Respiration in Plants

Respiration and Its Types

We know that there is a constant exchange of atmospheric gases. Oxygen is inhaled and carbon dioxide is exhaled. If oxygen is inhaled, then it must be used for some activity in the body. Similarly, if carbon dioxide is exhaled out of the body, then it must be because it is not required. This important life process is called **respiration**.

What is the role of oxygen in the body? Why is carbon dioxide thrown out of the body?

Respiration is the bodily process of inhalation and exhalation. It is the process of taking in oxygen and releasing carbon dioxide. The process involves the consumption of oxygen and liberation of carbon dioxide and water.

The oxygen inhaled is used to burn/oxidize/break down the food (glucose). This reaction produces energy required for all activities. Water and carbon dioxide are by-products of this reaction. This process occurs inside the mitochondria and is called **cellular respiration**. It is exactly opposite to the process of photosynthesis. It can be represented as:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$$

Thus, **cellular respiration** is the process by which energy is released from the breakdown of organic substances (glucose).

Is oxygen the only molecule used to burn food and produce energy? What happens to the organisms living in regions with no oxygen?

Respiration can occur both in the presence and absence of O_2. On this basis, it can be classified into two types: **aerobic and anaerobic.**

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.

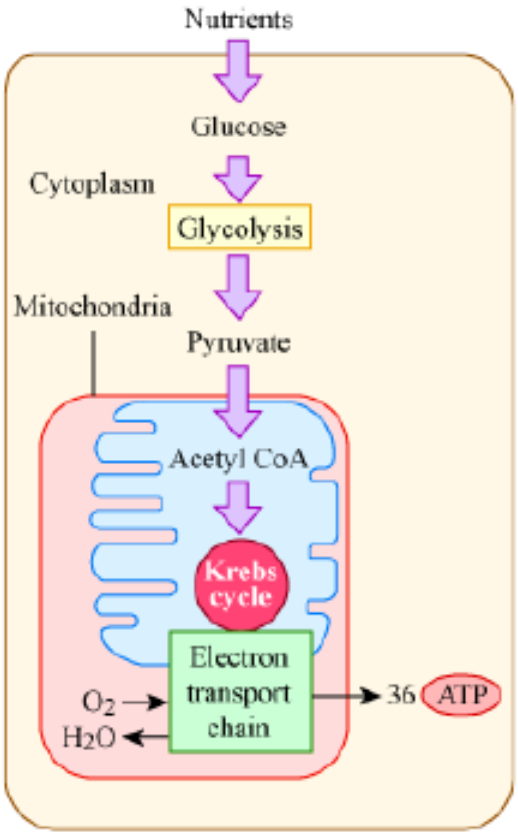
Is glucose the only carbohydrate which is broken down? Are not proteins and lipids utilized to produce energy?

Glucose is the simplest molecule that enters a series of reactions called **Glycolysis** and the **Krebs cycle** to produce energy.

Proteins and fatty acids are broken down and enter the cycle at different regions. Amino acids, depending upon the length of the carbon chain, enter the Krebs cycle at different places.

Lipids are fist converted into fatty acids and then into acetyl-CoA, which enters the Krebs cycle.

Aerobic respiration: It involves four main steps:



Step 1: The first step is called **glycolysis**. It occurs in the cytoplasm of a cell. It does not require oxygen. Here, the 6-carbon molecule glucose is partially broken down into a 3-carbon molecule, pyruvate or pyruvic acid. In this step, one glucose molecule produces 2 molecules of pyruvate.

$$\text{Glucose} \xrightarrow{\text{Glycolysis}} 2 \text{ Pyruvate}$$

Step 2: The two pyruvic acid molecules are converted into acetyl CoA, which can easily enter the mitochondria, which is the site for further reactions.

Step 3: These acetyl CoA molecules enter the mitochondrial matrix and take part in the Krebs cycle. This occurs in the presence of O_2.

Step 4: In this step, the energy released in all the above steps is converted to ATP by ATP synthase enzyme.

In aerobic respiration, a total of 38 ATP molecules are produced from one molecule of glucose.

Anaerobic respiration: It is a two step process.

Step 1: The first step, glycolysis, is the same as that of aerobic respiration.

Glucose $\xrightarrow{\text{Glycolysis}}$ 2 pyruvic acid

Step 2: Pyruvic acid is not transported to the mitochondria. It remains in the cytoplasm. It is then broken down into waste products that can be removed from the cell. This entire process occurs in the absence of oxygen.

Glucose $\xrightarrow{\text{Glycolysis}}$ Pyruvic acid $\xrightarrow[\text{of } O_2]{\text{In absence}} \underbrace{2C_2H_5OH + 2CO_2}_{\text{Waste product}} + 2ATP$

Anaerobic respiration occurs in the roots of some species of water logged plants, parasitic worms, yeast, animal muscles, and microorganisms.

In some microorganisms such as yeasts, anaerobic respiration is called **fermentation**. In the process of fermentation, ethanol is formed as a by-product. This is represented in the above reaction.

Illustration of anaerobic respiration

Aerobic respiration produces large amounts of energy. **What about regions where energy is required, but oxygen is not available?** In muscle cells, when there is a lack of oxygen, anaerobic respiration occurs where pyruvic acid is converted into lactic acid. This accumulation of lactic acid causes muscle cramps.

Let us discuss what fermentation is.

Brewing is an industrial application of fermentation.

Do you know that brewing industries utilize yeast?

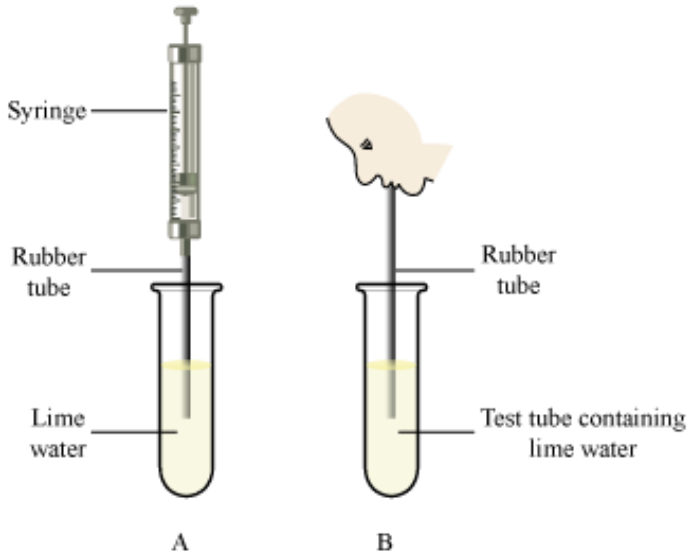
Alcoholic fermentation is the conversion of sugar into ethyl alcohol and CO_2. One of the by-products, CO_2, dissipates into air whereas the other by-product, ethyl alcohol, remains in the medium. This alcohol is processed in the brewing industry and is utilized commercially.

Some interesting facts:

- Do you know that fermentation predigests foods and improves the availability of nutrients present in them?
- Fermentation adds nutrients such as B-vitamin.

Is CO_2 a product of respiration? Let us find out.

Take freshly prepared lime water in two test tubes and label them as **A** and **B**. Use a syringe to pass air in test tube **A** and blow air in test tube **B** through a straw.



You will observe that limewater turns milky in both test tubes. However, it was faster in test tube **B**.

Explanation:

Limewater is the common name for saturated calcium hydroxide solution.

Its chemical formula is **$Ca(OH)_2$**.

When CO_2 is passed through lime water, it turns milky due to the formation of calcium carbonate. This reaction can be denoted as:

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

In test tube **B**, lime water turned milky faster because the air we exhale is CO_2. In comparison, the introduced air is atmospheric air in test tube **A,** which contains only 0.03% CO_2.

Exchange of gases in plants

Plants exchange gases through stomata. This exchange of gases occurs through the process of **diffusion**.

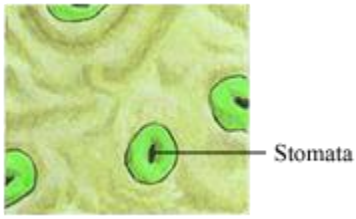
When CO_2 is present in high concentration inside the plant body, it moves out into the atmosphere (where its concentration is low) and allows O_2 to enter the plants.

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.

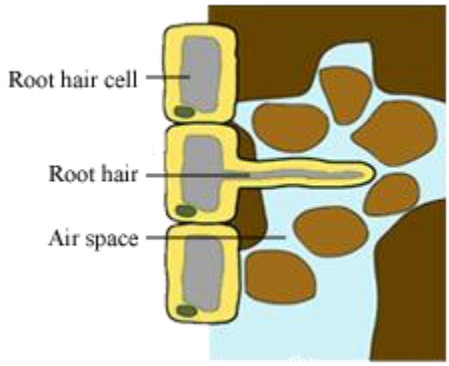
The roots of plants also respire.



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

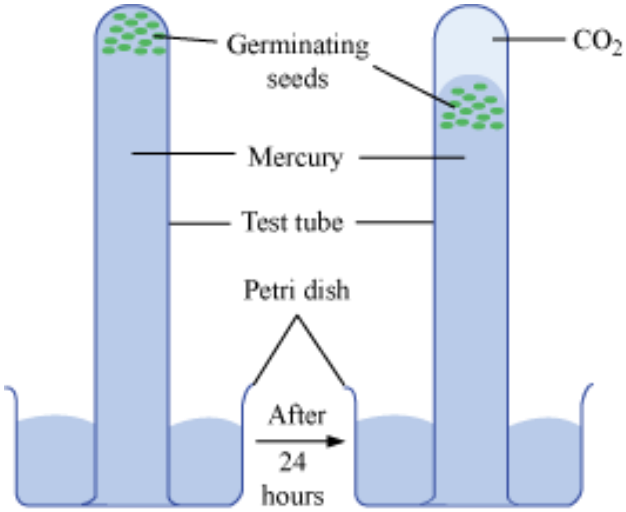
Aim - To demonstrate anaerobic respiration.

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.

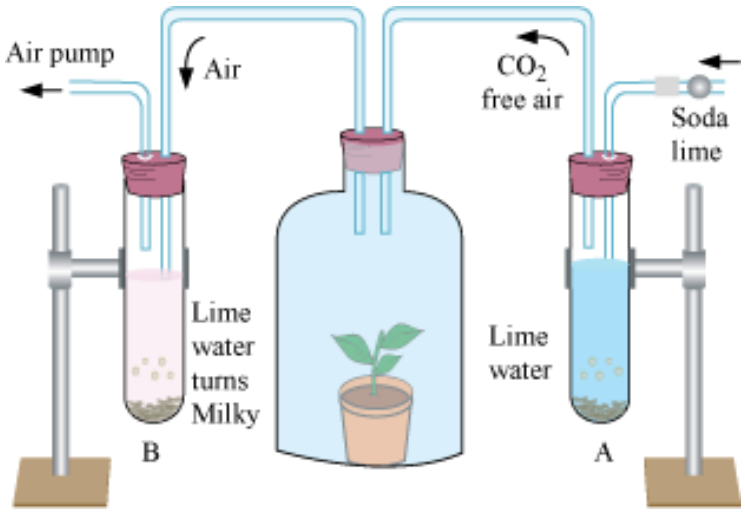
Activity 2

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.