CHAPTER – 14: RESPIRATION IN PLANTS

Cellular Respiration

- It is the process of oxidation /breakdown of food materials within the cell to release energy. Respiratory substrate to be oxidised during respiration is usually glucose, but these can also be proteins, fats or organic acids.
- In plants respiration gas exchange occurs through stomata and lenticels.
- Overall cellular respiration is:
  - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy(36 ATPs)

Types of respiration:

- Aerobic respiration
- Anaerobic respiration

	Aerobic respiration	Anaerobic respiration
1.	**It occurs in the presence of oxygen.**	**It occurs in the absence of oxygen.**
2.	**Respiratory substrate (glucose)is completely oxidised.**	**Partially oxidised.**
3.	**Products are CO_2, H_2O and 36 ATPs.**	**Products are ethyl alcohol / lactic acid, CO_2, 2 ATPs.**
4.	**Energy is released in large quantities.**	**Lesser quantity of energy.**
5.	**Cytoplasm and Mitochondria are the sites of break down.**	**Only cytoplasm is the site of break down.**

Mechanism of respiration:

- Glycolysis – it is common to both aerobic and anaerobic respiration
- Citric acid cycle / Krebs cycle - Aerobic respiration in mitochondria
- Electron transport system – in the inner membrane of mitochondria
- Both aerobic and anaerobic respiration starts with Glycolysis.
- In aerobic respiration Glycolysis is followed by Citric acid cycle and ETS (both occur in mitochondria).
- In anaerobic respiration Glycolysis is followed by formation of ethyl alcohol / lactic acid in the cytoplasm.

Fermentation :

Incomplete oxidation of pyruvic acid, under anaerobic respiration forms lactic acid/ ethyl alcohol. It occurs in bacteria, yeast and striated muscles.

In yeast fermentation:

- Pyruvic acid→ Ethanol + CO_2
- Enzymes involved − Pyruvic acid decarboxylase, Alcohol dehydrogenas.

- Only 7% of energy of glucose is released during fermentation.
- Yeasts poison themselves to death when alcohol concentration reaches about 13%.

In bacterial fermentation:

- Pyruvic acid ⟶ Lactate
- Enzyme involved − dehydrogenase.
- While doing severe exercise similar reaction occurs in animal muscles in anaerobic conditions.

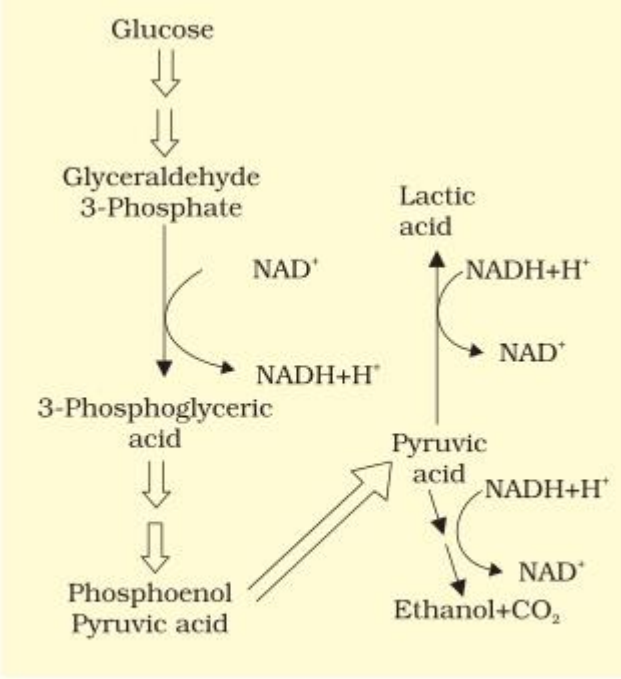
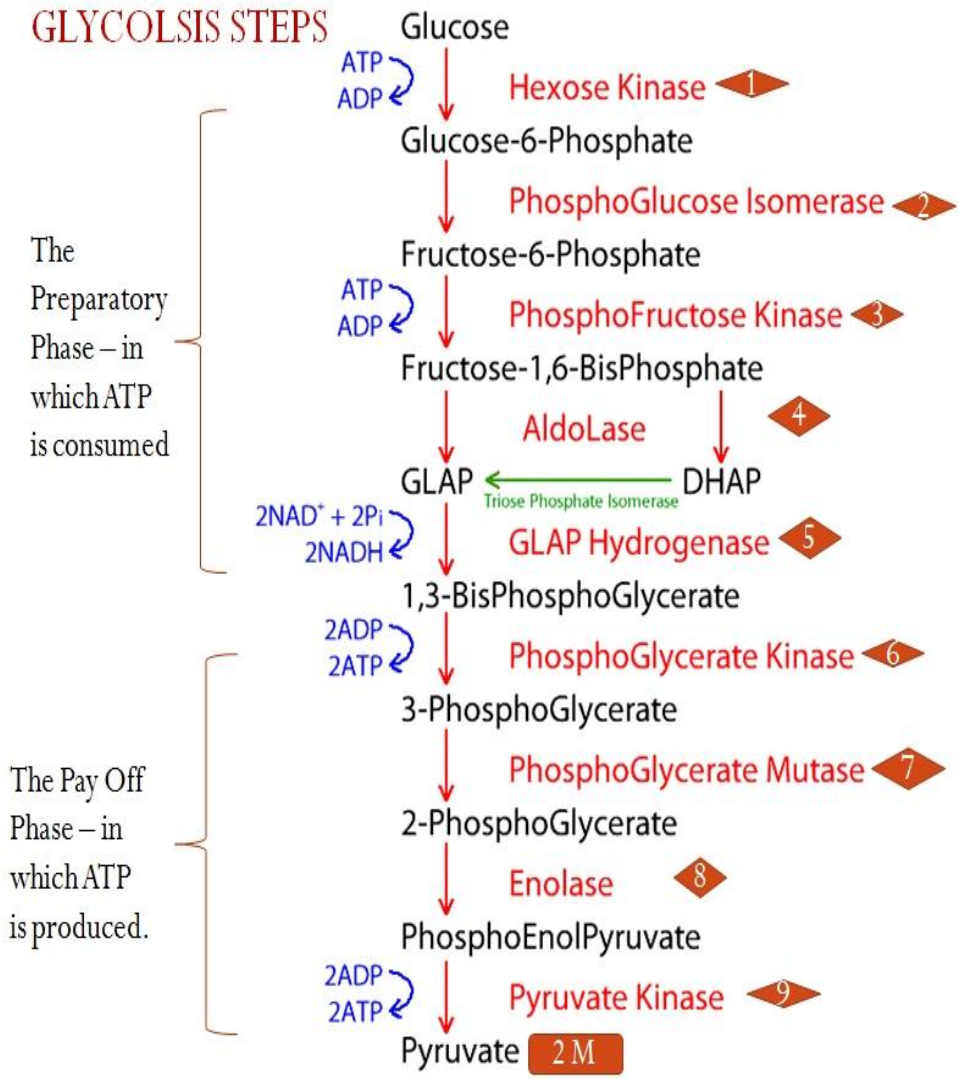


Figure 14.2 Major pathways of anaerobic respiration

Glycolysis:

- It is the process of breaking down of glucose to pyruvic acid.
- It was given by Embden, Meyerhof and Parnas
- A chain of 10 reactions converts glucose into pyruvate.
- Net ATPs produced = 4 (produced) − 2 (consumed) = 2 ATPs



The pyruvate, so produced, may undergo:

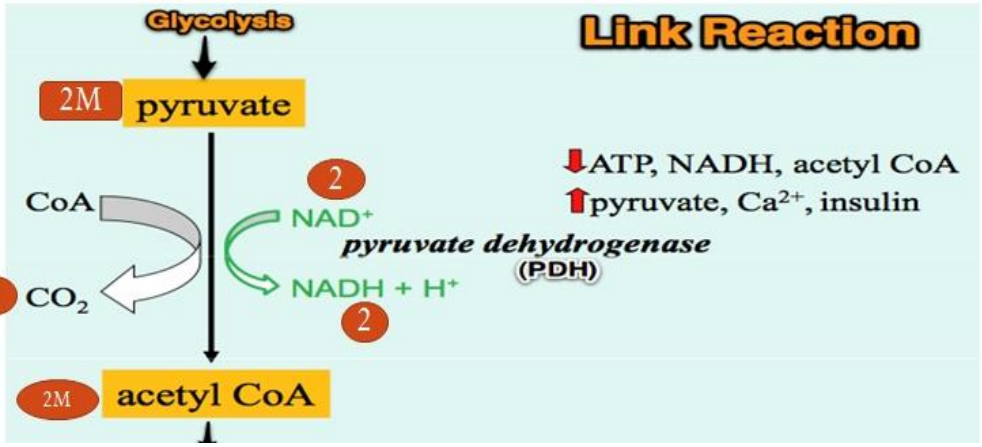
- Lactic acid fermentation
- Alcoholic fermentation
- Aerobic respiration (Krebs cycle)

Aerobic Respiration

Citric acid cycle / Tricarboxylic acid cycle / Kreb's cycle:

- **TCA cycle** – it takes place in the mitochondrial matrix – it is the process of complete oxidation of pyruvate by stepwise removal of all hydrogen atoms, which leaves three molecules of CO_2
- **Electron Transport Chain and Oxidative phosphorylation** – it takes placein the inner membrane of the mitochondria – it is the process of synthesis of ATPfron $NADH_2$ and $FADH_2$.

Formation of Acetyl CoenzymeA



Krebs cycle /Tricarboxylic acid cycle/ Citric acid cycle:

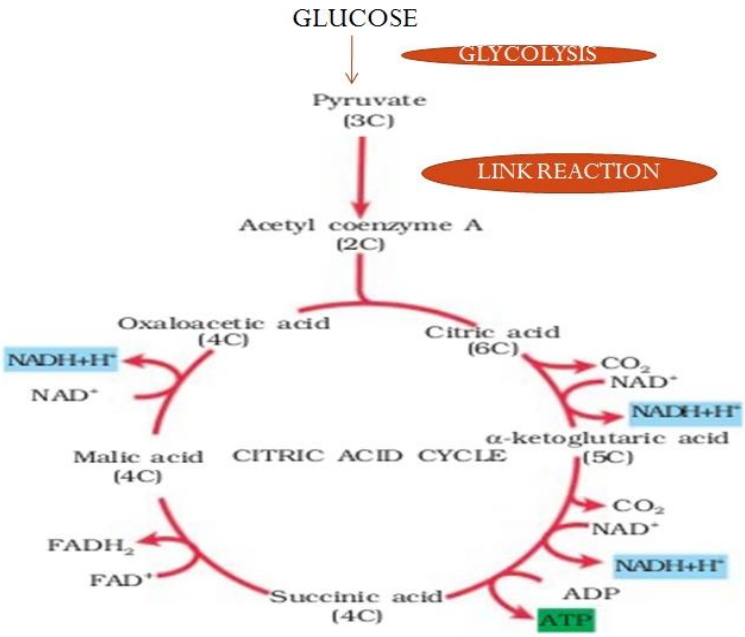


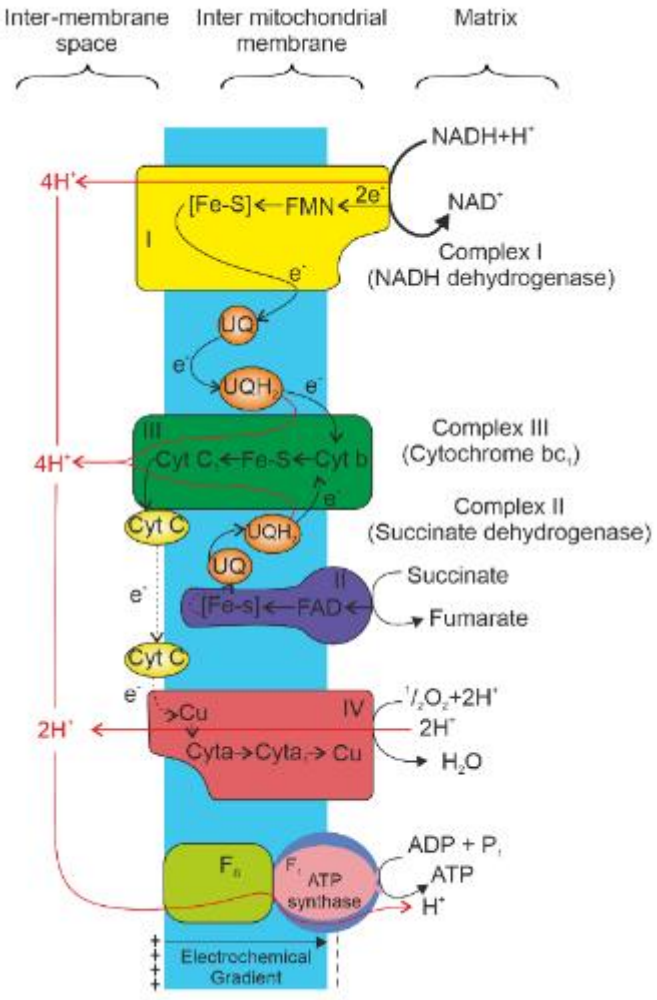
Figure 14.3 The Citric acid cycle

$$\text{Pyruvic acid} + 4NAD^+ + FAD^+ + 2H_2O + ADP + Pi \xrightarrow{\text{Mitochondrial Matrix}} 3CO_2 + 4NADH + 4H^+ + FADH_2 + ATP$$

Overall equation:

$$\text{Pyruvic acid} + 4NAD^+ + FAD^+ + 2H_2O + ADP + Pi \xrightarrow[\text{Matrix}]{\text{Mitochondrial}} 3CO_2 + 4NADH + 4H^+ + FADH_2 + ATP$$

Electron Transport Chain (ETS)



$NADH_2$ and $FADH_2$ are oxidised to release the energy stored in them in the form of ATPs.

Electrons are passed from one carrier to another, and finally to oxygen, resulting in the formation of water.

Oxidation of 1 NADH produces 3 ATPs.

Oxidation of 1 $FADH_2$ produces 2 ATPs.

Oxidative Phosphorylation

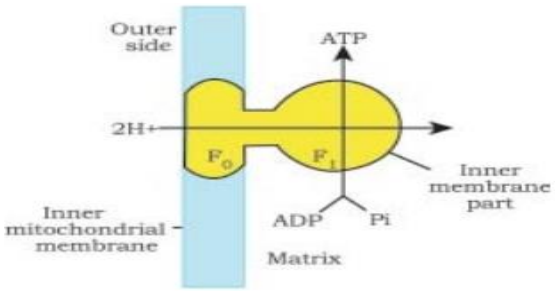
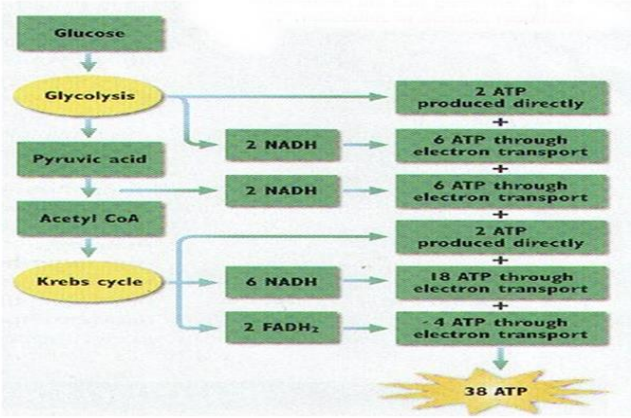


Figure 14.5 Diagramatic presentation of ATP synthesis in mitochondria

Respiratory Balance Sheet

$$Glucose + 6O_2 + 36ADP + 36Pi \rightarrow 6CO_2 + 6H_2O + 36ATP$$

TOTAL ATP FORMATION



Amphibolic Pathway: Involved in both anabolism and catabolism

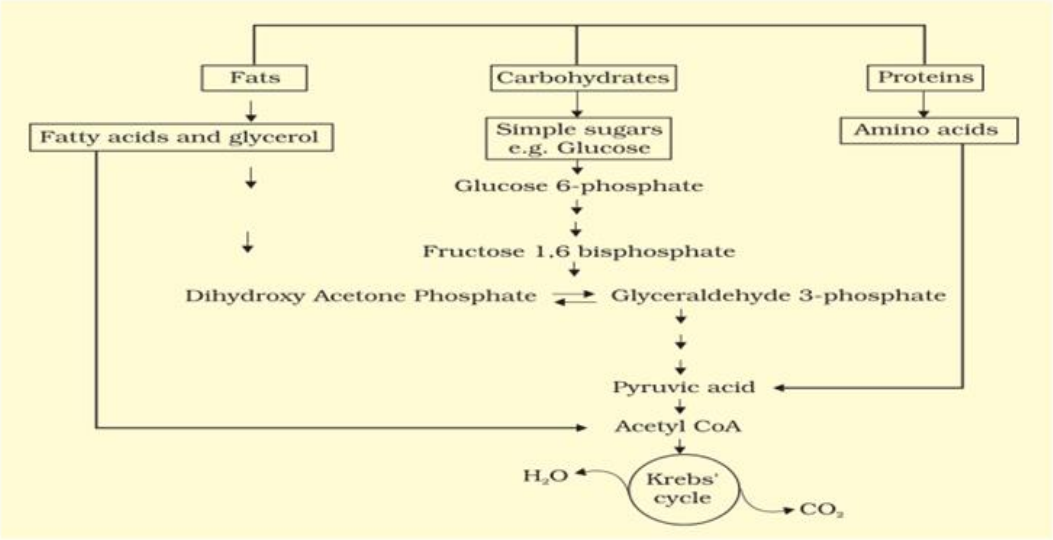


Figure 14.6 Interrelationship among metabolic pathways showing respiration mediated breakdown of different organic molecules to CO_2 and H_2O

Respiratory Quotient (RQ)

- It is the ratio of the volume of CO_2 evolved to the volume of O_2 consumed during respiration.

- RQ = 1 (When carbohydrate is used as substrate)
    - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + Energy$

- RQ is less than 1 for fats.
- RQ is 0.9 for proteins.
- RQ is more than 1 for organic acids.
- RQ is infinite in case of anaerobic resp. because CO_2 is evolved but O_2 is not consumed

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