RESPIRATION AND TRANSPIRATION 6

SYLLABUS

1. The respiratory system in human beings.
   Test for carbon dioxide (link with Chemistry - class VII) — getting rid of waste carbon dioxide/water vapour through exhalation.
   Difference between respiration and breathing (inhalation and exhalation).
2. The respiratory organs of some animals — e.g. fish, amphibians, insects.
3. Respiration in plants.
   Difference between respiration and photosynthesis.
   Transpiration in plants.
   * Exhaled air contains carbon dioxide — breathing into fresh lime water (E).
   * Experiment to show that soaked/germinating seeds respire (D).

Every cell of a plant, an animal or our own body requires energy for various activities. The muscle cells contract for movement, the brain cells receive and send messages, the root cells penetrate the soil and absorb nutrients, and so on. Even when we are sleeping, we need energy. How do we get this energy? We get it through respiration.

WHAT IS RESPIRATION ?

Respiration is the process of releasing energy by breaking down food (glucose) needed for various body activities.

The breakdown of glucose occurs by utilising oxygen which we breathe in alongwith air. The plants release oxygen into the atmosphere during photosynthesis.

Some of the energy liberated in the breakdown of the glucose molecule, is in the form of heat, but a large part of it is converted into chemical energy in the form of a chemical substance called **adenosine triphosphate** (ATP). Any activity inside the cell is carried out by the energy released by this chemical.

Types of Respiration

There are *two* types of respiration :

(i) Aerobic respiration that utilizes oxygen.

(ii) Anaerobic respiration does not utilize oxygen.

(i) Aerobic Respiration

Usually, all cells throughout life perform aerobic respiration which occurs utilizing oxygen to breakdown the food and get energy. In aerobic respiration, glucose is completely oxidised into carbon dioxide, water and energy. The excess energy gets stored in the cell in the form of ATP.

Aerobic respiration follows the following equation :

$$\underset{\text{(Glucose)}}{C_6H_{12}O_6} + 6O_2 \rightarrow 6CO_2 + 6H_2O + \underset{\text{(38 ATP)}}{\text{energy}}$$

(ii) Anaerobic Respiration

Anaerobic respiration occurs usually in intestinal parasites, yeast, most bacteria and in our own muscles under certain special conditions when sufficient oxygen is not available to the body.

Anaerobic respiration follows the following equation :

$$\underset{\text{(Glucose)}}{C_6H_{12}O_6} \xrightarrow{\text{Enzymes}} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2 + \underset{\text{(2 ATP)}}{\text{Energy}}$$

In anaerobic respiration the food (glucose) is broken down into **ethanol** (in plants) or into **lactic acid** (in animals) and carbon dioxide, but the energy given out is less (only 2 ATP). Differences between aerobic and anaerobic respiration are given below in the table.

Table 6.1 : Differences between aerobic and anaerobic respiration

Aerobic Respiration	Anaerobic Respiration
1. It utilizes oxygen.	1. It does not utilize oxygen.
2. Food molecules (glucose) completely break down into carbon dioxide, water and energy.	2. Food molecules (glucose) partially break down into ethanol/lactic acid, carbon dioxide and energy.
3. Carbon dioxide and water are formed.	3. Ethanol (in plants) and lactic acid (in animals) alongwith carbon dioxide are formed.
4. More energy is released (38 ATP molecules).	4. Less energy is released (2 ATP molecules).

Anaerobic respiration in plants, like in the yeast, is also called *fermentation*. During physical exercise, our muscle tissues respire anaerobically and form lactic acid which accumulates in the muscle cells, causing toxic effect, fatigue and pain. Lactic acid during rest, slowly gets oxidised in the presence of oxygen into carbon dioxide.

RESPIRATION IN HUMANS

It occurs in three phases; (i) Breathing, (ii) Gaseous transport and (iii)Cellular respiration.

(i) **Breathing** (external respiration). It involves *inhalation* (drawing in) of the air through the nostrils into the nasal cavity and finally into the lungs, and *exhalation* is forcing the air out of the lungs.

(ii) **Gaseous transport.** Oxygen of the inhaled air is absorbed by the

blood in the lungs where it combines with the haemoglobin in the red blood cells forming an unstable compound ***oxyhaemoglobin***. The blood carries this oxygen from lungs to the body tissues or cells. It delivers the oxygen there and collects the carbon dioxide from the cells and tissues, transporting it back to lungs for its removal.

(iii) **Cellular respiration** (internal respiration). It is the process of breakdown of food in the cell with the release of energy. Cellular respiration takes place in the cells of all living organisms. It occurs in a series of chemical reactions. The energy released is in chemical form along with some amount of heat.

Respiratory System in Humans

In humans, the respiratory (breathing) organs include **nose, pharynx, larynx, trachea, bronchi** and the **lungs**.

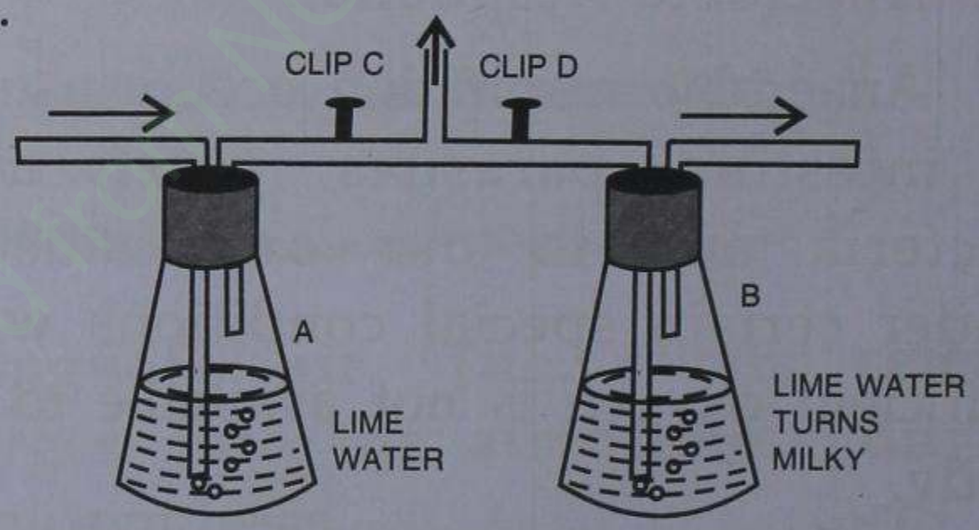
Nose

It has two openings called **nostrils**, leading into nasal chamber. It has hairy lining to prevent dust particles from reaching into the lungs. The lining of the nasal chamber has mucous (a sticky fluid) which too traps germs and dust. The nasal chamber warms and moistens the air entering the lungs. One should always breathe through the nose and not through the mouth.

ACTIVITY 1

Exhaled air contains more carbon dioxide than in atmospheric air : Set up an apparatus as shown here — clip 'C' is opened and clip 'D' is closed. Air is sucked in with the mouth through the tube at the centre. Atmospheric air rushes in flask 'A' bubbling through the lime water. Next, clip 'C' is closed and clip 'D' is opened. Now blow the exhaled air through the same central tube. This time the exhaled air is forced into flask 'B' bubbling through its lime water. Repeat this process 8-10 times. The lime water in flask 'B' turns milky much faster than in flask 'A'.

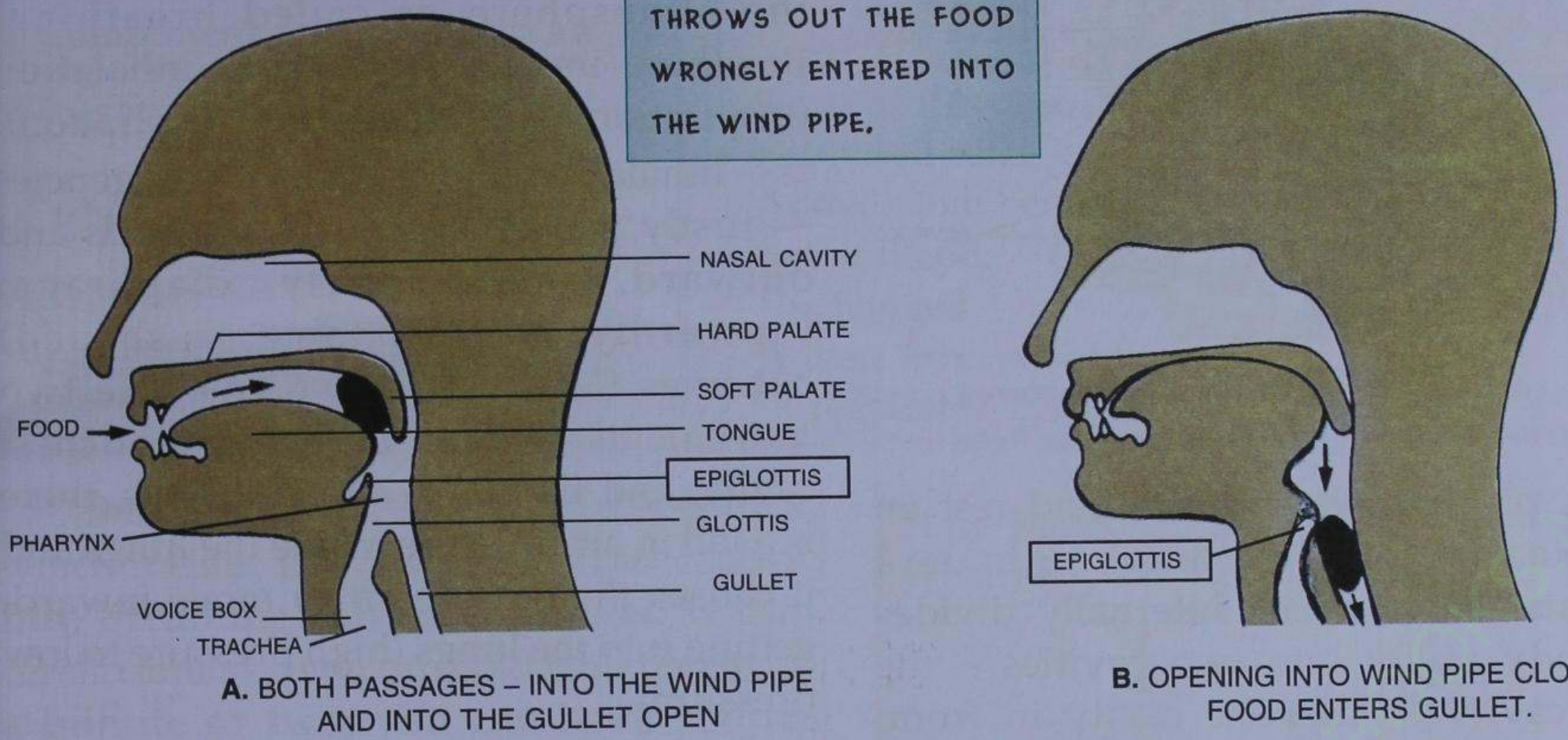
This proves that expired air contains more carbon dioxide than the atmospheric air.



Pharynx

From the nose, the air passes into the **pharynx** or throat which is a common passage for the air and the food, behind the mouth. It leads into the air tube called wind pipe or **trachea**. Just at the entrance of the trachea, there is a voice box called **larynx** (or 'Adams apple' — you can feel it by your hand on the front of your neck). It contains two ligamentous folds called **'vocal cords'**. Air expelled forcibly through the vocal cords vibrates them to produce

COUGHING WHILE EATING THROWS OUT THE FOOD WRONGLY ENTERED INTO THE WIND PIPE.



A. BOTH PASSAGES – INTO THE WIND PIPE AND INTO THE GULLET OPEN

B. OPENING INTO WIND PIPE CLOSED FOOD ENTERS GULLET.

Fig. 6.1 Epiglottis protects any wrongful entry of food into the wind pipe

sound. The front opening (glottis) of the wind pipe is guarded by a muscular flap called **epiglottis** (Fig. 6.1). The epiglottis closes the wind pipe at the time of swallowing of food. Incomplete closure by the epiglottis during swallowing causes coughing.

Trachea (Wind pipe)

The trachea or the wind pipe emerges from the larynx voice box down below in the neck. It runs in the middle of the chest upto a short distance between the two lungs where it divides into two branches called **bronchi** (Fig. 6.2). The wall of the trachea is strengthened by C-shaped rings of cartilage to keep it distended permanently.

Bronchi (*Singular* : bronchus)

The two bronchi lead into right and left lungs respectively. Each bronchus is further divided into smaller and smaller branches called **'bronchioles'**. At the end of these bronchioles are the microscopic air sacs called **'alveoli'**. Each lung contains millions of alveoli (*singular*: alveolus) (Fig. 6.3). These are richly supplied with blood capillaries covering their walls. Their walls are extremely thin and moist for allowing diffusion of gases.

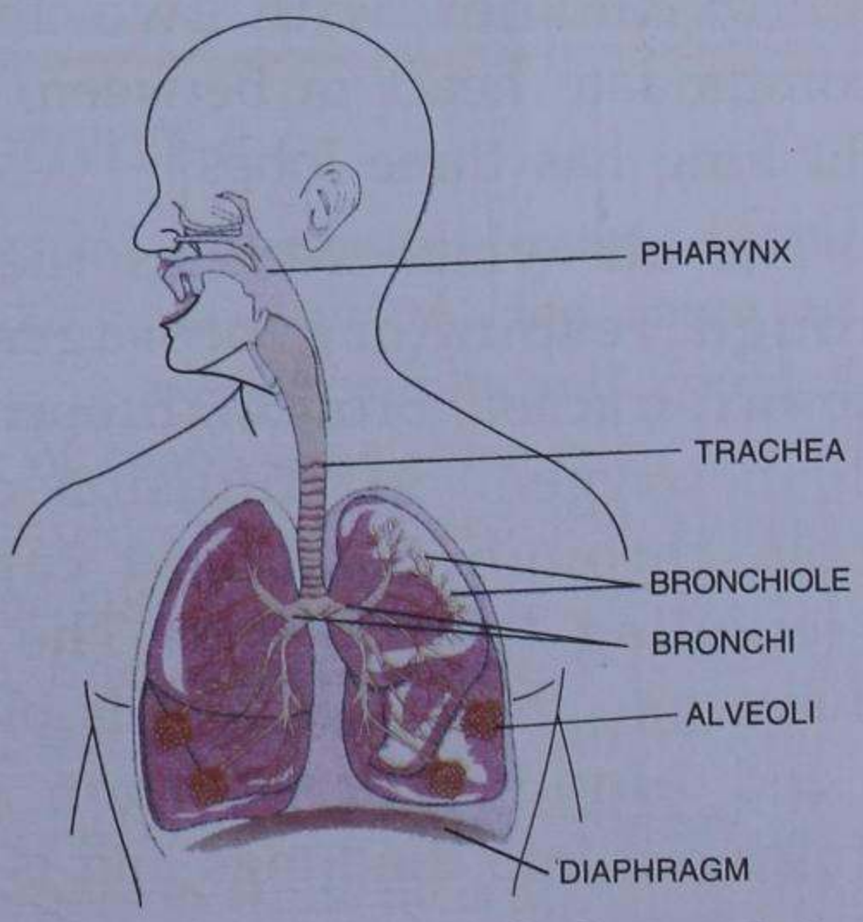


Fig. 6.2 Respiratory system of a human being

Lungs

The lungs are a pair of spongy, elastic organs. They lie in the thoracic

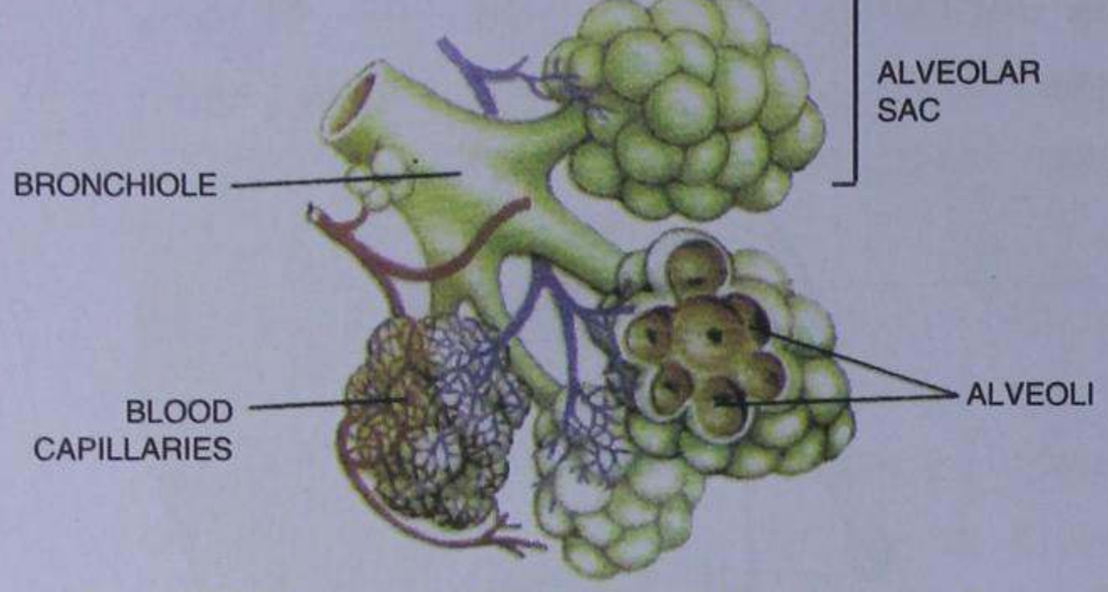


Fig. 6.3 Air sacs with its capillary network (Exchange of O_2 and CO_2 takes place here)

cavity, protected by rib cage and rest on the diaphragm. The diaphragm is a muscular sheet which internally divides the body cavity into two cavities – the chest cavity or thoracic cavity in front, and the abdominal cavity behind.

The lungs are protected from outside by two membranes called the **outer** and **inner pleura**. The space between the membranes is filled with a fluid. The two lungs are more or less cone shaped, broader at the bottom. The left lung is slightly smaller with two lobes (to accommodate heart in between) and the right lung has three lobes.

The air which reaches the alveoli through respiratory passages (nose, pharynx, trachea, bronchi, bronchioles) is rich in oxygen. So, diffusion of gases occurs through the blood capillaries surrounding the air sacs. The oxygen diffuses into the blood, and is picked up by red blood cells. Carbon dioxide diffuses out into the lungs and is exhaled out through the same passage.

Mechanism of Breathing

The process, by which the air is drawn in from atmosphere into the lungs and forced out from lungs back into the atmosphere, is called **breathing**. Breathing involves two steps, **inhalation** (inspiration) and **exhalation** (expiration).

Inhalation is caused by two agencies — firstly, movement of ribs upwards and outward, and secondly, diaphragm (upwardly arched/dome – shaped) becomes flattened (Fig. 6.4A). The two movements increase the volume of chest cavity, and the lungs expand. Thus, there is a fall in air pressure inside the lungs and it causes the outside air to move inward, getting into the lungs (high pressure to low pressure).

Exhalation involves downward and inward movement of ribs back to their original position on their own and with assistance from rib muscles. Diaphragm muscles relax, moves up and back into its convex (dome) shape partly assisted by the contraction of abdomen. These movements compress the chest cavity and lungs contract (Fig. 6.4B). The pressure on the air inside the lung increases, which forces the air out through the respiratory passages.

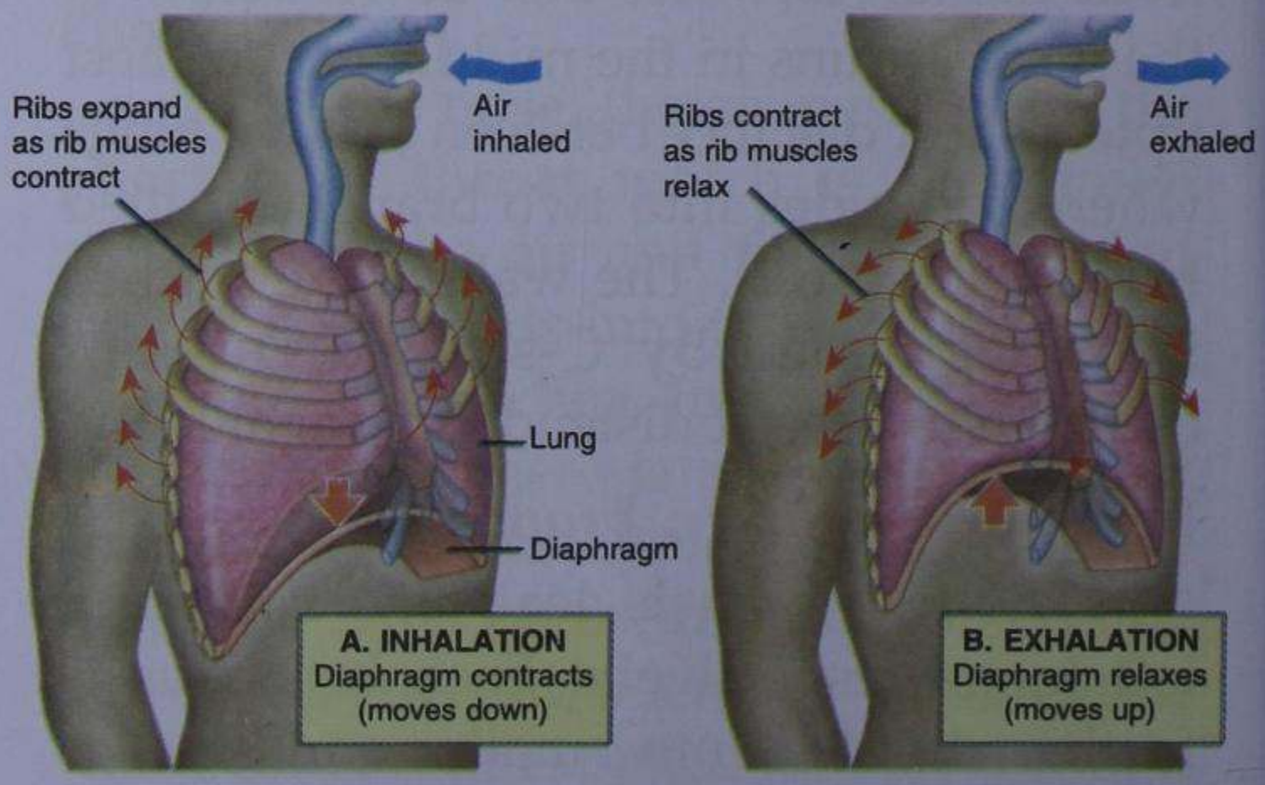


Fig. 6.4 Rib movement during breathing (inhalation and exhalation)

Table 6.2 : Components of inspired air and the changes taking place

Component	Inspired air	The change	Expired air
Oxygen	21%	Some of it is absorbed into red blood cells.	16%
Carbon dioxide	0.03%	Added from being diffused out of blood.	4%
Nitrogen	Approx. 79%	Unchanged.	Approx. 79.0%
Water vapours	low	Added from moist lining of respiratory passages.	high

Breathing normally is an involuntary act, which means, it is not under your control. But, breathing can be controlled within certain limits — you can hold your breath for a minute or two, you can have shorter breaths, or you can take deeper breaths.

ACTIVITY 2

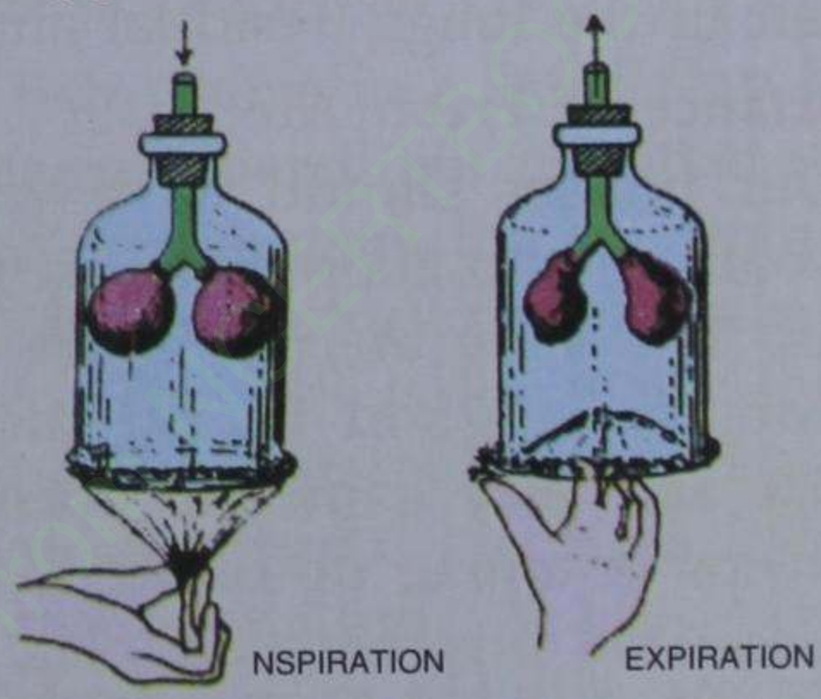
Try It : Put your hands on your chest, and take a gradual deep breath. You can feel the rising of the ribs and bulging of your abdomen. The abdomen bulges due to the lowering of the diaphragm pressing the intestine downwards.

ACTIVITY 3

You can easily demonstrate the action of diaphragm. Take a bell-jar as shown in the figure given here. Fix two rubber balloons tied at the ends of two small arms of a Y-shaped glass tube. Insert the long arm of the glass tube through the cork and fix the cork tightly on the mouth of the jar. Tie a sheet of rubber at the wide mouth of the bell-jar.

(contd.)

Now pull the rubber sheet downwards. What happens to the balloons ?



Demonstration of breathing process

ACTIVITY 4

Record your own breathing rate. Take a wrist watch. Lie down on a bed in a relaxed position and count the number of times your chest rises and falls in a minute. Next, record the breathing rate after running for about ten minutes. Do you find any difference? If yes, can you tell the reason for the difference?

Similarly, you can count the breathing rate of a person while he is sleeping, sitting at rest, and after he has climbed stairs. Likewise, you would find some difference in the breathing rate of a young boy and an old person.

Breathe through the nose : Some people at times breathe through their mouth. This is not correct. One should always breathe through the nose. Do you know why ?

Lungs are Never Empty

A deep breath means taking in air in excess of what we take in during normal breathing. Similarly, we can force out more air than what we breathe out during normal breathing. Even after maximum forceful expiration, some air is still left in the lungs (residual air).

Importance of Fresh Air

Our houses should have windows and ventilators to allow fresh air into the rooms. The stale air has more carbon dioxide. It is good to do moderate exercise and play games in open fields. This helps in toning up of the lungs and the associated breathing muscles.

Breathing Rate

One complete breath includes both inspiration and expiration. In normal adults, breathing rate is 12–18 per minute. A new born infant breathes much faster, about 60 breaths per minute.

Breathing rate is 4 to 5 times lower than the heart beat. The breathing rate changes according to the state of the body (resting or moving) controlled by respiratory centre located in the brain. Increasing amount of CO_2 in the blood stimulates the respiratory centre in the brain to breathe faster.

As we go higher up in the atmosphere (above 5000 ft. height) as on mountain hills, the atmospheric pressure reduces and the oxygen content in it decreases. Due to less oxygen, one may suffer from dizziness, black outs, loss of hearing and lack of muscular coordination. Mountaineers going higher up have to use oxygen masks.

Asphyxiation (more CO_2 and less O_2 in blood)

It is a condition in which blood becomes venous by the accumulation of excess CO_2 and the oxygen supply is diminished. If one sleeps in a closed small room heated by burning coal as people sometime do in cold winter, the deficient oxygen leads to the production of CO (carbon monoxide) which forms a stable compound carboxy-haemoglobin. It reduces the efficiency of blood to transport oxygen, and the person may die due to the accumulation of carbon dioxide in the blood or lack of oxygen. In such cases artificial respiration is helpful (Gas composition : 95% oxygen, 5% carbon dioxide).

Hiccups : Jerky incomplete inspiration due to some blockage in the respiratory tract.

Snoring : Vibration of soft palate (roof of mouth cavity) during breathing when mouth is kept open while sleeping.

Sneezing : When an irritant enters the nasal cavity, to clear the passage, air is thrown out of the lungs suddenly and forcefully.

RESPIRATORY ORGANS OF SOME ANIMALS — Frog, fish and cockroach

(1) RESPIRATION IN FROG

The frog respires through three body parts :-

1. Skin
2. Lining of the mouth
3. Lungs

Respiration by Skin

The **skin** is richly supplied with blood vessels and it is always kept moist. While the frog is in water, the air dissolved in it provides oxygen to the blood in the skin. When the frog is on land, the oxygen of the air diffuses into the mucus of the skin and, then into the blood. The carbon dioxide is also given out the same way. Skin respiration is the sole method of respiration when the frog is hibernating (undergoing winter sleep in the ground pits).

Respiration by Mouth

In **mouth-respiration,** the frog draws air into the mouth cavity through the nostrils and, without taking it into the lungs, forces it back to the outside. The lining of mouth absorbs some oxygen from this air and the carbon dioxide is given out. A sitting or floating frog constantly keeps lowering and raising the lower part of its mouth to carry out respiration by this way.

Respiration by Lungs

When the frog needs more oxygen, as during and after active jumping on land, it breathes through the lungs. It takes the air into the mouth cavity through the nostrils and keeping the nostrils and the mouth closed, it forces this air into the lungs. After serving for respiration in the lungs, the air is drawn back into the mouth cavity and from there, it is forced out into the atmosphere by opening the nostrils.

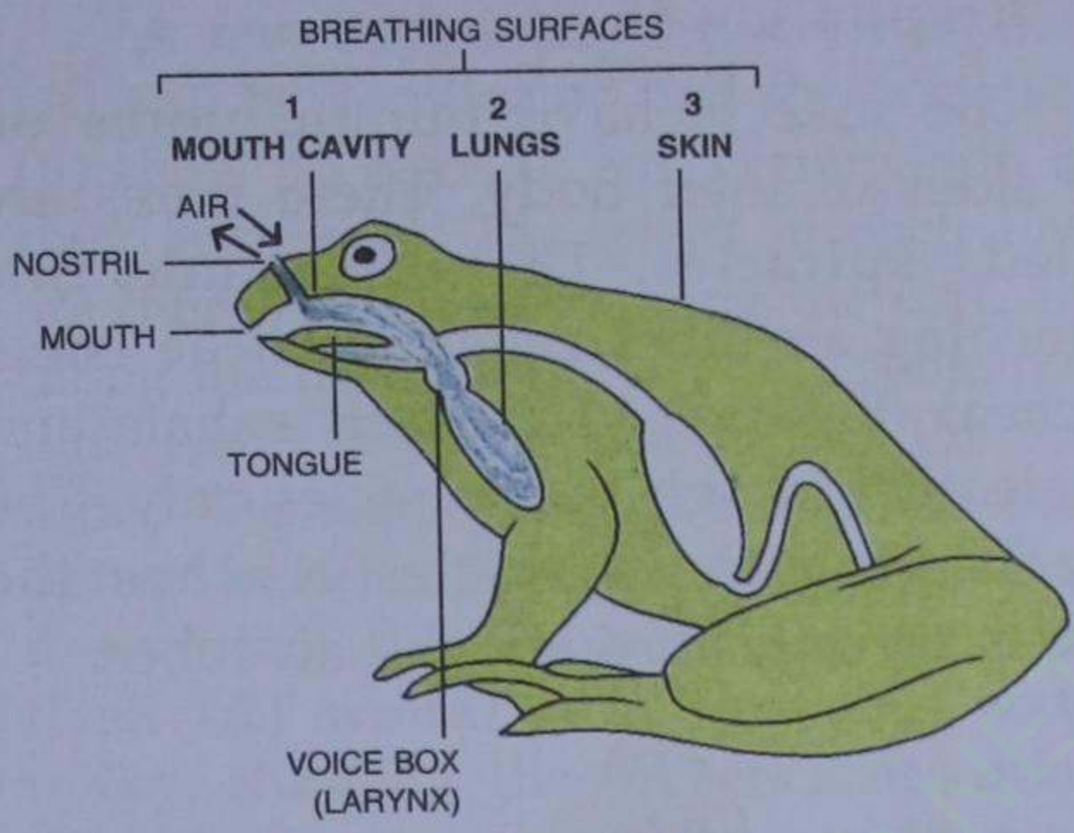


Fig. 6.5 Frog : Three breathing surfaces (1, 2, 3)

(2) RESPIRATION IN FISH

In fish, there is a hard flap called **gill cover** or **operculum** on either side of the head. Underneath the operculum are located the respiratory organs called **gills** (Fig. 6.6). The fish gulps water through the mouth, and forces it out through the sides of the throat through gill-slits under the operculum. In this way, the blood capillaries in the gills are brought in close contact with the current of water. The blood in the gills absorbs dissolved oxygen from water and gives out carbon dioxide.

You can see the gills by removing the operculum.

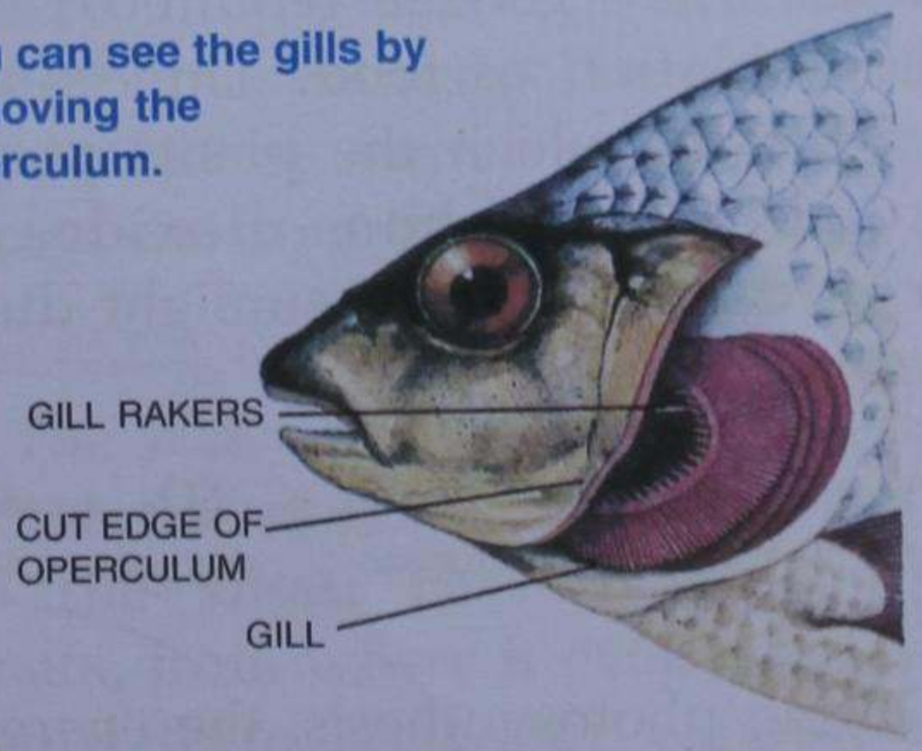


Fig. 6.6 Breathing organs of a fish

(3) Respiration in Insects

The insects have minute pores on the sides of their body. These pores are called **spiracles**. They open into fine branching air-tubes called **tracheae** (sing. trachea) (Fig. 6.7). All insects exhale and inhale air through the spiracles only. The air entering the spiracles reaches the tissues directly through the air-tubes.

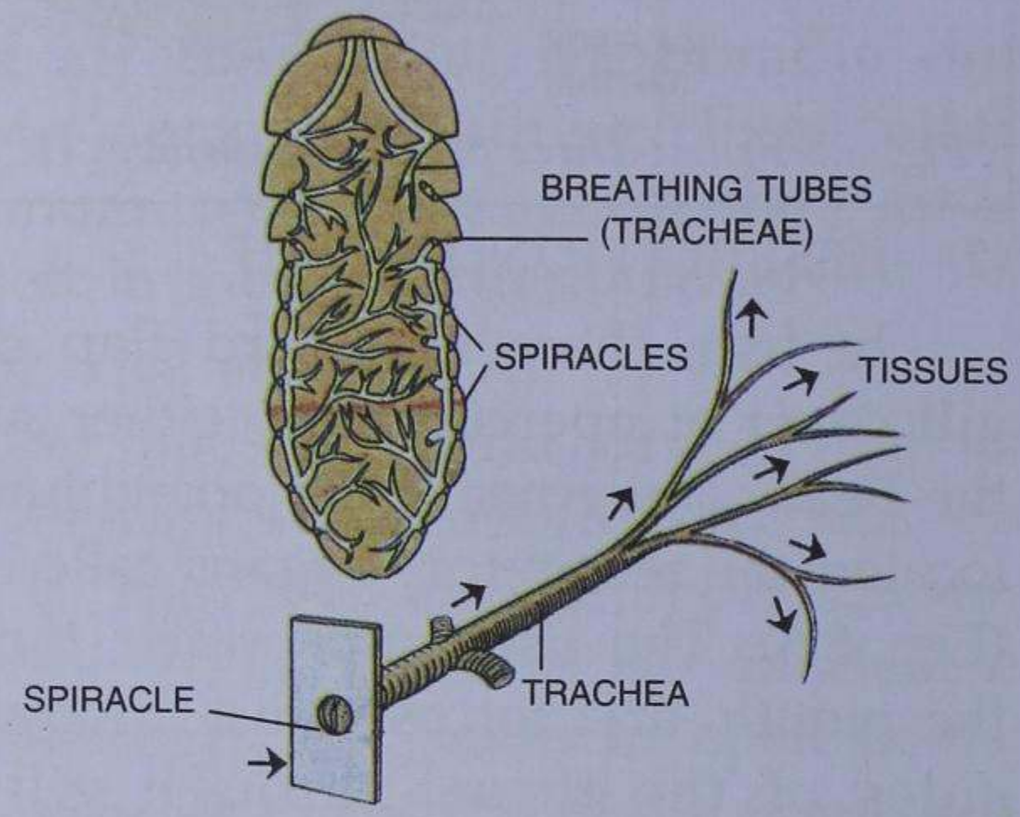


Fig. 6.7 Breathing tubes (tracheae) of an insect. One such tube has been shown separately arising from the spiracle and ending as very fine branches

RESPIRATION IN PLANTS

Plants also need energy for their life processes. They get the required energy by the oxidation of food. This is same food (glucose) which the plants prepare by combining carbon dioxide and water in the presence of sunlight during **photosynthesis**.

$$\underset{\text{corbon dioxide}}{6CO_2} + \underset{\text{water}}{12H_2O} \rightarrow \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2} + \underset{\text{water}}{6H_2O}$$

During photosynthesis, the energy is trapped by the chlorophyll – containing cells of the leaves from the sunlight.

At the first sight, it appears that respiration and photosynthesis in plants are two "OPPOSITE" processes. In some ways, it is correct. During photosynthesis, glucose is produced, and during respiration, glucose is broken down. During photosynthesis, the energy is obtained from sunlight, while in respiration, the energy, which is produced in the form of a chemical energy gets stored in some parts of the cell.

The process of respiration in plants includes the following steps :

- Absorption of oxygen from the atmosphere.
- Oxidation of stored food by absorbed oxygen.
- Release of energy as a result of oxidation.
- Carbon dioxide and water are the end products which go out of the plant.

Table : Differences between photosynthesis and respiration

Photosynthesis	Respiration
1. Food is synthesised.	1. Food is broken down.
2. Oxygen is released as a by-product.	2. CO_2 is released as a by-product.
3. Chlorophyll and sunlight are required.	3. Chlorophyll and sunlight are not required.

During night, even the leaves obtain oxygen from the atmosphere and give out carbon dioxide. Hence, **there is some truth in the belief that one should not sleep under the trees**

(contd.)

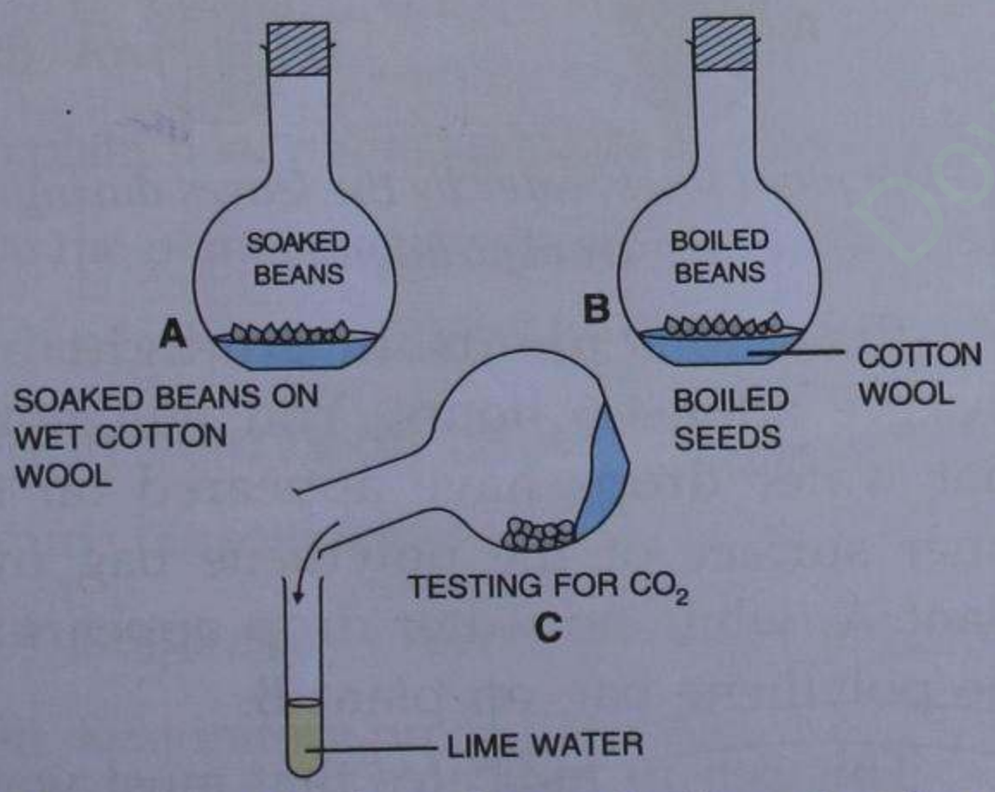
at night. But sleeping under the tree during hot mid-day is good as one gets both the oxygen due to photosynthesis and coolness due to transpiration.

ACTIVITY 5

To prove that carbon dioxide is produced during respiration in germinating seeds.

Take two flasks A and B. Place some wet cotton-wool at the bottom of each flask. Soaked seeds (such as pea or gram) are placed in flask (A) and an equal number of boiled (dead) seeds are placed in flask (B).

A little antiseptic (such as carbolic acid) is added to flask (B) to prevent bacterial growth on dead seeds, which would otherwise in turn respire and release carbon dioxide. The flasks are tightly corked and left in similar conditions of light and temperature.



Experiment to show the production of carbon dioxide in germinating seeds
A-Soaked bean seeds
B-Dead bean seeds
C-Testing for the presence of carbon dioxide

(contd.)

A few days later, the seeds in flask (A) will be germinated and those in flask (B) show no signs of any germination (as they are dead). The gases in each flask are then tested by removing the cork and tilting the flask over a test-tube containing lime water and then shaking up the test-tube. The expected gas carbon dioxide being heavier than air would "flow down" into the test tube. The gas from flask (A) would turn the lime water milky, showing the presence of carbon dioxide in it, while the gas in flask (B) will show no effect. Therefore, the conclusion is that the germinating (respiring) seeds give out carbon dioxide.

TRANSPIRATION IN PLANTS

Transpiration is the loss of water in the form of water vapour from the aerial parts of a plant.

You have learnt that plants continuously absorb water through their roots. This water is transported through the stem to all parts of the plant including leaves. Only a very little amount of it is retained in the plant or utilised by it during photosynthesis. The rest of it gets evaporated as water vapour into the atmosphere from the leaves.

PROCESS OF TRANSPIRATION

The water from the leaf veins moves into the leaf cells and from the leaf cells into the small cavities next to the stomata, from where it evaporates. In the gaseous form *i.e.* water vapour, water diffuses out through the stomata into the atmosphere.

You have experienced that standing under a tree on a hot summer midday, gives a cooling effect. This cooling is not entirely due to shade, but also due to the loss of water from the surface of the leaves by evaporation. You know that evaporation leaves a cooling effect. Cool air being heavier tends to settle down.

Factors affecting the rate of transpiration

1. **Sunlight :** During daytime, the rate of transpiration is faster, because the stomata remains open to allow the inward diffusion of carbon dioxide for photosynthesis. During dark, the stomata remains closed, and hence no transpiration occurs at night.
2. **Temperature :** Transpiration is faster in hot summer days as compared to cold winters.
3. **Wind :** Transpiration is more when the wind is blowing faster as the water vapour is removed faster from the leaves.
4. **Humidity :** Transpiration is reduced if the air is humid.

Significance of Transpiration

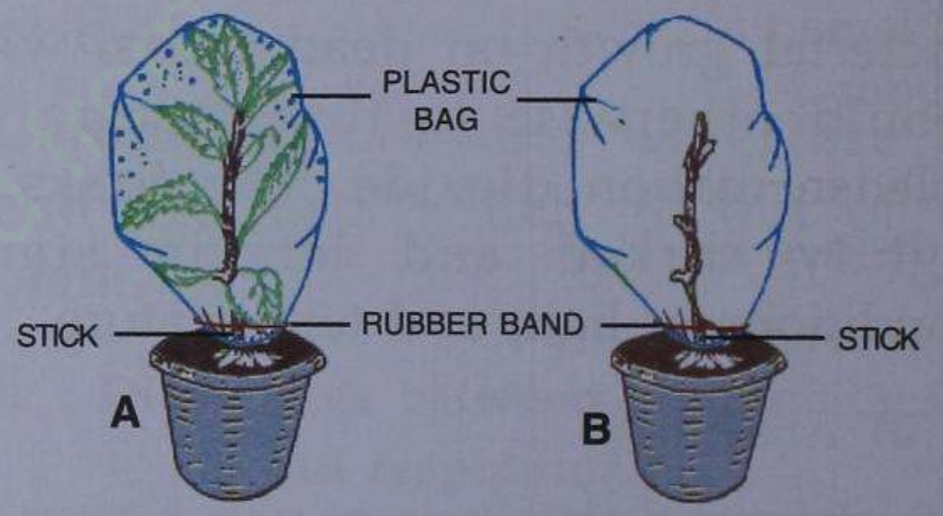
It helps to maintain the concentration of the sap inside the plant body : The roots continue to absorb water from the soil. If excess water does not evaporate through transpiration, the sap becomes diluted, preventing further absorption of water and minerals from the soil.

Cooling effect : In transpiration, water gets evaporated from the plant. The heat required for evaporation of water is obtained from the plant itself and thus, the plant cools itself when it is hot outside.

ACTIVITY 6

To demonstrate that a plant loses water by its leaves.

Take one small-sized well-watered potted plant with few branches. Place a polythene bag over the plant as shown in (A) and tie it with a rubber band. Remove all the leaves from another plant as shown in (B), cover this also with a polythene bag and tie it with a rubber band.



The plant loses water by the leaves during transpiration

Place the plants in sunlight and observe after 4-6 hours. You will notice that water drops have appeared on the inner surface of the polythene bag over plant A, while no water drop appears on the polythene bag on plant B.

This set-up indicates that most water from the plant is evaporated from its leaves.

REVIEW QUESTIONS

1. Answer briefly the following :
   (i) Why do our body cells require oxygen ?

   _____

   (ii) What is the difference between breathing and respiration ?

   _____

   (iii) Name the by-product formed during the oxidation of food.

   _____

   (iv) What is the breathing rate of a normal resting adult person ?

   _____

   (v) Name the agency which transports oxygen to all parts of the body.

   _____

   (vi) What is the role of epiglottis during swallowing ?

   _____

2. Describe in brief the function of rib muscles and diaphragm in breathing.
3. Name the gas which is expelled out during expiration. Where is it originally produced in our body ?
4. Differentiate between aerobic and anaerobic respiration. Write the overall chemical equations of the two kinds of respiration in **plants** :
   (i) Aerobic : _____
   (ii) Anaerobic : _____
5. Explain how photosynthesis is different from respiration.
6. Do the plants respire all day and night or only during the night ?
7. What happens to the energy liberated during respiration ?
8. Briefly describe the differences between photosynthesis and respiration in plants.
9. Name the following
   (i) Respiratory process in which oxygen is not utilized. _____
   (ii) Respiratory process in which oxygen is utilized. _____
   (iii) The microscopic air-sacs of the lungs. _____
   (iv) The *two* membranes which protect the lungs. _____
   (v) Minute pores on the sides of insect body for respiration. _____
10. Briefly describe the respiratory organs found in frog.