Chapter 12

Respiration in Plants

INTRODUCTION

In the realm of life, respiration emerges as a fundamental feature essential for the survival of organisms. Respiration serves as the dynamic force furnishing energy for a spectrum of daily life activities, encompassing absorption, transport, movement, reproduction, and even the basic act of breathing. The intricate process of gaseous exchange involves breathing—in taking oxygen and releasing carbon dioxide. On the other hand, respiration delves deeper, engaging in the biological oxidation of organic molecules. This entails the enzymatic breakdown of C-C bonds, culminating in the liberation of energy in the form of adenosine triphosphate (ATP). The overarching phenomenon of oxidizing macromolecules within the organism is encapsulated by the term "Respiration."

Among the life forms, only green plants and cyanobacteria possess the unique ability to synthesize their own food through photosynthesis. This intricate process entails capturing light energy and converting it into chemical energy, which becomes stored in the bonds of carbohydrates like glucose, sucrose, and starch. Notably, only cells housing chloroplasts exhibit photosynthesis. Consequently, in green plants, all non-green organs, tissues, and cells necessitate external food sources for oxidation. In the animal kingdom, food is either directly ingested (by herbivores) or indirectly through predation (by carnivores). Saprophytic organisms, such as fungi, derive sustenance by consuming deceased and decomposing matter. Thus, the overarching conclusion drawn from these processes is that photosynthesis provides the raw materials essential for the subsequent oxidation of food.

In eukaryotic organisms, the intricate dance of life unfolds within different cellular compartments. Photosynthesis orchestrates its magic within chloroplasts, while respiration takes center stage in the cytoplasm and mitochondria.

The compounds ushered into the realm of biological oxidation are termed respiratory substrates. Carbohydrates stand as the preferred substrate for this process, although other substrates—fats, proteins, or organic acids—come into play under specific conditions. Within the cellular milieu, energy is liberated through a series of deliberate, enzyme-controlled reactions during oxidation. This liberated energy is then harnessed and stored as chemical energy in the form of ATP. Serving as the cellular energy currency, ATP undergoes breakdown whenever and wherever energy is required. This stored energy, encapsulated within ATP molecules, fuels a myriad of energy-demanding processes within organisms. Moreover, the carbon skeleton produced during respiration serves as a precursor for the biosynthesis of various cellular molecules, completing the intricate cycle of life processes.

DO PLANTS BREATHE?

Plants, while lacking specialized organs akin to animals' lungs, gills, or trachea for breathing, indeed engage in respiration, requiring oxygen and releasing carbon dioxide. The absence of dedicated respiratory organs in plants can be attributed to several factors:

- **Localized Gas Exchange:** Each part of a plant manages its gas-exchange requirements independently, minimizing the need for extensive gas transport between different plant components.
- **Moderate Respiratory Demands:** Plants exhibit lower respiratory rates in roots, stems, and leaves compared to animals. Significant gas exchange occurs mainly during photosynthesis, and each leaf is adept at meeting its own requirements during these phases. Additionally, leaves utilize the oxygen released during photosynthesis.
- **Proximity of Cells:** Plant cells are densely packed and located close to the surface, facilitating efficient gas diffusion. Parenchyma cells in leaves, stems, and roots, characterized by loose packing and interconnected air spaces, contribute to an effective exchange of gases. Even cells in stems, organized in thin layers beneath the bark, possess lenticels for gas exchange.

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

- The combustion of glucose, producing carbon dioxide and water along with energy, is a pivotal process for energy utilization in cells. The catabolism of glucose in multiple small steps during cellular respiration prevents the dissipation of all liberated energy as heat. This strategic oxidation of glucose occurs gradually, releasing energy that can be harnessed for adenosine triphosphate (ATP) synthesis.

Types of Respiration

- **Classification by Respiratory Substrate:** Blackman categorized respiration into two types based on the respiratory substrate:
  Floating Respiration: Involves fat or carbohydrates as the respiratory substrate.
  Protoplasmic Respiration: Involves proteins as the respiratory substrate.
- **Classification by Oxygen Availability**
  Aerobic Respiration: Complete oxidation of organic molecules occurs in the presence of molecular oxygen, yielding carbon dioxide and water.
  Anaerobic Respiration: Involves incomplete oxidation of organic molecules in the absence of molecular oxygen. All reactions take place in the cytoplasm, and mitochondria are not required.

Types of Anaerobic Organisms

- **Facultative Anaerobes:** Aerobic organisms capable of respiration even in the absence of oxygen.
- **Obligate Anaerobes:** Organisms that exclusively respire anaerobically, lacking the enzymes needed for aerobic respiration.

Across living organisms, the enzymatic machinery for the partial oxidation of glucose, known as glycolysis, is retained even in anaerobic conditions. This intricate interplay of processes highlights the adaptability and resilience of life forms, emphasizing the essential role of respiration in sustaining diverse biological systems.