Respiration in Organisms

Aerobic and Anaerobic Respiration

You know that all activities performed by the body require energy. **Where does the body get energy from?** The food we eat contains stored energy.

How is the energy stored in food released to be used by the body?

You know that during the process of breathing, we take in air. Oxygen is taken in, while carbon dioxide is released out of the body during breathing. Oxygen is then circulated to all cells of the body. Food (glucose) is broken down in the cells with the help of oxygen.

The process in which food is broken down in the cells to release energy is known as **cellular respiration**.

Have you ever wondered what will happen if no or very little oxygen is available to cells? Will the process of cellular respiration stop?

Two types of respiration take place in the cells. One occurs in the presence of oxygen, while the other occurs in the absence of it. The process of breakdown of food (glucose) in the presence of oxygen is known as **aerobic respiration**. It takes place in all organisms and leads to the production of carbon dioxide, water, and energy.

$$\text{Glucose} \xrightarrow{\text{Oxygen}} \text{Carbon dioxide} + \text{Water} + \text{Energy}$$

Food is also broken down in the absence of oxygen. This process is known as **anaerobic respiration.** It occurs in organisms such as yeast. This process leads to the production of alcohol and carbon dioxide.

$$\text{Glucose} \xrightarrow[\text{Without oxygen}]{} \text{Alcohol} + \text{Carbon dioxide}$$

Difference between Aerobic and Anaerobic respiration

Aerobic respiration	Anaerobic respiration
It occurs in the presence of O_2.	It occurs in the absence of O_2.

It involves the exchange of gases between an organism and outside environment.	Exchange of gases is absent.
It occurs in the cytoplasm and mitochondria.	It occurs only in the cytoplasm.
It always releases CO_2 and H_2O.	End products may vary.
It yields 38 ATP.	It yields 2 ATP.
Example: Cells in our body	Example: Yeast and muscle cells

Have you experienced pain in your arms or legs after exercising for a long time?

When you exercise, your body experiences a temporary deficiency of oxygen and the muscle cells begin to undergo anaerobic respiration to provide energy to the body. This leads to the production and accumulation of lactic acid, which leads to muscle cramps and pain in the body.

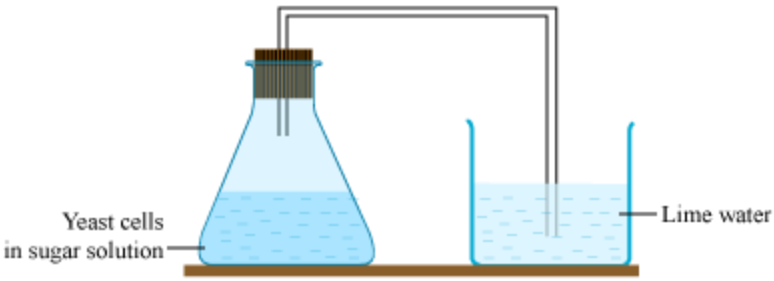
Do you know why yeast is used for preparing wine and beer?

Yeast performs the process of anaerobic respiration, which leads to the production of alcohol by incomplete breakdown of sugar. It is for this reason that yeast is used in the production of wine and beer.

How do we confirm that carbon dioxide is produced during respiration?

Let us perform the following activity to find out.

Yeast in a beaker



Take some yeast in a beaker with sugar solution. Close the lid of the beaker and pass a glass tube from the beaker into another beaker containing lime water.

What do you observe? What process do you think is responsible for this observation?

Lime water turns milky in the presence of carbon dioxide. This is the standard test for checking the presence of carbon dioxide. This test indicates that the process of respiration occurs in yeast, which leads to the release of carbon dioxide gas in the beaker.

The anaerobic conversion of sugar to carbon dioxide and alcohol by yeast is called **fermentation.**

Analysing Breathing Rate

During which physical activity do you think is the breathing rate highest?

This question can be answered by performing a few activities. However, let us first understand what **breathing rate** is.

The number of times a person inhales and exhales, or breathes in one minute is known as the breathing rate.

Breathing rate changes from time to time as the requirement for oxygen changes in the body. Therefore, let us start by performing some activities to have a better understanding of the respiratory system.

Try counting your breaths.

Breathing rate can be calculated by counting the number of breaths you take. So, calculate your breathing rate

- while at rest
- during normal walk
- after a brisk walk of 10 minutes

- after running very fast for 10 minutes

Now, make a table and note down your breathing rate during each activity.

You will notice that your breathing rate is the minimum when you are at rest and maximum when you run very fast. **What is the reason for this difference?**

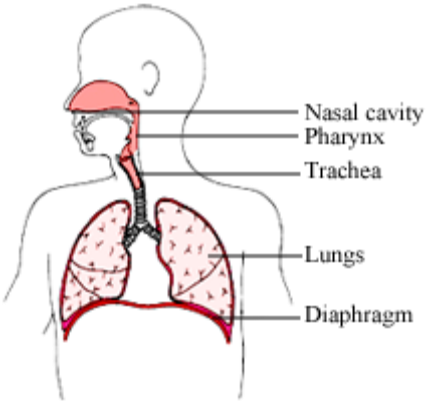
After heavy exercising, the body requires extra energy. The breathing rate tremendously increases to provide more oxygen to the body. Thus, the oxygen taken in will aid in cellular respiration. This will lead to the release of energy from food, which will be then available to the body.

Mechanism of Breathing

We breathe while performing all kinds of activities, even while we are asleep.

What is the biological mechanism involved in breathing? Let us explore.

Parts of the Human Respiratory System



Parts of Human Respiratory System

The organs of the respiratory system extend from the nose to lungs. They include the **nose, pharynx, trachea, bronchi, bronchioles and lungs.**

1) Nostrils: The air from outside first enters the nostrils, which is divided into the left and the right nostril. These nostrils lead to open spaces in the nose called the **nasal passage**. This passage contains hair and mucus, which perform the functions of filtering, moistening, and warming the air entering the nasal passage.

2) Pharynx: Air travels from the nasal passage to the pharynx, which is commonly known as **throat**. The pharynx is lined with a protective mucus membrane and cilia, which removes the impurities entering with air.

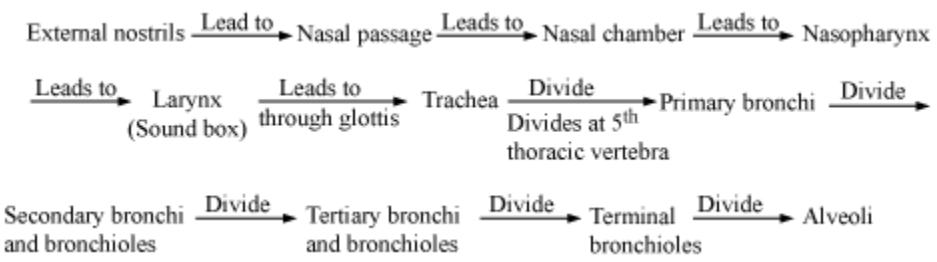
3) Larynx: The air from the pharynx enters the **larynx** or **voice box**. It contains two true vocal cords, which are made up of smooth muscle tissues. When air passes through this area, the vocal cords vibrate and this produces different sounds. Human beings can control this vibration. Thus, they can make various sounds and are capable of speech.

4) Trachea: From the larynx, the inhaled air moves into the **wind pipe** or **trachea**. The trachea is a long narrow tube, which is lined with ciliated mucus membrane. The trachea branches into two tubes, the left and right bronchi. The cilia move the mucus containing dust particles back to the pharynx, where it is swallowed.
The opening of trachea is guarded by a muscular flap called epiglottis. It closes the trachea while swallowing of food to avoid the entry of food particles in it. If, due to incomplete closure of epiglottis, a food particle may enter the trachea, it is expelled out through immediate coughing.

5) Bronchi and bronchioles: The air from the trachea moves into the **bronchi**, which are formed because of the division of the trachea. Each bronchus enters one of the lungs. Inside the lungs, the bronchi further divide into bronchioles. The air moves through these bronchioles.

6) Alveoli: The bronchiole further sub divide into smaller branches in the lung. These branches ultimately terminate into tiny air-sacs known as **alveoli**. These cells are surrounded by many blood capillaries.

7) Lungs: The lungs are a pair of spongy, elastic organs where the exchange of gases takes place. The left lung contains two lobes and is slightly smaller than the right lung, that has three lobes. The lungs are found enclosed within the rib cage. Both lungs are well covered and protected by two membranes, called inner and outer pleura. Further, a muscular sheet is present below the lungs, called diaphragm.



Phases in Respiration

In humans, respiration occurs in three main phases:

- **Breathing:** It is a physical process in which oxygen-rich air is taken in (inhalation) and CO_2 rich air (from our body's internal organs) is expelled out (exhalation).
- **Gaseous transport:** Firstly, the exchange of gases occurs in the lungs. The oxygen absorbed by the blood in lungs is then carried to other body parts. The CO_2 from the tissues is transported to the lungs through blood .
- **Cellular respiration:** It involves complex chemical reactions inside the cell in which oxygen is utilised to break down the glucose to release energy.

Process of Breathing in Human Beings

The process of breathing involves taking in oxygen-rich air and giving out carbon dioxide-rich air. This entire process occurs because of the actions of various organs of the respiratory system.

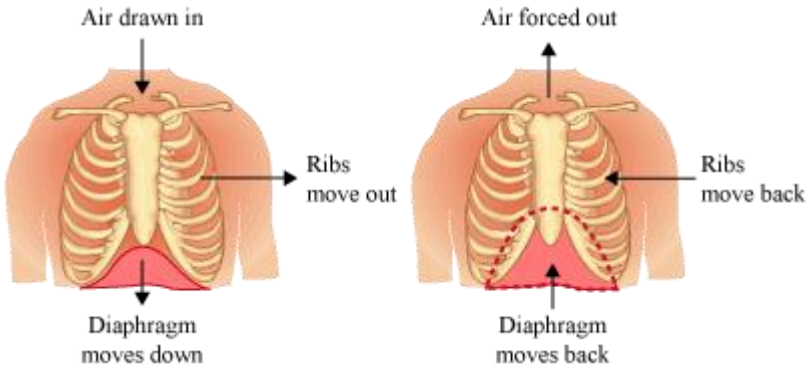
We all know that we take in air through our nostrils, and when we breathe in, air passes through our nostrils into the **nasal cavity**.

Air then reaches the lungs, which are located in the chest cavity. The actual mechanism of breathing involves the movement of the **ribs** and the **diaphragm,** which are located around and at the base of the chest cavity respectively.

The breathing involves two processes: Inhalation and exhalation.

During **inhalation**, the diaphragm moves down and the ribs move upwards and outwards, thereby increasing the space in the chest cavity. This leads to the movement of air inside the lungs.

During **exhalation**, the diaphragm moves to its former position and the ribs move downwards and inwards, thereby reducing the size of the chest cavity. This leads to the movement of air out of the lungs.



Inspired Air *vs* Expired Air

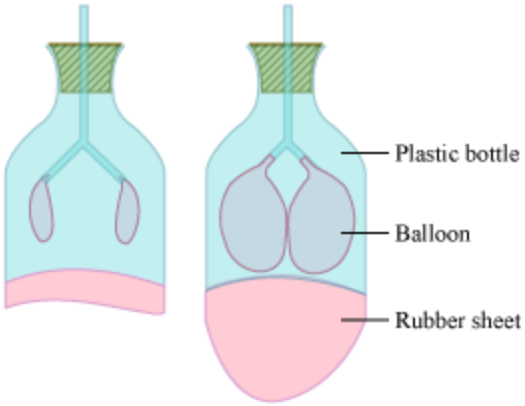
Component	Composition in Inspired Air	Composition in Expired Air
Oxygen	20.96%	16.4%
Carbon dioxide	0.04%	4.0%
Nitrogen	79%	79.6%
Water vapours	Low	High
Dust particles	Variably present	Little, if any

When we breathe in oxygen rich air through our nose, it passes to pharynx and then trachea, which contains cartilaginous rings in shape of C to prevent its collapse. There are two divisions of trachea known as bronchi one entering in left lung and the other enters the right lung. Bronchi are divided into branches known as bronchioles with air sacs at their ends. These air sacs are known as alveoli.

Exchange of oxygen and carbon dioxide is done through the blood surrounding the alveoli. Blood rich with oxygen reaches the various cells of our body and releases oxygen in the cells, where it used for oxidation of glucose to provide energy for functioning of the cells. The by product of this process is carbon dioxide which is absorbed by the blood and carried back to the alveoli, and then it is exhaled out of the body.

Let us understand the mechanism of breathing by performing a simple experiment.

Lungs in a bottle!



Take a plastic bottle and remove its bottom. Take a Y-shaped pipe and attach it to the lid of the bottle by making a hole in the lid.

Fix two deflated balloons to the forked-end of the pipe and place it in the bottle. Fix a thin plastic sheet at the base of the bottle using a large rubber band. Now, move the rubber/plastic sheet downwards and upwards and note the changes in the shape of the balloons. You will see that when the rubber/plastic sheet is pulled downwards, the balloons inflate and when the rubber/plastic sheet is pushed upwards, the balloons deflate**. Can you now guess what the balloons and the rubber/plastic sheet represent?**

The balloons here represent the lungs, while the rubber/plastic sheet represents the diaphragm. Therefore, similar to the model, when the diaphragm moves downwards, air rushes inside the lungs and inflates them. When the diaphragm moves up, air rushes out of the lungs and deflates them. This leads to the process of breathing.

Some interesting facts:

Hiccups occur due to the sudden movement of the diaphragm.
Do you know we lose half a litre of water in a day through breathing? This can be observed in the water vapour we see when we breathe out on a glass or a mirror.

Some Common Respiratory Diseases

Disease	Symptoms	Cause	Treatment
Asthma	Inflammation and swelling in airways, tightness in chest,	Air pollutants and allergens	Medicines containing corticosteroids are

	shortness of breath and wheezing		inhaled using broncho dilators
Pneumonia	Chest pain, chills, high fever	Respiratory infection caused by bacteria	Intake of antibiotics (penicillin)
Bronchitis	Inflammation and narrowing of bronchial passages, resulting in breathlessness and coughing	Mainly caused by virus infection; air pollution and smoking can also be reason	Can be prevented by drinking plenty of fluids, taking adequate diet and taking proper rest
Tuberculosis	Continuous coughing, low fever, chest pain and weight loss	Respiratory infection by bacteria	BCG vaccine; intake of antibiotics (streptomycin)

Respiration In other Animals

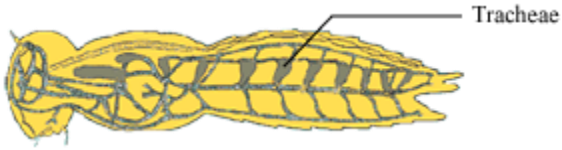
We know that humans breathe through their lungs, but how do other land animals, aquatic animals, and plants breathe? Let us explore.

Respiration in *Amoeba*

Amoeba respires by the process of diffusion through its body surface.

Respiration in land animals

Organisms such as elephants, lions, cows, frogs, and birds have lungs like that in human beings. **How do organisms such as cockroaches and earthworms breathe? Do they have breathing organs like that in humans or do they have other structures for breathing?**



A **cockroach** has small openings on the lateral sides of its body. These openings are called spiracles.Oxygen-rich air enters its body through the spiracles. The spiracles are connected to a network of tubes called **tracheae,** which are present all over its body. The oxygen then enters the tracheae from where it diffuses into the cells of the body. However, the movement of carbon dioxide follows the reverse path wherein the carbon dioxide in the cells of the body first enters the tracheae and then leaves the body through the spiracles. Blood of cockroach known as haemolymph is involved in exchange of gases between cells.

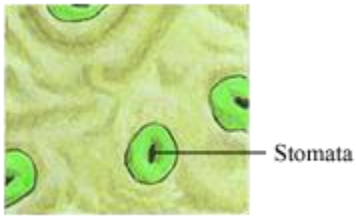
Did you know that a cockroach can hold its breath for 40 minutes?

In **earthworms**, respiration occurs through the surface of their skin. The skin of an earthworm is moist and slimy. Gases directly diffuse into its tissues through the skin.

Respiration in Plants

Do you think plants also respire like other organisms? If so, then how do plants take in oxygen?

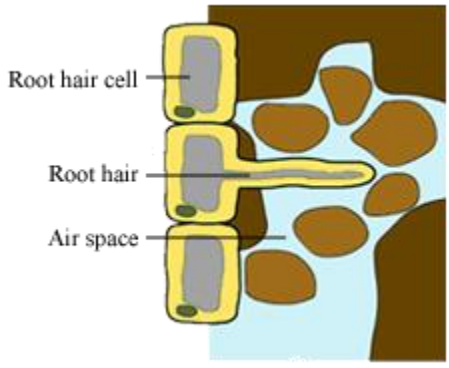
Just like all other living organisms, plants too respire. They respire through the tiny pores on the surface of their leaves called **stomata**. Oxygen enters the plant, while carbon dioxide leaves the plant through these pores.



The roots of plants also respire.

They do so by taking in oxygen from the **air spaces** present in soil by the process of diffusion. Oxygen is taken in and carbon dioxide moves out with the help of diffusion only. This type of gaseous exchange takes place in the younger roots only, and not in the older roots. In the older roots, the exchange of gases occurs by **lenticels**. The lenticels are thin walled loosely arranged cells with intercellular spaces present for gaseous exchange.

In plants growing in mangroves or saline swamps, the root is modified to **pneumatophores**. They bear breathing pores (lenticels) and emerge out of the soil for gaseous exchange.



In some trees, the trunk of the trees bear small openings called **lenticels**. Through these openings in the bark, gaseous exchange takes place. The lenticels look like scars on the tree bark.

The part of oxygen that is produced by the plant in photosynthesis is utilized by the plant for breathing and rest of the oxygen is given out by plants through stomata which we use for breathing.

Can you tell why farmers are advised against adding too much water to their fields?

They are advised to do so because too much water fills up the air spaces present in soil by replacing the air in it. Lack of oxygen can lead to the death of plants.

My potted plant!

Take a potted plant and keep watering it continuously for a week with more than the required amount of water.

What do you observe after a week? Does the plant survive? What is the reason behind your observation?

You will observe that the plant does not look healthy. This is because excess water blocks the pores of soil and does not allow oxygen to enter the plant body.

Large forests are called the '*lungs of the world*' because the oxygen produced by plants is used by humans and animals for respiration.

Activities

Activity 1

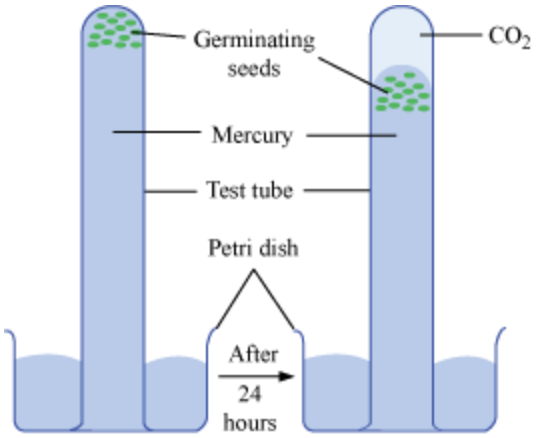
Aim - To demonstrate anaerobic respiration.

Procedure

1. Take about 6-7 germinating seeds of pea or gram and remove their outer layer (testa)

so that diffusion of CO_2 from the seeds takes place.

2. Invert a test tube filled with mercury over a petri dish half filled with mercury.



3. Introduce the germinating seeds in the test tube with the help of forceps. The seeds will move to the top of the test tube. We name this set up as A.

4. Prepare other set up B in the same manner as set up A, but taking germinating seeds which have been killed by boiling. This set up serves as the control experiment.

5. Keep both the set ups (A and B) for a few hours and then observe.

Observation

Level of mercury in set up A falls while in set up B it remains as such.

Explanation

Carbon dioxide gas liberated in set up A has pushed down the mercury.

In set up B, no gas is produced.

To check that the gas liberated is carbon dioxide introduced a crystal of potassium hydroxide in tube of set up A. The mercury level will again rise, indicating that the gas carbon dioxide is produced during anaerobic respiration.

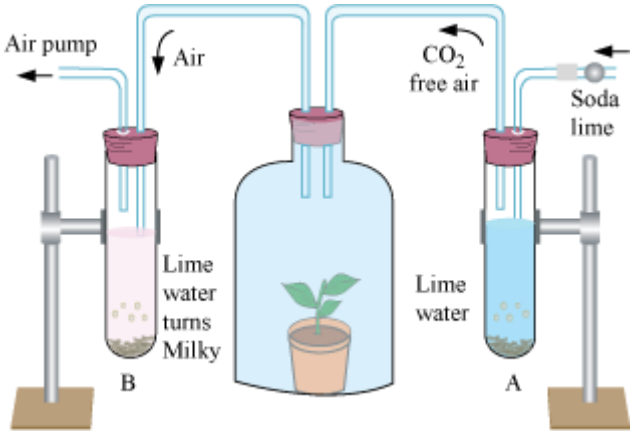
Activity 2

Aim - To demonstrate aerobic respiration or to demonstrate that green plants produce CO_2 during aerobic respiration.

Procedure

1. Take a small potted green plant and cover it with a bell jar.

2. Connect the bell jar on both sides with U-glass tubes to test tube/conical flasks containing lime water.



3. Vaseline is applied to make the set up air free.

4. Cover the bell jar with a black cloth, to prevent photosynthesis. So, CO_2 evolved during respiration will not be consumed in photosynthesis.

5. Introduce air into the apparatus with the help of an air pump and pass it first through soda lime. The soda lime will absorb any CO_2 present in the incoming air. As a result, when the air passes through the lime water in test tube A, it does not turn milky.

6. The air free from CO_2 enters the bell jar and comes in contact with the green plant.

7. The air from the bell jar now enters the test tube B containing lime water. The test tube B is also attached to the air pump.

Observation

It turns milky

Explanation

Lime water turns milky because the air coming from the bell jar contains CO_2 (while the air entering the bell jar is free from CO_2). This shows that CO_2 is produced by green plants during respiration.

Differences between Photosynthesis and Respiration

Photosynthesis	Respiration
Occurs in cells that have chlorophyll	Occurs in all living cells
Occurs in the presence of light only	Can occur all the time
Manufactures food	Breaks down food
Uses carbon dioxide and water	Uses oxygen and glucose
Liberates oxygen as one of the end products	Liberates carbon dioxide as one of the end products

Now as we have studied all the aspects of respiration in plants, can you figure out some differences between respiration in plants and animals?

Respiration in Plants	Respiration in Animals
Respiratory gases travel by simple diffusion.	Respiratory gases are transported across the body through blood.
End products of anaerobic respiration include ethanol.	End products of anaerobic respiration include lactic acid.
Lesser amount of heat is produced.	More amount of heat is produced.