Why Do We Respire

Respiration and Energy

All living organisms are made up of cells, which require energy to perform vital functions such as nutrition, transport, excretion, and reproduction. This energy is obtained by breaking down food molecules through a process called respiration.

Cellular Respiration

Cellular respiration is the process by which cells break down glucose in the presence of oxygen to release energy. This process produces carbon dioxide and water as byproducts. When oxygen is used, it is called aerobic respiration; when oxygen is absent, anaerobic respiration occurs.

Aerobic Respiration

In aerobic respiration, glucose reacts with oxygen to produce carbon dioxide, water, and energy. The chemical equation is:

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

Anaerobic Respiration

Some organisms like yeast can survive without oxygen and perform anaerobic respiration, breaking down glucose into alcohol, carbon dioxide, and energy:

$$C_6H_{12}O_6 \xrightarrow{\text{absence of oxygen}} 2C_2H_5OH + 2CO_2 + \text{energy}$$

In human muscles, anaerobic respiration occurs temporarily during intense exercise, producing lactic acid and energy:

$$\text{Glucose} \rightarrow \text{Lactic Acid} + \text{Energy}$$

Solved Examples

Example 1: Write the chemical equation for aerobic respiration.

Solution: The chemical equation for aerobic respiration is:

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

Example 2: What are the products of anaerobic respiration in yeast?

Solution: In yeast, anaerobic respiration produces alcohol (ethanol), carbon dioxide, and energy. The equation is:

$$C_6H_{12}O_6 \xrightarrow{\text{absence of oxygen}} 2C_2H_5OH + 2CO_2 + \text{energy}$$

Practice Set

- **Level 1:** Define cellular respiration.
- **Level 2:** Explain the difference between aerobic and anaerobic respiration.
- **Level 3:** Describe what happens in muscle cells during intense exercise when oxygen is scarce.

Answer Key

- **Level 1:** Cellular respiration is the process by which cells break down glucose to release energy.
- **Level 2:** Aerobic respiration uses oxygen to break down glucose producing carbon dioxide, water, and energy; anaerobic respiration occurs without oxygen, producing alcohol or lactic acid and less energy.
- **Level 3:** Muscle cells perform anaerobic respiration, breaking down glucose into lactic acid and energy, causing muscle fatigue.

Breathing

Definition and Process

Breathing is the process of taking in oxygen-rich air (inhalation) and expelling carbon dioxide-rich air (exhalation) using respiratory organs. It is continuous and essential for life.

Breathing Rate

The breathing rate is the number of breaths taken per minute. It varies with activity level, increasing during exercise to supply more oxygen to the body.

Observations from Activities

Physical activities like walking and running increase breathing rate, while rest and sleep decrease it. This is because the body's oxygen demand changes with activity.

Solved Examples

Example 1: What is inhalation?

Solution: Inhalation is the process of taking in air rich in oxygen into the lungs.

Example 2: How does breathing rate change during exercise?

Solution: Breathing rate increases during exercise to meet the higher oxygen demand of muscles.

Practice Set

- **Level 1:** What is exhalation?
- **Level 2:** Why does breathing rate increase during physical activity?
- **Level 3:** Design an activity to measure your breathing rate before and after exercise.

Answer Key

- **Level 1:** Exhalation is the process of expelling air rich in carbon dioxide from the lungs.
- **Level 2:** Breathing rate increases to supply more oxygen to muscles and remove carbon dioxide produced during activity.
- **Level 3:** Measure breaths per minute at rest, then after brisk walking or running, and compare the results.

How Do We Breathe

Respiratory Organs

Air enters through the nostrils, passes through the nasal cavity, pharynx, trachea, and reaches the lungs located in the chest cavity. The diaphragm and ribs assist in breathing movements.

Mechanism of Breathing

During inhalation, the diaphragm contracts and moves down, ribs move up and out, increasing chest cavity volume and causing air to enter the lungs. During exhalation, the diaphragm relaxes and moves up, ribs move down and in, decreasing volume and pushing air out.

Model Demonstration

A model using a bottle, balloons, and rubber sheet can simulate lung expansion and contraction, demonstrating the breathing mechanism.

Solved Examples

Example 1: What role does the diaphragm play in breathing?

Solution: The diaphragm contracts and moves down during inhalation to increase chest volume and relaxes during exhalation to decrease volume.

Example 2: Explain why air moves into the lungs during inhalation.

Solution: Increasing chest volume lowers pressure inside lungs below atmospheric pressure, causing air to flow in.

Practice Set

- **Level 1:** Name the respiratory organ where gas exchange occurs.
- **Level 2:** Describe the movement of ribs during exhalation.
- **Level 3:** Explain how Boyle's Law relates to breathing.

Answer Key

- **Level 1:** Gas exchange occurs in the lungs.
- **Level 2:** Ribs move down and inwards during exhalation.
- **Level 3:** Boyle's Law states that pressure and volume are inversely related; during inhalation volume increases and pressure decreases, drawing air in; during exhalation volume decreases and pressure increases, pushing air out.

What Do We Breathe Out

Composition of Exhaled Air

Exhaled air contains less oxygen and more carbon dioxide compared to inhaled air. Moisture is also present in exhaled air.

Lime Water Test

Blowing air into lime water causes it to turn milky due to the presence of carbon dioxide reacting with calcium hydroxide to form calcium carbonate.

Gas Exchange Summary

Oxygen is absorbed into the blood in the lungs, and carbon dioxide is expelled from the blood into the lungs to be exhaled.

Solved Examples

Example 1: What gas causes lime water to turn milky when exhaled air is bubbled through it?

Solution: Carbon dioxide causes lime water to turn milky.

Example 2: Why does exhaled air have less oxygen than inhaled air?

Solution: Because oxygen is absorbed by the blood during respiration.

Practice Set

- **Level 1:** What is the main gas exhaled by humans?
- **Level 2:** Explain the chemical reaction that occurs when carbon dioxide reacts with lime water.

- **Level 3:** Describe how moisture appears on a mirror when you exhale on it.

Answer Key

- **Level 1:** Carbon dioxide is the main gas exhaled.
- **Level 2:** $\mathrm{Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O}$, forming milky calcium carbonate.
- **Level 3:** Moisture in exhaled air condenses on the cool surface of the mirror forming droplets.

Breathing In Other Animals And Under Water

Insects and Tracheal System

Insects breathe through spiracles and a network of tracheae that deliver oxygen directly to body cells without lungs.

Earthworms and Skin Respiration

Earthworms breathe through their moist skin, allowing gas exchange directly with the environment.

Fish and Gills

Fish use gills to extract oxygen dissolved in water and expel carbon dioxide. Water flows over gill filaments where gas exchange occurs.

Solved Examples

Example 1: How do insects breathe?

Solution: Insects breathe through spiracles and tracheal tubes that carry air directly to cells.

Example 2: What is the function of gills in fish?

Solution: Gills extract oxygen from water and remove carbon dioxide from the fish's blood.

Practice Set

- **Level 1:** Name the breathing openings in insects.
- **Level 2:** Explain how earthworms breathe.
- **Level 3:** Describe the path of water in fish during breathing.

Answer Key

- **Level 1:** Spiracles are the breathing openings in insects.
- **Level 2:** Earthworms breathe through their moist skin by diffusion of gases.
- **Level 3:** Water enters the mouth, passes over gill filaments where oxygen is absorbed, and exits through gill slits.

Do Plants Also Respire

Respiration in Plants

Plants respire by taking in oxygen and giving out carbon dioxide through stomata in leaves and air spaces in soil for roots.

Root Respiration

Roots absorb oxygen from air spaces between soil particles to perform cellular respiration.

Effect of Overwatering

Overwatering reduces air spaces in soil, limiting oxygen availability to roots and affecting plant health.

Solved Examples

Example 1: How do roots obtain oxygen?

Solution: Roots absorb oxygen from air spaces in the soil through root hairs.

Example 2: What happens if a plant is overwatered?

Solution: Overwatering fills air spaces with water, reducing oxygen availability to roots and harming the plant.

Practice Set

- **Level 1:** What are stomata?
- **Level 2:** Why is oxygen important for plant roots?
- **Level 3:** Explain how soil structure affects root respiration.

Answer Key

- **Level 1:** Stomata are tiny pores on leaves for gas exchange.
- **Level 2:** Oxygen is needed for cellular respiration to release energy in roots.

- **Level 3:** Soil with good air spaces allows oxygen diffusion to roots; compacted or waterlogged soil reduces oxygen supply.

Quick Reference Table

- **Aerobic Respiration:** Glucose + Oxygen → Carbon dioxide + Water + Energy
- **Anaerobic Respiration (Yeast):** Glucose → Alcohol + Carbon dioxide + Energy
- **Anaerobic Respiration (Muscle):** Glucose → Lactic acid + Energy
- **Breathing Rate:** Number of breaths per minute; increases with activity
- **Respiratory Organs:** Humans - lungs; Insects - tracheae; Fish - gills; Earthworms - skin
- **Gas Exchange:** Oxygen absorbed, carbon dioxide expelled
- **Diaphragm:** Muscle that controls breathing by changing chest cavity volume
- **Stomata:** Pores on leaves for gas exchange in plants

Common Mistakes and Misconceptions

- Confusing breathing with respiration; breathing is the physical process of air movement, respiration is the chemical process of energy release.
- Believing anaerobic respiration produces more energy than aerobic; it produces less energy.
- Thinking all animals have lungs; many have different respiratory systems like gills or tracheae.
- Assuming plants do not respire; plants respire like animals but also perform photosynthesis.
- Believing lactic acid causes permanent muscle damage; it causes temporary fatigue and is removed when oxygen supply resumes.

Glossary

- **Aerobic Respiration:** Respiration using oxygen to break down glucose.
- **Anaerobic Respiration:** Respiration without oxygen producing less energy.
- **Cellular Respiration:** Process of breaking down glucose in cells to release energy.
- **Diaphragm:** Muscle that helps in breathing by changing chest volume.

- **Exhalation:** Breathing out air rich in carbon dioxide.
- **Gills:** Respiratory organs in fish for gas exchange in water.
- **Inhalation:** Breathing in air rich in oxygen.
- **Respiratory Organs:** Organs involved in breathing like lungs, gills, tracheae.
- **Stomata:** Tiny pores on plant leaves for gas exchange.
- **Tracheae:** Tubes in insects that carry air directly to cells.
- **Spiracles:** Openings on insect bodies for air entry.
- **Breathing Rate:** Number of breaths taken per minute.