Chapter: Respiration in Plants

Exercise

Question 1. Differentiate between:

(a) Respiration and Combustion

(b) Glycolysis and Krebs' cycle

(c) Aerobic respiration and Fermentation

Answer:

(a) Differences between respiration and combustion are as follows:

	Respiration	Combustion
1	It is a cellular process.	It is a non-cellular process.
2	It is a biochemical and slow process.	It is a physiochemical and fast process.
3	Energy is stored in ATP molecules.	In this process, no formation of ATP takes place.
4	It requires enzymes for its completion.	In this process, no enzymes are required.
5	In this process, the temperature of the system does not increase.	In this process, the temperature of the system rises abruptly.
6	Energy in the form of ATP in released slowly at various steps.	Energy in the form of heat and light is released a single step.

(b) Differences between glycolysis and Krebs' cycle are as follows:

	Glycolysis	Krebs'cycle
1	It takes place inside cytoplasm.	It takes place inside mitochondria.
2	In this process, one glucose molecule is broken down into two molecules of pyruvic acid.	In this process, pyruvic acid is completely oxidized into carbon dioxide and water.
3	It takes place in both aerobic and anaerobic respiration.	It takes place only in aerobic respiration.
4	This process is oxygen-independent.	This process is oxygen-dependent.
5	This process utilizes two ATP molecules.	This process does not utilize any ATP molecule.
6	It leads to a net gain of 8 ATP molecules.	It leads to a net gain of 24 ATP molecules.

(c) Aerobic respiration and Fermentation

	Aerobic respiration	Fermentation
1	In this process, oxygen is required.	In this process, Oxygen is not required.
2	It leads to a complete breakdown of the respiratory substrate.	It leads to the incomplete breakdown of the respiratory substrate.
3	The end products formed are carbon dioxide and water.	The end products formed are acid or alcohol and carbon dioxide.

4	It leads to a net gain of 36 to 38 ATP molecules.	It leads to a net gain of 2 ATP molecules.
5	It is completed in three steps namely glycolysis, Krebs cycle, and electron transport system.	It is completed in two steps namely glycolysis and incomplete oxidation of pyruvic acid.
6	It takes place in higher plants and animals.	It takes place in anaerobic organisms such as bacteria and yeast.

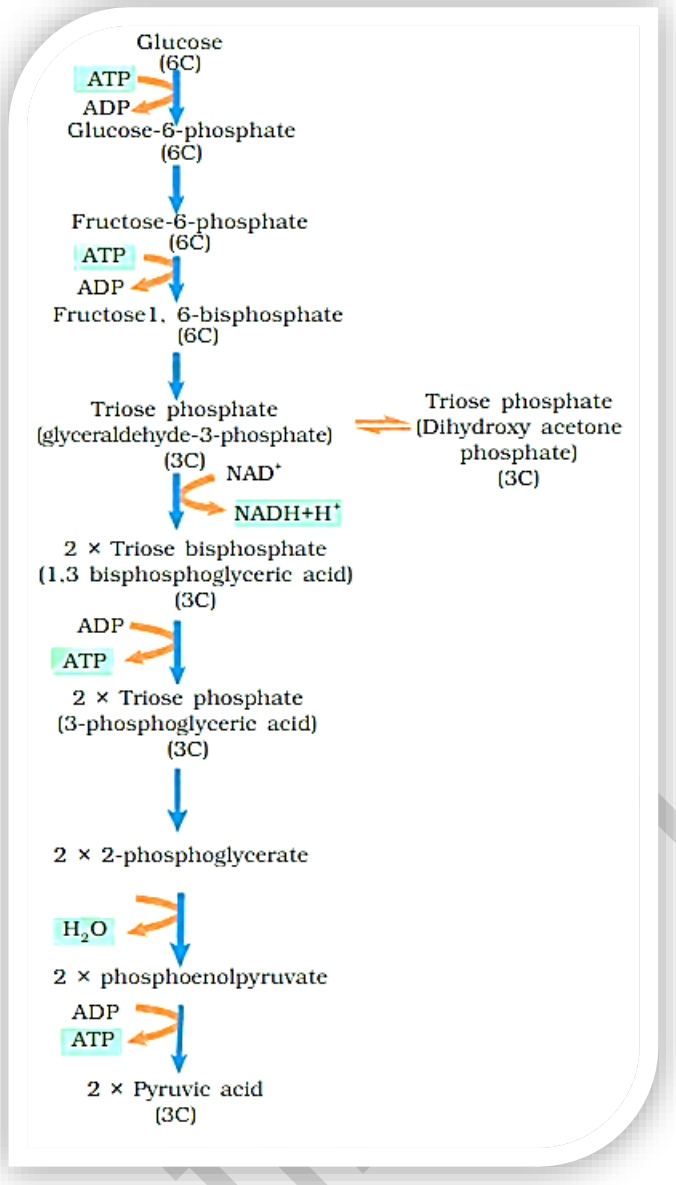
Question 2. What are respiratory substrates? Name the most common respiratory substrate.

Answer:

The compounds that are oxidized during the process of respiration to release energy required for various life processes are known as respiratory substrates. The most common respiratory substrate is carbohydrates, in the form of a glucose molecules. But proteins, fats, and organic acids can be used as respiratory substrates.

Question 3. Give the schematic representation of glycolysis.

Answer:



The above flowchart gives the schematic representation of various steps of glycolysis.

Question 4. What are the main steps in aerobic respiration? Where does it take place?

Answer:

The main steps in aerobic respiration and their site of occurrence are as follows:

a. Gylycolysis – It is the first step of aerobic respiration and takes place in the cytoplasm. In this process, one molecule of glucose is broken down into two molecules of pyruvic acid.

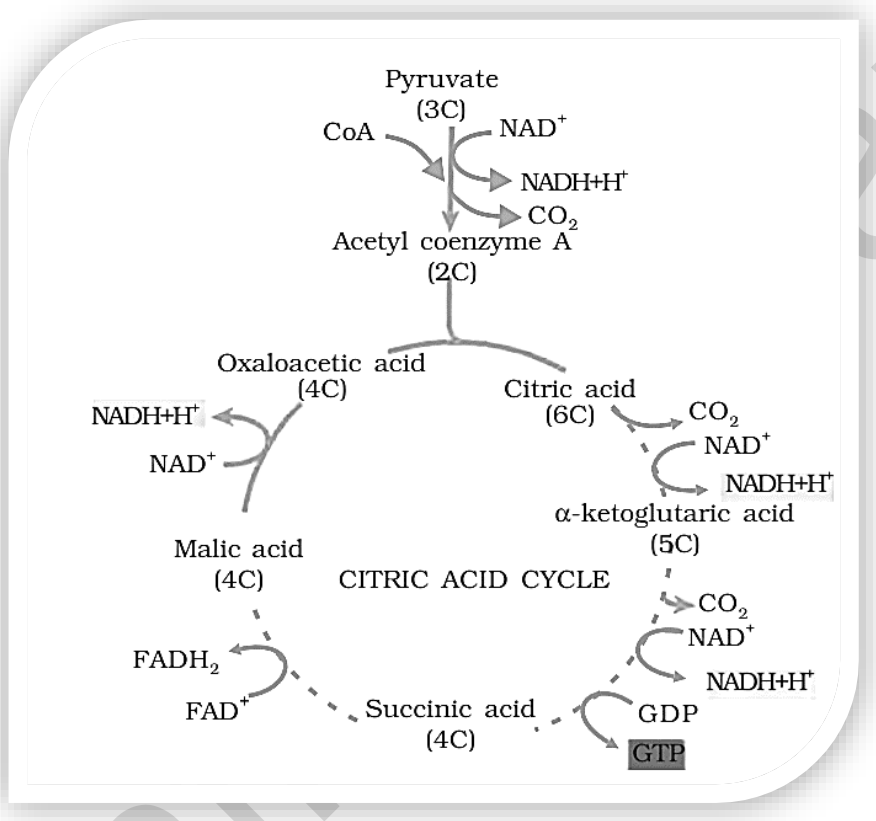
b. Krebs' cycle – It is the second step of aerobic respiration and takes place in the matrix of mitochondria.

c. Electron Transport System – It is the third step of aerobic respiration where the energy stored in $NADH+H^+$ and $FADH_2$ is released. It takes place in the inner mitochondrial membrane.

d. Oxidative phosphorylation – It is the fourth step of aerobic respiration, and produces the most of the energy in cellular respiration. It takes place in F_0-F_1 particles located in the inner mitochondrial membrane.

Question 5. Give the schematic representation of an overall view of Krebs' cycle.

Answer:



The above diagram gives the schematic representation of an overall view of Krebs' cycle.

Question 6. Explain ETS.

Answer:

ETS stands for electron transport system. It is located in the inner membrane of mitochondria. This is an essential step that releases the energy stored in $NADH+H^+$ and $FADH_2$. The various steps of ETS are as follows:

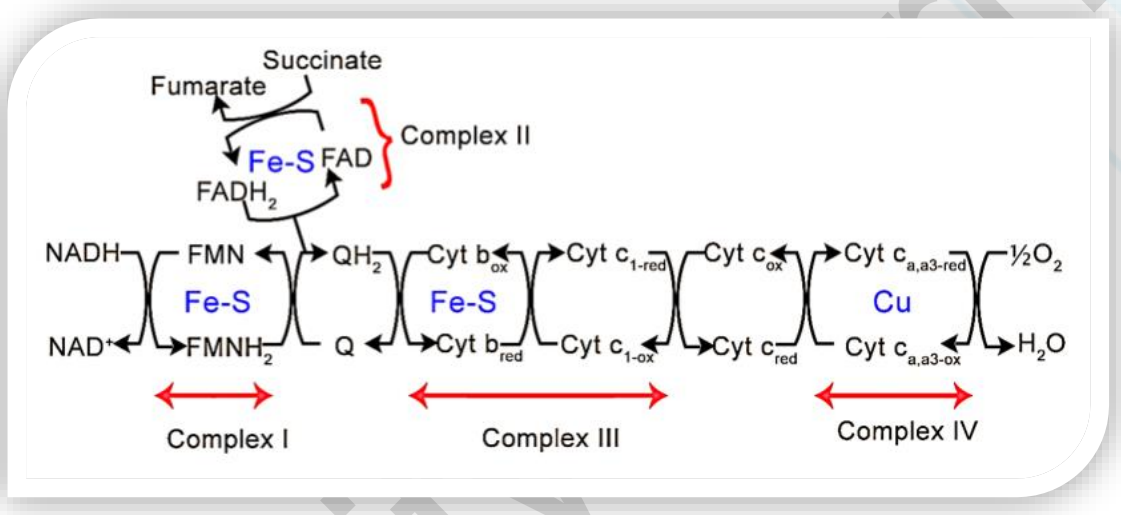
a. $NADH + H^+$ gets oxidized by NADH dehydrogenase (complex I). The electrons released get transferred to ubiquinone through FMN.

b. Ubiquinone also receives reducing equivalents via FADH2 through succinate dehydrogenase (complex II).

c. The electrons from ubiquinone are received by cytochrome bc1 (complex III) which is then transferred to cytochrome c.

d. The cytochrome c acts as a mobile electron carrier between complex III and cytochrome c oxidase complex (complex IV).

e. During the transfer of electrons from each complex, the process is accompanied by the production of ATP by the action of ATP synthase (complex V). The amount of ATP produced depends on the molecule, which is oxidized. 2 ATP molecules are produced by the oxidation of one molecule of NADH and 3 ATP molecules are produced by the oxidation of one molecule of FADH2.



Various steps of Electron Transport System

Question 7. Distinguish between the following:

(a) Aerobic respiration and Anaerobic respiration

(b) Glycolysis and Fermentation

(c) Glycolysis and Citric acid Cycle

Answer:

(a) Aerobic respiration and Anaerobic respiration

	Aerobic respiration	Anaerobic respiration
1	In this process, oxygen is used.	In this process, oxygen is not used.
2	It leads to complete breakdown of respiratory substrate.	It leads to incomplete breakdown of respiratory substrate.
3	The end products fprmed are carbon dioxide and water.	The end products formed are acid or alcohol and carbon dioxide.
4	It produces 36 to 38 ATP molecules.	It produces 2 ATP molecules.

5	It is completed in three steps namely glycolysis, Krebs cycle and electron transport system.	It is completed in two steps namely gylcolysis and incomplete oxidation of pyruvic acid.
6	It takes place in higher plants and animals.	It takes place in anaerobic organisms such as bacteria and yeast.

(b) Glycolysis and Fermentation

	Glycolysis	**Fermentation**
1	This process is oxygen independent.	This process takes place in absence of oxygen.
2	This step is common to both aerobic and anaerobic respiration.	It is anaerobic respiration.
3	It produces pyruvic acid.	It produces acid or alcohol and carbon dioxide.

(c) Glycolysis and Citric acid Cycle

	Glycolysis	**Citric acid Cycle**
1	It takes place inside cytoplasm.	It takes place inside mitochondria.
2	In this process, one glucose molecule is broken down into two molecules of pyruvic acid.	In this process, pyruvic acid is completely oxidised into carbon dioxide and water.
3	It takes place in both aerobic and anaerobic respiration.	It takes place only in aerobic respiration.
4	This process is oxygen independent.	This process is oxygen dependent.
5	This process utilises two ATP molecules.	This process does not utilise any ATP molecule.
6	One glucose molecule breaks down to generate 2 $NADH_2$ and 2 ATP molecules.	It produces 6$NADH_2$, 2$FADH_2$, and 2 ATP molecules on the breakdown of two acetyl-CoA molecules.

Question 8. What are the assumptions made during the calculation of the net gain of ATP?

Answer:

The assumptions made during the calculation of net gain of ATP are as follows:

(a) It is considered that various steps of aerobic respiration namely glycolysis, TCA cycle, and ETS occur in a sequential manner.

(b) NADH produced during glycolysis enters into mitochondria and undergo oxidative phosphorylation.

(c) It is assumed that it is only a glucose molecule that acts as a substrate.

(d) The intermediates produced during respiration are not utilized in any other metabolic pathway.

Question 9. Discuss "The respiratory pathway is an amphibolic pathway."

Answer:

In the process of respiration, various respiratory substrates are first broken down into simpler forms before they enter the respiratory pathway. The fate of various respiratory substrates are as follows:

a. Carbohydrate is broken down into glucose with which glycolysis starts.

b. Fat is broken down into fatty acids and glycerol. Fatty acid breaks into acetyl CoA and then enters the respiratory pathway.

c. Proteins are converted into amino acids, which enter respiration after deamination.

Here all the substrates are broken so we can say that respiration is a catabolic process.

On the other hand, when the organism needs to synthesize fatty acids, acetyl CoA is withdrawn from the respiratory pathway. The same thing happens during the breakdown and synthesis of protein also.

Hence we see that respiration is the process where we get the substances for the synthesis of various compounds. This process is called anabolism. Hence as the respiratory pathway involves both anabolism and catabolism, so it is referred to as an amphibolic pathway.

Question 10. Define RQ. What is its value for fats?

Answer:

The ratio of the volume of carbon dioxide evolved to the volume of oxygen consumed in respiration is called the respiratory quotient. It is given as

RQ = volume of CO_2 evolved volume of O2 consumed

The respiratory quotient depends upon the type of respiratory substrate used during respiration.

When fats are used in respiration, the RQ is less than 1. For example- Calculations of RQ for a fatty acid tripalmitin is given as below:

$2(C_5H_{98}O_6) + 145O_2 \rightarrow 102\ CO_2 + 98\ H_2O$

RQ = volume of CO2 evolved volume of O2 consumed

= 102 /145 = 0.7

Question 11. What is oxidative phosphorylation?

Answer:

The generation of ATP from ADP during the electron transport system by using the energy obtained from oxidation-reduction reactions is called oxidative phosphorylation. The process of oxidative phosphorylation is facilitated by the enzyme ATP synthase (complex V). This enzyme complex consists of F0 - F1 particles. For every two protons passing through F0–F1 particle, one ATP molecule is synthesized.

Question 12. What is the significance of the step-wise release of energy in respiration?

Answer:

The process of aerobic respiration is divided into four steps – glycolysis, TCA cycle, ETS, and oxidative phosphorylation. During oxidation, all the energy is not released in a single step. It is released in a series of slow step-wise reactions which are controlled by various enzymes. This energy is trapped as chemical energy in the form of ATP. The significance of this step-wise release of energy is that this energy is used to synthesize ATP. This ATP is stored for later use. Thus, ATP acts as the energy currency of the cell. This stored energy can be utilized in performing various life processes.