

# READING MATERIALS

## RESPIRATION IN PLANTS

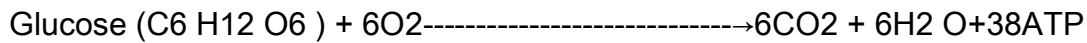
- Living cells require a continuous supply of energy for maintaining various life activities.
- The energy obtained by oxidizing the organic compounds (carbohydrates, proteins, and lipids) in the cells.
- This process of harvesting chemical energy for metabolic activities in the form of ATP by oxidizing the food molecules is called '**respiration**'.
- The most common substrate used in respiration for oxidation is glucose.

**Types of respiration:** There are two types of respirations in living systems.

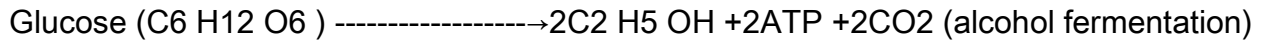
- **Aerobic respiration** is one in which molecular oxygen is used for the complete oxidation of glucose to yield CO<sub>2</sub>, H<sub>2</sub>O and 38 ATP molecules.
- **Anaerobic respiration** is one in which glucose is partially oxidized without using oxygen to yield lactic acid or ethyl alcohol and 2 ATP molecules.

Aerobic respiration	Anaerobic respiration
<ul style="list-style-type: none"><li>- Oxygen is used for the process.</li><li>- Takes place in the cells of all the higher plants and animals</li><li>- Glucose is completely oxidized.</li><li>- The end products are carbon dioxide and water</li><li>- Complete oxidation of one molecule of glucose yields 38 ATP molecules</li><li>- Process takes place in both cytoplasm and mitochondria of cell</li></ul>	<ul style="list-style-type: none"><li>- Oxygen is not utilized for the process.</li><li>- Takes place in some bacteria, fungi and certain endo parasites.</li><li>- Glucose is partially oxidized</li><li>- The end products are carbon dioxide and either ethyl alcohol or lactic acid</li><li>- Partial oxidation of one molecule of glucose yields only 2 ATP molecules.</li><li>- Takes place only in cytoplasm of the cell.</li></ul>

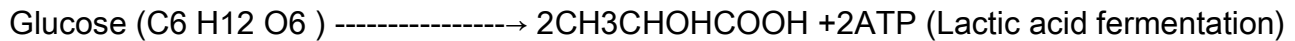
**Aerobic respiration equation:**



**Anaerobic respiration equations:**



OR



**Aerobic respiration:** It has three steps-

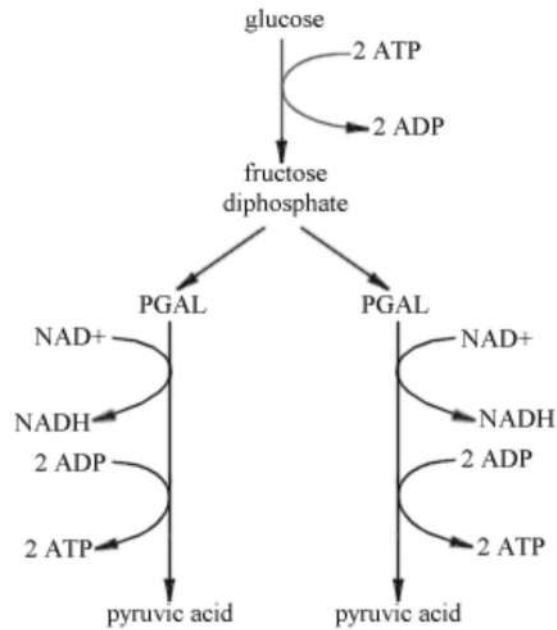
1. Glycolysis/Embden-Meyerhof-parnas pathway (EMP pathway).
2. Kreb's cycle/Citric acid cycle/Tricarboxylic acid cycle.
3. Electron transport system (ETS).

**Glycolysis:**

- Glycolysis takes place in the cytoplasm of the cell and is common to both aerobic and anaerobic respirations.
- In this step, glucose (6C) is broken in a stepwise manner into two molecules of 3C Pyruvic acid, without utilizing oxygen.
- The major events of glycolysis are given below.
- The overall reaction of glycolysis is,



# Glycolysis



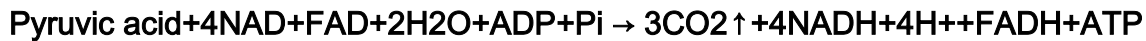
## Kerb's Cycle/ citric acid cycle/ tricarboxylic acid cycle:

- It is the second step in aerobic respiration, named after Sir Hans Krebs, who discovered the intermediate compounds of this cycle.
- Pyruvic acid, the product of glycolysis, enters the matrix of mitochondria, where it undergoes chemical reaction producing three molecules of carbon dioxide and NADH.
- At the end the kerbs' cycles starting compound, 4C Oxalo acetic acid (OAA) is regenerated. Before entering the krebs cycle,
- 3C Pyruvic acid by oxidative decarboxylation gets converted into acetyl Coenzyme A. This is called the preparatory phase.

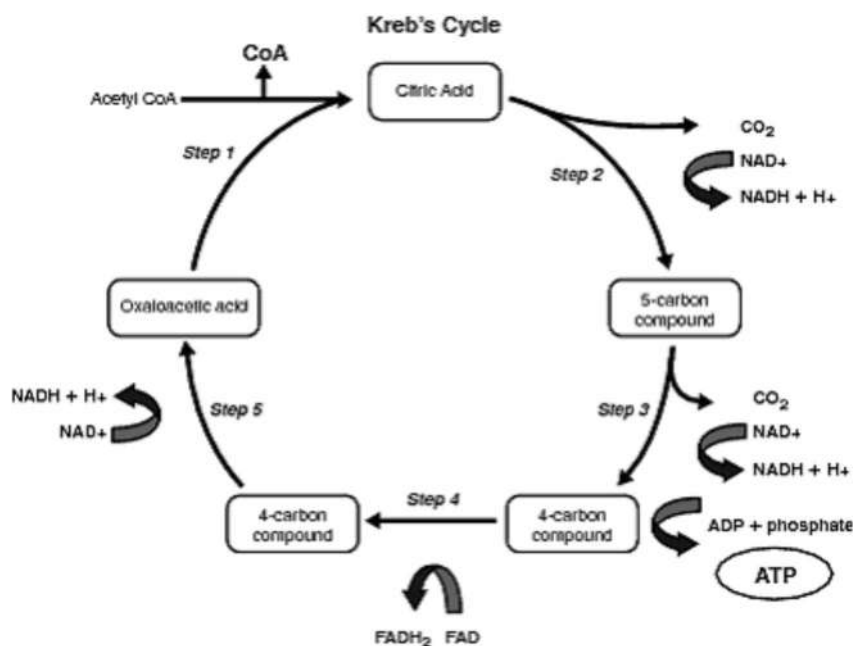
**Pyruvic acid + CoA + NAD.....→Acetyl CoA + CO<sub>2</sub> + NADH (preparatory phase)**

- Acetyl CoA condenses with a 4C compound called Oxalo acetic acid (OAA), forming a 6C citric acid.
- As the first compound formed during kreb's cycle is citric acid, this cycle is also called 'citric acid' cycle.
- Orgnic acids containing three carboxylic acid groups (COOH) are also formed during this cycle. Hence it is also called 'tricarboxylic acid' cycle.

- The overall reaction of citric acid cycle is,



- Carbon dioxide is released to the atmosphere or green cells may use it for photosynthesis.
- The hydrogen which is present in glucose will be used for reducing NAD and FAD to NADH and FADH<sub>2</sub> respectively. Krebs's cycle is represented.



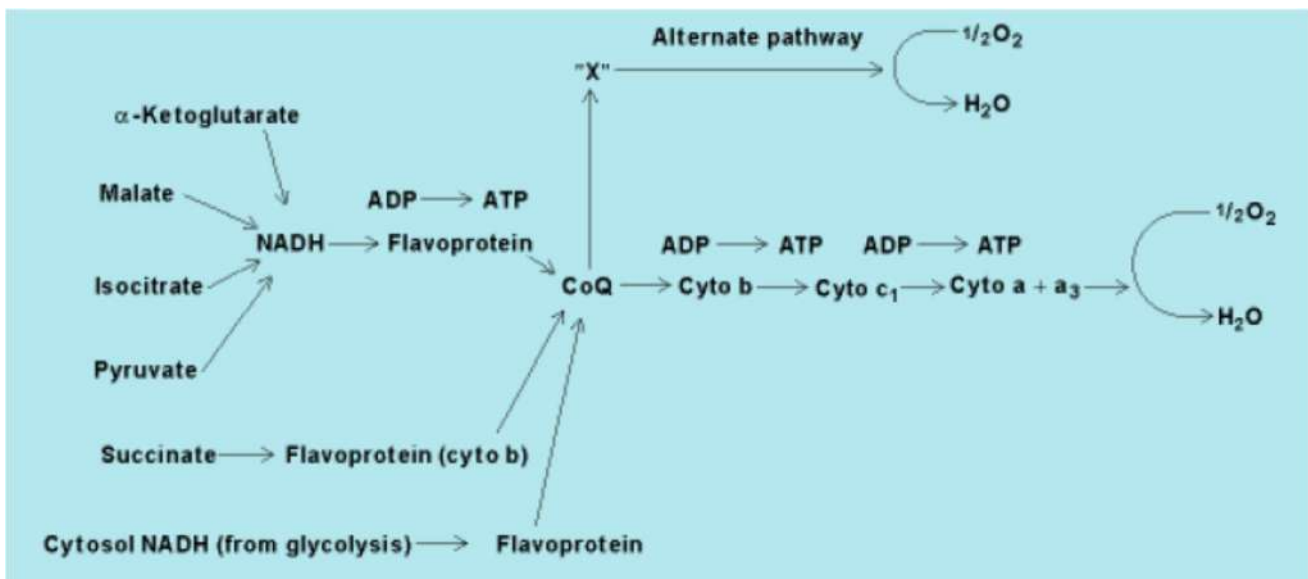
### Main events in Krebs cycle

(5C compound- α-ketoglutaric acid, 4C compounds- succinic acid and Malic acid)

### Electron transport system (ETS)/ oxidative phosphorylation:

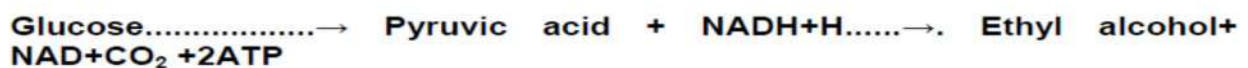
- It is third step of aerobic respiration, taking place in the inner mitochondrial membrane (Cristae). In this step of respiratory process, NADH and FADH<sub>2</sub> formed during glycolysis and Krebs's cycle are oxidized to NAD and FAD.
- During this oxidation process, electrons pass through series of electron carriers (like co-enzyme Q, cytochromes b, c, a and a<sub>3</sub>) and ADP is phosphorylated to ATP by the addition of P<sub>i</sub>. Since oxidation of NADH and FADH<sub>2</sub> is associated with the synthesis of ATP, it is called 'Oxidative Phosphorylation'.

- Oxidation of one NADH and one FADH<sub>2</sub> yields three and two ATP molecules respectively.
- The hydrogen atom (H<sup>+</sup>) and the electron (e<sup>-</sup>) of the reduced NADH and FADH<sub>2</sub> are accepted by the oxygen to form a molecule of water and it is called terminal oxidation.
- Total gain of ATP molecules at the end of the complete oxidation of one glucose molecule is 38.



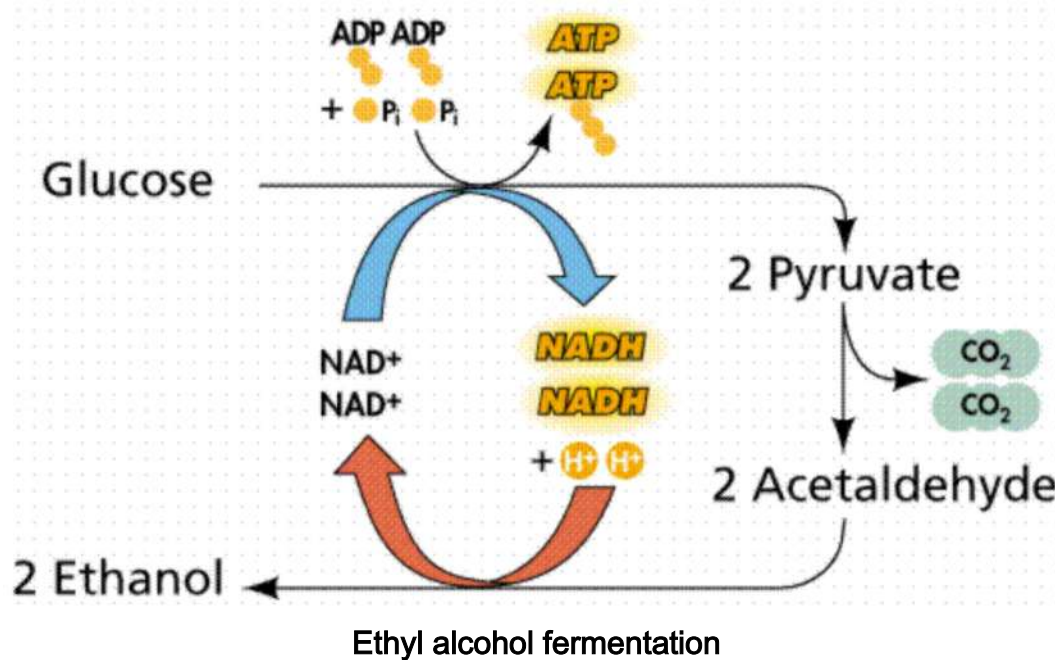
### Anaerobic respiration/Fermentation:

- It is the partial oxidative process of glucose taking place chiefly in microorganisms such as bacteria and yeast cells. It is also called fermentation.
- The Pyruvic acid formed at the end of the Glycolysis will further undergo chemical reaction in cytoplasm itself without utilisation of oxygen, forming ethyl alcohol in yeast cells and Lactic acid in bacteria.
- Based on the product the process is called ethyl alcohol fermentation or Lactic acid fermentation.



- Fermentation process has wide application in food, pharmaceutical and chemical industries.

- Both the types of fermentation are inefficient with respect to energy production.
- Only two ATP molecules are formed per glucose molecule.
- Roots of the plant in water logged and strained human muscle may switch over temporarily to anaerobic respiration when there is no oxygen supply.



### Amphibolic pathway :

- During aerobic respiration the organic substrates are broken down into simple substances such as carbon dioxide and water (Catabolism).
- However it also produces many intermediate organic compounds/acids during kreb's cycle which form the starting compound for the synthesis of other complex substances, needed for the cell. Hence respiration is said to be both catabolic and anabolic and is referred to as 'amphibolic pathway'.

### Respiratory quotient (RQ):

- Respiratory quotient is defined as the ratio of volume of CO<sub>2</sub> evolved to the volume of Oxygen consumed during respiration. The volume of carbon dioxide released and the volume of oxygen consumed by the cell during respiration depends upon the type of respiratory substrate utilized. Therefore RQ value indicates the substrate type used for respiration.

$$\text{RQ} = \frac{\text{Volume of carbon dioxide evolved}}{\text{Volume of oxygen consumed}} \quad \text{during respiration}$$

- When carbohydrates are used as substrate and are completely oxidized, the RQ will be 1, because equal amounts of CO<sub>2</sub> and O<sub>2</sub> are evolved and consumed, respectively.
- When fats are used in respiration, the RQ is less than 1.
- Proteins are respiratory substrates the ratio would be about 0.9.

### **SUMMARY:**

- Respiration is a cellular catabolic process where in glucose is oxidized to produce ATP, carbon dioxide and water.
- It is of two types- aerobic and anaerobic.
- Aerobic respiration is seen in higher plant and animal cells and it involves complete oxidation of glucose producing 38 ATP molecules.
- Aerobic respiration takes place in three stages- Glycolysis, Krebs's cycle and Electron transport system (ETS).
- Glycolysis is common to both aerobic and anaerobic respirations and it takes place in the cytoplasm of the cell. The other two steps are seen only in aerobic respiration and takes place in the mitochondrial matrix and the cristae present in the inner membrane of mitochondria.
- Anaerobic respiration is also called fermentation. It is seen in microorganisms and incomplete oxidation of glucose yields only 2 ATP molecules.
- Aerobic respiration is more efficient than anaerobic in terms of ATP production.
- Value of Respiratory quotient (RQ), indicates the type of respiratory substrate used.