CHAPTER 14

Respiration in Plants

EXAM DRILL

ANSWERS

1. (d) : Cyt *c* oxidase acts as complex IV in electron transport chain.

2. (b)

3. (d)

OR

(b) : ATP synthase is located in the F_1 part of F_1-F_0 particle.

4. (b) : Lactic acid fermentation occurs in lactic acid bacteria (*e.g., Lactobacillus*), some fungi and muscles. In lactic acid fermentation, pyruvic acid produced in glycolysis is directly reduced by NADH to form lactic acid. No CO_2 is produced. The enzyme is lactate dehydrogenase which requires FMN and Zn^{2+}.

$$\text{Pyruvic acid} + \text{NADH} \xrightarrow[\text{FMN, } Zn^{2+}]{\text{Lactate dehydrogenase}} \text{Lactic acid} + NAD^+$$

5. (c) : Succinate dehydrogenase is the only enzyme of Krebs' cycle which is located in inner mitochondrial membrane, in eukaryotes and in cytosol in prokaryotes while all other enzymes of this cycle are located in the mitochondrial matrix.

6. (a)

7. 2 ATP is net ATP production in glycolysis.

8. Acetyl CoA is the entrant molecule and oxaloacetate is the receptor molecule in TCA cycle.

9. Succinyl CoA is the intermediate product between α-ketoglutaric acid and succinic acid in citric acid cycle.

10. Glucose is the common respiratory substrate.

11. (b)

12. (c) : the complete oxidation of pyruvate is a stepwise removal of all the hydrogen atoms, leaving three molecules of CO_2 in aerobic respiration. This process takes place is the matrix of the mitochondria.

13. (d) : Cytochrome *c* oxidase is the IV complex of electron transport system (ETS).

14. (b)

15. (i) (a)

(ii) (d)

(iii) (c) : Chemiosmotic coupling hypothesis, proposed by Peter Mitchell (Nobel Prize in 1978), is the most widely accepted theory for oxidative phosphorylation. Reduced NAD (*i.e.,* NADH), released from Krebs' cycle, when enters in the ETS, transports three pairs of H^+ across the inner mitochondrial membrane to the intermembrane space. Similarly, NADH from glycolysis and $FADH_2$ from Krebs' cycle also transport pairs of H^+ into intermembrane space. Each molecule of NADH released from glycolysis or $FADH_2$ from Krebs' cycle transports two pairs of protons into intermembrane space. This unidirectional flow of protons results in the accumulation of protons in the intermembrane space.

(iv) (a) : Oxidation of one molecule of NADH gives rise to 3 molecules of ATP while that of one molecule of $FADH_2$ produces 2 molecules of ATP.

(v) (a)

16. There are three methods in which cell utilises pyruvic acid produced *via* glycolysis. These are aerobic respiration (Krebs' cycle), alcoholic fermentation and lactic acid fermentation. The fermentation is carried out in anaerobic condition, generally in case of unicellular eukaryotes and prokaryotes.

17. Fermentation process is commercially utilised in industries. Microorganisms, in very large number, are cultured and are used in following processes:

(i) In bakeries, fermentation is used for preparing bread, biscuits and cakes.

(ii) In breweries, it is used in preparing several alcoholic drinks.

(iii) Fermentation is used in producing vinegar and in tanning and curing of leather.

(iv) In everyday life, this process is used in preparing curd, dhoklas, idlis, bhatura, etc.

18. The diagram depicts alcoholic fermentation. Alcoholic fermentation is a complex biochemical process during which yeasts convert sugars to ethanol, carbon dioxide and other metabolic byproducts that contribute to the chemical composition and properties of the fermented foodstuffs. 'X' in the given diagram is acetaldehyde.

19. (i) Cyanide- Cyanide poisons the mitochondrial electron transport chain (ETC) within cells and renders the body unable to derive energy from oxygen. Specifically, it binds to a_3 portion (complex IV) of cytochrome oxidase and prevents cells from using oxygen, causing rapid death.

(ii) Anitimycin- It prevents the electron transport between cytochrome *b* and cytochrome c_1 of ETC.
(iii) 2,4 dinitrophenol- It allows electron transport but prevents ATP synthesis.

20. The product of glycolysis is pyruvate which has to enter Krebs' cycle or TCA cycle for further oxidation. Pyruvate converts into acetyl CoA which in turn enters TCA cycle.
Pyruvate enters mitochondria through a specific transport protein. It then undergoes oxidative decarboxylation to produce CO_2 and NADH. The products combine with sulphur containing coenzyme A to form acetyl CoA or activated acetate. The reaction occurs in presence of enzyme pyruvate dehydrogenase. Acetyl CoA functions as substrate entrant for Krebs' cycle. It is also the connecting link between glycolysis and Krebs' cycle.

OR

(a) In alcoholic fermentation, the pyruvic acid from glycolysis loses one carbon in the form of carbon dioxide to form acetaldehyde, which is reduced to ethyl alcohol by NADH. When acetaldehyde is reduced to ethyl alcohol, NADH becomes NAD^+ (oxidised). This is the fermentation that commonly occurs in yeast.
(b) Ethyl alcohol does not stay inside microorganisms. It is excreted in the external media. Accumulation of alcohol beyond a certain limit can kill the microorganisms *e.g.*, 13% in yeast.

21. Equation for aerobic respiration is :
$C_6H_{12}O_6 + O_2 \longrightarrow 6CO_2 + 6H_2O$ + Energy (ATP)
Equation for anaerobic respiration is :
Glucose $(C_6H_{12}O_6) \longrightarrow 2C_2H_5OH + 2ATP$ (Alcohol fermentation)
Glucose $(C_6H_{12}O_6) \longrightarrow 2CH_3CHOHCOOH + 2ATP$ (Lactic acid fermentation)

22. (i) It is the phosphorylation step of glucose. Glucose is phosphorylated to glucose 6-phosphate by ATP in the presence of enzyme hexokinase.
(ii) It is isomerisation of DHAP. Dihydroxy acetone 3-phosphate is isomerised to glyceraldehyde 3-phosphate with the help of enzyme triose phosphate isomerase.
(iii) This step is dehydration. 2-phosphoglycerate is converted to phosphoenol pyruvate in the presence of enzyme enolase. A molecule of water is removed in the process.

23. In the given reaction, 'X' is pyruvic acid and 'Y' is acetyl CoA.
The reaction is oxidation of pyruvate. It is also known as the link reaction between glycolysis and Krebs' cycle. It takes place inside the mitochondria.

24. (i) The given flow chart represents a part of Krebs' cycle.
(ii) A- Citric acid or citrate
B- Isocitrate
C- α- ketoglutarate
(iii) Citrate is a six carbon compound; Isocitrate is also a six carbon compound and alpha- ketoglutarate is a five carbon compound.

OR

In lactic acid fermentation, NADH transfers its electrons directly to pyruvate, generating lactate as a byproduct. Lactate, which is just the deprotonated form of lactic acid, gives the process its name. The bacteria that make yogurt carry out lactic acid fermentation, as do the red blood cells in your body, which don't have mitochondria and thus can't perform cellular respiration. Muscle cells also carry out lactic acid fermentation, though only when they have too little oxygen for aerobic respiration to continue—for instance, when you've been exercising very hard. It was once thought that the accumulation of lactate in muscles was responsible for soreness caused by exercise, but recent research suggests this is probably not the case. Lactic acid produced in muscle cells is transported through the bloodstream to the liver, where it's converted back to pyruvate and processed normally in the remaining reactions of cellular respiration.

25. **(a)** ATP provides the cell with a way to handle energy in an efficient manner. The molecule can be charged, stored, and used as needed. Moreover, the energy from hydrolyzing ATP is delivered as a consistent amount. Harvesting energy from the bonds of several different compounds would result in energy deliveries of different quantities.
(b) In a circular pathway, the final product of the reaction is also the initial reactant. The pathway is self-perpetuating, as long as any of the intermediates of the pathway are supplied. Circular pathways are able to accommodate multiple entry and exit points, thus being particularly well suited for amphibolic pathways. In a linear pathway, one trip through the pathway completes the pathway, and a second trip would be an independent event.
(c) Citrate can inhibit phosphofructokinase by feedback regulation.

26. Respiration involving carbohydrates and fats is called floating respiration whereas that involving proteins as respiratory substrate is called protoplasmic respiration. Protoplasmic respiration cannot be continued for long as it depletes some important structural and functional proteins as well as liberates toxic ammonia.

Different respiratory substrates are as follows:
(i) Carbohydrates: Starch and sucrose are the most important respiratory substrates. The most common respiratory substrate is glucose. It is a hexose monosaccharide. Another related compound is fructose. Glucose is formed from storage carbohydrates like starch in most plants and from glycogen in animals and fungi.

(ii) Fats: Fats are used as respiratory substrates in oily seeds, *e.g.*, castor seeds. Fats are also used as respiratory substrates by a number of organisms because they contain more energy as compared to carbohydrates. However, fats are not directly used in respiration. Instead they are first broken down to fatty acids and then into intermediates common to glucose oxidation, *viz.*, acetyl CoA, glyceraldehyde phosphate and enter Krebs' cycle.

(iii) Proteins: Proteins are used in respiration very rarely, as during germination of protein rich seeds and spores. Proteins are hydrolysed to form amino acids from which organic acids are produced through deamination. Some seeds are protein rich like, beans. In such seeds, protein serves as respiratory substrates. In animals, excess amino acids are regularly delaminated to produce organic acids. Organic acids enter Krebs' cycle, *e.g.*, aspartic acid, glutamic acid. At other times, proteins are employed as respiratory substrates under starvation conditions only when carbohydrates and fats become unavailable.

OR

The citric acid cycle captures the energy stored in the chemical bonds of acetyl CoA in a step-by-step process, trapping it in the form of high-energy intermediate molecules. The trapped energy from the citric acid cycle is then passed on to oxidative phosphorylation, where it is converted to a usable form of cellular energy, ATP. Krebs elucidated this cycle and explained how pyruvate is broken down to CO_2 and H_2O.

Significance of Krebs' cycle:

(i) Intermediate compounds formed during Krebs cycle are used for the synthesis of biomolecules like amino acids, nucleotides, chlorophyll, cytochromes and fats, etc.

(ii) Intermediates like succinyl CoA takes part in the formation of chlorophyll.

(iii) Amino acids are formed from α- Ketoglutaric acid, pyruvic acids and oxaloacetic acid.

(iv) Krebs' cycle (citric acid cycle) releases plenty of energy (ATP) required for various metabolic activities of cell.

(v) By this cycle, carbon skeleton are obtained, which are used in process of growth and for maintaining the cells.

27. **(a)** Complex-V- When electrons are transferred from one carrier to next carrier *via* complexes 1 to IV in electron transport system (ETS), they are coupled to ATP synthase enzyme complex for production of ATP from ADP and inorganic phosphate (iP). Here, number of ATP molecules synthesised during ETS, depends on nature of electron donor. Oxidation of one molecule of NADH gives rise to 3 molecules of ATP, and one molecule of $FADH_2$ gives rise to 2 molecules of ATP. ATP synthase complex is called complex V. During transportation of electrons, hydrogen atoms split into protons and electrons. The electrons are carried by cytochromes. Before last stage, where hydrogen atom is accepted by oxygen to form water, the electrons again recombine with their protons. Oxygen acts as final hydrogen acceptor.

Oxidative Phosphorylation- The whole process, where oxygen effectively allows the production of ATP by phosphorylation of ADP, is called oxidative phosphorylation. In other words, synthesis of ATP is called phosphorylation, and as it takes place in presence of oxygen, it is called oxidative phosphorylation.

The enzyme required for synthesis of ATP, is called ATP synthase. This is located in F_1, or head piece of $F_0 - F_1$ or elementary particles. ATP synthase enzyme becomes active in ATP formation, where there is a proton gradient saving higher concentration of H_2.

ATP synthase, also known as complex V consists of two major components, *i.e.*, F_1 and F_0. The F_1 headpiece is a peripheral membrane protein complex and contains the site for formation of ATP from ADP and inorganic phosphate (Pi). Whereas, F_0 is an integral membrane mitochondrial-protein complex which forms the channel through which protons cross the inner membrane. The passage of protons through the channel is coupled to the catalytic site of the F_1 component for the production of ATP.

OR

(a) Intermediates of glycolysis are used for synthesis of important biochemicals.

(i) Phosphoenol pyruvate yields shikimic acid which is a used in synthesis of amino acids, tryptophan, tyrosine and phenylalanine.

(ii) Tryptophan is raw material for indole acetic acid (IAA) synthesis. The amino acids are employed for the synthesis of proteins, alkaloids, flavonoids and lignin.

(iii) Pyruvic acid forms amino acid alanine.

(b) Amphibolic pathway is the one which is used for both breakdown (catabolism) and build-up (anabolism) reactions. Respiratory pathway is mainly a catabolic process which serves to run the living system by providing energy. The pathway produces a number of intermediates. Many of them are raw materials for building up both primary and secondary metabolites. Acetyl CoA is helpful not only in using fatty acids in Krebs' cycle but is also raw material for synthesis of fatty acids, steroids, terpenes, aromatic compounds and carotenoids. α-ketoglutarate is an organic acid which forms glutamate (an important amino acid) on amination. (iii) Oxaloacetate on amination produces aspartate (another important amino acid). (iv) Both aspartate and glutamate are components of proteins. Pyrimidines and alkaloids are other products. (v) Succinyl CoA forms cytochromes and chlorophyll.

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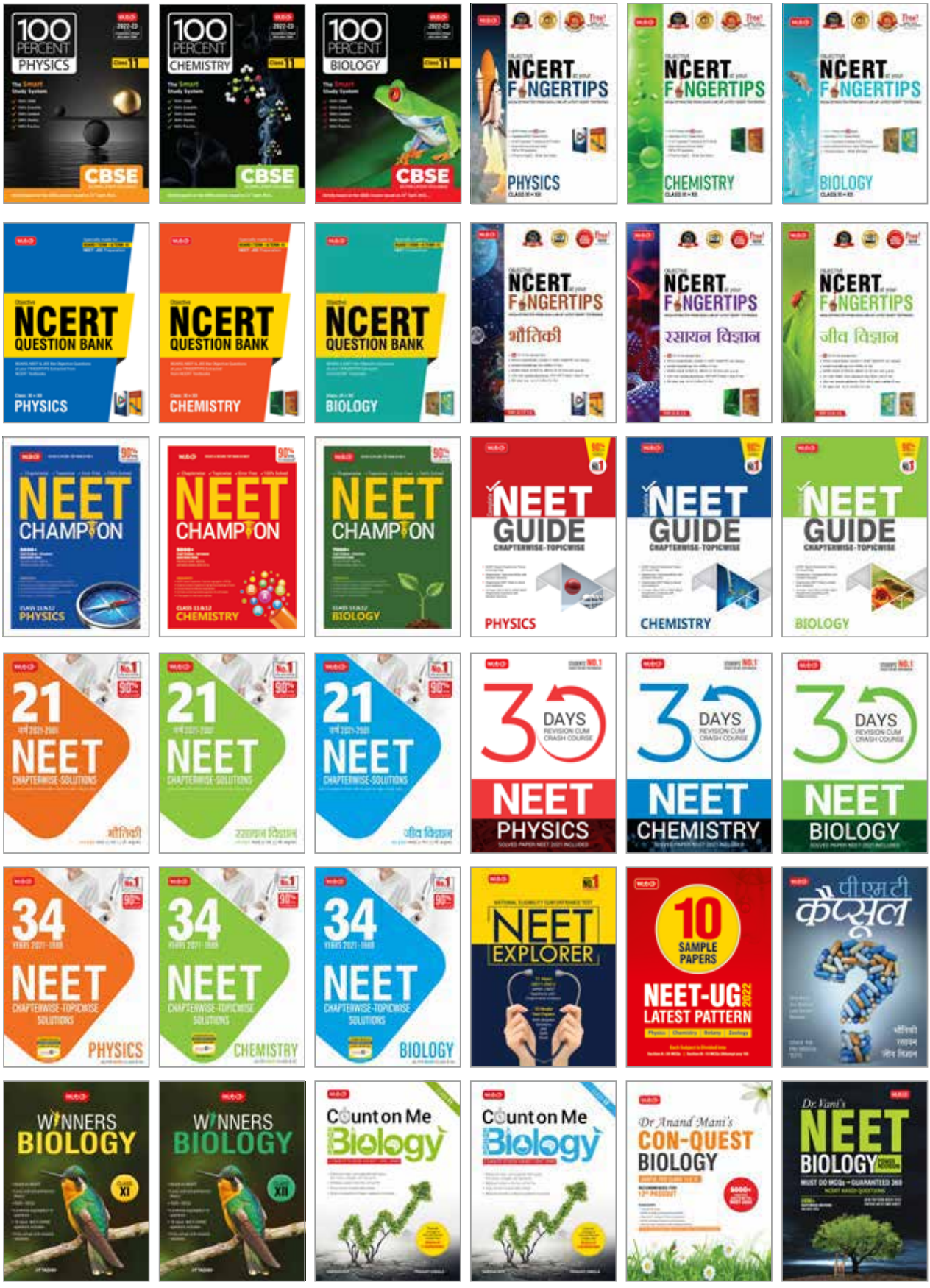

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