial organisms ?

44. Name the energy currency in the living organisms. When and where is it produced ?

45. Explain why, plants have low energy needs as compared to animals.

46. Explain how, it would benefit deep sea divers if humans also had gills.

Long Answer Type Questions

47. (*a*) What is the function of the respiratory system ?
(*b*) What are the major organs of respiratory system in man (or humans) ?
(*c*) Draw a labelled diagram of the human respiratory system.

48. (*a*) Explain how, the air we breathe in gets cleaned while passing through the nasal passage.
(*b*) Why do the walls of trachea not collapse when there is less air in it ?
(*c*) How are oxygen and carbon dioxide exchanged in our body during respiration ?
(*d*) How are lungs designed in human beings to maximise the exchange of gases ?

49. (*a*) Give the main points of difference between respiration in plants and respiration in animals.
(*b*) Describe the exchange of gases which takes place in the leaves of a plant (*a*) during daytime, and
(*b*) at night.
(*c*) Which contains more carbon dixoide : exhaled air or inhaled air ? Why ?

50. (*a*) "Respiration is a vital function of the body". Justify this statement.
(*b*) What is the main difference between aerobic respiration and anaerobic respiration ? Give one example of each.
(*c*) What type of repiration takes place (*i*) in yeast, and (*ii*) in humans ?

51. (*a*) Why is diffusion insufficient to meet the oxygen requirements of large multicellular organisms like humans ?
(*b*) What type of arrangement exists in the bodies of large animals to meet their oxygen requirements adequately ?
(*c*) What advantage a terrestrial animal has over an aquatic animal with regard to obtaining oxygen for respiration ?

Multiple Choice Questions (MCQs)

52. Which of the following is not produced during anaerobic respiration in unicellular fungus ?
(*a*) C_2H_5OH
(*b*) H_2O
(*c*) CO_2
(*d*) ATP

53. One of the following organisms can live without oxygen of air. This organism is :
(*a*) *Amoeba*
(*b*) Yak
(*c*) Yeast
(*d*) Leech

54. During respiration, the exchange of gases takes place in :
(*a*) bronchi
(*b*) alveoli
(*c*) bronchioles
(*d*) trachea

55. In one of the following organisms, the gaseous exchange during repiration does not take place through cell membrane/skin. This organism is :

(*a*) Electric eel
(*b*) Leech
(*c*) Earthworm
(*d*) *Amoeba*

56. Which of the following is correct for the process of anaerobic respiration ?

	Carbon dioxide always produced	*A lot of energy released*
(*a*)	No	Yes
(*b*)	No	No
(*c*)	Yes	No
(*d*)	Yes	Yes

57. Which of the following increases in muscle cells when they are lacking in oxygen ?

(*a*) carbon dioxide
(*b*) lactose
(*c*) lactic acid
(*d*) uric acid

58. Internal respiration may be defined as :

(*a*) breathing in and releasing of oxygen in the tissue
(*b*) the oxidation of food substances to release energy
(*c*) the building up (synthesis) of complex substances
(*d*) getting rid of carbon dixode that would accumulate in the tissues.

59. When air is blown from mouth into a test-tube containing lime water, the lime water turns milky due to the presence of :

(*a*) oxygen
(*b*) carbon dioxide
(*c*) nitrogen
(*d*) water vapour

60. Which of the following is the correct sequence of air passage during inhalation ?

(*a*) nostrils $\longrightarrow$ larynx $\longrightarrow$ pharynx $\longrightarrow$ trachea $\longrightarrow$ lungs
(*b*) nasal passage $\longrightarrow$ trachea $\longrightarrow$ pharynx $\longrightarrow$ larynx $\longrightarrow$ alveoli
(*c*) larynx $\longrightarrow$ nostrils $\longrightarrow$ pharynx $\longrightarrow$ lungs
(*d*) nostrils $\longrightarrow$ pharynx $\longrightarrow$ larynx $\longrightarrow$ trachea $\longrightarrow$ alevoli

61. Lack of oxygen in muscles often leads to cramps in the legs of sprinters. This is due to conversion of pyruvate to :

(*a*) ethanol
(*b*) carbon dioxide
(*c*) acetic acid
(*d*) lactic acid

62. During the deficiency of oxygen in tissues of human beings, pyruvic acid is converted into lactic acid in :

(*a*) cytoplasm
(*b*) chloroplast
(*c*) mitochondria
(*d*) golgi body

63. Which of the following statements are correct ?

(*i*) pyruvate can be converted into ethanol and carbon dioxide by yeast
(*ii*) fermentation takes place in the case of aerobic bacteria
(*iii*) fermentation takes place in mitochondria
(*iv*) fermentation is a form of anaerobic respiration

(*a*) (*i*) and (*iii*)

(*b*) (*ii*) and (*iv*)
(*c*) (*i*) and (*iv*)
(*d*) (*ii*) and (*iii*)

64. Which of the following statements are true about respiration ?

(*i*) during inhalation, ribs move inward and diaphragm is raised.
(*ii*) the gaseous exchange takes place in the alveoli.
(*iii*) haemoglobin has greater affinity for carbon dioxide than oxygen.
(*iv*) alveoli increase surface area for the exchange of gases

(*a*) (*i*) and (*iv*)
(*b*) (*ii*) and (*iii*)
(*c*) (*i*) and (*iii*)
(*d*) (*ii*) and (*iv*)

65. Which of the following is known as the energy currency of cells in biology ?

(*a*) DTP
(*b*) PDP
(*c*) ATP
(*d*) DDT

66. The two organisms which breathe only through their moist skin are :

(*a*) fish and frog
(*b*) frog and earthworm
(*c*) leech and earthworm
(*d*) fish and earthworm

67. One of the following animals does not use tracheae as the respiratory organs. This animal is :

(*a*) grasshopper
(*b*) prawn
(*c*) mosquito
(*d*) cockroach

68. The photosynthesis in a plant is not taking place during the day time if the plant is releasing :

(*a*) water vapour
(*b*) oxygen
(*c*) carbon dioxide
(*d*) all the above

69. The breathing and respiration in woody stem of a plant takes place through :

(*a*) root hair
(*b*) lenticels
(*c*) closed stomata
(*d*) open stomata

70. One of the following organism does not depend on simple diffusion of gases for breathing and respiration. This organism is :

(*a*) Amoeba
(*b*) Prawn
(*c*) Planaria
(*d*) Bryophyllum

71. During marathon, we sometimes get painful contractions of leg muscles due to the accumulation of one of the following in leg muscles. This is :

(*a*) carbon dioxide
(*b*) alcohol
(*c*) lactose
(*d*) lactic acid

72. In cockroaches, air enters the body through :

(*a*) lungs
(*b*) gills
(*c*) spiracles
(*d*) skin

73. Which of the following is most likely to have a much higher breathing rate ?
(*a*) man
(*b*) fish
(*c*) dog
(*d*) sparrow

Questions Based on High Order Thinking Skills (HOTS)

74. During the respiration of an organism A, 1 molecule of glucose produces 2 ATP molecules whereas in the respiration of another organism B, 1 molecule of glucose produces 38 ATP molecules.
(*a*) Which organism is undergoing aerobic respiration ?
(*b*) Which organism is undergoing anaerobic respiration ?
(*c*) Which type of organism, A or B, can convert glucose into alcohol ?
(*d*) Name one organism which behaves like A.
(*e*) Name two organisms which behave like B.

75. A, B and C are three living organisms. The organism A is a unicellullar fungus which can live without air. It is used in the commercial production of an organic compound P from molasses. The organism B is a unicellular animal which lives in water and feeds and moves by using pseudopodia. It breathes through an organelle Q. The organism C is a tiny animal which acts as a carrier of malarial parasite. It breathes and respires through a kind of tiny holes R and air-tubes S in its body.
(*a*) What are organisms (*i*) A (*ii*) B, and (*iii*) C ?
(*b*) Name (*i*) P (*ii*) Q (*iii*) R, and (*iv*) S.
(*c*) Which organism/organisms undergo aerobic respiration ?
(*d*) Which organism/organisms undergo anaerobic respiration ?

76. There are five animals P, Q, R, S and T. The animal P always lives in water and has gills for breathing. The animal Q can stay in water as well as on land and can breathe both, through moist skin and lungs. The animal R lives in soil and breathes only through its skin. The animal S lives on land and breathes through spiracles and tracheae. And animal T lives in water and breathes through its cell membrane.
(*a*) Which of the animals could be *Amoeba* ?
(*b*) Which of the animals could be frog ?
(*c*) Which animal could be fish ?
(*d*) Which animal could be grasshopper ?
(*e*) Which animal could be earthworm ?

77. Some sugar solution is taken in a test-tube and a little of substance X in powder form is added to it. The mouth of test-tube is closed with a cork and allowed to stand for sometime. On opening the cork, a characteristic smell of substance Y is obtained and a gas Z is also observed to be formed. The gas Z extinguishes a burning matchstick.
(*a*) What could be (*i*) X, (*ii*) Y, and (*iii*) Z ?
(*b*) What is the process of converting sugar into substance Y by the action of X known as ?
(*c*) What type of respiration is exhibited by X in the above process ?

78. Consider the following chemical reactions which take place in different organisms/tissues under various conditions :

(*i*) Glucose $\xrightarrow{\text{Respiration}}$ Ethanol + Carbon dioxide + Energy

(*ii*) Glucose $\xrightarrow{\text{Respiration}}$ Carbon dioxide + Water + Energy

(*iii*) Glucose $\xrightarrow{\text{Respiration}}$ Lactic acid + Energy

(*a*) Name one organism which respires according to equation (*i*) above.
(*b*) Name one organism which respires according to equation (*ii*) above.
(*c*) When and where does respiration represented by equation (*iii*) above take place ?
(*d*) Which equation/equations represent aerobic respiration ?
(*e*) Which equation/equations represent anaerobic respiration ?
(*f*) Which of the above reactions produces the maximum amount of energy ?

79. When a person breathes in air, the air enters into his body through an organ A having two holes B in it. The air then passes through pharynx and larynx and enters into a tube C. The tube C divides into two smaller tubes D at its lower end. The two smaller tubes are attached to two respiratory organs E. Each smaller tube divides inside the organs E to form a large number of still smaller tubes called F. The smallest tubes F have air-sacs G at their ends in which gaseous exchange takes place in the body of the person. What are A, B, C, D, E, F and G ?

80. An organism X having breathing organs A lives on land. When organism X goes under water, it cannot survive for a long time unless carrying an oxygen cylinder. On the other hand, the organism Y having breathing organs B always lives in water and if taken out of water, it dies after a short while. A third organism Z having breathing organs C and D which lives on the banks of ponds, lakes and rivers can survive on land as well as in water equally well.
(*a*) What could organism X be ? Name the breathing organs A.
(*b*) What could organism Y be ? Name the breathing organs B.
(*c*) What could organism Z be ? Name the breathing organs C and D.
(*d*) Out of X, Y and Z, which organism is (*i*) amphibian, (*ii*) aquatic, and (*iii*) terrestrial ?

ANSWERS

1. No **2.** Ethanol **5.** Lactic acid **7.** Diffusion **10.** Root hair **11.** (*a*) Respiration (*b*) Photosynthesis **17.** Alveoli in lungs **24.** (*a*) Oxygen (*b*) Carbon dioxide **25.** (*a*) False (*b*)True (*c*) False **26.** (*a*) lungs (*b*) alveoli (*c*) Alveoli (*d*) anaerobic; aerobic (*e*) fish **31.** (*a*) Anaerobic respiration in yeast (*b*) Aerobic respiration (*c*) Anaerobic respiration in muscle tissue of animals **44.** ATP **46.** The deep sea divers could remain under sea water even without carrying oxygen cylinders for breathing (because they could then extract dissolved oxygen from water for breathing purpose just like fish) **52.** (*b*) **53.** (*c*) **54.** (*b*) **55.** (*a*) **56.** (*b*) **57.** (*c*) **58.** (*b*) **59.** (*b*) **60.** (*d*) **61.** (*d*) **62.** (*a*) **63.** (*c*) **64.** (*d*) **65.** (*c*) **66.** (*c*) **67.** (*b*) **68.** (*c*) **69.** (*b*) **70.** (*b*) **71.** (*d*) **72.** (*c*) **73.** (*b*) **74.** (*a*) B (*b*) A (*c*) A (*d*) Yeast (*e*) Man, Dog **75.** (*a*) (*i*) Yeast (*ii*) *Amoeba* (*iii*) Mosquito (*b*) (*i*) Ethanol (*ii*) Cell membrane (*iii*) Spiracles (*iv*) Tracheae (*c*) B and C (*d*) A **76.** (*a*) T (*b*) Q (*c*) P (*d*) S (*e*) R **77.** (*a*) (*i*) Yeast (*ii*) Ethanol (*iii*) Carbon dioxide (*b*) Fermentation (*c*) Anaerobic respiration **78.** (*a*) Yeast (*b*) Man (*c*) In animal's muscles ; When the animal needs extra energy for doing heavy physical activity (*d*) (*ii*) (*e*) (*i*) and (*iii*) (*f*) (*ii*) **79.** A = Nose; B = Nostrils ; C = Trachea (or Windpipe) ; D = Bronchi ; E = Lungs ; F = Bronchioles ; G = Alveoli **80.** (*a*) Man; Lungs (*b*) Fish ; Gills (*c*) Frog ; Lungs and Skin (*d*) (*i*) Z (*ii*) Y (*iii*) X

TRANSPORT

The body of every organism (plant or animal) is made up of cells. A large organism has millions and millions of cells in its body. In order that the organism may be able to maintain its life and survive, all its cells must be supplied with essential substances like food, oxygen, water, etc. So, **some arrangement is required inside an organism which can carry the essential substances to all its parts so that they reach each and every cell of its body.**

In everyday language, ‘transport’ means ‘to carry things from one place to another’. **In biology, transport is a life process in which a substance absorbed (or made) in one part of the body of an organism is carried to other parts of its body.** Large organisms (large plants and animals) need transport systems in their bodies to supply all their cells with food, oxygen, water, and other materials. In fact, special tissues and organs are needed for the transport of substances in plants and animals because these tissues and organs can pick up the essential substances like food, oxygen, water, etc., at one end of their body and carry them to all other parts.

We will now study the transport system of plants and of human beings, and describe the parts which make up these systems. In other words, we will learn how plants and animals carry substances from one part of their body to another.

TRANSPORT IN PLANTS

Transport system in plants is less elaborate than in animals (including human beings). Plants are less active, so their cells do not need to be supplied with materials so quickly. Also, due to the branching shape of a plant, all the cells of a plant can get oxygen for respiration and carbon dioxide for photosynthesis directly from the air by diffusion. So, the only substances which are to be supplied to a plant through a transport system are water and minerals (which they can’t get from the air). Another job of the transport system of plants is to transport food prepared in the leaves to the various parts of the plant like stems, roots, etc. The plants have two types of conducting tissues called xylem and phloem. Xylem tissues carry water and minerals whereas phloem tissues carry the food prepared by the plants (see Figure 71). We can now say that :

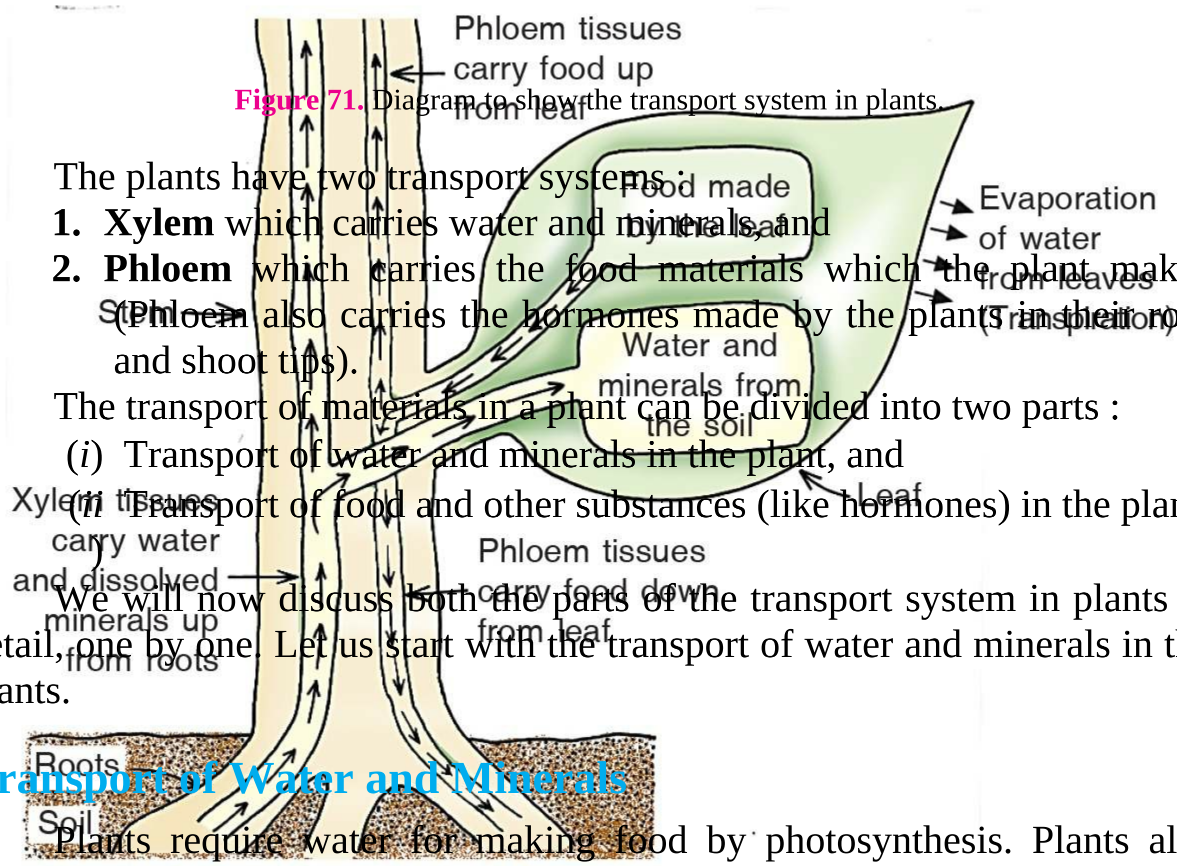


Figure 71. Diagram to show the transport system in plants.

The plants have two transport systems :

1. **Xylem** which carries water and minerals, and
2. **Phloem** which carries the food materials which the plant makes (Phloem also carries the hormones made by the plants in their root and shoot tips).

The transport of materials in a plant can be divided into two parts :

(*i*) Transport of water and minerals in the plant, and

(*ii*) Transport of food and other substances (like hormones) in the plant.

We will now discuss both the parts of the transport system in plants in detail, one by one. Let us start with the transport of water and minerals in the plants.

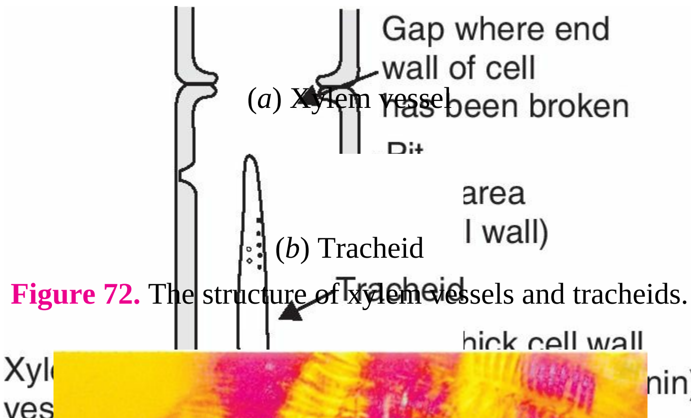
Transport of Water and Minerals

Plants require water for making food by photosynthesis. Plants also need mineral salts for various purposes (such as making proteins, etc.). Water and minerals are absorbed from the soil by the roots of the plant and transported to the various parts of the plant like stem, leaves and flowers. In the leaves, water is used in making food by photosynthesis. The water and minerals dissolved in it move from the roots of the plant to its leaves through the two kinds of elements of the xylem tissue called **xylem vessels** and **tracheids.** Xylem vessels and tracheids are both non-living conducting tissues which have thick walls. Let us discuss xylem vessels and tracheids in a little more detail.

1. Xylem Vessels

The xylem vessel is a non-living, long tube which runs like a drainpipe through the plant [see Figure 72(*a*)]. A xylem vessel is made of many hollow, dead cells (called vessel elements), joined end to end. The end walls of the cells have broken down so a long, open tube is formed. Xylem vessels run from the roots of the plant right up through the stem and reach the leaves. The xylem vessels branch into every leaf of the plant.

Xylem vessels do not contain the cytoplasm or nuclei. The walls of xylem vessels are made of cellulose and lignin. Lignin is a very hard and strong substance, so xylem vessels also provide strength to the stems and help to keep the plant upright. Wood is made almost entirely of lignified xylem vessels. Xylem vessels have pits in their thick cell walls. Pits are not open pores. Pits are the thin areas of the cell wall where no lignin has been deposited. Pits have unthickened cellulose cell wall. **In flowering plants, either only xylem vessels transport water or both xylem vessels and tracheids transport water.**



(*a*) Xylem vessel

(*b*) Tracheid

Figure 72. The structure of xylem vessels and tracheids.

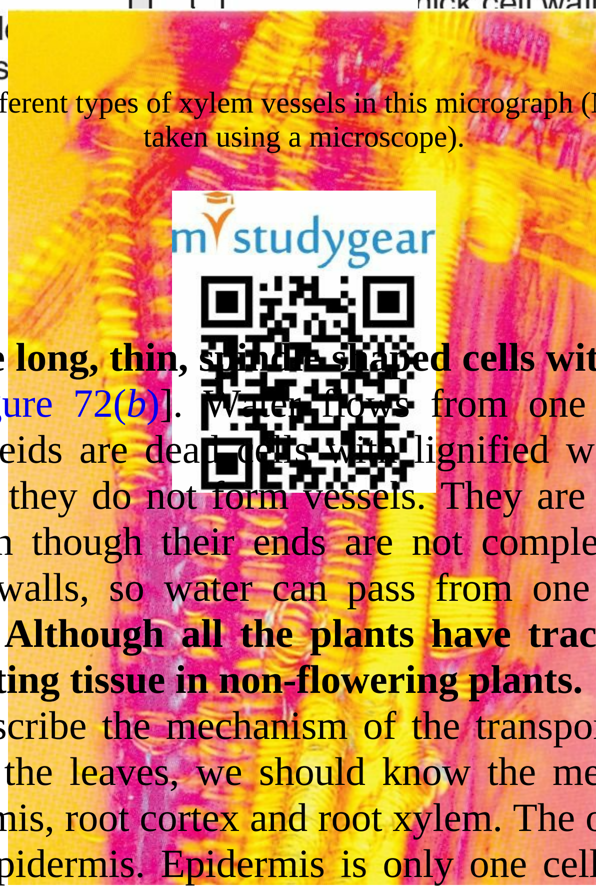


Figure 73. We can see different types of xylem vessels in this micrograph (Micrograph is a photograph taken using a microscope).

2. Tracheids

Tracheids are long, thin, spindle-shaped cells with pits in their thick cell walls [see Figure 72(*b*)]. Water flows from one tracheid to another through pits. Tracheids are dead cells with lignified walls but they do not have open ends, so they do not form vessels. They are elongated cells with tapering ends. Even though their ends are not completely open, tracheids have pits in their walls, so water can pass from one tracheid to another through these pits. **Although all the plants have tracheids, they are the only water conducting tissue in non-flowering plants.**

Before we describe the mechanism of the transport of water from the roots of a plant to the leaves, we should know the meanings of the terms epidermis, endodermis, root cortex and root xylem. The outer layer of cells in the root is called epidermis. Epidermis is only one cell thick. The layer of cells around the vascular tissues (xylem and phloem) in the root is called endodermis (It is the innermost layer of cortex). The part of root between the epidermis and endodermis is called root cortex. And the xylem tissue present in roots is called root xylem. Please note that in a root, the root hair are at its outer edge but the root xylem vessels (which carry water to the other parts of plant) are at the centre of the root. And in-between the root hair and root xylem are epidermis, root cortex and endodermis. So, before water absorbed by root hair from the soil reaches the root xylem, it has to pass through the epidermis, root cortex and endodermis.

Another point to be noted is that the minerals needed by the plants are taken up by the plants in inorganic form such as nitrates and phosphates. These minerals are present in the soil. The minerals present in soil dissolve in water to form an aqueous solution. So, when water is transported by the root of the plant to its leaves, then the minerals dissolved in it also get transported along with it.

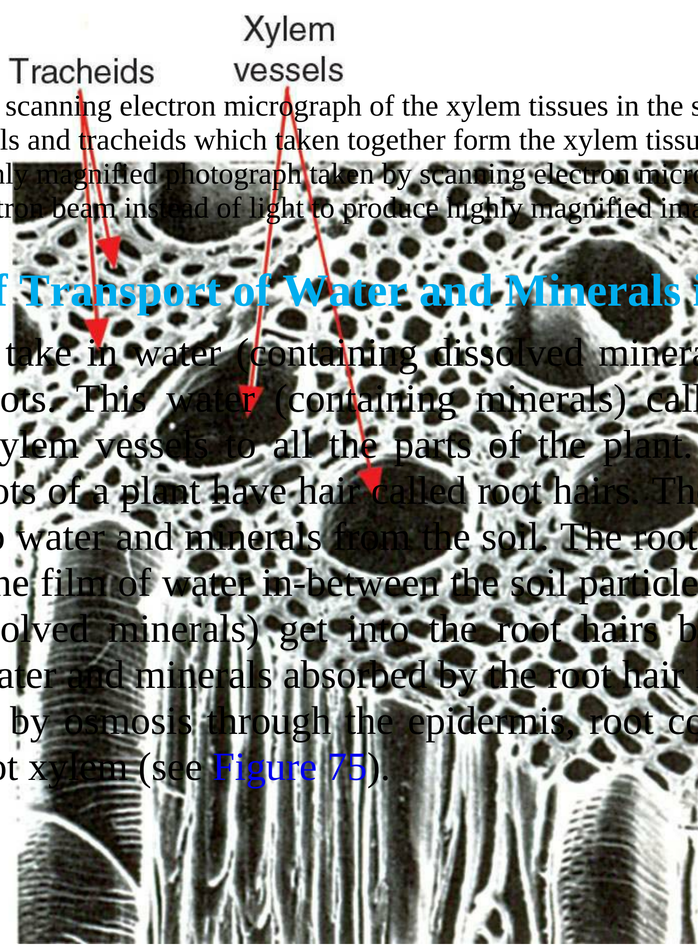


Figure 74. This is the scanning electron micrograph of the xylem tissues in the stem of a plant. We can see the xylem vessels and tracheids which taken together form the xylem tissue (Scanning electron micrograph is a highly magnified photograph taken by scanning electron microscope which uses an electron beam instead of light to produce highly magnified images).

Mechanism of Transport of Water and Minerals in a Plant

The plants take in water (containing dissolved minerals) from the soil through their roots. This water (containing minerals) called xylem sap is carried by the xylem vessels to all the parts of the plant. This happens as follows : The roots of a plant have hair called root hairs. The function of root hairs is to absorb water and minerals from the soil. The root hairs are directly in contact with the film of water in-between the soil particles (see Figure 75). Water (and dissolved minerals) get into the root hairs by the process of diffusion. The water and minerals absorbed by the root hair from the soil pass from cell to cell by osmosis through the epidermis, root cortex, endodermis and reach the root xylem (see Figure 75).

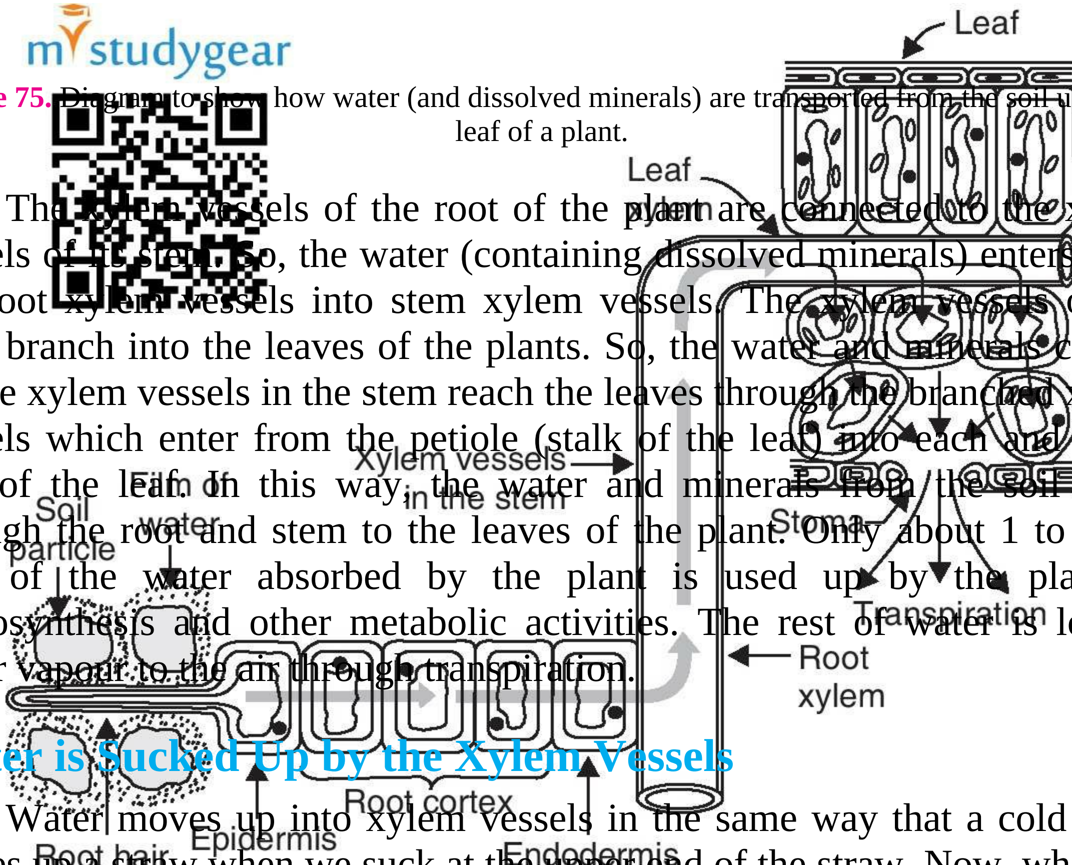


Figure 75. Diagram to show how water (and dissolved minerals) are transported from the soil up to the leaf of a plant.

The xylem vessels of the root of the plant are connected to the xylem vessels of its stem. So, the water (containing dissolved minerals) enters from the root xylem vessels into stem xylem vessels. The xylem vessels of the stem branch into the leaves of the plants. So, the water and minerals carried by the xylem vessels in the stem reach the leaves through the branched xylem vessels which enter from the petiole (stalk of the leaf) into each and every part of the leaf. In this way, the water and minerals from the soil reach through the root and stem to the leaves of the plant. Only about 1 to 2 per cent of the water absorbed by the plant is used up by the plant in photosynthesis and other metabolic activities. The rest of water is lost as water vapour to the air through transpiration.

Water is Sucked Up by the Xylem Vessels

Water moves up into xylem vessels in the same way that a cold drink moves up a straw when we suck at the upper end of the straw. Now, when we suck a straw, we are reducing the pressure at the top of the straw. The cold drink at the bottom of the straw is at a higher pressure (which is atmospheric pressure), so the cold drink flows up the straw into our mouth. The same thing happens with the water in the xylem vessels. The pressure at the top of the xylem vessels (in the leaves) is lowered whereas the pressure at the bottom of the xylem vessels remains high. Due to this water flows up the xylem vessels into the leaves. An important question now arises : How is the pressure at the top of the xylem vessels reduced ? **The pressure at the top of xylem vessels in a plant is reduced due to transpiration.** This is discussed below :

The evaporation of water from the leaves of a plant is called transpiration. The leaves of a plant have tiny pores on their surface which are called stomata. A lot of water from the leaves keeps on evaporating into the air through the stomata. This loss of water (as water vapour) from the leaves of a plant is called transpiration. Since the cells of the leaf are losing water by transpiration, so water from the xylem vessels in the leaf will travel to the cells by osmosis to make up this loss of water. Thus, water is constantly being taken away from the top of the xylem vessels in the leaves to supply it to the cells in the leaves. This reduces the effective pressure at the top of the xylem vessels, so that water flows up into them (from the soil). Thus, **the continuous evaporation of water (or transpiration) from the cells of a leaf creates a kind of suction which pulls up water through the xylem vessels.** In this way, the process of transpiration helps in the upward movement of water (and dissolved minerals) from the roots to the leaves through the stem.

Transport of Food and Other Substances

Leaves make food by the process of photosynthesis. The food made by leaves is in the form of simple sugar (glucose). Other types of substances called plant hormones are made in the tips of roots and shoots. Now, every part of the plant needs food. So, food made in the leaves of a plant has to be transported (or carried) to all the parts of the plant like branches, stem and roots, etc. The food manufactured by the leaves of a plant is transported to its all other parts through a kind of tubes called phloem (which are present in all the parts of a plant). **The transport of food from the leaves to other parts of the plant is called translocation**. Thus, phloem translocates the food (or sugar) made in the leaves. The movement of food materials (and other substances like hormones) through phloem depends on the action of living cells called sieve tubes.

Phloem Contains Sieve Tubes

Like xylem vessels, phloem is made of many cells joined end to end to form long tubes (see Figure 76). However, the end walls of the cells which form phloem are not completely broken down. The end walls of cells in the phloem form sieve plates, which have small holes in them. These holes in the sieve plates allow the food to pass along the phloem tubes. The cells of phloem are called sieve tubes (or sieve elements). **Sieve tubes which form phloem are living cells which contain cytoplasm but no nucleus.** The sieve tube cells do not have lignin in their walls. **Each sieve tube cell has a companion cell next to it** (see Figure 76). The companion cell has a nucleus and many other organelles. Companion cells supply the sieve tubes with some of their requirements.

Figure 76. The structure of phloem (made of sieve tubes).

Figure 77. This is the micrograph of a longitudinal section through phloem tissue of a plant made up of sieve tubes (alongwith their companion cells). The red triangles in the above micrograph are the places where sieve plates existed.

The food is made in the mesophyll cells (or photosynthetic cells) of a leaf. The food (like sugar) made by the mesophyll cells of a leaf enters into the sieve tubes of the phloem. Interconnected phloem tubes are present in all the parts of the plant. So, once the food (like sugar) enters the phloem tubes in the leaves, it is transported (or carried) to all other parts of the plant by the network of phloem tubes present in all the parts of the plant like stem and roots. The translocation (transport of food from leaves to other parts of the plant) is necessary because every part of the plant needs food for obtaining energy, for building its parts and maintaining its life. Please note that when food is transported in a plant through a network of phloem tubes, then other substances made by the plant (like hormones) are also carried by the phloem tubes from one part of the plant to its other parts.

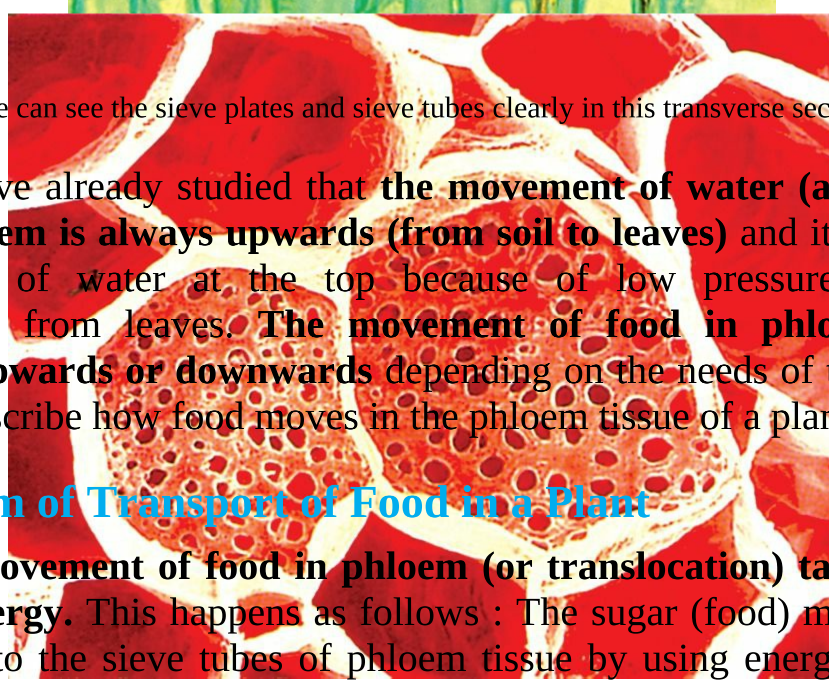


Figure 78. We can see the sieve plates and sieve tubes clearly in this transverse section of phloem.

We have already studied that **the movement of water (and dissolved salts) in xylem is always upwards (from soil to leaves)** and it is caused by the suction of water at the top because of low pressure created by transpiration from leaves. **The movement of food in phloem can be, however, upwards or downwards** depending on the needs of the plant. We will now describe how food moves in the phloem tissue of a plant.

Mechanism of Transport of Food in a Plant

The movement of food in phloem (or translocation) takes place by utilising energy. This happens as follows : The sugar (food) made in leaves is loaded into the sieve tubes of phloem tissue by using energy from ATP.

Water now enters into sieve tubes containing sugar by the process of osmosis due to which the pressure in the phloem tissue rises. This high pressure produced in the phloem tissue moves the food to all the parts of the plant having less pressure in their tissues. This allows the phloem to transport food according to the needs of the plant. For example, in spring, even the sugar stored in the root or stem tissue of a plant would be transported through phloem to the buds which need energy to grow. Let us answer one question now.

Sample Problem. The xylem in plants are responsible for :

(*a*) transport of water

(*b*) transport of food

(*c*) transport of amino acids

(*d*) transport of oxygen

Answer. (*a*) transport of water.

(NCERT Book Question)

BLOOD

Blood is a red coloured liquid which circulates in our body. Blood is red because it contains a red pigment called haemoglobin in its red cells. Blood is a connective tissue. Blood consists of four things : plasma, red blood corpuscles, white blood corpuscles and platelets. Thus, **the main components of blood are :**

1. Plasma,
2. Red Blood Corpuscles (or Red Blood Cells),
3. White Blood Corpuscles (or White Blood Cells), and
4. Platelets.

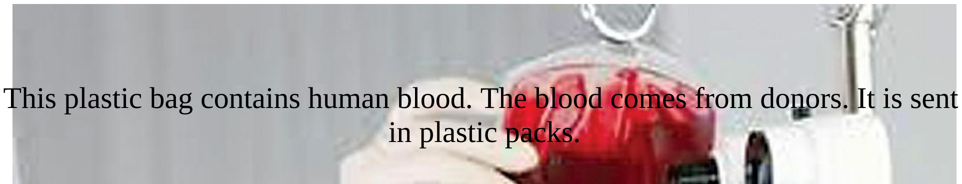


Figure 79. This plastic bag contains human blood. The blood comes from donors. It is sent to hospitals in plastic packs.

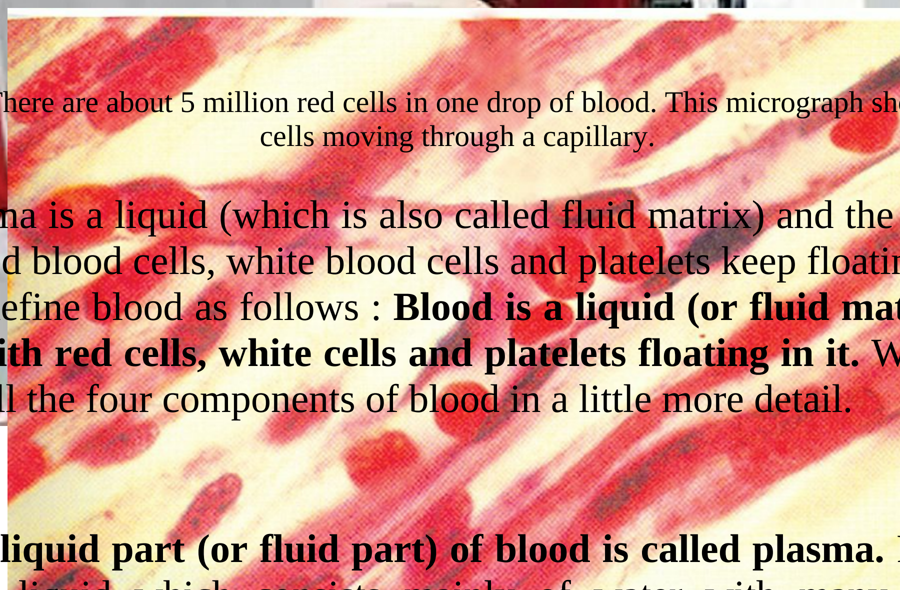


Figure 80. There are about 5 million red cells in one drop of blood. This micrograph shows red blood cells moving through a capillary.

Plasma is a liquid (which is also called fluid matrix) and the three types of cells, red blood cells, white blood cells and platelets keep floating in it. We can now define blood as follows : **Blood is a liquid (or fluid matrix) called plasma with red cells, white cells and platelets floating in it.** We will now describe all the four components of blood in a little more detail.

Plasma

The liquid part (or fluid part) of blood is called plasma. Plasma is a colourless liquid which consists mainly of water with many substances dissolved in it. Plasma contains about 90 per cent water. Plasma also contains dissolved substances such as proteins, digested food, common salt, waste products (like carbon dioxide and urea), and hormones. Plasma carries all these dissolved substances from one part to another part in the body. Red blood cells, white blood cells and platelets are immersed in this liquid called plasma.

Red Blood Cells

Red blood cells are red in colour due to the presence of a red pigment called haemoglobin inside them (see Figure 81). Red blood cells (RBC) are carriers of oxygen. **Red blood cells carry oxygen from the lungs to all the cells of the body.** It is actually the haemoglobin present in red blood cells which carries oxygen in the body. Haemoglobin performs a very important function of carrying oxygen from lungs to body tissues. Haemoglobin also carries some of the carbon dioxide from body tissues to the lungs (most of carbon dioxide is carried by plasma of blood in the dissolved form). Red blood cells are circular in shape. **Red blood cells do not have nuclei.** Red blood cells have to be made quickly because they do not live for very long. Each red blood cell lives for about four months. One reason for the short life of red blood cells is that they do not have nuclei. It has been estimated that about three million red blood cells of the human blood die everyday but four times that number are made in the bone marrow everyday. So, **when we donate blood to save the life of a person, then the loss of blood from our body can be made up very quickly, within a day.** This is because red blood cells are made very fast in our bone marrow. Please note that most of the cells in blood are red blood cells.

Figure 81. This micrograph shows the different types of cells in blood : red cells, white cells and platelets (small pink cells).

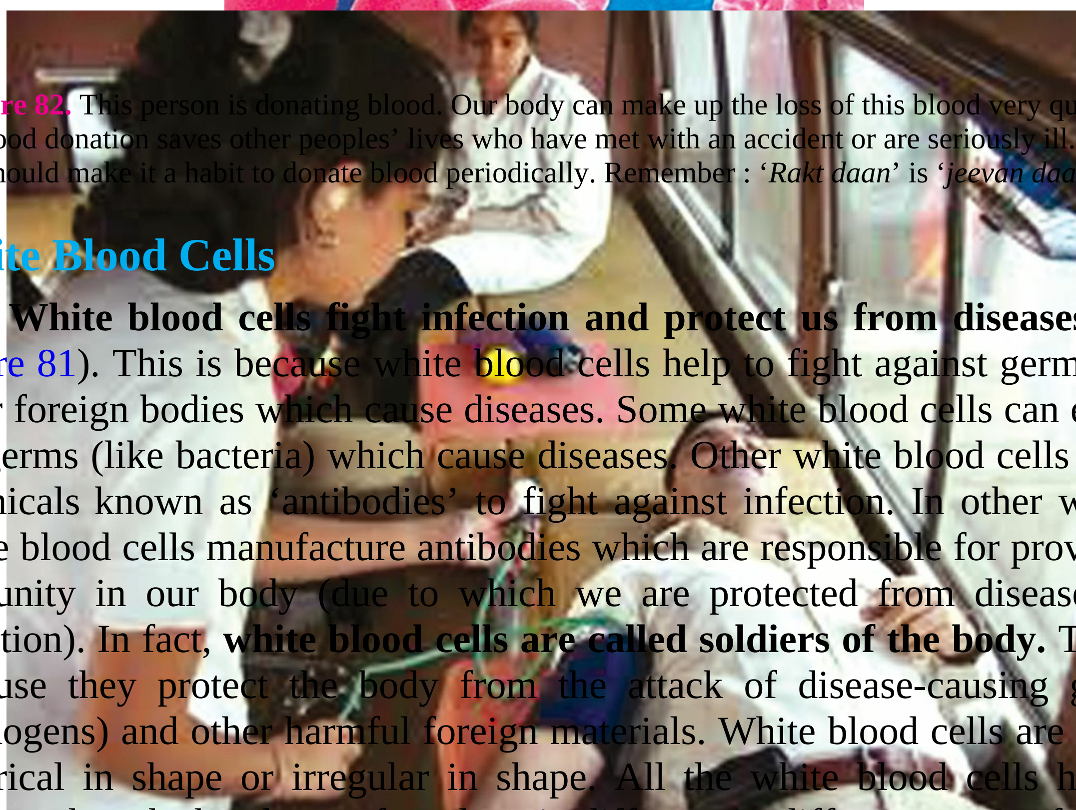


Figure 82. This person is donating blood. Our body can make up the loss of this blood very quickly. Blood donation saves other peoples' lives who have met with an accident or are seriously ill. We should make it a habit to donate blood periodically. Remember : '*Rakt daan*' is '*jeevan daan*'.

White Blood Cells

White blood cells fight infection and protect us from diseases (see Figure 81). This is because white blood cells help to fight against germs and other foreign bodies which cause diseases. Some white blood cells can eat up the germs (like bacteria) which cause diseases. Other white blood cells make chemicals known as 'antibodies' to fight against infection. In other words, white blood cells manufacture antibodies which are responsible for providing immunity in our body (due to which we are protected from disease and infection). In fact, **white blood cells are called soldiers of the body.** This is because they protect the body from the attack of disease-causing germs (pathogens) and other harmful foreign materials. White blood cells are either spherical in shape or irregular in shape. All the white blood cells have a nucleus though the shape of nucleus is different in different types of white blood cells. White blood cells (WBC) in the blood are much smaller in number than red blood cells.

Platelets

Platelets are the tiny fragments of special cells formed in the bone marrow (see Figure 81). Platelets do not have nuclei. **Platelets help in the coagulation of blood (or clotting of blood) in a cut or wound.** For example, when a cut or wound starts bleeding, then platelets help clot the blood (make the blood semi-solid) due to which further bleeding stops (see Figure 83). All the blood cells are made in the bone marrow from the cells called stem cells.

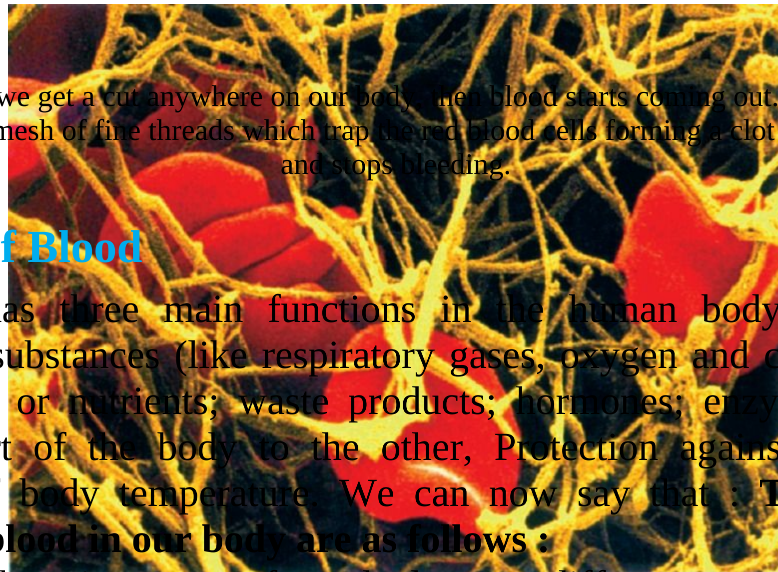


Figure 83. When we get a cut anywhere on our body, then blood starts coming out. Platelets present in blood produce a mesh of fine threads which trap the red blood cells forming a clot that blocks the cut and stops bleeding.

Functions of Blood

Blood has three main functions in the human body. These are : Transport of substances (like respiratory gases, oxygen and carbon dioxide; digested food or nutrients; waste products; hormones; enzymes and ions) from one part of the body to the other, Protection against disease, and Regulation of body temperature. We can now say that : **The important functions of blood in our body are as follows :**

1. Blood carries **oxygen** from the lungs to different parts of the body.
2. Blood carries **carbon dioxide** from the body cells to the lungs for breathing out.
3. Blood carries **digested food** from the small intestine to all the parts of the body.
4. Blood carries **hormones** from the endocrine glands to different organs of the body (where they are needed).
5. Blood carries a waste product called **urea** from the liver to the kidneys for excretion in urine.
6. Blood **protects** the body from diseases. This is because white blood cells kill the bacteria and other germs which cause diseases.
7. Blood regulates the body temperature. This is because the blood capillaries in our skin help to keep our body temperature constant at about 37°C.

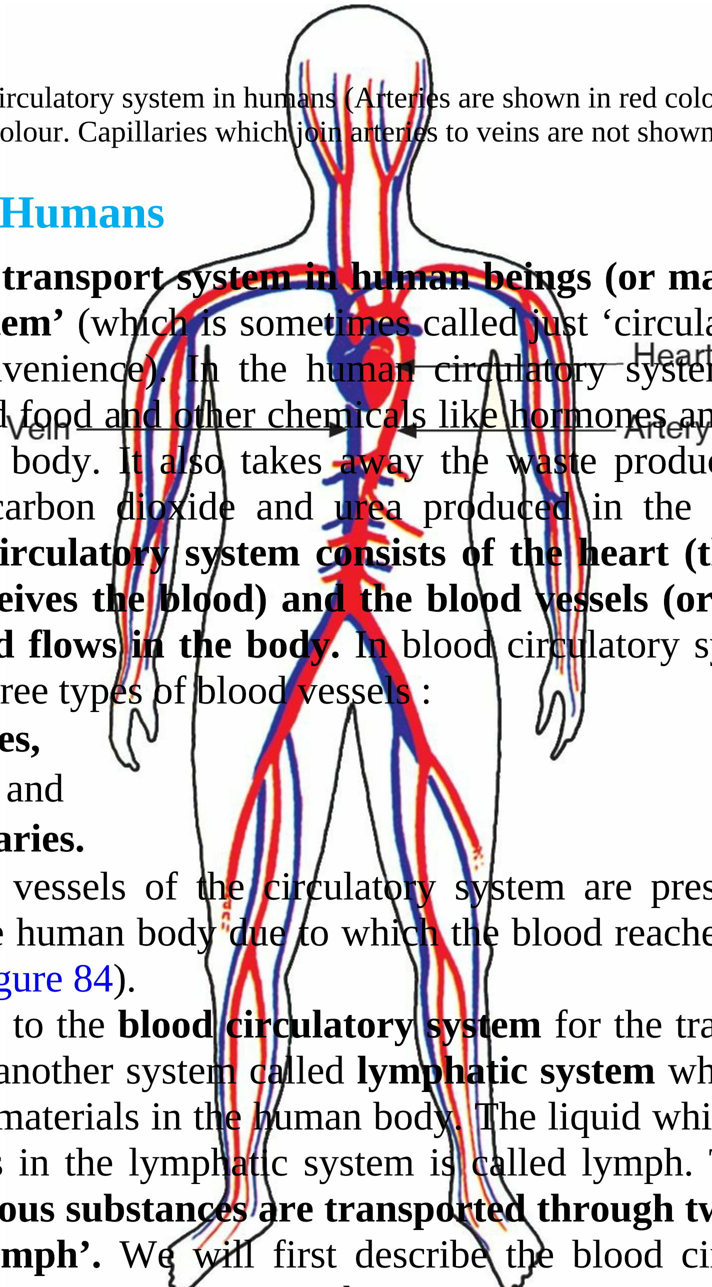


Figure 84. Blood circulatory system in humans (Arteries are shown in red colour and veins in blue colour. Capillaries which join arteries to veins are not shown).

Transport in Humans

The main transport system in human beings (or man) is the 'blood circulatory system' (which is sometimes called just 'circulatory system' for the sake of convenience). In the human circulatory system, blood carries oxygen, digested food and other chemicals like hormones and enzymes to all the parts of the body. It also takes away the waste products (or excretory products) like carbon dioxide and urea produced in the body cells. **The human blood circulatory system consists of the heart (the organ which pumps and receives the blood) and the blood vessels (or tubes) through which the blood flows in the body.** In blood circulatory system, the blood flows through three types of blood vessels :

(*i*) **arteries,**
(*ii*) **veins,** and
(*iii*) **capillaries.**

The blood vessels of the circulatory system are present in each and every part of the human body due to which the blood reaches all the parts of the body (see Figure 84).

In addition to the **blood circulatory system** for the transport in human beings, there is another system called **lymphatic system** which also helps in the transport of materials in the human body. The liquid which circulates and carries materials in the lymphatic system is called lymph. Thus, **in human beings, the various substances are transported through two liquids called 'blood' and 'lymph'.** We will first describe the blood circulatory system which is the main transport system in humans.

HUMAN CIRCULATORY SYSTEM

The organ system of human beings (and other animals) which is responsible for the transport of materials inside the body is called circulatory system. **The various organs of the circulatory system in humans are : Heart, Arteries, Veins and Capillaries.** Blood is also considered a part of the circulatory system. So, **the human circulatory system consists of the heart, arteries, veins, capillaries, and blood.** In the circulatory system, the heart acts as a pump to push out blood. The arteries, veins and capillaries act as pipes (or tubes) through which the blood flows. These tubes which carry blood are called

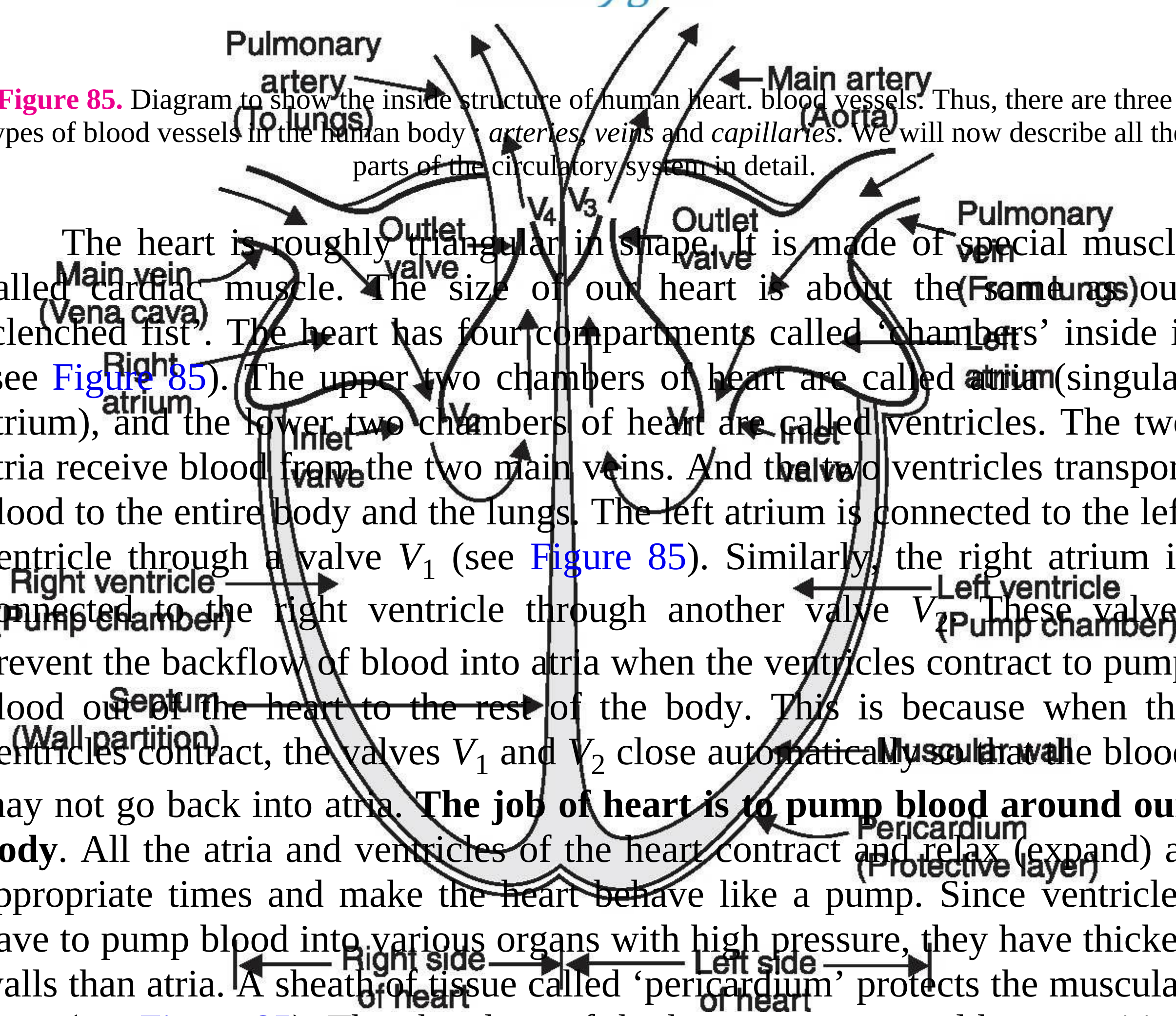


Figure 85. Diagram to show the inside structure of human heart. blood vessels. Thus, there are three types of blood vessels in the human body : *arteries, veins* and *capillaries*. We will now describe all the parts of the circulatory system in detail.

The heart is roughly triangular in shape. It is made of special muscle called 'cardiac muscle'. The size of our heart is about the same as our 'clenched fist'. The heart has four compartments called 'chambers' inside it (see Figure 85). The upper two chambers of heart are called atria (singular atrium), and the lower two chambers of heart are called ventricles. The two atria receive blood from the two main veins. And the two ventricles transport blood to the entire body and the lungs. The left atrium is connected to the left ventricle through a valve V_1 (see Figure 85). Similarly, the right atrium is connected to the right ventricle through another valve V_2. These valves prevent the backflow of blood into atria when the ventricles contract to pump blood out of the heart to the rest of the body. This is because when the ventricles contract, the valves V_1 and V_2 close automatically so that the blood may not go back into atria. **The job of heart is to pump blood around our body**. All the atria and ventricles of the heart contract and relax (expand) at appropriate times and make the heart behave like a pump. Since ventricles have to pump blood into various organs with high pressure, they have thicker walls than atria. A sheath of tissue called 'pericardium' protects the muscular heart (see Figure 85). The chambers of the heart are separated by a partition called septum.

The arteries, veins and capillaries are a kind of thin pipes (or tubes) through which blood flows in the body. Arteries, veins and capillaries are called blood vessels. **Arteries are the thick walled blood vessels which carry blood from the heart to all the parts of the body.** Arteries have thick walls because blood emerges from the heart under high pressure. Arteries are found in the whole of our body. The main artery (called aorta) is connected to the left ventricle of the heart through a valve V_3 (see Figure 85). The main artery carries *oxygenated* blood from the left ventricle to all the parts of the body (except the lungs). Another artery called pulmonary artery is connected to the right ventricle of the heart through another valve V_4 (see Figure 85). The pulmonary artery carries *deoxygenated* blood from the right ventricle to the lungs (see Figure 85).

The capillaries are thin walled and extremely narrow tubes or blood vessels which connect arteries to veins. Thus, the capillaries are in-between the arteries and veins (see Figure 86). The blood from arteries enters the capillaries in the body. Every living cell of our body is close to a capillary. The walls of capillaries are only one-cell thick. The various dissolved substances (like oxygen, food, etc.) present in blood pass into the body cells through the thin walls of the capillaries (see Figure 86). At the same time, the waste substances (like carbon dioxide) formed in the cells enter into capillaries. Thus, **the exchange of various materials like oxygen, food, carbon dioxide, etc., between the blood and the body cells takes place through capillaries.** The other end of capillaries is joined to some wider tubes called veins. The deoxygenated blood (or dirty blood) coming from the capillaries enters into veins.

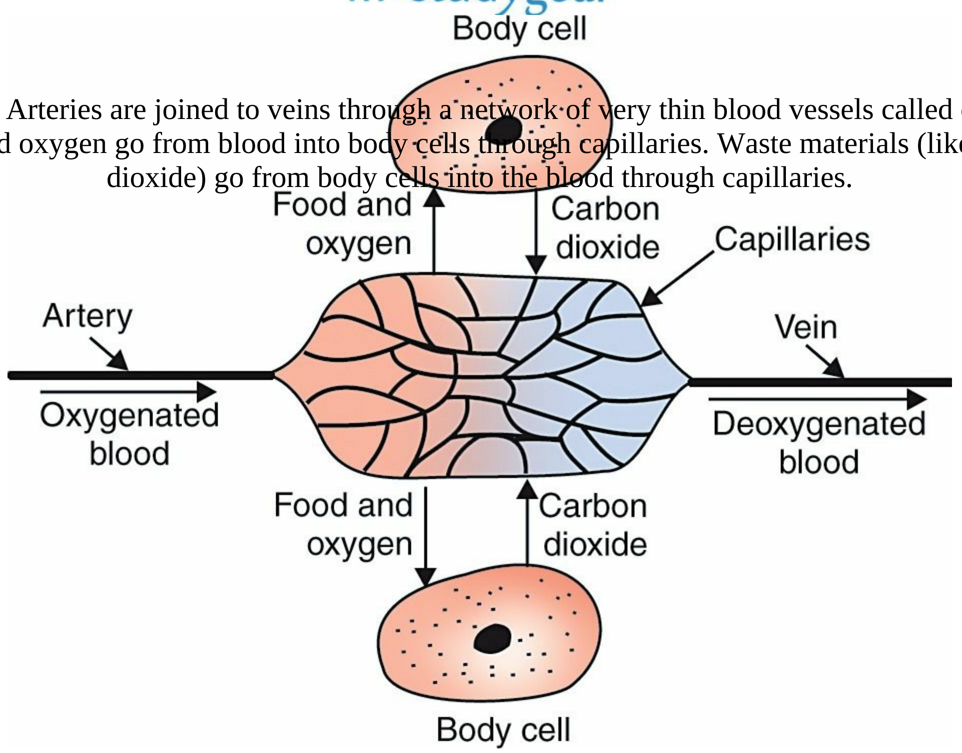


Figure 86. Arteries are joined to veins through a network of very thin blood vessels called capillaries. Food and oxygen go from blood into body cells through capillaries. Waste materials (like carbon dioxide) go from body cells into the blood through capillaries.

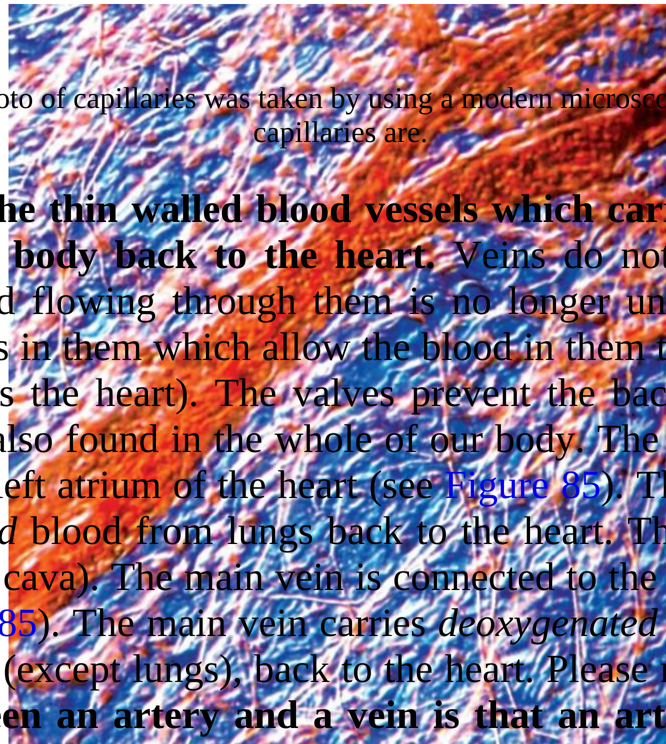


Figure 87. This photo of capillaries was taken by using a modern microscope. See how thin the capillaries are.

Veins are the thin walled blood vessels which carry blood from all the parts of the body back to the heart. Veins do not need thick walls because the blood flowing through them is no longer under high pressure. Veins have valves in them which allow the blood in them to flow in only one direction (towards the heart). The valves prevent the backflow of blood in veins. Veins are also found in the whole of our body. The pulmonary vein is connected to the left atrium of the heart (see Figure 85). The pulmonary vein carries *oxygenated* blood from lungs back to the heart. There is also a main vein (called vena cava). The main vein is connected to the right atrium of the heart (see Figure 85). The main vein carries *deoxygenated* blood from all the parts of the body (except lungs), back to the heart. Please note that **the main difference between an artery and a vein is that an artery carries blood from the heart to the body organs whereas a vein carries blood from the body organs back to the heart.**

We have just studied that the heart is a kind of pump which pumps blood around our body continuously, without stopping. Actually, heart is not a single pump. **Heart is really a double pump**. The left side of heart (left atrium and left ventricle) acts as one pump which pumps blood into the whole body, except the lungs. The right side of heart (right atrium and right ventricle) acts as another pump which pumps blood only into the lungs. We can see from Figure 85 that the left side of heart is completely separated from the right side by a partition called septum. So, **the two pumps in the heart work independently**. The separation of left and right sides of the heart is necessary to prevent the mixing of the oxygenated blood on the left side with the deoxygenated blood on the right side.

Before we describe the circulation of blood in the human body with the help of a diagram, we should keep the following two points in mind : First that the blood circulates in our body in two forms : oxygenated blood and deoxygenated blood. **The blood carrying oxygen in it is called oxygenated blood.** We get oxygenated blood in the lungs where the fresh oxygen of air passes into the blood. **The blood having no oxygen in it is called deoxygenated blood.** The deoxygenated blood is formed in all the organs of the body (except the lungs). This is because when the oxygenated blood passes through the organs of the body, the body cells use up its oxygen and make it deoxygenated. **The deoxygenated blood, however, carries carbon dioxide in it** (which is produced during respiration in body cells). The second point to remember is that when blood circulates in the body, then it supplies oxygen, digested food and other chemicals (like hormones) to all the cells of the body. It also carries back waste products like carbon dioxide, etc., from the body cells.

The heart beats non-stop all the time. The heart beat is due to the rhythmic contraction and relaxation of the heart muscles which make up the atria and the ventricles. Please note that the two atria (left atrium and right atrium) contract together and relax together. Similarly, the two ventricles (left ventricle and right ventricle) contract together and relax together. The contraction of two atria is immediately followed by the contraction of the two ventricles.

The heart beats (or beating of heart) circulates the blood in the human body. We will now describe the circulation of blood in the human body with the help of a highly simplified diagram (see Figure 88)

1. When the muscles of all the four chambers of the heart are relaxed, the pulmonary vein brings the oxygenated blood (oxygen-carrying blood) from the lungs into the left atrium of the heart (see step 1 in Figure 88).

2. When the left atrium contracts, the oxygenated blood is pushed into the left ventricle through the valve V_1 (see step 2 in Figure 88).

3. When the left ventricle contracts, the oxygenated blood is forced into the main artery called ‘aorta’ (see step 3 in Figure 88). This main artery then branches into smaller arteries which go into different body organs (except the lungs). The smaller arteries (called arterioles) further branch into capillaries (The smaller arteries and capillaries have not been shown in Figure 88 to keep the diagram simple).

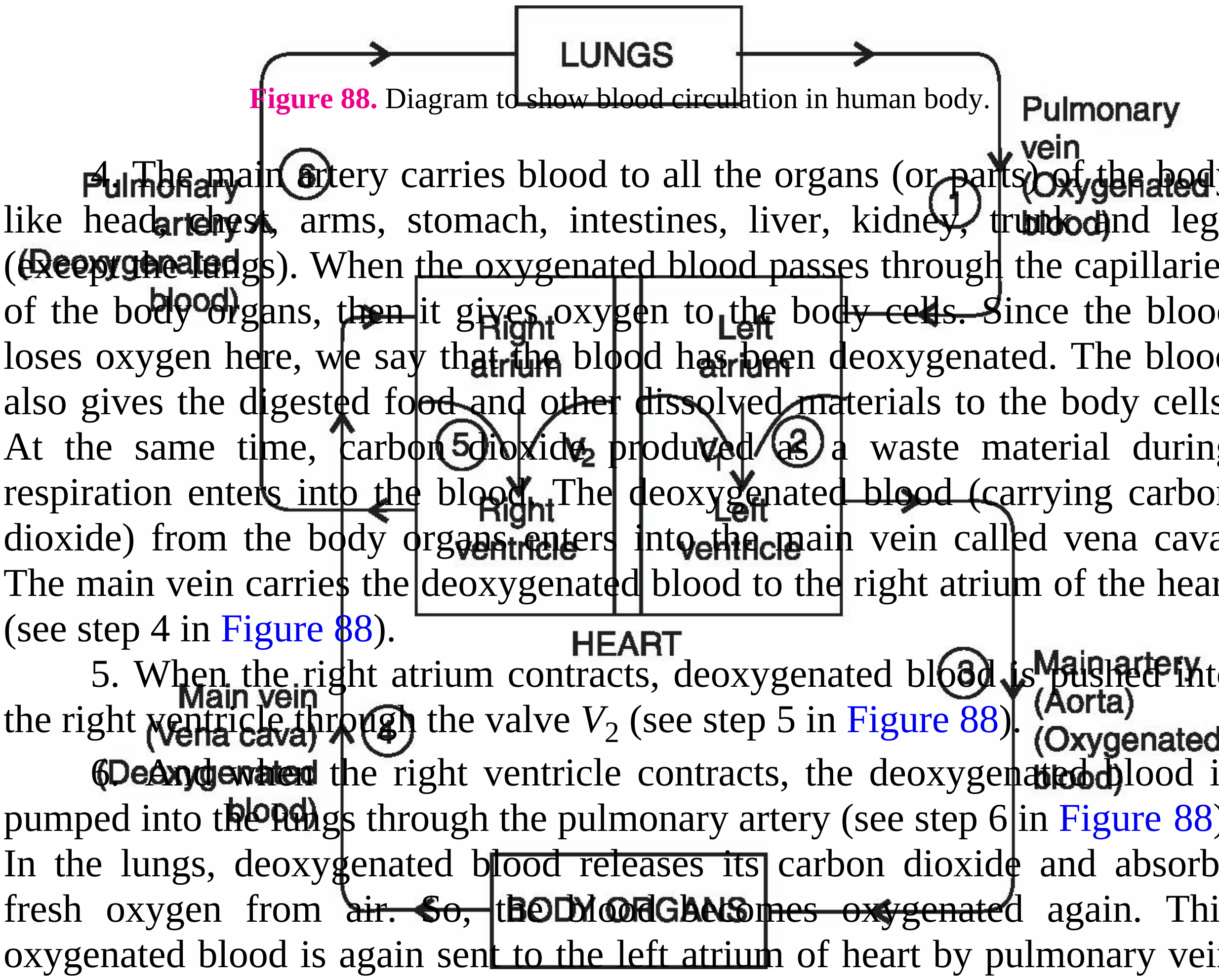


Figure 88. Diagram to show blood circulation in human body.

4. The main artery carries blood to all the organs (or parts) of the body like head, chest, arms, stomach, intestines, liver, kidney, trunk and legs (except the lungs). When the oxygenated blood passes through the capillaries of the body organs, then it gives oxygen to the body cells. Since the blood loses oxygen here, we say that the blood has been deoxygenated. The blood also gives the digested food and other dissolved materials to the body cells. At the same time, carbon dioxide produced as a waste material during respiration enters into the blood. The deoxygenated blood (carrying carbon dioxide) from the body organs enters into the main vein called vena cava. The main vein carries the deoxygenated blood to the right atrium of the heart (see step 4 in Figure 88).

5. When the right atrium contracts, deoxygenated blood is pushed into the right ventricle through the valve V_2 (see step 5 in Figure 88).

6. And when the right ventricle contracts, the deoxygenated blood is pumped into the lungs through the pulmonary artery (see step 6 in Figure 88). In the lungs, deoxygenated blood releases its carbon dioxide and absorbs fresh oxygen from air. So, the blood becomes oxygenated again. This oxygenated blood is again sent to the left atrium of heart by pulmonary vein for circulation in the body.

This whole process is repeated continuously. In this way, the blood keeps on circulating in our body without stopping due to which all the body parts keep on getting oxygen, digested food and other materials all the time. The blood circulation also keeps on removing waste products formed in the cells of the body.

The blood circulatory system in human beings is an example of double circulation. This can be explained as follows : **A circulatory system in which the blood travels twice through the heart in one complete cycle of the body is called double circulation.** In the human circulatory system the pathway of blood from the heart to the lungs and back to the heart is called **pulmonary circulation**; and the pathway of blood from the heart to the rest of the body and back to the heart is called the **systemic circulation.** These two types of circulation taken together make double circulation.

The animals such as mammals (including human beings), and birds have four-chambered heart (which consists of two atria and two

ventricles). In a four-chambered heart, the left side and right side of the heart are completely *separated* to prevent the oxygenated blood from mixing with deoxygenated blood. Such a separation allows a highly efficient supply of oxygen to the body cells which is necessary for producing a lot of energy. This energy is useful in *warm-blooded* animals (like mammals and birds) which have high energy needs because they constantly require energy to maintain their body temperature. All the animals having four-chambered hearts have **double circulation** in which the blood passes through the heart 'twice' in one complete cycle of the body.

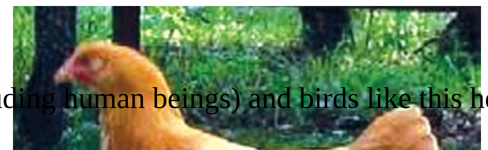


Figure 89. Mammals (including human beings) and birds like this hen) have 4-chambered heart.

Figure 90. Amphibians (like this frog) have a 3-chambered heart.

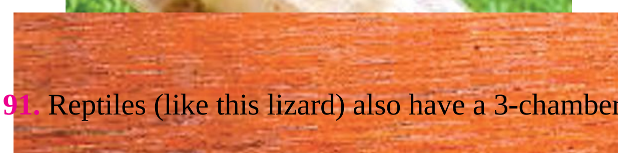


Figure 91. Reptiles (like this lizard) also have a 3-chambered heart.

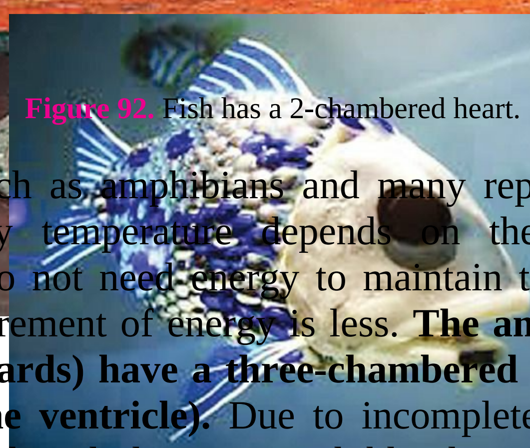


Figure 92. Fish has a 2-chambered heart.

The animals such as amphibians and many reptiles are *cold-blooded* animals whose body temperature depends on the temperature in the environment. They do not need energy to maintain their body temperature and hence their requirement of energy is less. **The amphibians (like frogs) and reptiles (like lizards) have a three-chambered heart (which consists of two atria and one ventricle).** Due to incomplete division within their heart, the oxygenated and deoxygenated bloods mix to some extent in amphibians and reptiles. This reduces the production of energy. The amphibians and reptiles have, however, a **double circulation** that delivers blood to the lungs and the rest of the body, respectively.

The fish has a two-chambered heart (which consists of one atrium and one ventricle). The fish does not have lungs, it has gills to oxygenate blood. In a fish, the heart pumps deoxygenated blood to the gills. Oxygenation of blood takes place in the gills. The oxygenated blood from the gills is supplied to the body parts of the fish where oxygen is utilised and carbon dioxide enters into it making it deoxygenated. This deoxygenated blood returns to the heart to be pumped into gills again. The flow of blood in a fish is called **single circulation** because the blood passes through the heart of fish only once in one complete cycle of the body.

Heart Beats

The heart pumps blood into our arteries by contracting. When the heart contracts, it becomes smaller in size and pushes the blood into main artery with a great force. Then the heart relaxes (comes back to its original size) and gets filled up with blood from pulmonary vein. In this way, the heart keeps on contracting and relaxing again and again to pump blood into the body continuously. **One complete contraction and relaxation of the heart is called a heart beat.** The heart usually beats about 70 to 72 times in a minute when we are resting. This means that the heart pumps out blood to the arteries about 70 to 72 times per minute. We can feel our heart beats if we place our hand on the chest just above the heart region (see Figure 93). A doctor listens to our heart beats by using an apparatus called stethoscope (see Figures 94 and 95). The stethoscope magnifies the sound of heart beats so that the doctor can hear the heart beats clearly.

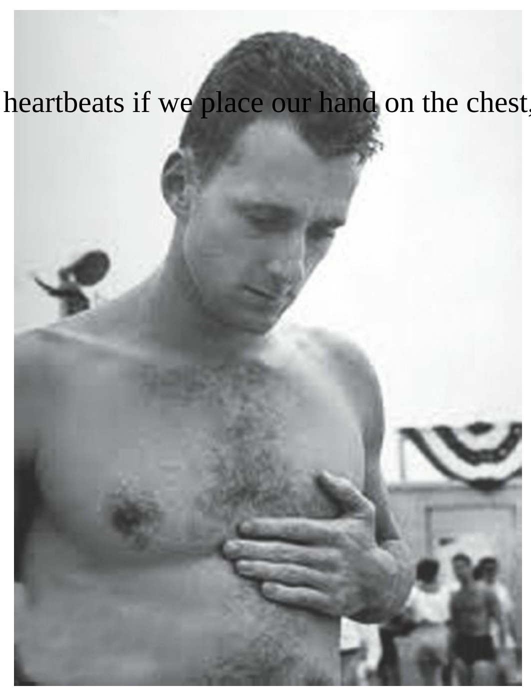


Figure 93. We can feel our heartbeats if we place our hand on the chest, just above the heart region.

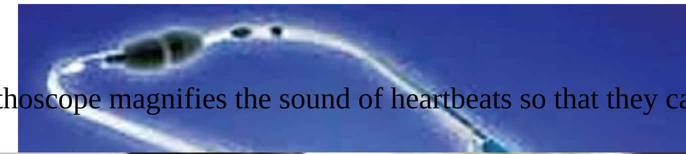


Figure 94. A stethoscope magnifies the sound of heartbeats so that they can be heard clearly.

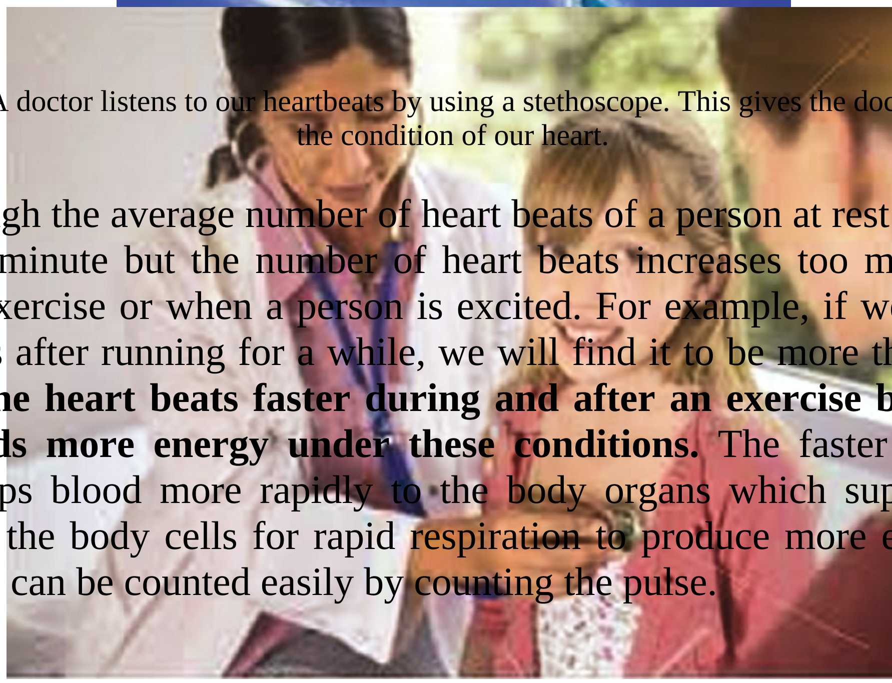


Figure 95. A doctor listens to our heartbeats by using a stethoscope. This gives the doctor an idea of the condition of our heart.

Though the average number of heart beats of a person at rest is about 70 to 72 per minute but the number of heart beats increases too much after a physical exercise or when a person is excited. For example, if we count our heart beats after running for a while, we will find it to be more than 100 per minute. **The heart beats faster during and after an exercise because the body needs more energy under these conditions.** The faster beating of heart pumps blood more rapidly to the body organs which supplies more oxygen to the body cells for rapid respiration to produce more energy. The heart beats can be counted easily by counting the pulse.

Pulse

Every time the heart beats, blood is *forced* into arteries. This blood makes the arteries expand a little. **The expansion of an artery each time the blood is forced into it, is called pulse**. Each heartbeat generates one pulse in the arteries, so *the pulse rate of a person is equal to the number of heartbeats per minute*. Since the heart beats about 70 to 72 times per minute, therefore, **the pulse rate of an adult person while resting is 70 to 72 per minute**. Thus, the pulse rate is the *same* as the heart rate. Just like heartbeats, the pulse rate of a person is higher after a physical exercise or when a person is excited.

Most of our arteries lie deep inside our body and hence cannot be used to feel the pulse. But at some places in our body like the wrist, temple and neck, the arteries are close to the surface of skin and pass over bones. So, we can feel the pulse at wrist, temple and neck by pressing the artery lightly with our finger tips. **The pulse is traditionally taken above the wrist**. We can feel our own pulse and find the pulse rate as follows :

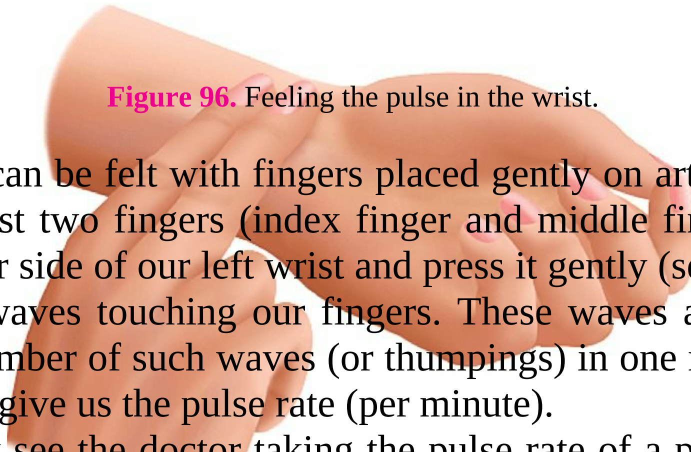


Figure 96. Feeling the pulse in the wrist.

The pulse can be felt with fingers placed gently on arteries at the wrist. We place the first two fingers (index finger and middle finger) of our right hand on the inner side of our left wrist and press it gently (see Figure 96). We will feel some waves touching our fingers. These waves are the pulse. We can count the number of such waves (or thumpings) in one minute by using a watch. This will give us the pulse rate (per minute).

We usually see the doctor taking the pulse rate of a patient by keeping his fingers on the wrist of the patient and at the same time looking into his watch. Doctors can tell by counting the pulse rate and listening to heartbeats whether a person is well or not. This is because the pulse rate and heartbeats change according to the condition of our heart.

Blood Pressure

The pressure at which blood is pumped around the body by the heart is called blood pressure. The blood pressure of a person is always expressed in the form of two values called '**systolic pressure'** and **'diastolic pressure'.** In order to understand this, we should first know the meaning of 'systole' and 'diastole'. The phase of the heart beat when the heart contracts and pumps the blood into arteries is called 'systole'. And the phase of heart beat when the heart relaxes (or expands) and allows the chambers to fill with blood is called 'diastole'.

The maximum pressure at which the blood leaves the heart through the main artery (aorta) during contraction phase, is called the systolic pressure. This high pressure in the main artery maintains a steady flow of blood in all the arteries towards the capillaries. **The minimum pressure in the arteries during the relaxation phase of heart is called the diastolic pressure.** The value of diastolic pressure is always *lower* than that of the systolic pressure. The blood pressure of a person is expressed in terms of millimetres of mercury (which is written as mm Hg). **The normal blood pressure values are :**

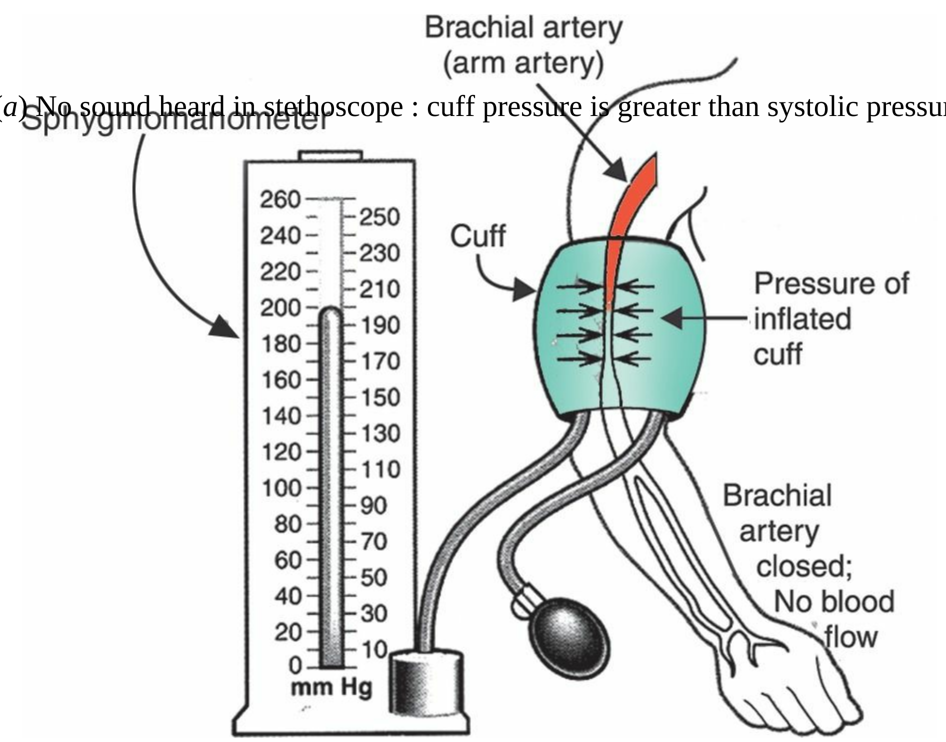
Systolic pressure : 120 mm Hg
Diastolic pressure : 80 mm Hg
This is usually written as 120/80

The blood pressure values vary from person to person and from time to time. They also vary with age. For example, a young person may have blood pressure of 110/75 but at the age of 60 years it could be 145/90. **High blood pressure is called hypertension.** High blood pressure is caused by the constriction (narrowing) of very small arteries (called arterioles) which results in *increased* resistance to blood flow. Very high blood pressure can lead to rupture of an artery and internal bleeding.

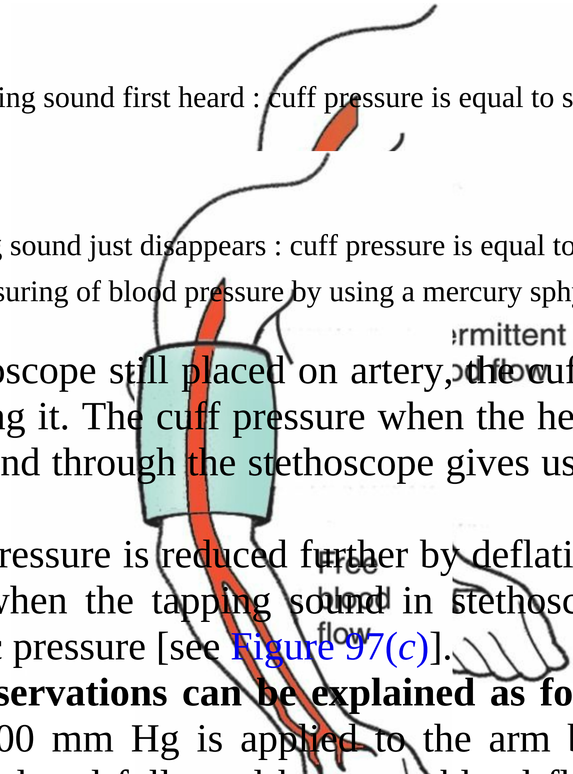
How to Measure Blood Pressure

Blood pressure is measured by using an instrument called sphygmomanometer. Two readings of blood pressure are taken : **systolic pressure** (when the heart is contracting and pumping out blood), and **diastolic pressure** (when the heart relaxes and fills with blood). The various steps in measuring the blood pressure of a person are as follows :

(*i*) A rubber cuff (which is a flat rubber tube) is wrapped around the person's arm [see Figure 97(*a*)]. The rubber cuff is inflated by pumping air into it to give a pressure of about 200 mm Hg to the brachial artery (which runs down the arm). This pressure can be seen on the scale of the instrument sphygmomanometer. If a stethoscope is now placed on the artery of the arm, no sound is heard through it.



(*a*) No sound heard in stethoscope : cuff pressure is greater than systolic pressure



(*b*) When tapping sound first heard : cuff pressure is equal to systolic pressure

(*c*) When tapping sound just disappears : cuff pressure is equal to diastolic pressure

Figure 97. Measuring of blood pressure by using a mercury sphygmomanometer.

(*ii*) With stethoscope still placed on artery, the cuff pressure is reduced gradually by deflating it. The cuff pressure when the heart beat is *first heard* as a soft tapping sound through the stethoscope gives us the systolic pressure [see Figure 97(*b*)]

(*iii*) The cuff pressure is reduced further by deflating it more and more. The cuff pressure when the tapping sound in stethoscope *just disappears*, gives us the diastolic pressure [see Figure 97(*c*)].

The above observations can be explained as follows : When a high pressure of about 200 mm Hg is applied to the arm by the cuff, then the brachial artery gets closed fully and hence no blood flows in it [see Figure 97(*a*)]. Since no blood flows in the brachial artery at this stage, therefore, no tapping sound is heard in the stethoscope. When the cuff pressure is reduced and becomes equal to the systolic pressure, then the brachial artery opens up slightly and there is an intermittent blood flow in it due to which a soft tapping sound just begins to be heard in the stethoscope [see Figure 97(*b*)]. And finally, when the cuff pressure is reduced further and it becomes equal to diastolic pressure, then the brachial artery opens up fully, the blood flow in it is fully restored and hence the tapping sound just disappears [see Figure 97(*c*)].

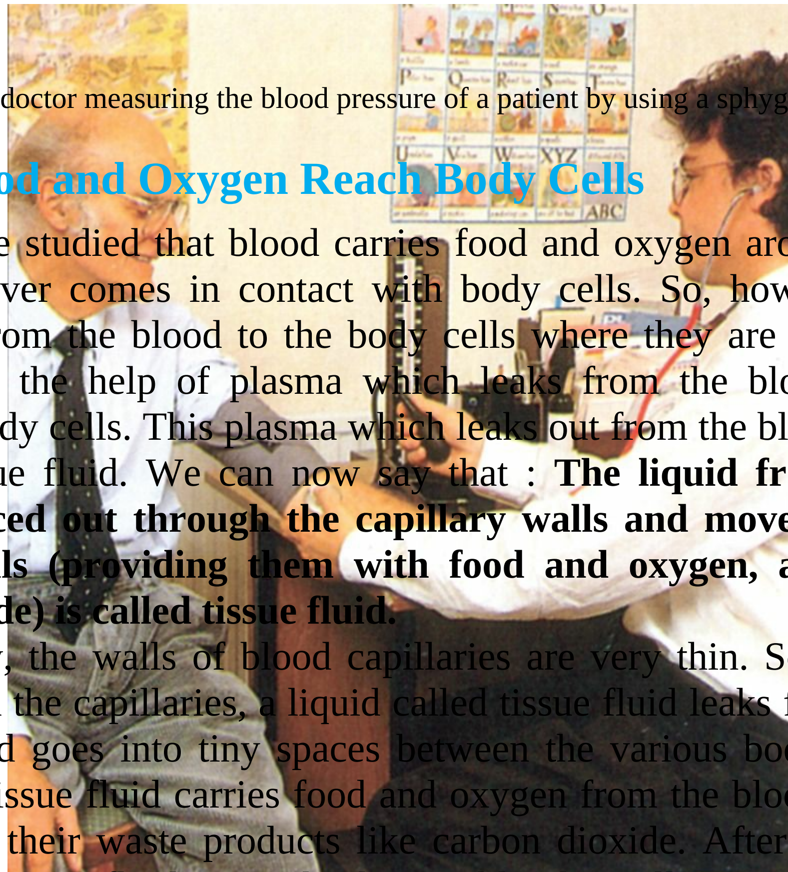


Figure 98. A doctor measuring the blood pressure of a patient by using a sphygmomanometer.

How do Food and Oxygen Reach Body Cells

We have studied that blood carries food and oxygen around the body. But blood never comes in contact with body cells. So, how do food and oxygen get from the blood to the body cells where they are needed ? This happens with the help of plasma which leaks from the blood capillaries around the body cells. This plasma which leaks out from the blood capillaries is called tissue fluid. We can now say that : **The liquid from the blood which is forced out through the capillary walls and moves between all the body cells (providing them with food and oxygen, and removing carbon dioxide) is called tissue fluid.**

Actually, the walls of blood capillaries are very thin. So, when blood flows through the capillaries, a liquid called tissue fluid leaks from the blood capillaries and goes into tiny spaces between the various body cells in the tissues. The tissue fluid carries food and oxygen from the blood to the cells, and picks up their waste products like carbon dioxide. After doing its job, most of the tissue fluid seeps back into blood capillaries. The remaining tissue fluid carrying large protein molecules, digested fat, germs from the cells and fragments of dead cells, enters into another type of tiny tubes called lymph capillaries and it becomes lymph. This lymph (alongwith its contents) is returned to the blood by another type of transport system in the human body called lymphatic system. We will now describe the lymphatic system in brief.

LYMPHATIC SYSTEM

A system of tiny tubes called lymph vessels (or lymphatics) and lymph nodes (or lymph glands) in the human body which transports the liquid called lymph from the body tissues to the blood circulatory system is called lymphatic system. The lymphatic system consists of the following parts :

(*i*) Lymph capillaries,
(*ii*) Larger lymph vessels,
(*iii*) Lymph nodes (or Lymph glands), and
(*iv*) Lymph.

Lymph capillaries are tiny tubes which are present in the whole body (just like blood capillaries) (see Figure 99). Lymph capillaries, however, differ from blood capillaries in two ways : lymph capillaries are closed ended (the end of lymph capillaries in the tissues of the body is closed), and the pores in the walls of lymph capillaries are bigger in size (than that of blood capillaries). Since the ends of the lymph capillaries in the body tissues are closed, so the tissue fluid can only seep into the walls of the lymph capillaries present in the body tissues. Moreover, since the pores in the walls of the lymph capillaries are somewhat bigger, so even large protein molecules present in the tissue fluid can enter into lymph capillaries (which could not pass into blood capillaries).

The lymph capillaries join to form larger lymph vessels. The lymph vessels have lymph nodes (or lymph glands) at intervals (see Figure 99). The lymph nodes contain special type of cells called lymphocytes. Lymph nodes containing lymphocytes are involved in the cleaning of lymph and protecting the body from disease. The lymph vessels are connected to large veins of the blood circulatory system (see Figure 99).

Lymph is a light yellow liquid which is somewhat similar in composition to blood plasma. Lymph is not red like blood because it does not contain red blood cells. Lymph contains large protein molecules and digested food (which come into it from the tissue fluid between the cells). It also contains germs from the cells and fragments of dead cells. **Lymph is another medium of circulation in the human body.** But lymph flows in only **one direction** – from body tissues to the heart. Since lymph is derived from the tissue fluid which remains outside the cells of the body, so it is also called extracellular fluid. **Lymph contains a special type of white blood cells called lymphocytes which help in fighting infection and disease.**

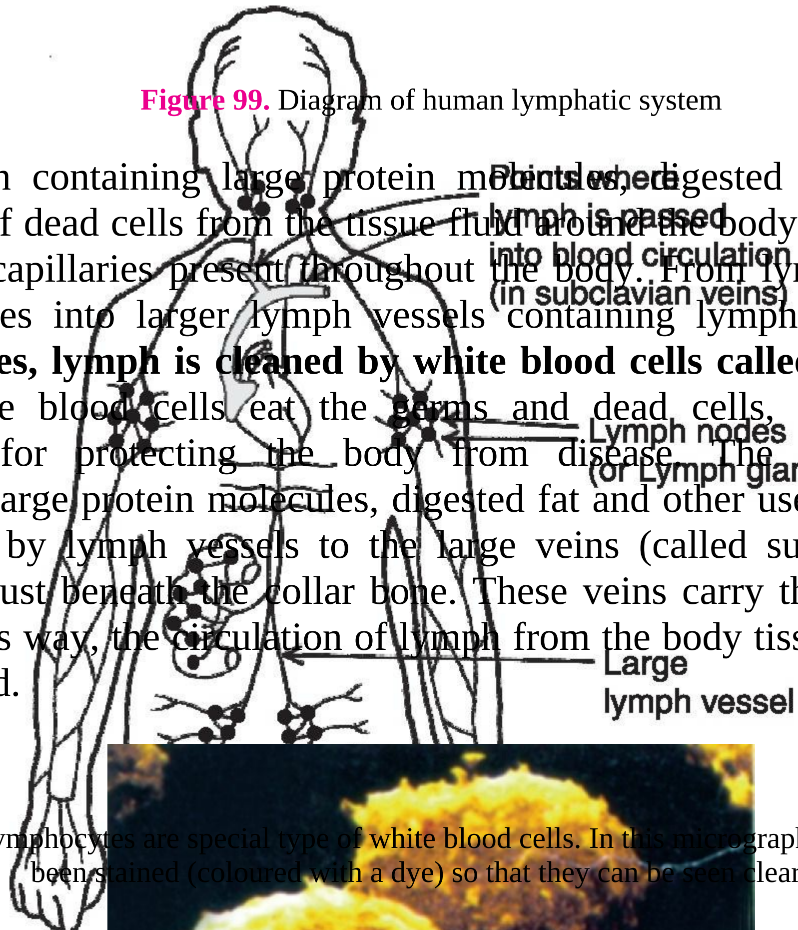


Figure 99. Diagram of human lymphatic system

Lymph containing large protein molecules, digested fat, germs and fragments of dead cells from the tissue fluid around the body cells seeps into the lymph capillaries present throughout the body. From lymph capillaries, lymph passes into larger lymph vessels containing lymph nodes. **In the lymph nodes, lymph is cleaned by white blood cells called lymphocytes.** These white blood cells eat the germs and dead cells, and also make antibodies for protecting the body from disease. The cleaned lymph containing large protein molecules, digested fat and other useful materials is transported by lymph vessels to the large veins (called subclavian veins) which run just beneath the collar bone. These veins carry the lymph to the heart. In this way, the circulation of lymph from the body tissues to the heart is completed.

Figure 100. Lymphocytes are special type of white blood cells. In this micrograph, lymphocytes have been stained (coloured with a dye) so that they can be seen clearly.

The Functions of Lymph (or Lymphatic System)

1. Lymph (or lymphatic system) takes part in the nutritive process of the body. For example, it puts into circulation large protein molecules by carrying them from the tissues into the blood stream (which could not be absorbed by blood capillaries due to their large size). Lymph also carries digested fat for the nutritive process.
2. Lymph (or lymphatic system) protects the body by killing the germs drained out of the body tissues with the help of lymphocytes contained in the lymph nodes, and by making antibodies.
3. Lymph (or lymphatic system) helps in removing the waste products like fragments of dead cells, etc.

EXCRETION

All the organisms (plants and animals) are made up of cells. These cells work all the time for sustaining the life of the organism. Most of the work of the cells is in the form of biochemical reactions which they carry out all the time. The biochemical reactions taking place in the cells of an organism may produce toxic wastes (poisonous wastes) in the body. The accumulation of toxic wastes in the body harms an organism. So, for an organism to lead a normal life, the toxic wastes being produced in its body must be removed continuously. **The process of removal of toxic wastes from the body of an organism is called excretion.** Excretion takes place in plants as well as in animals.

EXCRETION IN PLANTS

Like animals, plants also produce a number of waste products during their life processes. As compared to animals, the plants produce waste products very slowly and in very small amounts. The plants have no special organs for waste removal like the animals. The plants remove their waste products by different methods. Some of the important plant wastes and the methods by which they are removed are described below.

The main waste products produced by plants are carbon dioxide, water vapour and oxygen. Carbon dioxide and water vapour are produced as wastes during respiration by plants whereas oxygen is produced as a waste during photosynthesis. **The gaseous wastes of respiration and photosynthesis in plants (carbon dioxide, water vapour and oxygen) are removed through the 'stomata' in leaves and 'lenticels' in stems and released to the air.** The plants excrete carbon dioxide produced as a waste during respiration only at night time. This is because the carbon dioxide produced during respiration in day time is all used up by the plant itself in photosynthesis. The plants excrete oxygen as a waste only during the day time (because oxygen is produced by photosynthesis only during the day time when the sunlight is there). Water vapour produced as a waste by respiration is, however, excreted by plants all the time (day as well as night). This waste water is got rid of by transpiration.

The plants also store some of the waste products in their body parts. For example, some of the waste products collect in the leaves, bark and fruits of the plants (or trees). **The plants get rid of these wastes by shedding of leaves, peeling of bark and felling of fruits.** So, when the dead leaves, bark and ripe fruits fall off from a tree, then the waste products contained in them are got rid of (see Figure 101). Some of the plant wastes get stored in the fruits of the plant in the form of solid bodies called **raphides.** These wastes are removed when the fruits get detached from the plant. For example, the fruit called 'yam' (*zamikand*) has needle-shaped raphides on its surface. The plants secrete their wastes in the form of gum and resins from their stems and branches (see Figure 102). The plants also excrete some waste substances into the soil around them.

Figure 101. The plants store some of their waste products in old leaves which fall in autumn.

Figure 102. The stem of this tree is secreting some of its waste products in the form of gum.

From the above discussion we conclude that the various methods used by the plants to get rid of their waste products are the following :

(*i*) The plants get rid of gaseous waste products through stomata in leaves and lenticels in stems.

(*ii*) The plants get rid of stored solid and liquid wastes by the shedding of leaves, peeling of bark and felling of fruits.

(*iii*) The plants get rid of wastes by secreting them in the form of gums and resins.

(*iv*) Plants also excrete some waste substances into the soil around them.

EXCRETION IN ANIMALS

Different animals have different arrangements (or organs) for excretion, which depend on the constitution of the animal. For example :

1. In *Amoeba* (and other single celled animals), the waste material carbon dioxide is removed by diffusion through the cell membrane, but nitrogenous wastes (like ammonia) and excess water are removed by the contractile vacuole.
2. In earthworm, the tubular structures called nephridia are the excretory organs. In addition to nephridia, the moist skin of earthworm also acts as an excretory organ.
3. In human beings, the microscopic thin tubules form nephron, which functions as excretory unit. About 1 million nephrons taken together form the excretory organ of human beings called kidney.

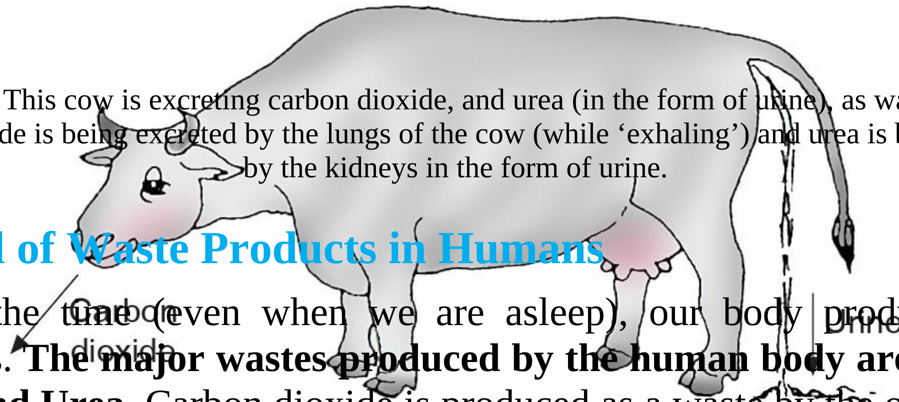


Figure 103. This cow is excreting carbon dioxide, and urea (in the form of urine), as waste products. Carbon dioxide is being excreted by the lungs of the cow (while 'exhaling') and urea is being excreted by the kidneys in the form of urine.

Removal of Waste Products in Humans

All the time (even when we are asleep), our body produces waste substances. **The major wastes produced by the human body are : Carbon dioxide and Urea.** Carbon dioxide is produced as a waste by the oxidation of food during the process of respiration. Urea is produced as a waste by the decomposition of unused proteins in the liver. Our body must get rid of these waste materials because their accumulation in the body is poisonous and harms us. **Waste removal is called excretion.**

The human body has different organs for the removal of wastes from the body. These are our lungs and kidneys. **Our lungs excrete carbon dioxide. Our kidneys excrete urea.** The kidneys are the main excretory organs of the human body. So, the main excretory system in human beings involves the kidneys. We will first describe how lungs excrete carbon dioxide and then study the main excretory system of human body.

The lungs remove respiratory waste carbon dioxide. This happens as follows : Carbon dioxide is produced as a waste product in the body by the oxidation of food during respiration. This carbon dioxide enters from the body tissues into the blood stream by diffusion. Blood carries this carbon dioxide to the lungs. When we breathe out, then the lungs excrete carbon dioxide which goes into the air through nostrils. Thus, **our lungs act as the excretory organs for removing the waste product carbon dioxide from the body.**

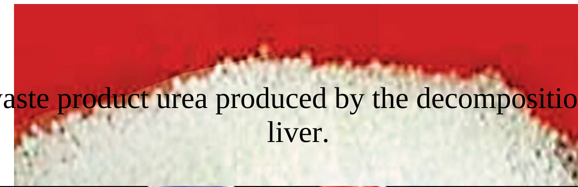


Figure 104. This is the waste product urea produced by the decomposition of unused proteins in our liver.

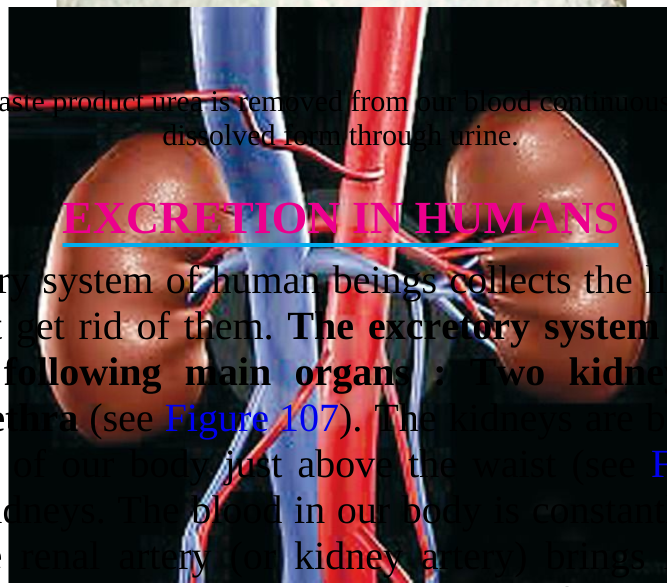


Figure 105. The waste product urea is removed from our blood continuously by our kidneys in dissolved form through urine.

EXCRETION IN HUMANS

The excretory system of human beings collects the liquid wastes of the body and helps it get rid of them. **The excretory system of human beings consists of the following main organs : Two kidneys, Two ureters, Bladder and Urethra** (see Figure 107). The kidneys are bean shaped organs towards the back of our body just above the waist (see Figure 106). Every person has two kidneys. The blood in our body is constantly passing through our kidneys. The renal artery (or kidney artery) brings in the dirty blood (containing waste substances) into the kidneys. **The function of kidneys is to remove the poisonous substance urea, other waste salts and excess water from the blood and excrete them in the form of a yellowish liquid called urine.** Thus, kidneys clean our blood by filtering it to remove unwanted substances present in it. The cleaned blood is carried away from the kidneys by the renal vein (or kidney vein). The ureters (or excretory tubes), one from each kidney, opens into urinary bladder (see Figure 107). Ureters are the tubes which carry urine from the kidneys to the bladder. Urine is stored in the bladder. The bladder is a bag which stores urine till the time we go to the toilet. The urethra is a tube. The urine collected in the bladder is passed out from the body through the urethra (see Figure 107). We will now describe a kidney in detail.

Figure 106. This picture shows where in the body our kidneys are.

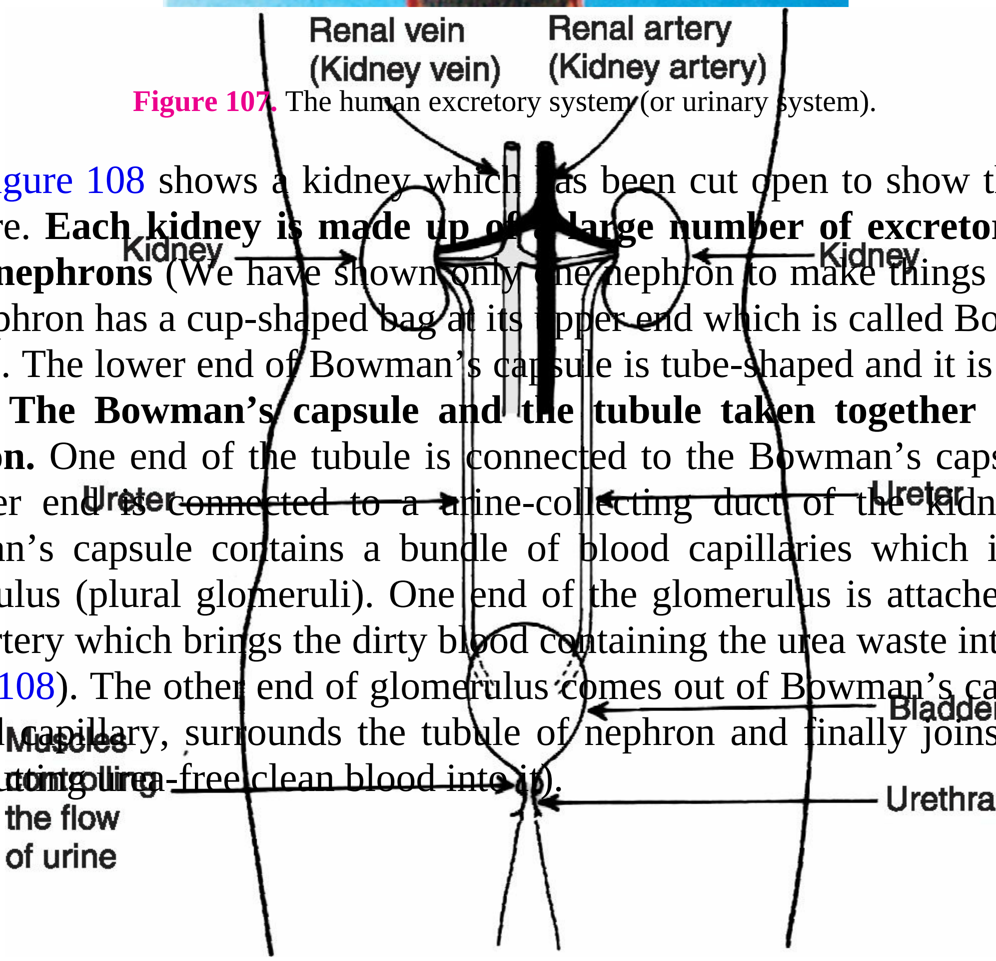


Figure 107. The human excretory system (or urinary system).

Figure 108 shows a kidney which has been cut open to show the inner structure. **Each kidney is made up of a large number of excretory units called nephrons** (We have shown only one nephron to make things simple). The nephron has a cup-shaped bag at its upper end which is called Bowman's capsule. The lower end of Bowman's capsule is tube-shaped and it is called a tubule. **The Bowman's capsule and the tubule taken together make a nephron.** One end of the tubule is connected to the Bowman's capsule and its other end is connected to a urine-collecting duct of the kidney. The Bowman's capsule contains a bundle of blood capillaries which is called glomerulus (plural glomeruli). One end of the glomerulus is attached to the renal artery which brings the dirty blood containing the urea waste into it (see Figure 108). The other end of glomerulus comes out of Bowman's capsule as a blood capillary, surrounds the tubule of nephron and finally joins a renal vein (putting urea-free clean blood into it).

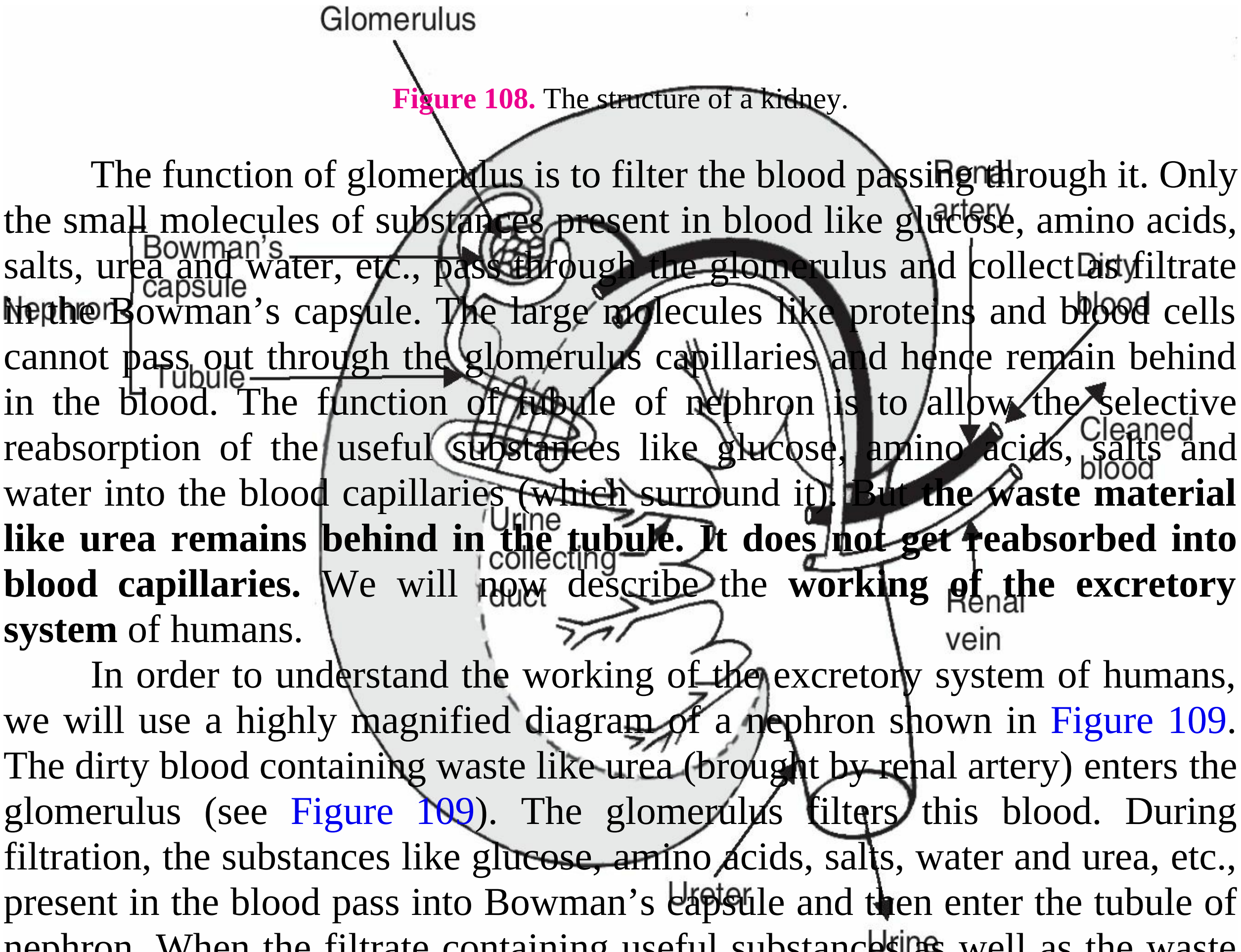


Figure 108. The structure of a kidney.

The function of glomerulus is to filter the blood passing through it. Only the small molecules of substances present in blood like glucose, amino acids, salts, urea and water, etc., pass through the glomerulus and collect as filtrate in the Bowman's capsule. The large molecules like proteins and blood cells cannot pass out through the glomerulus capillaries and hence remain behind in the blood. The function of tubule of nephron is to allow the selective reabsorption of the useful substances like glucose, amino acids, salts and water into the blood capillaries (which surround it). **But the waste material like urea remains behind in the tubule. It does not get reabsorbed into blood capillaries.** We will now describe the **working of the excretory system** of humans.

In order to understand the working of the excretory system of humans, we will use a highly magnified diagram of a nephron shown in Figure 109. The dirty blood containing waste like urea (brought by renal artery) enters the glomerulus (see Figure 109). The glomerulus filters this blood. During filtration, the substances like glucose, amino acids, salts, water and urea, etc., present in the blood pass into Bowman's capsule and then enter the tubule of nephron. When the filtrate containing useful substances as well as the waste substances passes through the tubule, then the useful substances like all glucose, all amino acids, most salts, and most water, etc., are reabsorbed into the blood through blood capillaries surrounding the tubule. Only the waste substances urea, some unwanted salts and excess water remain behind in the tubule. The liquid left behind in the tubule of nephron is urine. The nephron carries this urine into the collecting duct of the kidney from where it is carried to ureter. From the ureter, urine passes into urinary bladder. Urine is stored in the bladder for some time and ultimately passed out of the body through urethra. Please note that the human urine contains water, some salts and nitrogenous substances, most of which is urea (and some uric acid).

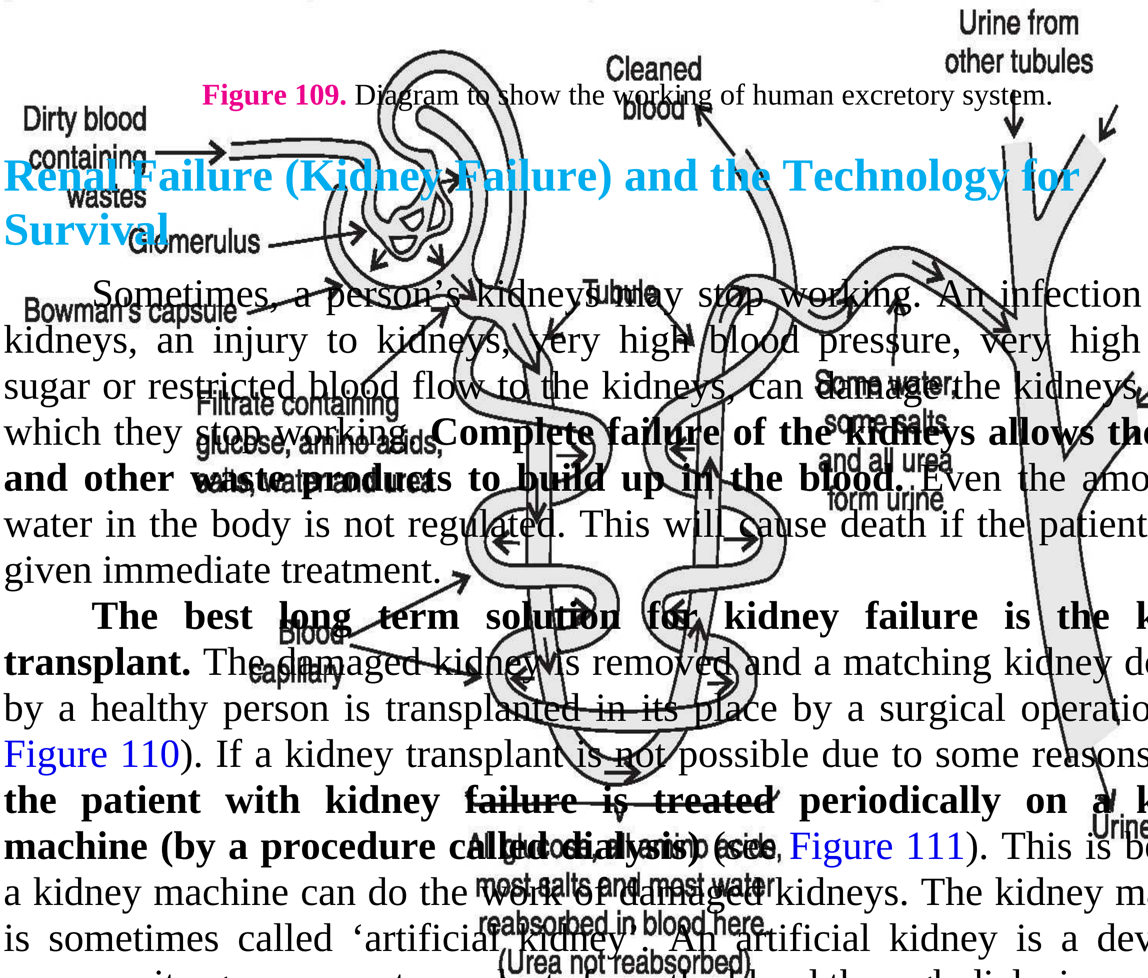


Figure 109. Diagram to show the working of human excretory system.

Renal Failure (Kidney Failure) and the Technology for Survival

Sometimes, a person's kidneys may stop working. An infection in the kidneys, an injury to kidneys, very high blood pressure, very high blood sugar or restricted blood flow to the kidneys, can damage the kidneys due to which they stop working. **Complete failure of the kidneys allows the urea and other waste products to build up in the blood.** Even the amount of water in the body is not regulated. This will cause death if the patient is not given immediate treatment.

The best long term solution for kidney failure is the kidney transplant. The damaged kidney is removed and a matching kidney donated by a healthy person is transplanted in its place by a surgical operation (see Figure 110). If a kidney transplant is not possible due to some reasons, **then the patient with kidney failure is treated periodically on a kidney machine (by a procedure called dialysis)** (see Figure 111). This is because a kidney machine can do the work of damaged kidneys. The kidney machine is sometimes called 'artificial kidney'. An artificial kidney is a device to remove nitrogenous waste products from the blood through dialysis.

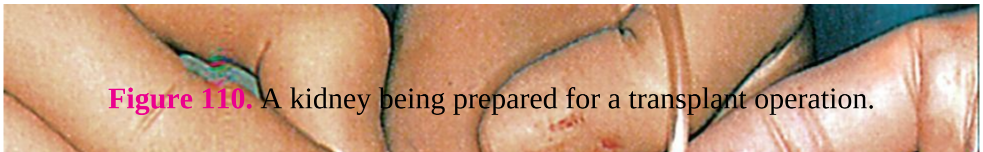


Figure 110. A kidney being prepared for a transplant operation.

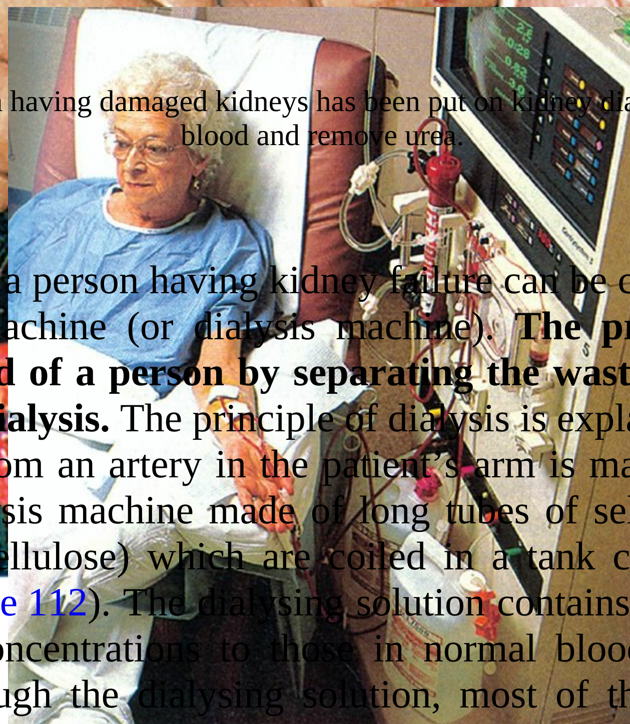


Figure 111. This woman having damaged kidneys has been put on kidney dialysis machine to filter her blood and remove urea.

Dialysis

The blood of a person having kidney failure can be cleaned regularly by using a kidney machine (or dialysis machine). **The procedure used for cleaning the blood of a person by separating the waste substance (urea) from it is called dialysis.** The principle of dialysis is explained below.

The blood from an artery in the patient's arm is made to flow into the dialyser of a dialysis machine made of long tubes of selectively permeable membrane (like cellulose) which are coiled in a tank containing dialysing solution (see Figure 112). The dialysing solution contains water, glucose and salts in similar concentrations to those in normal blood. As the patient's blood passes through the dialysing solution, most of the wastes like urea present in it pass through the selectively permeable cellulose tubes into the dialysing solution. The clean blood is pumped back into a vein of the patient's arm.

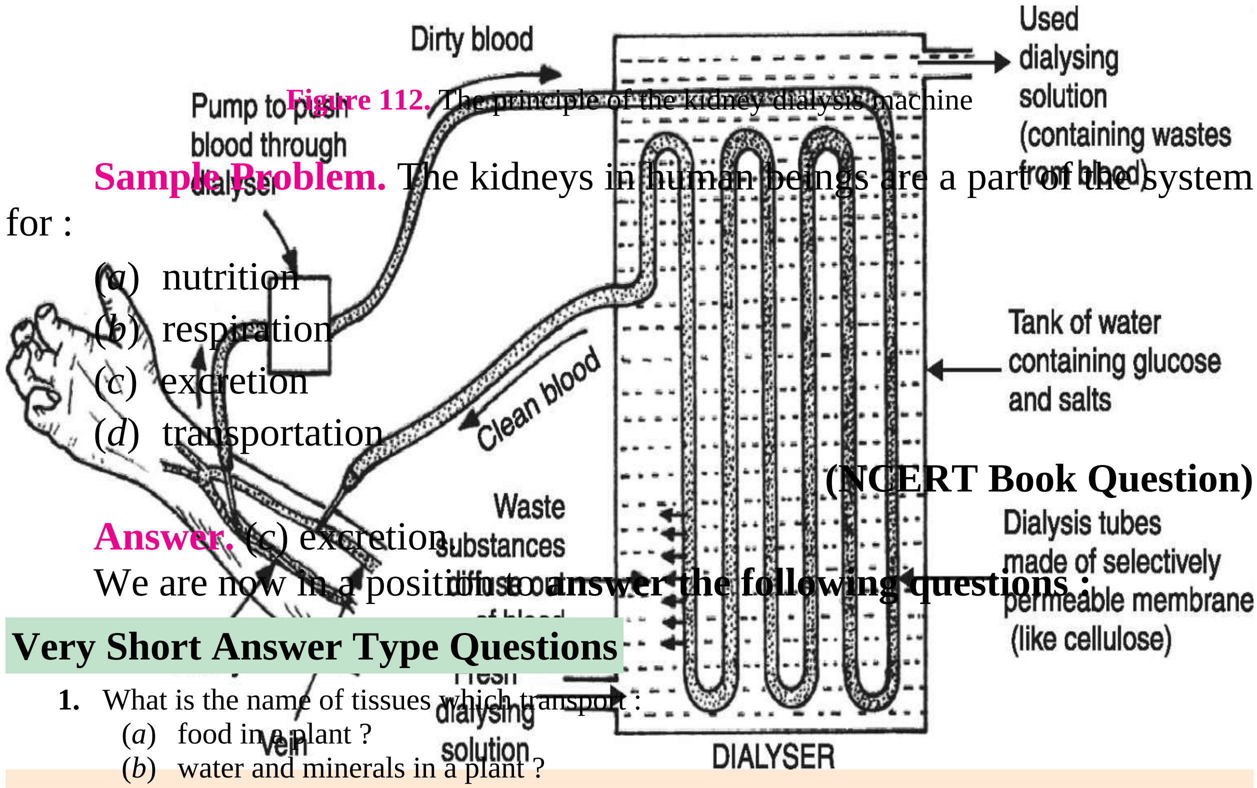


Figure 112. The principle of the kidney dialysis machine

Sample Problem. The kidneys in human beings are a part of the system for :

(*a*) nutrition
(*b*) respiration
(*c*) excretion
(*d*) transportation

(NCERT Book Question)

Answer. (*c*) excretion

We are now in a position to **answer the following questions :**

Very Short Answer Type Questions

1. What is the name of tissues which transport :
   (*a*) food in a plant ?
   (*b*) water and minerals in a plant ?
2. What substance/substances are transported in plants by :
   (*a*) xylem vessels and tracheids ?
   (*b*) sieve tubes (or phloem) ?
3. Which organ acts as a pump in the circulatory system ?
4. Veins and arteries carry blood. Which of these carry blood :
   (*a*) away from the heart ?
   (*b*) back to the heart ?
5. Where does blood absorb oxygen ?
6. What stops blood from flowing backwards through the heart ?
7. Name (*i*) largest artery, and (*ii*) largest vein, in our body.
8. What gaseous waste products are excreted by plants ?
9. Where is the dirty blood in our body filtered ?
10. Name the procedure used in the working of artificial kidney.
11. From the following terms, choose one term which includes the other four : Plasma, Platelets, Blood, RBC, WBC
12. What are the components of the transport system in highly organised plants ?
13. Out of xylem and phloem, which one carries materials :
    (*a*) upwards as well as downwards ?
    (*b*) only upwards ?
14. Name two liquids which help in the transport of substances in the human body.
15. What is the other name of main vein ?
16. Name the conducting tissue of plants which is made of sieve tubes alongwith companion cells.
17. Name the conducting tissue in plants which is made of (*a*) living cells, and (*b*) dead cells.
18. State the term used for the transport of food from leaves to other parts of plant.
19. Which process in a plant is accomplished by utilising energy from ATP : transport of water and minerals or transport of food ?
20. Name the two types of transport systems in the human beings.

21. Name a waste gas released by the plants (*a*) only during the day time, and (*b*) only during the night time.

22. Name one animal having single circulation of blood and another having double circulation.

23. State whether the following statements are true or false :

(*a*) Some organisms store wastes in body parts.

(*b*) The value of systolic pressure is always lower than that of diastolic pressure.

24. Name the two parts of a plant through which its gaseous waste products are released into the air.

25. What happens to the glucose which enters the nephron tubule alongwith the filtrate ?

26. Name the two waste products of the human body which are produced in the body cells.

27. What is the role of glomerulus in the kidney ?

28. What is the the other name of 'high blood pressure' ?

29. Fill in the following blanks with suitable words :

(*a*) Gums and resins are the …………….. products of plants.

(*b*) Bowman's capsule and tubule taken together make a……………….

(*c*) The organs which extract the nitrogenous wastes from the blood are ………………

(*d*) The extracellular fluid which always flows from body tissues to the heart is called………………

(*e*) The ……………..blood cells make antibodies whereas…………….. blood cells help in respiration.

Short Answer Type Questions

30. What is xylem tissue ? Name the two kinds of cells in xylem tissue. State whether these cells are living or dead.

31. What is phloem tissue ? Phloem contains two types of cells joined side by side. Name these two types of cells. State whether these cells are living or dead.

32. (*a*) What is transpiration ?

(*b*) What do you mean by 'translocation' with respect to transport in plants ?

(*c*) Which plant tissue is involved in translocation : xylem or phloem ?

33. (*a*) Draw a labelled diagram of (*i*) a xylem vessel, and (*ii*) a sieve tube (or phloem).

(*b*) What are the differences between the transport of materials in xylem and phloem ?

34. Match the terms in column I with their uses in column II

Column I	*Column II*
(*i*) Heart	(*a*) Pipes for transport in humans
(*ii*) Arteries and Veins	(*b*) Clotting of blood
(*iii*) Xylem vessels	(*c*) Pumping organ
(*iv*) RBC	(*d*) Water transport in plants
(*v*) Platelets	(*e*) Carrier of oxygen

35. Define excretion. Name the excretory unit of a kidney.

36. (*a*) What job is done by the kidneys ?

(*b*) What do kidneys excrete ?

(*c*) What is the name of the tubes which connect the kidneys to bladder ?

(*d*) What does the bladder in our body do ?

37. Why do some people need to use a dialysis machine ? What does the machine do ?

38. What is the liquid part of the blood called ? What is the function of platelets in the blood ?

39. (*a*) How many types of blood vessels are there in the human body ? Name them.

(*b*) Why does the heart need valves ?

40. A dialysis machine contains long tubes coiled in a tank containing dialysing solution :

(*i*) Of what substance are the tubes made ?

(*ii*) What does the dialysing solution contain ?

(*iii*) Name the main waste which passes into the dialysing solution.

41. State the differences between artery, vein and capillary.

42. (*a*) What are the upper parts of the heart called ?

(*b*) What are the lower parts of the heart called ?

(*c*) What is the name of blood vessels which connect arteries to veins ?

(*d*) (*i*) Which side of the heart pumps blood into the lungs ?

(*ii*) Which side of the heart pumps blood into entire body (except the lungs) ?

43. (*a*) What are the methods used by plants to get rid of their waste products ?

(*b*) How are waste products excreted in *Amoeba* ?

44. (*a*) What is lymph ? State two major functions of lymph.

(*b*) What is meant by saying that the blood pressure of a person is 120/80 ?

45. What is hypertension ? Why is it caused ? What harm can it do ?

46. What are the various components of blood ? State their functions.

47. With which human organ systems (or human systems) are the following associated ?

(*i*) vena cava

(*ii*) glomerulus

(*iii*) alveoli

(*iv*) villi

48. What is meant by 'systolic pressure' and 'diastolic pressure' ? What are their normal values ?

49. (*a*) What is meant by 'heart beat' ? What is the usual heart beat rate at rest ?

(*b*) What change occurs in heart beats if a person runs for a while ? Why ?

Long Answer Type Questions

50. (*a*) What is blood ? Why is it red ?

(*b*) State the functions of blood in our body.

(*c*) Name a circulatory fluid in the human body other than blood.

51. (*a*) What is meant by human circulatory system ? Name the organs of the circulatory system in humans.

(*b*) Draw a diagram of the human heart and label its parts.

(*c*) What is meant by the terms 'single circulation' and 'double circulation' ?

52. Describe the working of human blood circulatory system with the help of a suitable diagram which shows all the steps involved.

53. (*a*) Name the red pigment which carries oxygen in the blood.

(*b*) Why is it necessary to separate oxygenated and deoxygenated blood in mammals and birds ?

(*c*) How many chambers are there in the heart of : (*i*) an amphibian, (*ii*) a mammal, and (*iii*) a fish ?

(*d*) Describe the circulatory system in a fish.

54. (*a*) What is lymphatic system ? What are its functions ?

(*b*) What is blood pressure ? What are the two factors used to express the blood pressure of a person ?

(*c*) Name the main nitrogenous waste in the human blood. How is it removed from the blood ?

55. (*a*) Name the various organs of the human excretory system.

(*b*) Draw a neat labelled diagram of the human excretory system.

(*c*) What is the function of excretory system in humans ?

56. (*a*) Describe the mechanism of urine formation in human excretory system. Draw a labelled diagram to illustrate your answer.

(*b*) Where is urine carried through ureters ?
(*c*) What is urethra ?

57. (*a*) What is meant by dialysis ? What type of patients are put on dialysis ?
(*b*) Explain the principle of dialysis with the help of a labelled diagram.

58. (*a*) Why is transport of materials necessary in an organism (plant or animal) ?
(*b*) What is the need of special tissues or organs for transport of substances in plants and animals ?
(*c*) How are water and minerals transported in plants ?
(*d*) How is food transported in plants ?

Multiple Choice Questions (MCQs)

59. One of the following does not have a nucleus. This one is :
(*a*) red blood cell
(*b*) white blood cell
(*c*) guard cell
(*d*) epidermal cell

60. The component of blood which makes chemicals known as antibodies is :
(*a*) platelets
(*b*) white blood cells
(*c*) red blood cells
(*d*) plasma

61. An animal in which the oxygenation of blood does not take place in the lungs is :
(*a*) cow
(*b*) fish
(*c*) frog
(*d*) fox

62. Which of the following carries substances upwards as well as downwards in a plant ?
(*a*) xylem
(*b*) companion cells
(*c*) phloem
(*d*) tracheids

63. One of the following is not a constituent of blood. This one is :
(*a*) red blood cells
(*b*) white blood cells
(*c*) sieve plates
(*d*) platelets

64. If a patient is put on dialysis, he is most likely suffering from a severe ailment of the :
(*a*) circulatory system
(*b*) respiratory system
(*c*) excretory system
(*d*) digestive system

65. Water absorption through roots can be increased by keeping the potted plants :
(*a*) in the shade
(*b*) in dim light
(*c*) under the fan
(*d*) covered with a polythene bag

66. A blood vessel which carries blood back to the heart is :
(*a*) artery
(*b*) vein
(*c*) capillary

(*d*) platelet

67. Blood is pumped from the heart to the entire body by the :

(*a*) lungs
(*b*) ventricles
(*c*) atria
(*d*) nerves

68. The blood leaving the tissues becomes richer in :

(*a*) carbon dioxide
(*b*) water
(c) haemoglobin
(*d*) oxygen

69. What prevents the backflow of blood inside the heart during contraction ?

(*a*) thick muscular walls of ventricles
(*b*) valves
(*c*) thin walls of atria
(*d*) all of the above

70. Which of the following is the correct path taken by urine in our body ?

(*a*) kidney $\longrightarrow$ ureter $\longrightarrow$ urethra $\longrightarrow$ bladder
(*b*) kidney $\longrightarrow$ bladder $\longrightarrow$ urethra $\longrightarrow$ ureter
(*c*) kidney $\longrightarrow$ ureter $\longrightarrow$ bladder $\longrightarrow$ urethra
(*d*) bladder $\longrightarrow$ kidney $\longrightarrow$ ureter $\longrightarrow$ urethra

71. In which of the following vertebrate group/groups, heart does not pump oxygenated blood to different parts of the body ?

(*a*) pisces and amphibians
(*b*) amphibians and reptiles
(*c*) amphibians only
(*d*) pisces only

72. Which vein brings clean blood from the lungs into the heart ?

(*a*) renal vein
(*b*) pulmonary vein
(*c*) vena cava
(*d*) hepatic vein

73. Which blood vessel does not carry any carbon dioxide ?

(*a*) pulmonary artery
(*b*) vena cava
(*c*) hepatic vein
(*d*) pulmonary vein

74. It has been found that people living in very high mountains have many more red corpuscles in their blood than people living in plains. Which one of the following best accounts for this phenomenon ?

(*a*) the cold climate stimulates the production of red corpuscles to keep the body warm
(*b*) people of high mountains breathe more quickly
(*c*) the low air pressure requires more red corpuscles to supply the body cells with oxygen.
(*d*) the low air pressure in high mountains speeds up the blood circulation so that more red corpuscles are needed

75. The phloem tissue in plants is responsible for the transport of :

(*a*) water
(*b*) water and minerals
(*c*) sugar
(*d*) all of the above

76. Which of the following has a three-chambered heart ?
(*a*) pigeon
(*b*) lizard
(*c*) fish
(*d*) lion

77. In which of the following are the largest amounts of nitrogen excreted from a mammalian body ?
(*a*) breath
(*b*) sweat
(*c*) urine
(*d*) faeces

78. Which one of the following has cytoplasm but no nucleus :
(*a*) xylem vessel
(*b*) sieve tube
(*c*) tracheid
(*d*) companion cell

79. The process of carrying food from the leaves to other parts of a plant is called :
(*a*) transpiration
(*b*) transportation
(*c*) translocation
(*d*) transformation

80. Which of the following is the only conducting tissue in non-flowering plants ?
(*a*) xylem vessels
(*b*) sieve tubes
(*c*) companion cells
(*d*) tracheids

81. Which of the following helps in the upward movement of water and dissolved minerals from the roots to the leaves through the stem ?
(*a*) transportation
(*b*) translocation
(*c*) tropic movement
(*d*) transpiration

82. Which one of the following does not have valves ?
(*a*) heart
(*b*) arteries
(*c*) capillaries
(*d*) veins

83. Which of the following is accomplished in a plant by utilising the energy stored in ATP ?
(*a*) transport of food
(*b*) transport of water and minerals
(*c*) transport of oxygen
(*d*) transport of water, minerals and food

84. Coagulation of blood in a cut or wound is brought about by :
(*a*) plasma
(*b*) platelets
(*c*) WBC
(*d*) RBC

85. The blood vessel which carries oxygenated blood from the lungs to the heart is :
(*a*) main artery
(*b*) pulmonary artery

(*c*) main vein
(*d*) pulmonary vein

86. The instrument for measuring blood pressure is called :
(*a*) manometer
(*b*) sphygmomanometer
(*c*) barometer
(*d*) potentiometer

87. The excretory unit in the human excretory system is called :
(*a*) nephron
(*b*) neuron
(*c*) nephridia
(*d*) kidneyon

88. The substance which is not reabsorbed into the blood capillaries surrounding the tubule of a nephron is mainly :
(*a*) glucose
(*b*) amino acid
(*c*) urea
(*d*) water

89. The procedure of cleaning the blood of a person by using a kidney machine is known as :
(*a*) ketolysis
(*b*) hydrolysis
(*c*) dialysis
(*d*) photolysis

90. The excretory organs in an earthworm are :
(*a*) nephridia
(*b*) nephrons
(*c*) raphides
(*d*) ureters

91. The cells in our blood which destroy disease-causing germs, are :
(*a*) platelets
(*b*) skin cells
(*c*) RBCs
(*d*) WBCs

92. The wave of expansion of an artery when blood is forced into it is called :
(*a*) flow
(*b*) heart beat
(*c*) pulse
(*d*) ticking

93. In autotrophs, water is transported through :
(*a*) root hair
(*b*) phloem
(*c*) stomata
(*d*) xylem

94. An animal having double circulation in a three-chambered heart is :
(*a*) fish
(*b*) snake
(*c*) deer
(*d*) sparrow

Questions Based on High Order Thinking Skills (HOTS)

95. The transport system in plants consists of two kinds of tissues X and Y. The tissue X is made up of living cells and consists of two components A and B. The component A has tiny pores in its end walls and contains only cytoplasm but no nucleus. On the other hand, component B has cytoplasm as well as nucleus. The tissue Y is made up of dead cells and consists of two components C and D. The component C has open ends whereas component D does not have open ends. In flowering plants, either only C or both C and D transport water but D is the only water conducting tissue in non-flowering plants.

(*a*) What is (*i*) tissue X (*ii*) component A, and (*iii*) component B ?

(*b*) What is (*i*) tissue Y (*ii*) component C, and (*iii*) component D ?

96. Water and dissolved minerals get into the root hair of a plant by a process called A and enter the conducting tissue B. The process C helps the water and dissolved minerals to move up through the tissue B in roots and stem, and reach the leaves of a plant. In the leaves food is made by a process D. This food is then transported to all the parts of a plant through tissue E. The process of distributing food made in the leaves to all the parts of the plant is called F.

(*a*) What are (*i*) A (*ii*) B (*iii*) C (*iv*) D (*v*) E, and (*vi*) F ?

(*b*) Which tissue is made up of living cells : B or E ?

(*c*) Which tissue, B or E, contains sieve tubes ?

(*d*) Which tissue, B or E, contains tracheids ?

97. The liquid connective tissue A circulates in our body continuously without stopping. This tissue contains a pigment B which imparts it a colour C. The tissue A consists of four components D, E, F and G. The component D fights infection and protects us from diseases. The component E helps in the clotting of tissue A if a person gets a cut. The component F is a liquid which consists mainly of water with many substances dissolved in it and component G carries oxygen from the lungs to all the parts of the body.

(*a*) What is (*i*) tissue A (*ii*) pigment B, and (*iii*) colour C ?

(*b*) Name (*i*) D (*ii*) E (*iii*) F, and (*iv*) G.

(*c*) Name one substance (other than oxygen) which is transported by tissue A in the human body.

(*d*) Which two components of tissue A are the cells without nucleus ?

(*e*) Name any two organisms (animals) which do not have liquid like A in their body.

98. The human body has an organ A which acts as a double pump. The oxygenated blood coming from the lungs through a blood vessel B enters the upper left chamber C of the double pump. When chamber C contracts, then blood goes into lower left chamber D. The contraction of chamber D forces the blood to go into a blood vessel E which supplies oxygenated blood to all the organs of the body (except the lungs). The deoxygenated blood coming out of the body organs is taken by a blood vessel F to the right upper chamber G of pumping organ. Contraction of chamber G forces the deoxygenated blood into right lower chamber H. And finally the contraction of chamber H sends the deoxygenated blood into lungs through a blood vessel I.

(*a*) What is organ A ?

(*b*) Name the blood vessel (*i*) B (*ii*) E (*iii*) F, and (*iv*) I.

(*c*) What are chambers (*i*) C, and (*ii*) D ?

(*d*) What are chambers (*i*) G and (*ii*) H ?

99. A liquid X of colour Y circulates in the human body only in one direction : from body tissues to the heart. Among other things, liquid X contains germs from cells and dead cells. The liquid X is cleaned of germs and dead cells by a special type of white blood cells called Z. This cleaned liquid is then put into blood circulatory system in subclavian veins.

(*a*) What is (*i*) liquid X, and (*ii*) colour Y ?

(*b*) What are Z ?

(*c*) The liquid X is somewhat similar to a component of blood. Name this component.

(*d*) Why is liquid X not red ?

100. There is a pair of bean-shaped organs P in the human body towards the back, just above the waist. A waste product Q formed by the decomposition of unused proteins in the liver is brought into organ P through blood by an artery R. The numerous tiny filters S present in organ P clean the dirty blood by removing the waste product Q. The clean blood goes into circulation through a vein T. The waste substance Q, other waste salts, and excess water form a yellowish liquid U which goes from organ P into a bag-like structure V through two tubes W. This liquid is then thrown out of the body through a tube X.

(*a*) What is (*i*) organ P, and (*ii*) waste substance Q ?

(*b*) Name (*i*) artery R, and (*ii*) vein T.

(*c*) What are tiny filters S known as ?

(*d*) Name (*i*) liquid U (*ii*) structure V (*iii*) tubes W, and (*iv*) tube X.

101. The organs A of a person have been damaged completely due to which too much of a poisonous waste material B has started accumulating in his blood, making it dirty. In order to save this person's life, the blood from an artery in the person's arm is made to flow into long tubes made of substance E which are kept in coiled form in a tank containing solution F. This solution contains three materials G, H and I in similar proportions to those in normal blood. As the person's blood passes through long tubes of substance E, most of the wastes present in it go into solution. The clean blood is then put back into a vein in the arm of the person for circulation.

(*a*) What are organs A ?

(*b*) Name the waste substance B.

(*c*) What are (*i*) E, and (*ii*) F ?

(*d*) Name G, H and I.

(*e*) What is the process described above known as ?

ANSWERS

4. (*a*) Arteries (*b*) Veins **6.** Valves **7.** (*i*) Aorta (*ii*) Vena cava **11.** Blood **13.** (*a*) Phloem (*b*) Xylem **14.** Blood and Lymph **15.** Vena cava **16.** Phloem **17.** (*a*) Phloem (*b*) Xylem **18.** Translocation **19.** Transport of food **21.** (*a*) Oxygen (*b*) Carbon dioxide **23.** (*a*) True (*b*) False **24.** Lenticels and Stomata **25.** It is reabsorbed into the blood through blood capillaries surroundings the tubule **26.** Carbon dioxide and Urea **28.** Hypertension **29.** (*a*) waste (*b*) nephron (*c*) kidneys (*d*) lymph (*e*) white ; red **34.** (*i*) *c* (*ii*) *a* (*iii*) *d* (*iv*) *e* (*v*) *b* **40.** (*i*) Cellulose (*ii*) Water, glucose and salts in similar concentrations to those in normal blood (*iii*) Urea **42.** (*a*) Atria (*b*) Ventricles (*c*) Capillaries (*d*) (*i*) Right side (*ii*) Left side **47.** (*i*) Circulatory system (*ii*) Excretory system (*iii*) Respiratory system (*iv*) Digestive system **50.** (*c*) Lymph **59.** (*a*) **60.** (*b*) **61.** (*b*) **62.** (*c*) **63.** (*c*) **64.** (*c*) **65.** (*c*) **66.** (*b*) **67.** (*b*) **68.** (*a*) **69.** (*b*) **70.** (*c*) **71.** (*d*) **72.** (*b*) **73.** (*d*) **74.** (*c*) **75.** (*c*) **76.** (*b*) **77.** (*c*) **78.** (*b*) **79.** (*c*) **80.** (*d*) **81.** (*d*) **82.** (*c*) **83.** (*a*) **84** (*b*) **85.** (*d*) **86.** (*b*) **87.** (*a*) **88.** (*c*) **89.** (*c*) **90.** (*a*) **91.** (*d*) **92.** (*c*) **93.** (*d*) **94.** (*b*) **95.** (*a*) (*i*) Phloem (*ii*) Sieve tube (*iii*) Companion cell (*b*) (*i*) Xylem (*ii*) Xylem vessel (*iii*) Tracheids **96.** (*a*) (*i*) Diffusion (*ii*) Xylem (*iii*) Transpiration (*iv*) Photosynthesis (*v*) Phloem (*vi*) Translocation (*b*) E (*c*) E (*d*) B **97.** (*a*) (*i*) Blood (*ii*) Haemoglobin (*iii*) Red (*b*) (*i*) White blood cells (*ii*) Platelets (*iii*) Plasma (iv) Red blood cells (*c*) Digested food (*d*) E (Platelets) and G (Red blood cells) (*e*) *Amoeba* and Grasshopper **98.** (*a*) Heart (*b*) (*i*) Pulmonary vein (*ii*) Aorta (*iii*) Vena cava (*iv*) Pulmonary artery (*c*) (*i*) Left atrium (*ii*) Left ventricle (*d*) (*i*) Right atrium (*ii*) Right ventricle **99.** (*a*) (*i*) Lymph (*ii*) Light yellow (*b*) Lymphocytes (*c*) Plasma (*d*) It does not contain red blood cells having the red pigment haemoglobin **100.** (*a*) (*i*) Kidneys (*ii*) Urea (*b*) (*i*) Renal artery (*ii*) Renal vein (*c*) Nephrons (*d*) (*i*) Urine (*ii*) Bladder (*iii*) Ureters (*iv*) Urethra **101.** (*a*) Kidneys (*b*) Urea (*c*) (*i*) Cellulose (*ii*) Dialysing solution (*d*) Water, Glucose and Salts (*e*) Dialysis.