Chapter 14 Respiration in Plants

Respiration is the process through which oxygen and complex organisms mix and disintegrate to create simpler molecules and release energy. It causes carbon dioxide and water to be produced.

It was Dutrochet who first used the word “respiration.” Cellular respiration is the process by which complex molecules containing C-C bonds undergo oxidation, producing energy as a byproduct. There are two types of amphibolic processes in respiration: catabolic and anabolic.

Numerous different respiratory intermediates are used in the synthesis of other compounds.

Acetyl coenzyme A is used to synthesize fatty acids and gibberellic acid; succinyl coenzyme A is used to synthesize chlorophyll, phytochrome, and cytochrome; and oxaloacetic acid and alpha-ketoglutaric acid are used to synthesize amino acids, such as aspartic acid, glutamic acid, etc.

Respiratory substrates are created during respiration, following the oxidation of organic materials. Two categories of cellular respiration are distinguished based on the kinds of substrates used:

1. Floating Respiration: It is a common type of respiration whereas substrate, fat, or carbohydrates are used.

2. Protoplasmic Respiration: This type occurs when plants are starved and here as substrate proteins are used.

Do Plants Breathe

In the case of plants, there is no unique breathing or gas exchange system. During respiration, plants need oxygen and release carbon dioxide. Plants use their lenticels and stomata to facilitate the exchange of gases, with only a small amount of gases moving from one area of the plant to another.

Plants don't need a lot of gases to exchange or multiple requirements to proceed through respiration.

The majority of the time when they conduct gaseous exchange is during photosynthesis. Since oxygen is released during photosynthesis together with energy, it is not required to come from the outside world.

The synthesis of biomolecules and other biological processes can make use of the 50% of total energy generated during respiration. One can use the carbon created during respiration as a precursor to aid in the creation of other chemicals found in the cell.

Types of Respiration

Depending on whether oxygen is present during cellular respiration, there are two types of respiration. Anaerobic and aerobic respiration are the two types.

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{Cellular respiration}} 6CO_2 + 6H_2O + ATP$$

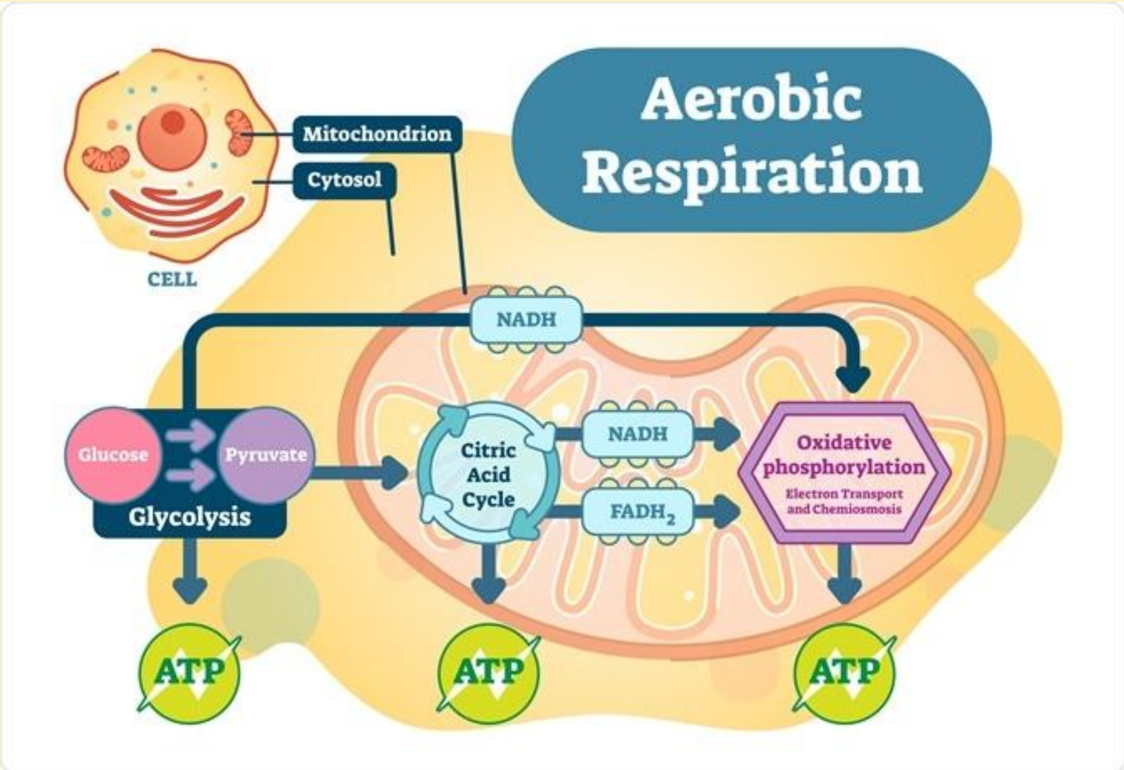
Salt respiration increases when plants exhibit active absorption.

The process of ripening fruits is known as climatic respiration.

E.g.: Apple, Mango, etc.

Aerobic Respiration

It is the process by which carbon dioxide and water are created when raw materials, including oxygen, are used. The equation is shown below:



It happens in the cell's mitochondria when energy, or about 2870 kJ, is released.

There are two primary phases of aerobic respiration: the citric acid cycle and glycolysis.

Kollicker made the initial discovery of it in the striated muscles of insects.

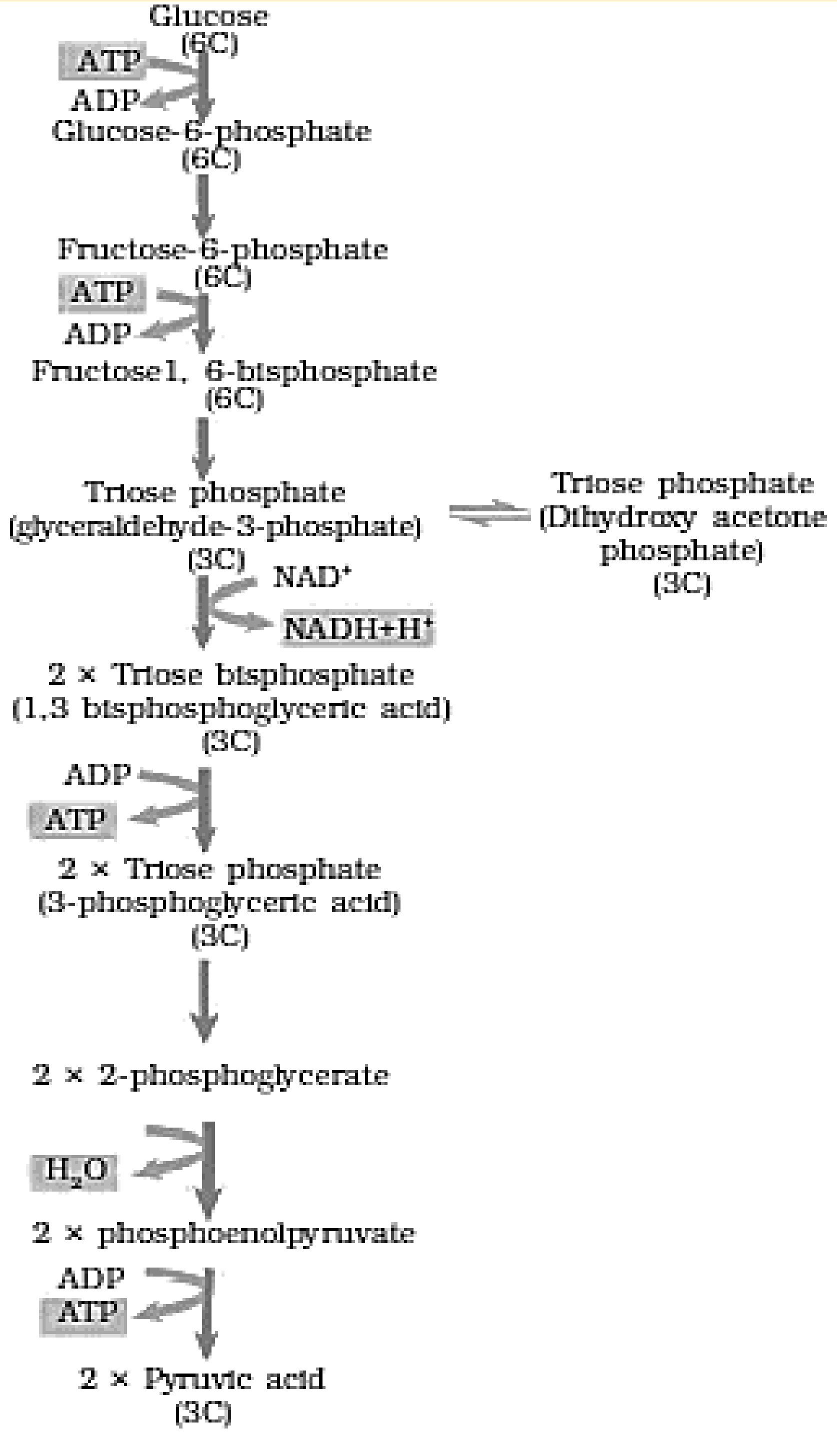
On the other hand, C. Benda coined the term mitochondria.

Hoyeboom postulated that the mitochondria serve as the site of cellular respiration.

Mitochondria are referred to as the semi-autonomous organelles since they have their ribosomes, DNA, RNA, and proteins. They are found as endosymbionts, symbiotic relationships inside eukaryotic cells.

Glycolysis

It is the initial stage of respiration, both anaerobic and aerobic. It involves a sequence of enzyme-catalyzed events that result in the creation of pyruvic acid when the glucose oxidizes. Because of the names of the biologists who found it—Gustav Embden, Otto Meyerhof, and J. Paranas—it is often referred to as the EMP pathway.



Glucose forms two molecules of pyruvic acid after it undergoes oxidation.

Glycolysis includes two major phases.

- Preparatory phase and cleavage

- Oxidative and payoff phase.

The Steps Found in Both these Phases are as Follows

Hexokinase and glucose are needed for the phosphorylation of glucose, which produces glucose 6 phosphatases and requires ATP as energy.

using the enzyme phosphorgluco isomerase to convert glucose 6 phosphates into fructose 6 phosphate, which is its isomeric form.

The remaining steps in the metabolism of fructose and glucose are identical.

Fructose 6 phosphate is transformed into fructose 1,6 bisphosphate with the use of just one ATP molecule.

Following the breakdown of fructose 1,6 biphosphate, two molecules of triose phosphate—three-carbon compounds—are formed. These are glyceraldehyde phosphate and dihydroxyacetone phosphate, which are both interconvertible and catalyzed by the enzyme aldolase.

Now, dihydroxyacetone phosphate isomerizes to produce two molecules of glyceraldehyde 3 phosphate, which is how glyceraldehyde 3 phosphate is created.

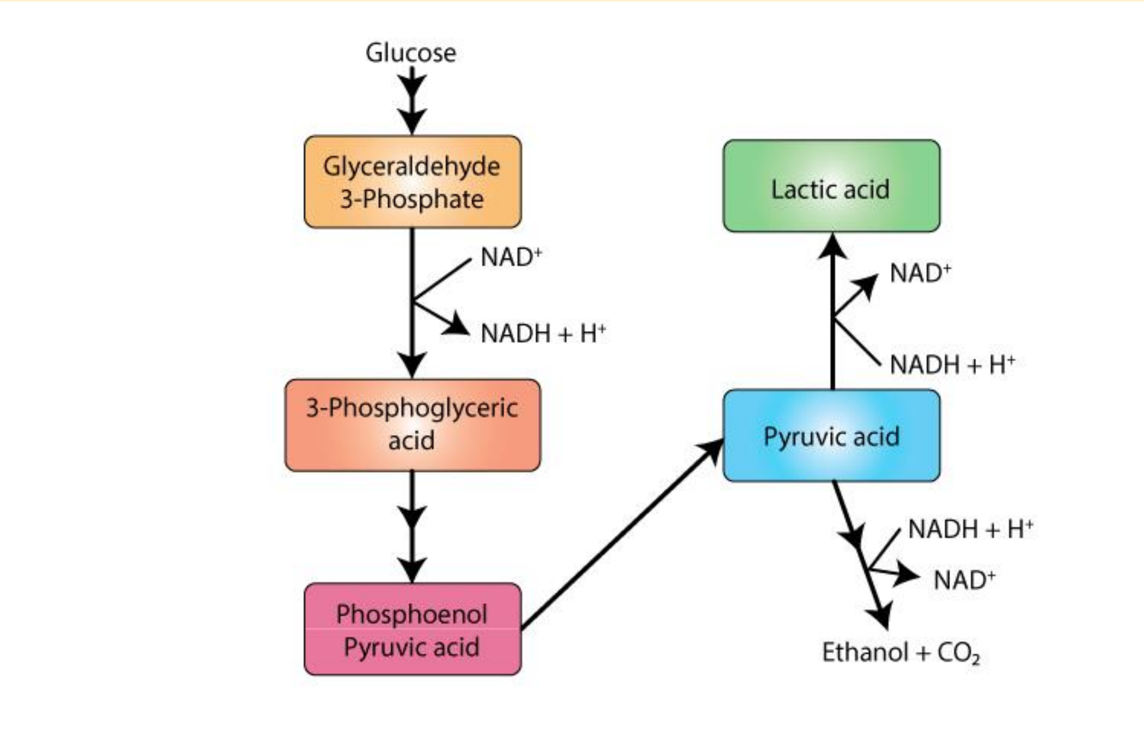
Two phosphoglycerates are formed from every three phosphoglyceric acids.

Since ATP is an excellent donor, each 2 phosphoglycerate is subsequently transformed into 2 phosphoenol-pyruvate, which leads to the synthesis of a water molecule.

An enzyme known as pyruvate kinase aids in the conversion of each 2 phosphoenol-pyruvate into pyruvic acid. In this phase, the substrate's phosphate group will be directly transformed from ADP to ATP, resulting in the release of an ATP molecule and substrate-level ATP production.

Fermentation

Anaerobic respiration, also known as fermentation or zymosis, is the process that takes place in the absence of oxygen and involves the incomplete oxidation of food ingredients that produce CO2 and ethanol as end products. Yeast aids in the completion of the procedure. Shank was the one who came up with the name "fermentation," while Gay Lussac was the one who initially discovered the process.



Fermentation takes place in a variety of organisms, such as many prokaryotes, unicellular eukaryotes, and seeds that germinate in an anaerobic environment. Alcoholic and lactic acid fermentation are the two different types of fermentation processes.

Alcoholic Fermentation

Carbon dioxide and ethanol (ethyl alcohol) are the products of it.

It takes two steps: first, glucose molecules undergo glycolysis, which yields pyruvic acid. Pyruvic acid is subsequently converted to carbon dioxide and ethanol. The two actions are as follows:

An enzyme known as pyruvic acid decarboxylase aids in the conversion of pyruvic acid into carbon dioxide and acetaldehyde.

The process of acetaldehyde, which yields ethanol and carbon dioxide, is aided by an enzyme known as alcohol dehydrogenase as well as a coenzyme.

Aerobic respiration

Glycolysis produces end products from glucose that include Pyruvic acid is the final byproduct of glycolysis and is a three-carbon molecule that is found in the cell's cytoplasm.

The Main Events are

By gradually removing the hydrogen atoms from the pyruvic acid, the acid is fully oxidized.

Following the ATP synthesis, the electrons will proceed to migrate in the direction of the oxygen molecules, with this process occurring inside the cell's inner mitochondrial membrane.

Subsequently, the carbon dioxide molecules are eliminated within the cell's mitochondrial matrix.

Tricarboxylic Acid Cycle

Following the full oxidation of pyruvic acid, which happens in a sequence of step-by-step reactions and needs oxygen, this cycle involves the creation of carbon dioxide and water. This process occurs within the cell's mitochondria.

Since Hans Krebs followed the steps, the cycle bears his name, the Krebs cycle. The cycle is also known as the citric acid cycle since its initial constituent is tricarboxylic acid, which is also known as citric acid. since the cycle consists of three acids, it is also known as the tricarboxylic acid cycle.

In the TCA cycle, acetyl coenzyme A serves as the respiratory substrate, and acetic acid, a four-carbon complex, serves as the acceptor molecule. This cycle consists of two decarboxylation reactions (removing CO2) and four dehydrogenation reactions (removing hydrogen). Here, carbon dioxide will be produced as a result of the coenzyme reduction.

Together with four carbon oxaloacetic acids, one molecule of acetyl coenzyme A is involved in the synthesis of citric acid, a six-carbon chemical. Citrus synthase is an enzyme that helps this reaction happen. The creation of CoA is the result of this reaction, which needs a water molecule.

With the aid of a water molecule, isocitric acid isomerizes to generate citric acid.