Chapter-14

RESPIRATION IN PLANTS

POINTS TO REMEMBER

Aerobic respiration : Complete oxidation of organic food in presence of oxygen thereby producing CO_2, water and energy.

Anaerobic respiration : Incomplete breakdown of organic food to liberate energy in the absence of oxygen.

ATP Synthetase : An enzyme complex that catalyses synthesis of ATP during oxidative phospho-relation.

Biological oxidation : Oxidation in a series of reaction inside a cell.

Cytochromes : A group of iron containing compounds of electron transport system present in inner wall of mitochondria.

Dehydrogenase : Enzyme that catalyses removal of H atom from the substrate.

Electron acceptor : Organic compound which recieve electrons produced during oxidation-reduction reactions.

Electron transport : Movement of electron from substrate to oxygen through respiratory chain during respiration.

Fermentation : Breakdown of organic substance that takes place in certain microbe like yeast under anaerobic condition with the production of CO_2 and ethanol.

Glycolysis : Enzymatic breakdown of glucose into pyruvic acid that occurs in the cytoplasm.

Oxidative phosphorylation : Process of formation of ATP from ADP and Pi using the energy from proton gradient.

Respiration : Biochemical oxidation food to release energy.

Respiratory Quotient : The ratio of the volume of CO_2 produced to the volume of oxygen consumed.

Proton gradient : Difference in proton concentration across the tissue membrane.

Mitochondrial matrix : The ground material of mitochondria in which

pyruvic acid undergoes aerobic oxidation through Kreb's cycle.

Abbreviations

ATP	–	Adenosine tri phosphate
ADP	–	Adenosine di phosphate
NAD	–	Nicotinamide Adenine dinucleotide
NADP	–	Nicotinamide Adenine dinucleotide Phosphate
NADH	–	Reduced Nicotinamide Adenine dinucleotide
PGA	–	Phosphoglyceric acid
PGAL	–	Phospho glyceraldehyde
FAD	–	Flavin adenine dinucleotide
ETS	–	Electron transport system
ETC	–	Electron transport chain
TCA	–	Tricarboxylic acid
OAA	–	Oxalo acetic acid
FMN	–	Flavin mono nucleotide
PPP	–	Pentose phosphate pathway

AEROBIC RESPIRATION

The overall mechanism of aerobic respiration can be studied under the following steps :

(A) Glycolysis (EMP pathway)

(B) Oxidative Decarboxylation

(C) Kreb's cycle (TCA-cycle)

(D) Oxidative phosphorylation

Glycolysis : The term has originated from the Greek word, *glycos* = glucose, *lysis* = splitting or breakdown means breakdown of glucose molecule.

- It is also called Embeden-Meyerhof-Paranus pathway. (EMP pathway)
- It is common in both aerobic and anaerobic respiration.
- It takes place outside the mitochondria, in the cytoplasm.
- One molecule of glucose (Hexose sugar) ultimately produces two molecules of pyruvic acid through glycolysis.

- During this process 4 molecules of ATP are produced while 2 molecules of ATP are utilised. Thus net gain of ATP is of 2 molecules.

Oxidative decarboxylation : Pyruvic acid is converted into Acetyle CoA in presence of pyruvate dehydrogenase complex.

$$\text{Pyruvic acid} + \text{CoA} + \text{NAD}^+ \xrightarrow[\text{Pyruvate dehydrogenase}]{Mg^{2+}} \text{Acetyle CoA} + CO_2 + \text{NADH} + H^+$$

The Acetyle CoA enters in TCA cycle.

Tri Carboxylic Acid Cycle (Kreb's cycle) or Citric acid Cycle : This cycle starts with condensation of acetyle group with oxaloacitic acid and water to yield citric acid which undergoes a series of reactions.

- It is aerobic and takes place in mitochondrial matrix.
- Each pyruvic acid molecule produces 4 NADH + H^+, one $FADH_2$, one ATP.
- One glucose molecule has been broken down to release CO_2 and eight molecules of NADH + H^+, two molecules of $FADH_2$ and 2 molecules of ATP.

Electron transport system and oxidative phosphorylation : The metabolic pathway through which the electron passes from one carrier to another, is called Electron transport system and it is present in the inner mitochondrial membrane.

ETS comprises of the following :

(i) NAD and NADH + H^+

(ii) FAD and $FADH_2$

(iii) UQ (Ubquinone)

(iv) Cyt b, Cyt c_1, Cyt c, Cyt a and Cyt a_3.

Oxygen acts as final hydrogen acceptor. The oxidation of $NADH_2$ or $FADH_2$ occurs by transfer of their electrons to a series of electron acceptors and finally they combine with oxygen to form water and ATP. The oxidation of each molecule of $NADH_2$ and $FADH_2$ give rise to 3 ATP and 2 ATP molecules respectively.

Oxidative Phasphorylation :

The synthesis of ATP from ADP and inorganic phosphate using energy from proton gradient is called oxidative phosphorylation. This takes place in elementry particles present on the inner membrane of cristae of mitochondria. This process in mitochondria is catalysed by ATP synthetase (complex V). This complex has two major components F_0 and F_1. F_0 acts a channel for proton and F_1 acts as an ATP synthetase.

Total ATP Production

Process	Total ATP produced
1. Glycolysis	$2ATP + 2NADH_2$ (6ATP) = 8ATP
2. Oxidative decarboxylation	$2NADH_2$ (6ATP) = 6ATP
3. Kreb's Cycle	$2GTP$ (2ATP) + $6NADH_2$ (18ATP) + $2FADH_2$ (4ATP) = 24ATP

Energy production in prokaryotes during aerobic respiration = 38 ATP

Energy production in eukaryotes during aerobic respiration = 38 – 2 = 36 ATP

(2ATP are used up in transporting 2 molecule of pyruvic acid in mitochondria.)

Fermentation : It is the process of anaerobic respiration which occurs in yeast and some bacteria. Fermentation involves incomplete oxidation of food into ethanol and carbon-di-oxide. It results in the production of 2 ATP molecules.

$$\text{glucose} \rightarrow \text{Pyruvic Acid} \rightarrow \text{Ethanol} + Co_2$$

Anaerobic respiration in muscles : During strenuous exercise a person feels pain and fatigue in his muscles. This is due to accumulation of lactic acid in muscles. When oxygen inadequate pyruvic acid is reduced to lactic acid in presence of enzyne-lactic dehydrogenase

$$\text{Pyruvic acid} \xrightarrow{\text{Lactic dehydrogenase}} \text{Lactic acid}$$

During rest, lactic acid is reconverted to pyruvic acid.

Respiratory pathway as on Amphibolic pathway

During the process of cellular respiration Carbohydrates, fats and protiens are broken down to release energy and hence respiration is a catabolic process/catabolic pathway. From this pathway many compound are withdrawn for synthesis of substrates. Here some anabolic processes are –

– Acetyle Co A is with drawn for the synthesis of fat

– Respiratory intermediate in many plants are linked for formation of protien

Because repiratory pathway is involved in both catabolism and anabolism, it is better to consider the respiratory pathway as an anphibolic pathway

QUESTIONS

Very Short Answer Questions (1 mark each)

1. Name the molecule which is terminal acceptor of electron.
2. How many ATP molecules are produced from a molecule of glucose on it complete oxidation in eukaryotes ?
3. Where does ETC found in eukaryotic cell ?
4. Name the enzyme which convert sugar into glucose and fructose.
5. How many molecules of ATP are produced by the oxidation of one molecule of $FADH_2$?
6. Why do the person with sufficient white fibres get fatigued in a short period ?
7. Write the name of end product of glycolysis.
8. Name the first product formed in Kerb's cycle.

Short Answer Questions-II (2 marks each)

9. Differentiate between aerobic respiration and anaerobic respiration.
10. Mention two steps of glycolysis in which ATP is utilised.
11. Why does anaerobic respiration produces less energy than aerobic respiration ?
12. Define Respiratory Quotient. What is its value for fat and protein ?
13. Distinguish between glycolysis and fermentation.
14. What are respiratory substrates ? Name the most common respiratory substrate.

Short Answer Questions-I (3 marks each)

15. Give the schematic representation of an overall view of TCA cycle.
16. Where does electron transport system oparative in mitochondria ? Explain the system giving the role of oxygen ?
17. Give a brief account of ATP molecules produced in aerobic respiration in eukaryotes.
18. Discuss The respiratory pathway is an amphibolic pathway

Long Answer Questions (5 marks each)

19. What is glycolysis ? Where does glycolysis takes place in a cell ? Give schematic representation of glycolysis.

ANSWERS

Very Short Answers (1 mark each)

1. Oxygen.

2. 36 ATP.

3. Mitochondrial membrane.

4. Invertase.

5. 2 ATP molecules.

6. due to formation of Lactic acid.

7. Pyruvic acid.

8. Citric acid.

Short Answers-II (2 marks each)

9. Refer NCERT Text Book Chapter 14 (14.3 and 14.4).

10. (i) ATP molecules are formed by direct transfer of Pi to ADP.

(ii) By oxidation of NADH.

11. Refer NCERT Tex Book Chapter 14, Page 230.

12. Refer NCERT Text Book Page no. 236.

13. Refer NCERT Text Book Page no. 229 and page no. 230.

14. Refer NCERT Text Book Page no. 227.

Short Answers-I (3 marks each)

15. Refer NCERT Text Book, Fig. 14.3 Page no. 232.

16. Refer NCERT Text Book Page no. 232 and page no. 233.

17. Refer notes.

18. Refer NCERT Text Book Page no. 235.

Long Answers (5 marks each)

19. Refer NCERT Text Book Page no. 228 and page no. 229.