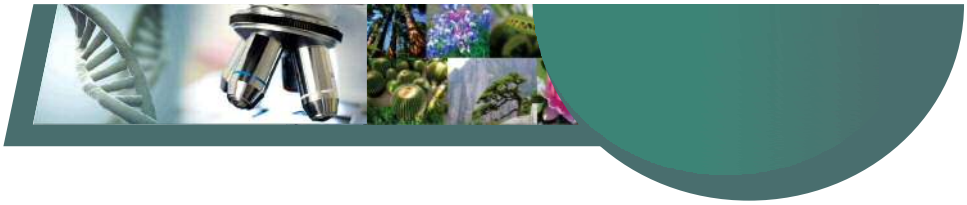

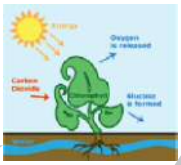

Chapter - 14

Respiration in Plants

Points To Remember

Aerobic respiration : Complete oxidation of organic food in presence of oxygem therby 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 catalysis 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 tranaport system present in inner wall of mitochondria.

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

Electron acceptor : Organic compound which receive electrrons produced during oxidation-reduction reactions.

Electron trnasport : 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.

Respriation : 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.

Electron Transport Chains (ETC)—A series of co-enzymes and electron/ carries where electrons can pass along increasing redox potential losing a bit of energy at every step of transfer.

Abbreviations

ATP	—	Adenosine tri phosphate
ADP	—	Adenosne 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 **(Cycle)**
OAA	—	Oxalo acetic acid
FMN	—	Flavin mono nucleotide
PPP	—	Pentose phosphate pathway

Cellular Rispiration—The process of oxidation/breakdown of food materials within the cell to release energy. Respiratory substarate to be oxidized 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 :

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy (36ATPs)}$$

Aerobic Respiration

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

(A) Glycolysis (EMP pathway) in cytoplasm

(B) Oxidative Decarboxylation—(Gateway Reaction)—in Mitochondrial matrix

(C) Kreb's cycle (TCA—cycle)—Matrix of mitochondria

(D) Oxidative phosphorylation

A. Glycolysis : The term has origianted from the Greek word, *glycos* = glucose, *lysis* = splitting, or breakdown means breakdown of glucose molecule to pyruvic acid. It was given by Embden Meyerhof and Parnas. It is a chainof 10 reactions to convert glucose into pyruvate. It is common for acerobic and anaerdomic respiration.

Steps for Glycolysis—(EMP Pathway)

1. Phosphorylation of glucose 2. Formation of fructose 6—phosphate 3. Second phosphorylation 4. Lysis (splitting) 5. Isomerisation of DiHAP 6. Oxidation 7. Substrate Level ATP synthesis 8. Isomerisation or Rearrangement 9. Dehydration 10. Substrate Level ATP Synthesis and formation of Pyruvate.
   - It is also called Embden—Meyerhof—Paranas pathway. (EMP pathway)
   - It is common in both aerobic and anaerobic respiration.
   - It takes palce 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 ATP are utilised. Thus net gain of ATP is of 2 molecules.

Input and Output of glycolysis

S. No.	Input	Output
1.	Glucose (6—C) —1 molecule	Pyruvate (3—C) 2 molecules
2.	2 ATP	2 ADP
3.	4 ADP + 2 Pi	4 ADP + $2H_2O$
4.	2 NAD^+	2 NADH (H^+)

Net out put ..... 2 Pyruvate + 2ATP + 2NADH (+ H^+) OR 2 Pyruvate + 8 ATP

The pyruvate, so produced, may under go (i) Lactic acid fermentation, Alcoholic fermentation of Aerobic Respiration (Krebs Cycle)

B. 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.

C. Tri Carboxylic Acid Cycle (Kereb's cycle) or Citric acid Cycle : This cycle starts with condensation of acetyle group with oxaloacitic acid and water t o yield citric acid which under goes a series of reactions.

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

Compensation Point : It is the value of a factor at which the rate of photosynthesis controlled by it is just equal to the rate of respiration and photorespiration so that there is not net exchcange of gases between the phtosynthetic organ and the environment.

At compensation point the photosynthetic tissue manufacture only such amount of food which of sufficient for it to remain alive. No food is supplied to rest of the plant. Therefore, net photosynthesis is zero.

(D) Oxidative Phosphorylation

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 synthestase (complex V). This compmlex has two major components F_0 and and F_1, F_0 acts a channel for proton and F_1 acts as an ATP synthetase.

Electron Transport System and Oxidative Phosphorylation

Name of Complex	Components of ETS
Complex I	FMN and Fe-S are prosthetic groups and NADH dehydrogenase
Complex II	$FADH_2$ dehydrogenase (succinate dehydrogenase), Fe-S, UQ
Complex III	Cytochrome bc, complex–cytochrome b, cytochrome C, Fe-S, UQ
Complex IV	Cytochrome Coxidase–Cytochrome a_1, cytochrome a_3 which posses two copper centres.
Complex V	F_0–F_1 particles Flow of protein through F_0 channel induces F_1 partcile to function as ATP synthatase.

Respiratory Balance Sheet :

$$\text{glucose} + 6O_2 + 36ADP + 36Pi \rightarrow 6CO_2 + 6H_2O + 36\ ATP$$

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) = 24 ATP

Energy production in prokaryotes during aerobic respiration = 38 ATP

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

In eukaryotes 2 ATP are used in transporting 2 molucules of $NADH + H^+$ formed in glycolysis from cytoplasm to mitochandria for oxidation through ETS shuttle.

(2) **Anaerobic Rispiration**—In anaerobic respiration, Glycolysis is followed by formation of Ethylacl ohol, lactic acid in the cytoplasm.

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

$$\text{glucose} \longrightarrow \text{Pyruvic Acid} \xrightarrow[2NADH_2 \quad 2NAD]{\text{Decarboxylase / Alcohol dehydrogenase}} \text{Ethanol} + CO_2$$

(i) Conversion of Acetyl CoA into fatty acid and PGA.

(ii) Synthesis of chlorophyll and cytochromes from Succinyl CoA

(iii) Synthesis of Amino acids from OAA and α-ketoglutase acid

(iv) Synthesis of Alkaloid from OAA.

Enzymes involved-Pyruvic acid decarboxylase, Alcohol dehydrogenase

Anaerobic respiration in muslces : During vigrous 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.

$$\text{Pyruvic Acid} \xrightarrow[2NADH_2 \quad 2NAD]{\text{Lacticdehydrogenase}} \text{Lactic acid}$$

During rest lactic acid is reconverted to pyruvic acid.

Amphibolic Pathway :

During the process of cellular respiration Carbohydrates, fats and protiens are broken down t o release energy and hence respiration is a catabolic process/ catabolic pathway. From t his pathway many compund are wit hdarw for synthesis of substrates. Some anabolic prcesses are—repiratory pathway is involved in both catabolism and anabolism, it is better to consider the respiratory pathway as an amphibalic pathway.

RQ (Respiratory quotient)

(a) RQ = 1 (When carbohydrate is used as substrate)

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6\ H_2O$ + Energy

(b) RQ is less than 1 (*i.e.,* < 1) for fats.

$2C_{51}H_{98}O_6 + 145O_2 \rightarrow 102CO_2 + 98\ H_2O$ + Energy

$$\text{R.Q.} \Rightarrow \frac{102\ CO_2}{145\ O_2} = 0.7$$

(c) RQ is 0.9 for proteins.

(d) RQ is more than 1 (*i.e.,* > 1) for organic acids.

(e) RQ is inifinite in case of anerobic respiration, because CO_2 is evolved but O_2 is not consumed.

Questions

Very Short Answer Question (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 Kreb's cycle.
9. Define the term 'Respiratory substrate'.

10. Which intermediate undergoes lysis in glycolysis ?
11. Write the other two names of Krebs cycle.
12. Name the acceptor molecule of Krebs cycle.
13. Name the substrate entrant of Krebs cycle.
14. Name the first chemical produced in Krebs cycle.
15. What is Electron Transport Chain ? (ETC).
16. F_0–F_1 Protein complexes participate in the synthesis of .....

Short Answer Questions-I (2 mark each)

17. Differentiate between aerobic respiration and anerobic respiration.
18. Mention two steps of glycolysis in which ATP is utilised.
19. Why does anaeriobic respiration produces less energy than aerobic respiration ?
20. Define Respiration Quotient. What is its value for fat and protein ?
21. Distinguish between glycolysis and fermentation.
22. What are respiratory substrates ? Name the most common respiratory substrate.

Short Answer Questions-II (3 marks each)

23. Pyruvic acid is the end product of glycolysis. What are the three metabolic fates of pyruvic acid under aerobic and anaerobic conditions ?
24. Give the schematic representation of an overall view of TCA cycle.
25. Where does electron transport system operative in mitochondria ? Explain the system giving the role of oxygen ?
26. Give a brief account of ATP molecules produced in aerobic respiration in eukaryotes.
27. Discuss the respiratory pathway is an amphibolic pathway.
28. Exapnd ETC., ETS and TCA.

Long Answer Questions (5 marks each)

29. 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 membrance.
4. Invertase.
5. 2 ATP molecules.
6. due to formation of Lactic acid.
7. Pyruvic acid.
8. Citric acid.
9. The organic substances which is catabolised or brokendown enzymatically in cellular respiration for releasing energy.
10. Frutosel, 6-bisphosphate.
11. (i) Citric acid cycle (ii) Tricarboxylic acid cycle.
12. Oxaloacetate.
13. Acetyl Co-A.
14. Citrate
15. See text (Points to remember)
16. ATP

Short Answers-I (2 mark each)

17. Refer NCERT Text Book Chapter 14 (14.3 and14.4).
18. (i) ATP molecules are formed by direct transfer of Pi to 'ADP'.
    (ii) By oxidation of NADH.
19. Refer NCERT Text Book Chapter 14, Page 230.
20. Refer NCERT Text Book Page no. 236.
21. Refer NCERT Text Book Page no. 229 and page no. 230.
22. Refer NCERT Tex Book Page no. 227.

Short Answers-II (3 marks each)

23. (i) Aerobic conditions–$CO_2 + H_2O$ + Energy

    (ii) Anaerobic conditions–(fermentation)

(a) In muscles – Lactic acid + Energy

(b) Yeast-Ehtanol + CO_2 + Energy

24. Refer NCERT Text Book Fig. 14.3 Page 232.

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

26. Refer notes.

27. Refer NCERT Text Book Page no. 235.

28. Seet text (abbreviations).

Long Answers (5 mark each)

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