14

Respiration in Plants

Multiple Choice Questions (MCQs)

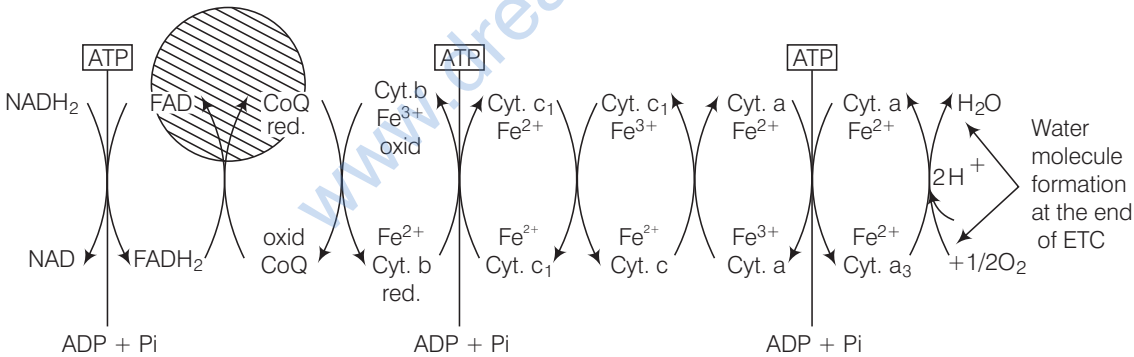
Q. 1 The ultimate electron acceptor of respiration in an aerobic organism is

(a) cytochrome (b) oxygen (c) hydrogen (d) glucose

Thinking Process

Oxygen is the driving force for respiration in aerobic conditions.

Ans. ***(b)*** Oxygen is the ultimate hydrogen acceptor in aerobic respiration because at the end of electron transport chain it accepts a pair of electron and combines with hydrogen atom to form water molecule.



Q. 2 Phosphorylation of glucose during glycolysis is catalysed by

(a) phosphoglucomutase (b) phosphoglucoisomerase
(c) hexokinase (d) phosphorylase

Ans. ***(c)*** **Hexokinase** catalyses the conversion of glucose into glucose 6-phosphate by the use of ATP molecule in phosphorylation reaction.

The other options are incorrect because

Phosphoglucomutase is an enzyme that transfers a phosphate group in D-glucose monomer from 1-to 6 position of carbon in forward direction (changes glucose 1-phosphate to glucose-6 phosphate).

Phosphoglucoisomerase catalyses conversion of glucose 6 phosphate to fructose 6 phosphate.

Phosphorylase is an enzyme which catalyses the addition of phosphate PO_4^- group from inorganic phosphate to an acceptor.

www.dreamtopper.in

Q. 3 Pyruvic acid, the key product of glycolysis can have many metabolic fates. Under aerobic condition it forms

(a) lactic acid
(b) $CO_2 + H_2O$
(c) acetyl Co - A + CO_2
(d) ethanol + CO_2

Thinking Process

Glycolysis occurs in the cytosol of the living cell and produces two pyruvic acid molecules from one glucose molecule

Ans. ***(c)*** Pyruvate, the product obtained through glycolysis, gets oxidised with the loss of its carboxy group as CO_2, to give acetyl Co-A, under aerobic condition. This acetyl Co-A is further oxidised completely to $CO_2 + H_2O$ in citric acid cycle. Other options are incorrect as

Lactic acid is formed in muscles under anaerobic conditions.

Ethanol and CO_2 are products of anaerobic respiration in yeast cells.

CO_2 and H_2O are final and complete reaction products released at the end of cellular respiration.

Q. 4 Electron Transport System (ETS) is located in mitochondrial

(a) outer membrane
(b) inter membrane space
(c) inner membrane
(d) matrix

Ans. ***(c)*** Electron transport system is present in the inner mitochondrial membrane, which has groups of several proton (H^+) and electron (e^-) acceptors.

Q. 5 Which of the following exhibits the highest rate of respiration?

(a) Growing shoot apex
(b) Germinating seed
(c) Root tip
(d) Leaf bud

Thinking Process

All metabolically active cells and tissues have high rate of respiration

Ans. ***(b)*** **Germinating seeds** have the highest rate of respiration. As soon as the water is imbibed by seeds, hydrolytic enzymes come into action and mobilise the reserve food materials so the seeds show high metabolic activity and germinate into a tiny plant.

All these activities require energy, which is derived from increased rate of respiration.

Q. 7 Mitochondria are called powerhouses of the cell. Which of the following observations support this statement?

(a) Mitochondria synthesise ATP
(b) Mitochondria have a double membrane
(c) The enzymes of the Krebs' cycle and the cytochromes are found in mitochondria.
(d) Mitochondria are found in almost all plants and animal cells.

Ans. ***(a)*** Mitochondria are a double membrane bound structures and are the site of ATP production which is the energy currency of the cell.

The rest of the statements, though are correct but, does not verify and support the fact that mitochondria are the powerhouses of the cell.

www.dreamtopper.in

Q. 8 The end product of oxidative phosphorylation is

(a) NADH (b) oxygen (c) ADP (d) ATP + H_2O

Thinking Process

Formation of ATP from ADP + Pi under certain set of enzymatically controlled reaction is called phosphorylation.

Ans. ***(d)*** Complete oxidation of glucose molecule produces 38 ATP molecules, water and carbon dioxide with the help of energy released during oxidation of reduced co-enzymes. This process is called oxidation phosphorylation.

Q. 9 Match the following columns.

	Column I		Column II
A.	Molecular oxygen	1.	α- ketoglutaric acid (1)
B.	Electron acceptor	2.	Hydrogen acceptor (A)
C.	Pyruvate dehydrogenase	3.	Cytochrome- *c* (B)
D.	Decarboxylation	4.	Acetyl Co - A (C)

Codes

	A	B	C	D
(a)	2	3	4	1
(c)	2	1	3	4

	A	B	C	D
(b)	3	4	2	1
(d)	4	3	1	2

Ans. ***(a)*** **Molecular oxygen** ultimately combines with hydrogen to form water at the end of Electron Transport Chain (ETC).

Cytochrome-*c* is an electron acceptor in ETS.

Pyruvate dehydrogenase catalyses reaction converting pyruvic acid into acetyl Co- A. Decarboxylation oxalosuccinate forms **α-ketoglutaric acid** in a decarboxylation reaction.

www.dreamtopper.in

Very Short Answer Type Questions

Q. 1 Energy is released during the oxidation of compounds in respiration. How is this energy stored and released as and when it is needed?

Thinking Process

Adenosine Triphosphate (ATP) molecules are the energy currency of every living cell.

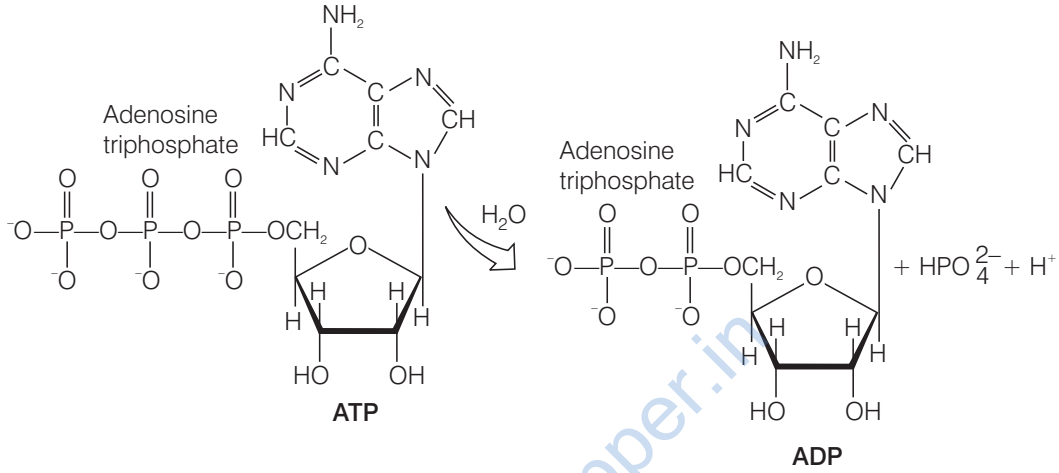
Ans. Complex organic food molecules such as sugars, fats and proteins are rich sources of energy for cells because much of the energy used to form these molecules is stored within the chemical bonds that hold them together. The cells release the stored energy through a series of oxidation reactions.

During each oxidation reaction involved in food breakdown, the product of reaction has a lower energy content than the donor molecule. At the same time, electron acceptor molecules capture some of the energy lost during oxidation and store it for later use.

Cells convert the energy from oxidation reactions to energy-rich molecules such as ATP which can be used throught the cell to power metabolism and construct new cellular components.

Q. 2 Explain the term 'energy currency'. Which substance acts as energy currency in plants and animals?

Ans. The term energy currency refers to that molecule which provides energy for cellular activities, whenever required. ATP is termed as energy currency because the energy is present in the form of high energy bonds of ATP. Other energy yielding molecules are GTP, CTP, UTP, etc.



The conversion of ATP to ADP yields about 7.3 kcal/mol of energy. This is the energy source in a variety of biological processes occurring in both plants and animals.

Justification for the term 'energy currency' for ATP can be given as

(i) Store small packets of energy as soon as it is available thus, minimising its wastage.

(ii) Can make energy available to a distant location in cell away from where the site it is produced.

(iii) Can carry out heavy work/activity by continuosly supplying large amount of energy through its accumulation at one place.

Q. 3 Different substrates get oxidised during respiration. How does Respiratory Quotient (RQ) indicate which type of substrate, *i.e.,* carbohydrate, fat or protein is getting oxidised?

$$R.Q. = \frac{A}{B}$$

What do *A* and *B* stand for?

What type of substrates have *R.Q.* of 1, < 1 or > 1?

Ans. The ratio of CO_2 evolved and consumption of O_2 in respiration is called the **Respiratory Quotient** (RQ) or respiratory ratio.

$$R.Q. = \frac{A}{B} = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ consumed}}$$

Substrates like carbohydrates have RQ = 1 during, aerobic respiration.

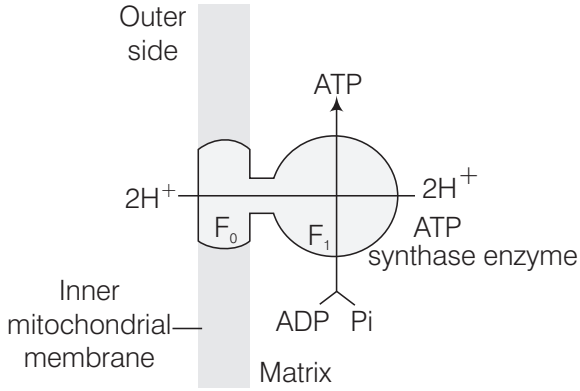
Proteins and fats have RQ of < 1 and it occurs during germination of seeds.

Substrates like organic acids have RQ of > 1 under aerobic conditions.

www.dreamtopper.in

Q. 4 F_0 - F_1 particles participate in the synthesis of ..... .

Ans. F_0 – F_1 particles present in the inner mitochondrial membrane are involved in the synthesis of ATP (Adenosine Triphosphate), the energy currency of the cell.



ATP synthesis by F_0 - F_1 particle

Q. 5 When does anaerobic respiration occur in man and yeast?

Thinking Process

Anaerobic respiration is the form of respiration occurring and using electron acceptors other than oxygen occurring.

Ans. (a) **In animals anaerobic respiration** occurs in the situation of deficiency of oxygen during heavy exercise when pyruvic acid is reduced to lactic acid by the enzyme lactate dehydrogenase.

(b) **In yeast, the incomplete oxidation of glucose** occurs under anaerobic conditions, where pyruvic acid is converted to CO_2 and ethanol by the action of enzyme pyruvic acid decarboxylase and alcohol dehydrogenase.

Q. 6 Which of the following will release more energy on oxidation? Arrange them in ascending order.

(a) 1 gm of fat
(b) 1 gm of protein
(c) 1 gm of glucose
(d) 0.5 gm of protein + 0.5 gm glucose

Thinking Process

Many biological organic molecules serve as substrate for cellular respiration and break down to produce energy in the form of ATP molecules

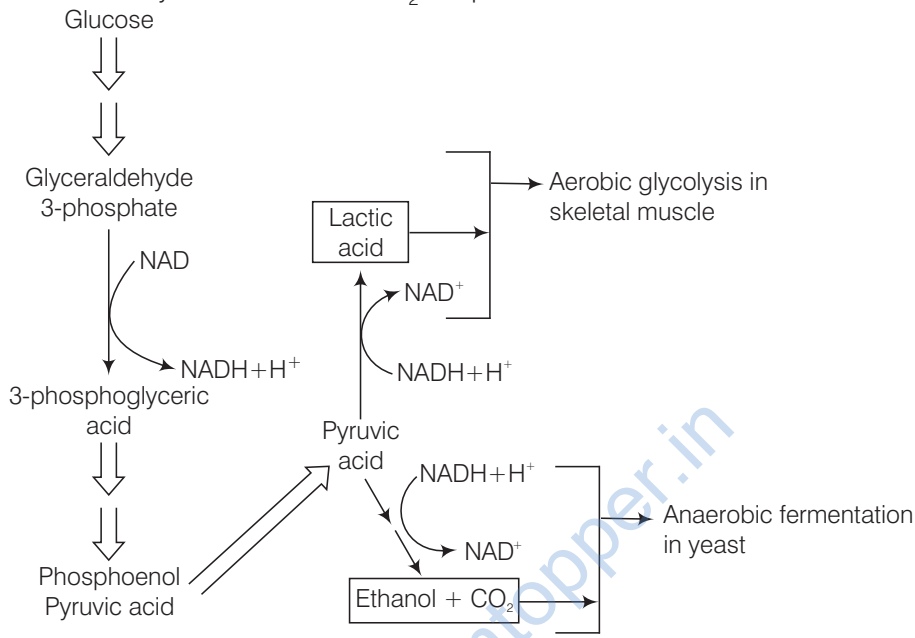
Ans. *The ascending order of substrate that will release more energy on oxidation will be as follows*

1 gm protein < 0.5gm In protein < 1 gm glucose < 1gm fat +0.5 gm glucose

www.dreamtopper.in

Q. 7 The product of aerobic glycolysis in skeletal muscle and anaerobic fermentation in yeast are respectively ..... and ..... .

Ans. The product of aerobic glycolysis in skeletal muscles is pyruvic acid while in anaerobic fermentation in yeast ethanol and CO_2 are produced.



Glucose as substrate in aerobic and anaerobic respiration

www.dreamtopper.in

Short Answer Type Questions

Q. 1 If a person is feeling dizzy, glucose or fruit juice is given immediately but not a cheese sandwich, which might have more energy. Explain.

Thinking Process

Energy is required by every living is cell to carry out its own metabolism and hence to stay alive.

Ans. The glucose as absorbed and reaches blood, giving instant energy. Whereas, cheese sandwich will require time for digestion, and absorption. Sick person requires immediate energy supply, so glucose or fruit juices contains glucose are given to them.

Q. 2 What is meant by the statement 'aerobic respiration is more efficient'?

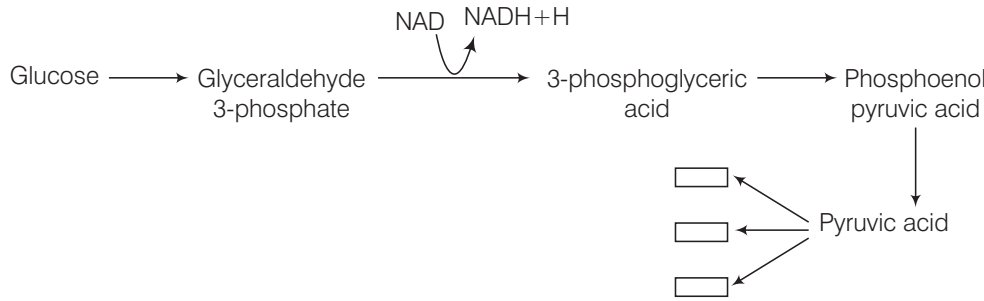
Thinking Process

Aerobic respiration is the process that leads to the complete oxidation of organic substances in the presence of oxygen and release of CO_2, water and energy.

Ans. In the process of aerobic respiration, a single molecule of glucose can yield up to 36 ATP molecules. However, in fermentation or anaerobic respiration there is net gain of only 2 molecules of ATP from each glucose molecule, which is comparatively much less than that of aerobic respiration.

Hence, aerobic respiration is more efficient process.

Q. 3 Pyruvic acid is the end product of glycolysis. What are the three metabolic fates of pyruvic acid under aerobic and anaerobic conditions? Write in the space provided in the diagram.



Ans. *The three metabolic products formed under aerobic and anaerobic conditions are*
(i) Lactic acid (ii) Ethanol (iii) Acetyl Co -A

Lactic acid is formed by the oxidation of pyruvic acid in under anaerobic condition in skeletal muscles.

Ethanol is formed by the oxidation of pyruvic acid in yeast under anaerobic condition.

Acetyl Co-A is formed by the oxidation of pyruvic acid that take place within the mitochondria under aerobic condition.

$$\text{Pyruvic acid} + \text{Co - A} + \text{NAD}^+ \xrightarrow[\text{Pyruvate dehydrogenase}]{\text{Mg}^{2+}} \text{Acetyl Co - A} + \text{CO}_2 + \text{NADH} + \text{H}^+$$

Q. 4 The energy yield in terms of ATP is higher in aerobic respiration than during anaerobic respiration. Why is there anaerobic respiration even in organisms that live in aerobic condition like human beings and angiosperms?

Thinking Process
Many ways of metabolism have evolved to give energy to metabolically active cells. Anaerobic respiration is one of them

Ans. Aerobic respiration occurs in normal conditions in human beings. Under intense conditions such as excercises heavy, muscles demand too much energy (ATP) and consume much more oxygen to produce that energy.

This high consumption leads to oxygen scarcity and the muscle cells begin to make lactic acid by anaerobic respiration to fulfill their energetic needs. Similarly, yeast cells under deficient conditions of oxygen carry out anaerobic respiration, forming ethyl alcohol and CO_2.

Q. 5 Oxygen is an essential requirement for aerobic respiration but it enters the respiratory process at the end? Discuss.

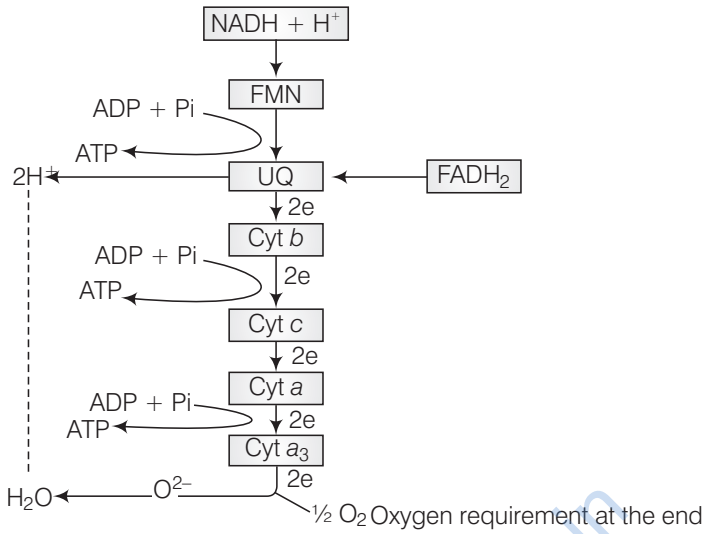
Ans. Aerobic respiration requires oxygen in order to generate ATP. Oxygen is strongly electronegative element and acts as final acceptor in respiratory process.

It pulls e^- (electrons) that energy from the electron transport chain ETC and take up protons from medium to form water.

O_2 enters in the respiratory process at the end, though it's presence is vital. It drives the process of aerobic respiration by removing hydrogen from the system. Thus, acting as final hydrogen acceptor.

www.dreamtopper.in

The energy is produced by the process of oxidative phosphorylation, utilising the energy of exidation reduction reactions.



Electron transport chain showing release of O_2 at end

Q. 6 Respiration is an energy releasing and enzymatically controlled catabolic process which involves a step-wise oxidative breakdown of organic substances inside living cells. In this statement about respiration explain the meaning of

(a) Step-wise oxidative breakdown

(b) Organic substances (used as substrates).

Ans. (a) Respiration is a stepwise oxidation of organic molecules in a cell involving main three steps.

(i) Glycolysis (ii) Krebs' cycle (iii) Electron transport chain

Glucose passes through series of enzymatically controlled reactions and is finally converted into H_2O + ATP + CO_2.

(b) Organic substances are the molecules normally found in living systems. They are usually composed of carbon atoms in rings or long chains to which other atoms such as hydrogen, oxygen and nitrogen are attached. *e.g.,* glucose, fatty acids, amino acids etc.

These molecules burnt as substrate to produce energy. Respiration of glucose and fatty acids is called floating respiration and respiration of protein and amino acids are called protoplasmic respiration.

Q. 7 Comment on the statement respiration is an energy producing process but ATP is being used in some steps of the process.

Thinking Process

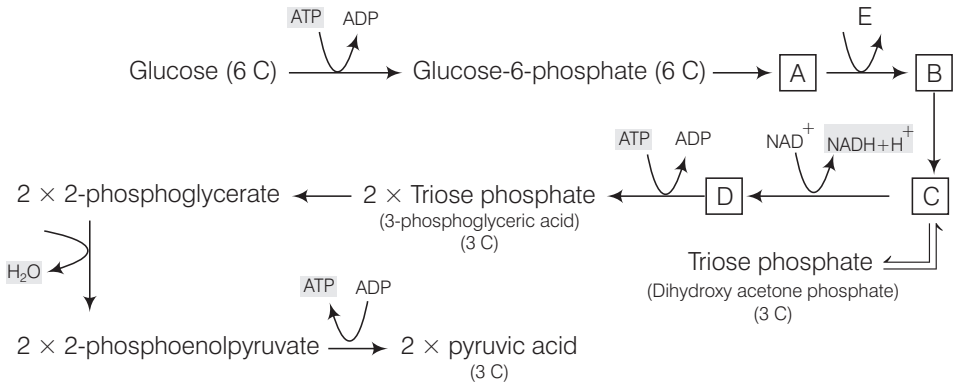
Energy is either produced or consumed in each metabolic reaction. Respiration involves many enzymatically controlled intermediate reactions

Ans. Respiration is necessary catabolic process which occurs in stepwise to produce energy. Whenever biological system requires energy it is provided by hydrolysis of ATP molecule. When one ATP is hydrolysed to ADP + Pi, *i.e.,* one phosphate bond is broken down, thus producing 73 kcal energy.

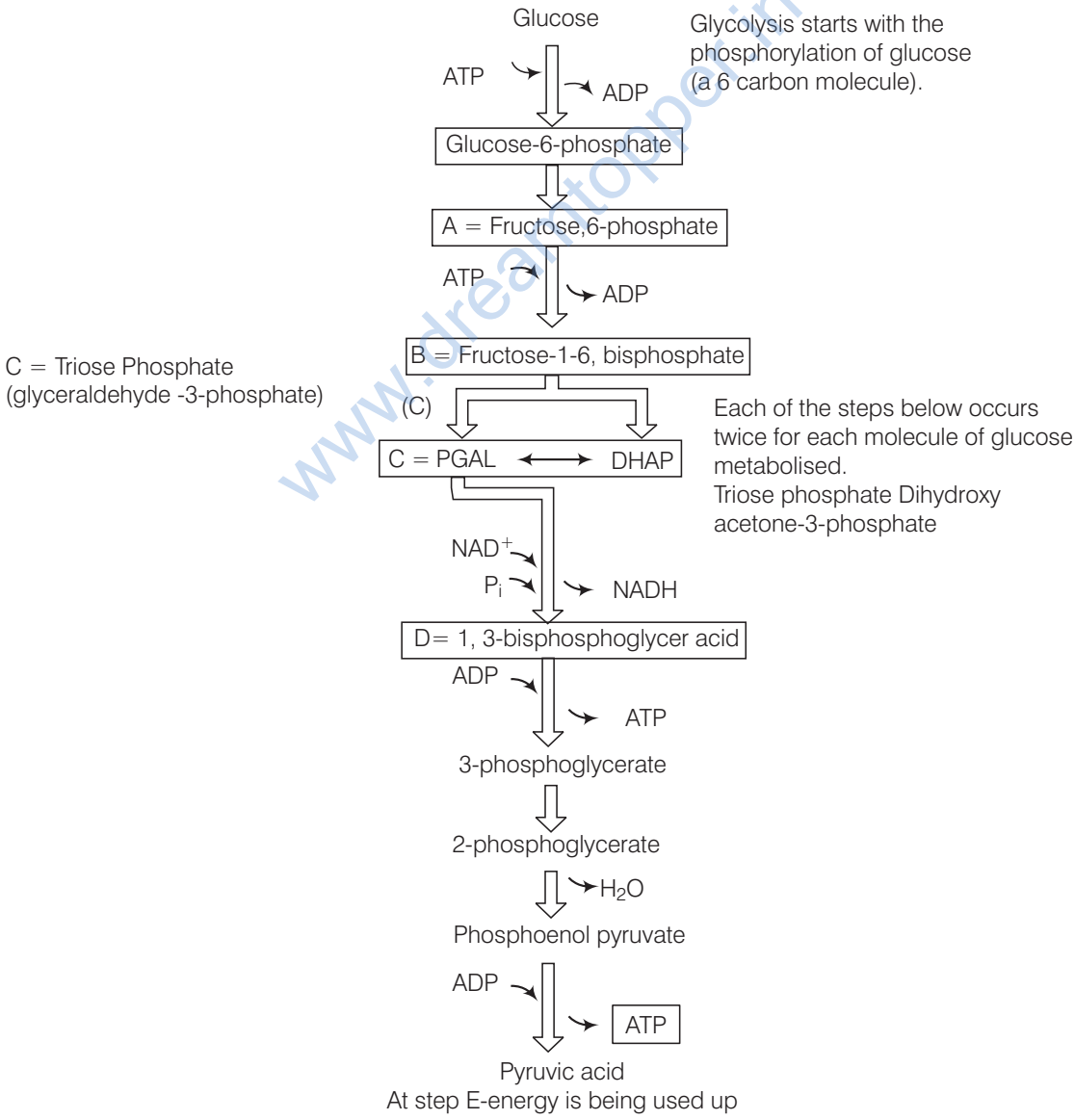
Thus, ATP is utilised only when it is required so as to maintain the respiratory balance sheet.

www.dreamOBpen.in

Q. 8 The figure given below shows the steps in glycolysis. Fill in the missing steps *A*, *B*, *C*, *D* and also indicate whether ATP is being used up or released at step *E*?



Ans. *Process of glycolysis is summarised as follow*



www.dreamtopper.in

Q. 9 Why is respiratory pathway referred to as an amphibolic pathway?

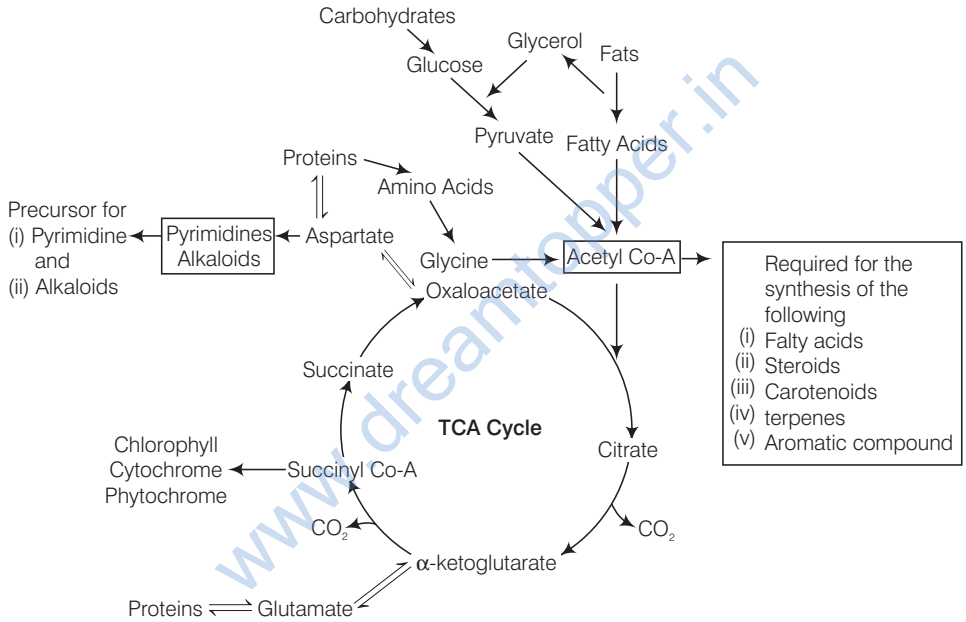
Thinking Process

Krebs' cycle is amphibolic (Gk. amphi – both, bole –throw). There is the involvement of both anabolic and catabolic reactions in this cycle.

Ans. Glucose is the favourite sulphate for respiration as carbohydrates are first converted into glucose. Prior to used for respiration. Fats are acetyl CO-A are broken down into glycerol and fatty acid which is further degraded into acetyl Co-A, while protein is degraded into, smaller units anino acids.

Respiratory process involves the breaking down of substrate is catabolic proceses. Sometime the fatty acid is required them synthesis of it occurs by withdrawing acetly Co-A. This synthesising phase is the anabolic process.

Thus, respiratory pathway involves the catabolic process (break down) and anabolic pathway synthesis of molecules using respiratory intermediates frant link, it is called as an amphibolic pathway.



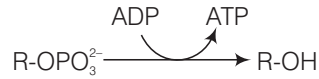
www.dreamtopper.in

Q. 10 We commonly call ATP as the energy currency of the cell. Can you think of some other energy carriers present in a cell? Name any two.

Ans. An energy carrier is a highly specialised molecule that transfers, recieves and stores energy within the cell. This energy is then used to facilitate the chemical reactions within the cell. The three major types of energy carriers are ATP, NADPH and NADH.

Q. 11 ATP produced during glycolysis is a result of substrate level phosphorylation. Explain.

Ans. **Substrate-level phosphorylation** is a type of metabolic reaction that results in the formation of Adenosine Triphosphate (ATP) or Guanosine Triphosphate (GTP) by the direct transfer and donation of a phosphoryl (PO_3) group to Adenosine Diphosphate (ADP) or Guanosine Diphosphate (GDP) from a phosphorylated reactive intermediate.



Substrate-level phosphorylation

In glycolysis substrate level phosphorylation occurs in following two reactions

(i) 2 molecules of 1, 3-diphosphoglyceric acid react with 2 molecules of ADP to form 2 molecules of 3-phosphoglyceric acid and 2 molecules of ATP .

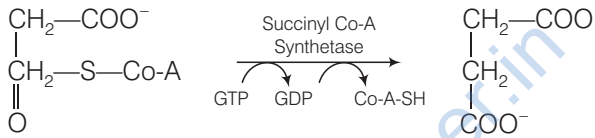
$$\underset{\text{(2 molecules)}}{\text{1, 3 – diphosphoglyceric acid}} + 2\,\text{ADP} \xrightarrow[Mg^{2+}]{\text{Phosphotransferase}} \underset{\text{(2 molecules)}}{\text{2 – phosphoglyceric acid}} + 2\,\text{ATP}$$

(ii) 2 molecules of phosphoenolpyruvic acid reacts with 2 molecules of ADP to form 2 molecules of pyruvic acid and 2 ATP.

$$\underset{\text{(2 molecules)}}{\text{2 – phosphoenolpyruvic acid}}\ 2\text{ADP} \xrightarrow[Mg^{2+}]{\text{Pyruvic kinase}} \underset{\text{(2 molecules)}}{\text{Pyruvic acid}} + 2\text{ATP}$$

Q. 12 Do you know any step in the TCA cycle where there is substrate level phosphorylation. Which one?

Ans. In an intermediate reaction of TCA cycle, succinyl Co-A is converted to succinic acid and one GTP molecule is synthesised through substrate level phosphorylation.



GTP formed in this reaction gives rise to ATP as follows

$$\text{GTP} + \text{ADP} \rightarrow \text{GDP} + \text{ATP}$$

Q. 13 In a way green plants and cyanobacteria have synthesised all the food on the earth. Comment.

Thinking Process

All heterotrophs depend on food synthesised by autotrophs, such as cyanobacteria or green plants.

Ans. Cyanobacteria are unicellular prokaryotic organisms. Besides, some primitive cellular cell organelles, they have photosynthetic lamellae where photosynthetic pigments are present. There are chlorophyll-*a c*, phycocyanin and phycoerythrin.

These coloured pigments impart typical blue green colour to the bacteria and enable them to manufacture food for themselves and aquatic animals. Green plants are multicellular organisms capable of making food by using CO_2, H_2O and light energy in special cell organelles called chloroplast.

So, bacteria and green plants make food for living organisms on earth.

Q. 14 When a substrate is being metabolised, why does not all the energy that is produced get released in one step. It is released in multiple steps. What is the advantage of step-wise release?

Ans. The process of aerobic respiration is divided into four phases-glycolysis, TCA cycle, ETS and oxidative phosphorylation. The process of respiration and production of ATP in each phase takes place in a step-wise manner.

The product of one pathway forms the substrate of the other pathway and these substrates enter or withdrawn from the pathway according to the necessity ATP gets utilised wherever required and enzymatic rates are generally controlled. Thus, the step-wise released of energy makes the system more efficient is extracting and storing energy.

www.dreamtopper.in

Q. 15 Respiration requires O_2. How did the first cells on the earth manage to survive in an atmosphere that lacked O_2?

Ans. Respiration always does not require O_2. There are organisms which respire even in absence of O_2 through anaerobic respiration.

The first cells of earth *i.e.,* chemosynthetic bacteria are the primitive organisms of early life on earth. Obtained energy by breaking down inorganic molecules like H_2S, NO_2^-, etc.

e.g., chemosynthesis occured in sulphur bacteria in the following way

$$12H_2S + 6\,CO_2 \rightarrow C_6H_{12}O_6 + 6H_2O + 12S\downarrow$$

Q. 16 It is known that red muscle fibres in animals can work for longer periods of time continuously. How is this possible?

Ans. *There are basically two kinds of muscle fibers*

(i) Red muscles (ii) White muscles

Red muscles work for a longer time continuously because

(i) These muscle fibres are dark red which is due to the presence of red haemoprotein called **myoglobin**. Myoglobin binds and stores oxygen as **oxymyoglobin** in the red fibres. Oxymyoglobin releases oxygen for utilisation during muscle contraction.

(ii) Mitochondria are more in number, hence they work for long periods of time.

(iii) Red muscles have less sarcoplasmic reticulum.

(iv) They carry out considerable aerobic oxidation without accumulating much lactic acid. Thus, red muscle fibres can contract for a longer period without fatigue.

(v) These muscle fibres have slow rate of contraction for long periods.
e.g., extensor muscles of the human back.

Q. 17 The energy yield in terms of ATP is higher in aerobic respiration than during anaerobic respiration. Explain.

Thinking Process

Respiration is a catabolic process occurring in all living cells providing them energy to stay alive and to remain metabolically active.

Ans. *The energy yield in terms of* ATP *is higher in aerobic respiration than during anaerobic respiration is as given*

Aerobic Respiration	Anaerobic Respiration
In aerobic respiration, there is complete oxidation of substrate molecules producing ATP molecules.	In anaerobic respiration there is incomplete oxidation of substrate molecules so the ATP produced are less in number.
Aerobic respiration of glucose produces 36 ATP molecules + H_2O + CO_2.	Anaerobic respiration of glucose, when occurs in yeast, produces 2 ATP molecules+ ethy lalcohol + CO_2.

www.dreamtopper.in

Q. 18 RuBP carboxylase, PEPcase, pyruvate dehydrogenase, ATPase, cytochrome oxidase, hexokinase, lactate dehydrogenase. Select/choose enzymes from the list above which are involved in

(a) Photosynthesis (b) Respiration

(c) Both in photosynthesis and respiration

Ans. **RuBP Carboxylase** This is a part of dark reaction of **photosynthesis**. It catalyses the fixing of CO_2 in C_3 cycle.

PEPcase This is a part of **photosynthesis** of C_4 plants. It catalyses the reaction of fixing of CO_2 to form first stable product oxaloacetate. 4 carbon compound.

Pyruvate dehydrogenase It is involved in aerobic respiration and catalyses the reaction of formation of acetyl Co-A from pyruvic acid. It requires the participation of NAD and Co-enzyme-A.

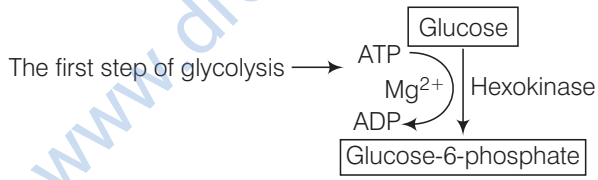
$$\text{Pyruvic acid} + \text{Co-A} + \text{NAD}^+ \xrightarrow[\text{Pyruvate dehydrogenase}]{Mg^{2+}} \text{Acetyl Co-A} + CO_2 + \text{NADH} + H^+$$

ATPase It is a part of both respiration and photosynthesis. Both these processes uses electron transport chain and associated proton pump and ATP synthase as a key part of process. ETC uses the energy to pump hydrogen ions across a membrane.

The protons flows back through ATP synthase, driving the production of ATP.

Cytochrome Oxidase This is involved in both respiration and photosynthesis. It is an electron carrier in the electron transport chain.

Hexokinase This enzyme is also involved in, **respiration**. In glycolysis, it catalyses the first reaction, *i.e.,* formation of glucose -6- phosphate from glucose molecule. It uses one ATP molecule which transfers PO_4 group to glucose molecules.



Lactate Dehydrogenase

This enzyme is involved in **anaerobic respiration** in bacteria *Lactobacillus.*

Pyruvic acid formed at the end of glycolysis is converted to lactic acid by homo-fermentative lactic acid bacteria. Hydrogen from NADH molecule is transferred to pyruvate is transferred to pyruvate molecule lactic acid molecule leading formation of acid.

$$\underset{\text{Pyruvic acid}}{CH_3COCOOH} + \text{NADH}. \xrightarrow[\text{Dehydrogenase}]{\text{Lactate}} \underset{\text{Lactic acid}}{C_3H_6O_3} + \text{NAD}$$

Q. 19 How does a tree trunk exchange gases with the environment although it lacks stomata?

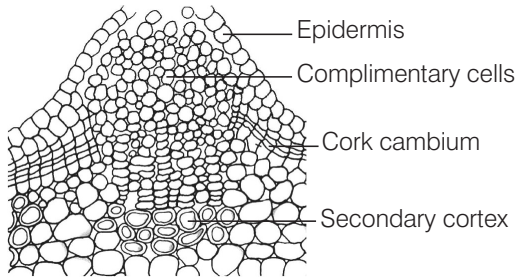
Thinking Process

Gaseous exchange is an important phenomenon in plants. Plants take up CO_2 for photosynthesis and release O_2 as by product. They have devised structural adaptations in them to carry out this phenomenon.

Ans. The old tree trunk is covered by dead woody tissue called cork. The epidermal layers of such tree get ruptured and outer cortical cells are loosely arranged. These structures are called as **lenticels**.

www.dreamtopper.in

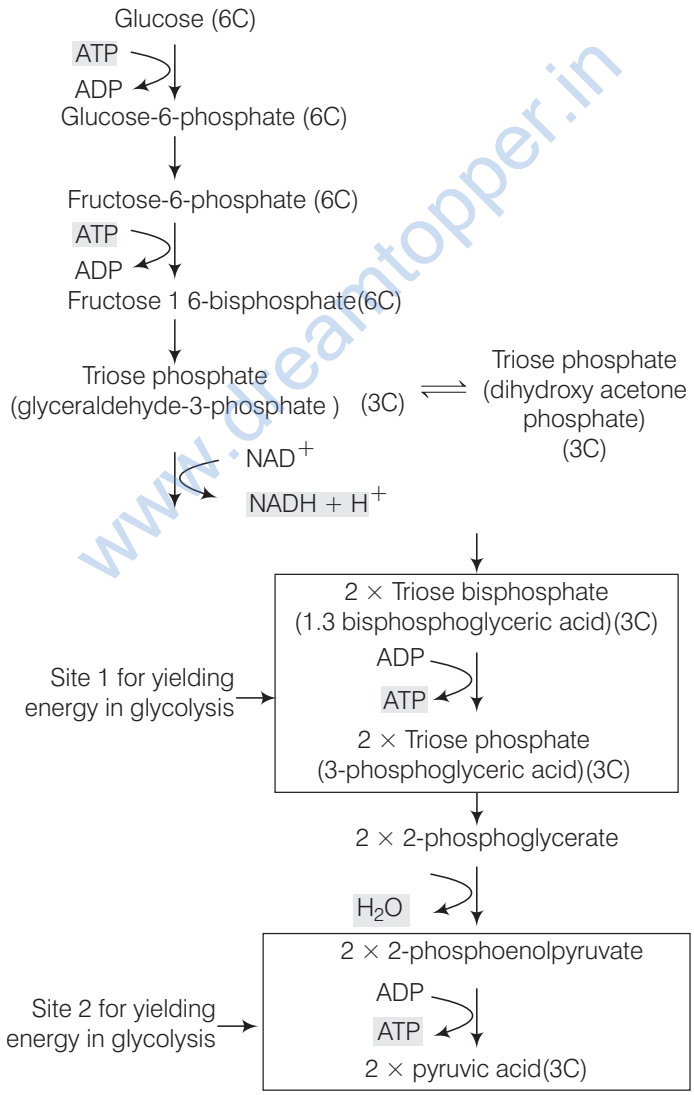
These are the sites of gases exchange and transpiration.



Structure of lenticel

Q. 20 Write two energy yielding reactions of glycolysis.

Ans. *The following figure shows the process of glycolysis, and sites for yielding energy during glycolysis*



Thus, ATP is produced during degradation of 1,3 biphosphoglyceric acid into 3-phosphoglyceric acid and during degradation of 2-phosphoenol pyruvate into pyruvic acid.

www.dreamtopper.in

Q. 21 Name the site(s) of pyruvate synthesis. Also, write the chemical reaction wherein pyruvic acid dehydrogenase acts as a catalyst.

Ans. **Pyruvate** is synthesised in cytoplasm of the cell by the process of glycolysis. 1 molecule of glucose forms 2 molecules of pyruvate through a series of reactions.

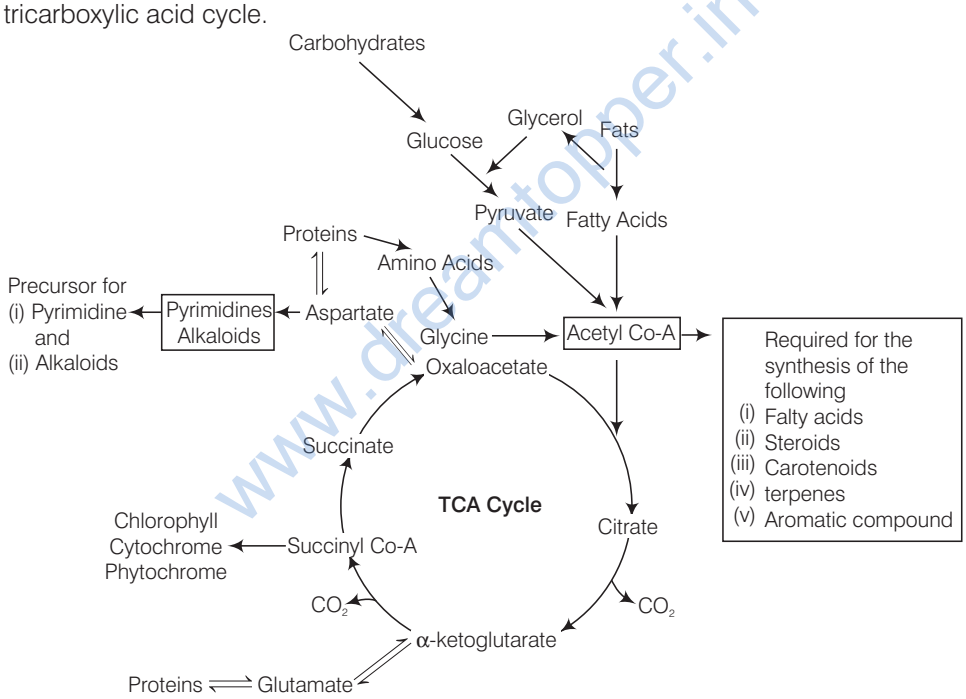
Pyruvic acid dehydrogenase catalyses the reaction in which pyruvate forms acetyl Co-A. It requires NAD^+, Co-enzyme A and Mg^{2+} ions for its activity. *The reaction is as follows*

$$\text{Pyruvic acid} + \text{Co - A} + NAD^+ \xrightarrow[\text{Pyruvate Dehydrogenase}]{Mg^{2+}} \text{Acetyl Co-A} + NADH + H^+ + CO_2 \uparrow$$

Q. 22 Respiratory pathway is believed to be a catabolic pathway. However, nature of TCA cycle is amphibolic. Explain.

Ans. Living cells obtain energy through respiration. It is the process of generating energy in the form of ATP molecules by breaking down food molecules like glucose, fats, etc.

The process starts with glycolysis which occurs in cytoplasm producing pyruvic acid. It is then converted to acetyl Co-A, which enters mitochondrial matrix. This initiates the tricarboxylic acid cycle.



This cycle is said to be amphibolic because many intermediate compounds formed in this cycle act as precursors for biosynthesis of many important biological molecules, *i.e.,* co-enzymes, vitamins, hormones. Besides this, many molecules, *i.e.,* fatty acids, aminoacids, co-enzymes etc, can enter this cycle directly.

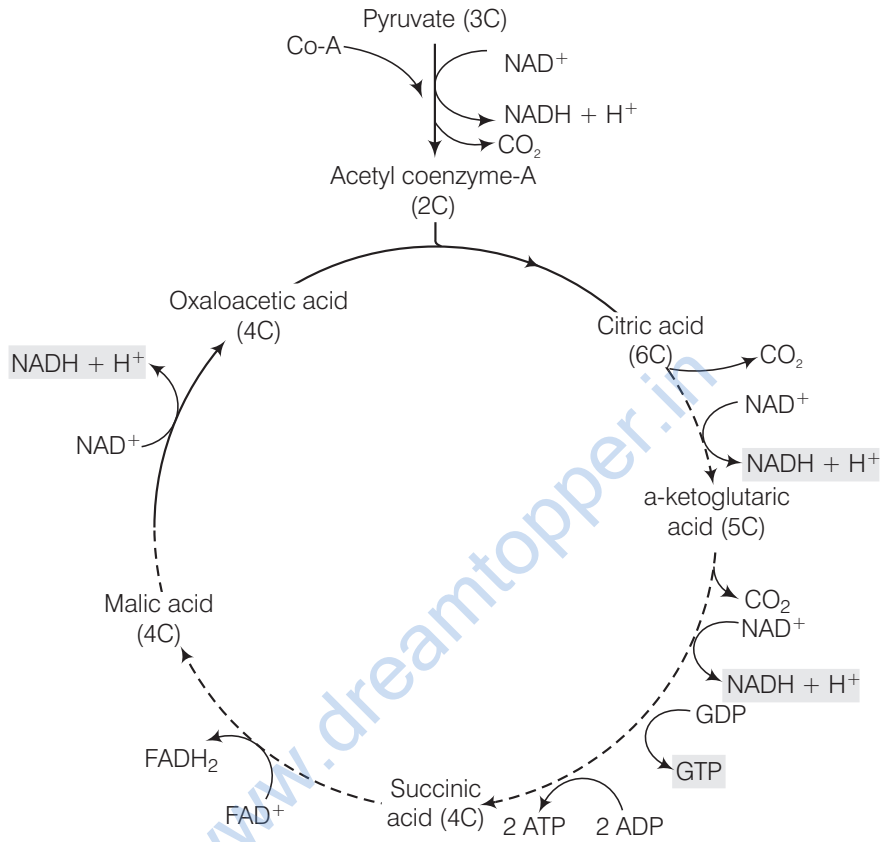
Acetyl Co-A is related to synthesis and breakdown of fatty acids, steroids, carotenoids terpenes and aromatic compounds. α- ketoglutarate and oxaloacetate are row materials for synthesis of amino acids like glutamate and aspartate and also pyrimidines and alkaloids. Succinyl forms pyrroole compunds like cytochrome and chlorophyll.

So, it is the cycle where both breakdown and synthesis reactions keep on going simultaneously. the following figure shows interrelationship among netabolic pathway showing respiration mediated break down of different organic molecule.

www.dreamtopper.in

Q. 23 Mention the important series of events of aerobic respiration that occur in the matrix of the mitochondrion as well as one that take place in inner membrane of the mitochondrion.

Ans. Krebs' cycle occurs in the matrix of mitochondria. *It is depicted in the following series of reactions*



Krebs' cycle (tricarboxylic acid cycle)

www.dreamtopper.in

Electron transport chain is carried out in the inner mitochondria membrane

The inner mitochondrial membrane is specific about possessing proton (H^+) and electron (e^-) acceptors in a particular sequence called electron transport chain. It has four enzyme complexes.

The electrons either follow the pathway of complexes I, III and IV or II, III and IV depending upon the substrates from Krebs' cycle.

The transfer of electrons and hydrogen atoms takes place in the following way

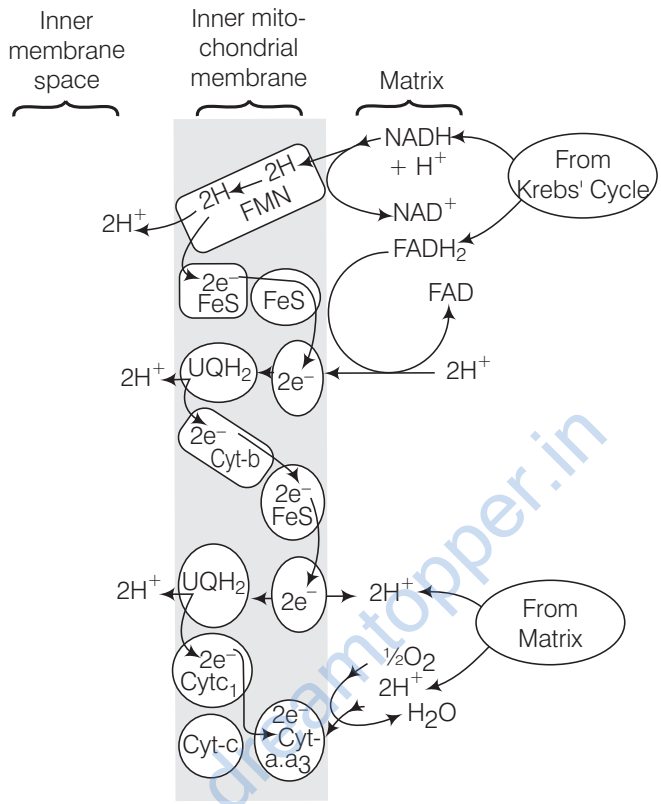
Complex I Consists of flavoproteins of NADH dehydrogenase (FP_N) of which FMN is the prosthetic group. Combined with the flavoprotein is non-heme iron of NADH dehydrogenase. This complex spans inner mitochondrial membrane and is able to translocate protons across it from matrix side to outer side.

Complex II Consists of flavoprotein of succinate dehydrogenase, of which FAD is the prosthetic group. Combined with the flavoprotein is non-heme iron of succinate dehydrogenase.

Between complexes II and III is the **mobile carrier coenzyme-Q** (Co-Q) **or ubiquinone** (UQ).

Complex III Consists of cytochrome-*b* and cytochrome-c_1. Associated with cytochrome-*b* is non-heme iron of complex III. Between complexes III and IV is the **mobile carrier cytochrome-*c*.**

Complex IV Consists of cytochrome-*a* and cytochrome- a_3, and bound copper that are required for this complex reaction to occur. This cytochrome also called **cytochrome oxidase**, is the only electron carrier in which the heme iron has a free ligand that can react directly with molecular oxygen.



Transfer of electrons in ETS

Thus, hydride ions are transferred from the substance to be oxidised to NAD^+. From NAD^+ the hydrogen atoms are transferred to FMN of flavoprotein 1 (Fp'N). After FMN the hydrogen atom undergoes ionisation, *i.e.,* it splits into an electron and a proton.

In further stages there is no longer a transfer of hydrogens but of electrons. The electron passes to co-enzyme- Q, and from co-enzyme Q to cytochromes- *b*, c_1, *c*, *a* and a_3. The proton is released free.

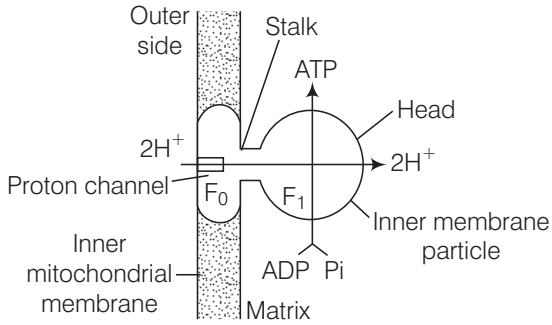
As the hydrogen atom or electron passes down by F_0-F_1 particle the chain, there is simultaneous oxidation of one coenzyme and reduction at another steps. Oxygen is able to diffuse indside the mitochondria.

It is converted to anionic form O_2^-, combines with $2H^+$ and forms metabolic water reduced co-enzyme $NADH + H^+$ helps in pushing out three pairs of H^+ to outer chamber while $FADH_2$ sends two pairs of H^+ to outer chamber.

Oxidative phosphorylation is the synthesis of energy rich ATP molecules, with the help of energy liberated during oxidation of reduced co-enzyme ($NADH_2$, $FADH_2$) produced in respiration. The enzyme required for this synthesis is called ATP synthase present in inner mitochondria membrane.

www.dreamtopper.in

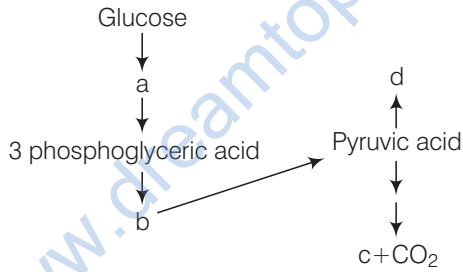
The following figures shows this process



Showing the process of ATP synthesis

Long Answer Type Questions

Q. 1 In the following flow chart, replace the symbols a, b, c and d with appropriate terms. Briefly explain the process and give any two application of it.

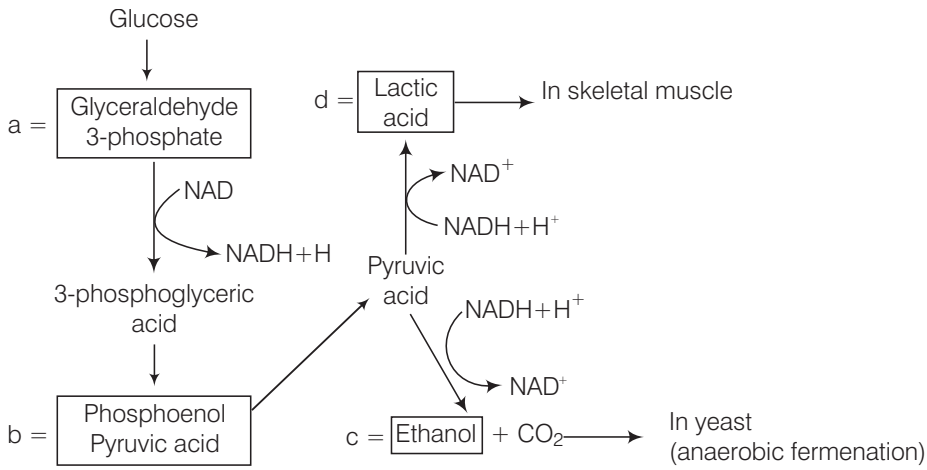


Thinking Process

The pyruvic acid is the end product of glycolysis. It is further broken down depending on the circumstances and requirement of the cell .

Ans. The metabolic pathway given in the figure is **fermentation**. *The products marked as a, b, c and d represents*

a—Glyceraldehyde 3 phosphate, b—Phosphoenol pyruvic acid
c—Ethanol, d—Lactic acid



www.dreamtopper.in

The fermentation is of two types

(i) **Alcohol Fermentation in Yeast** Fermentation is an incomplete oxidation of glucose under anaerobic condition. Alcohol fermentation in yeast occurs in 2 sets of reaction thus, converting pyruvic acid into ethanol and CO_2.

A. In the first step, pyruvic acid is decarboxylated (equation I), resulting in the formation of acetaldehyde and CO_2.

$$\underset{\text{Pyruvic acid}}{2CH_3COCOOH} \xrightarrow{\text{Pyruvic decarboxylase}} \underset{\text{Acetaldehyde}}{2CH_3CHO} \quad \ldots(i)$$

B. In the second step acetaldehyde is reduced to alcohol by $NADH_2$ (equation (ii))

$$\underset{\text{Acetabdehyde}}{2CH_3CHO} \xrightarrow[NADH_2 \quad NAD]{\text{Alcohol}} \underset{\substack{\text{Ethyl alcohol}\\ \text{NAD}}}{2C_2H_5OH + CO_2} \quad (ii)$$

(ii) **Lactic Acid Fermentation in Muscles**

In animal tissue like muscles, during exercise, when oxygen is inadequate for cellular respiration pyruvic acid is reduced to lactic acid by lactate dehydrogenase. The reducing agent is $NADH+H^+$ which is reoxidised to NAD^+ in the subsequent processes.

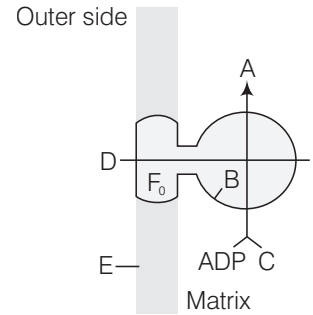
Two applications of fermentation process are

(i) It helps in manufacture of ethyl alcohol.

(ii) It also helps in curdling of milk to make curd aided by bacteria *Lactobacillus.*

Q. 2 Given below is a diagram showing ATP synthesis during aerobic respiration, replace the symbols A, B, C, D and E by appropriate terms as given below.

F1, particle, formation of Pi, $2H^+$, inner mitochondrial membrane, ATP, Fo particle, ADP.



Thinking Process

Phosphorylation of ATP from ADP + Pi is an important step occurring in every cell to obtain energy. This process takes place in the inner mitochondrial membrane

Ans. Symbol A, B, C, D and E in the diagram represents

A — ATP B — F_1 particle C — Pi
D — $2H^+$ E — inner mitochondria membrane.

Q. 3 Oxygen is critical for aerobic respiration. Explain its role with respect to ETS.

Ans. **Role of O_2 in Aerobic Respiration**

The respiration of glucose starts with glycolysis in cytoplasm, followed by in Krebs' cycle and finally Electron Transport Chain (ETC) in inner mitochondrial membrane. The requirement of O_2 is at the end of ETC.

Where, it acts as final hydrogen acceptor. O_2 is responsible for removing electrons from the system. If oxygen is not available, electrons could not be passed through the co-enzymes, inturn proton pump will not be established and ATP will not be produced *via* oxidative phosphorylation. Thus Oxygen play a critical role in aerobic respiration in mitochondrial matrix.

www.dreamtopper.in

Q. 4 Enumerate the assumptions that we undertake in making the respiratory balance sheet. Are these assumptions valid for a living system? Compare fermentation and aerobic respiration in this context.

Ans. *The calculations of the net gain of ATP for every glucose molecule oxidised can be made on the following assumptions*

(i) There is sequential pathway that follows, *i.e.,* glycolysis, TCA cycle and ETS in cytoplasm, mitochondrial matrix and inner mitochondrial membrane respectively.

(ii) NADH, synthesised in glycolysis enters in to ETC for phosphorylation.

(iii) None of the intermediates in the pathway are utilised to synthesise any other compound.

(iv) Glucose forms respiratory substrate.

These assumptions are not valid for a living system because of following reasons

(i) These all pathways work simultaneously and do not take place one after the other.

(ii) ATP is utilised when needed.

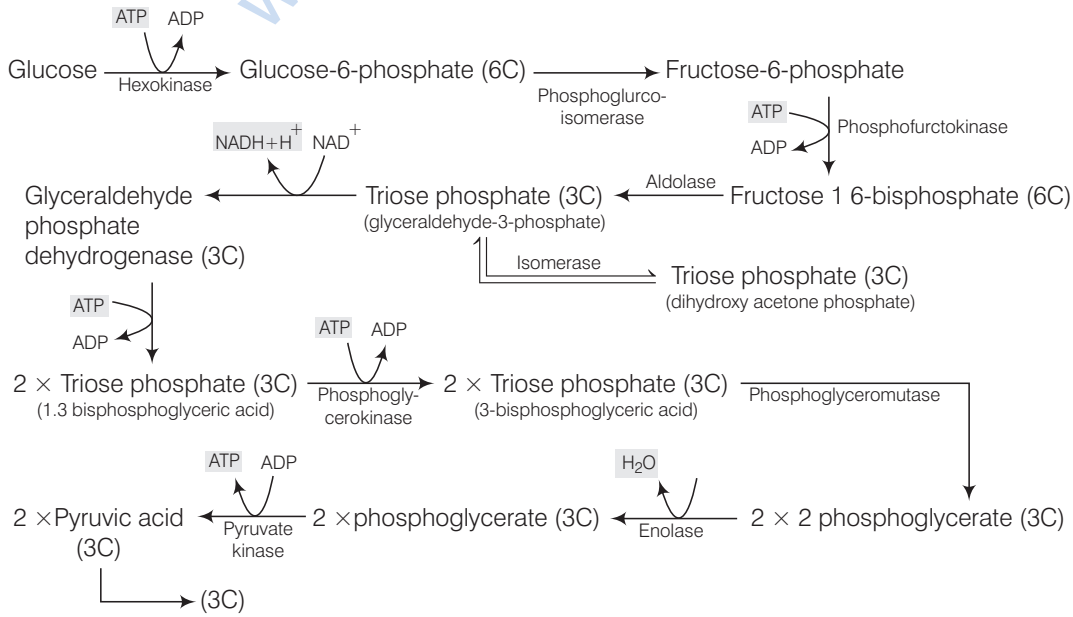
(iii) Rate of enzyme actions is controlled by multiple means.

Comparisan between fermentation and aerobic respiration are as follows

Fermentation	Aerobic Respiration
Fermentation is partial breakdown of glucose.	It is complete breakdown of glucose.
Net gain of only 2 ATP.	38 ATP are produced.
Oxidation of NADH to NAD^+ is slow process.	It is a vigorous reaction in aerobic respiration.

Q. 5 Give an account of glycolysis. Where does it occur? What are the end products? Trace the fate of these products in both aerobic and anaerobic respiration.

Ans. Glycolysis occurs in cytoplasm. One glucose molecule forms 2 pyruvic acid molecules.
In anaerobic conditions it forms 2 ATP and ethanol + water.
In aerobic conditions it form 36 ATP + water + CO_2. *The steps of glycolysis are as follows*



Steps of glycolysis

www.dreamtopper.in