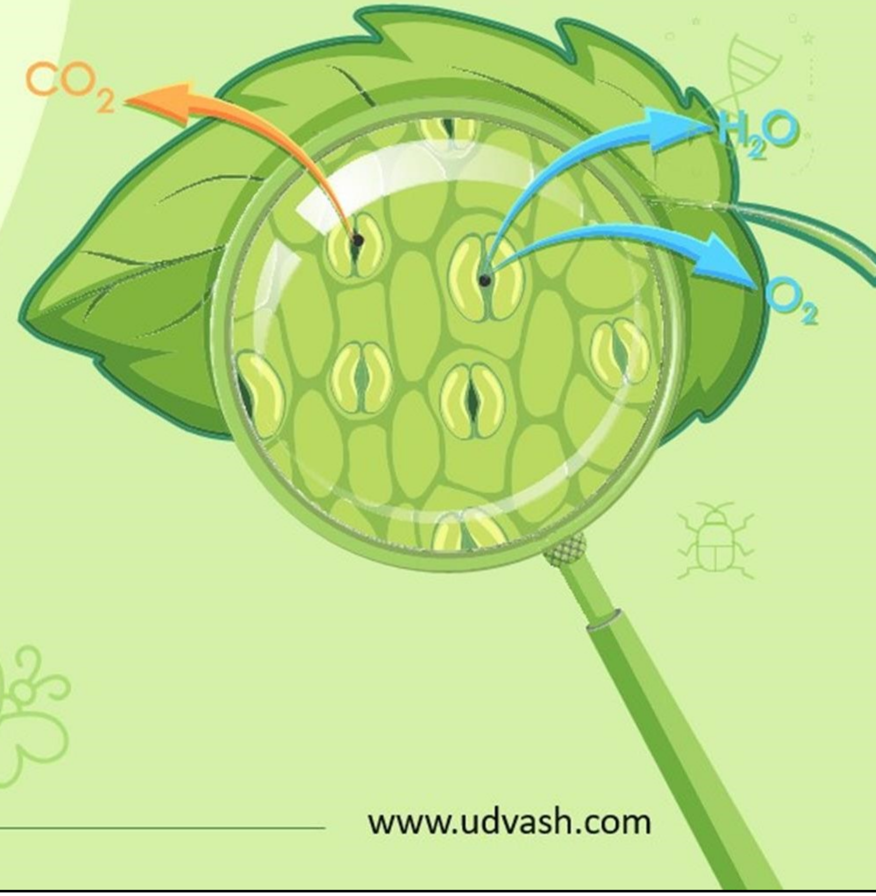
Class 12 Academic Program-2020

BIOLOGY 1ST PAPER

Lecture : B-17

Chapter 9 : Plant Physiology



উদ্ভাস
একাডেমিক এন্ড এডমিশন কেয়ার

Source of oxygen released in photosynthesis

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

In this process, 6 molecules of O_2 are released during synthesis of one molecule of glucose. CO_2 and H_2O participate in the reaction. So the source of the released oxygen in photosynthesis might be CO_2 or H_2O. But experiments show that the released O_2 comes from H_2O, not from CO_2. So the source of oxygen in photosynthesis is H_2O.

Source of oxygen released in photosynthesis

Hill reaction:

- A (inorganic) + $H_2O \xrightarrow[\text{Chlorphyll}]{\text{light}} AH_2 + \frac{1}{2}O_2$

Experiment of Van Niel:

- $2H_2S + CO_2 \xrightarrow[\text{Chlorphyll}]{\text{light}} 2S + (CH_2O) + H_2O$

Source of oxygen released in photosynthesis

Ruben and Kamen:

$$6CO_2 + 12H_2O^{18} \xrightarrow[\text{Chlorphyll}]{\text{light}} C_6H_{12}O_6 + 6H_2O + 6O_2^{18}$$

It was found that the released oxygen is radioactive. This undoubtedly proved that the source of the released oxygen in photosynthesis is water. In the same way, same experiment was conducted by identifying carbon-di-oxide with O_2^{18} and using normal water.

$$6CO_2^{18} + 12H_2O \xrightarrow[\text{Chlorphyll}]{\text{Sunlight}} C_6H_{12}O_6^{18} + 6H_2O^{18} + 6O_2$$

Then it was found that, radioactive isotope was present in both carbohydrate and water but the released oxygen in photosynthesis is not radioactive at all. So, it was undoubtedly proved that, the source of the released oxygen in photosynthesis is solely water. Not a single part of it comes from CO_2.

Factors Affecting Photosynthesis

External factors:

(1) Light:

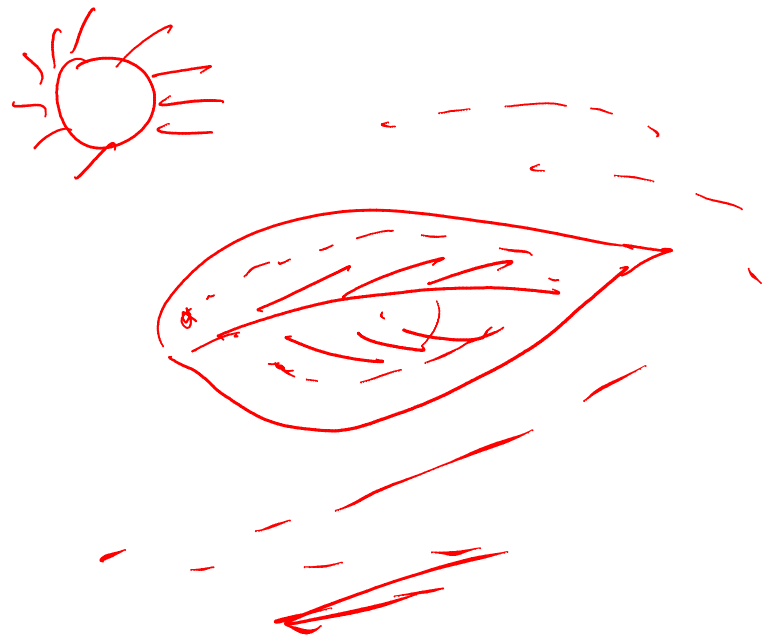
(2) Carbon-di-oxide:

(3) Water:

(4) Temperature

(5) Oxygen:

(6) Minerals:



Factors Affecting Photosynthesis

(B) Internal factors:

(1) Age of leaf:

(2) Internal structure of leaf:

(3) Chlorophyll:

(4) Amount of carbohydrate:

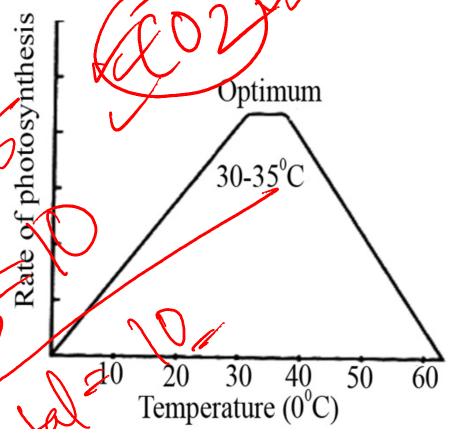
(5) Protoplasm:

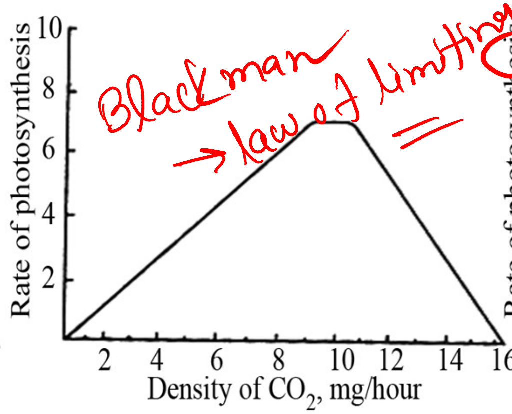
(6) Potassium:

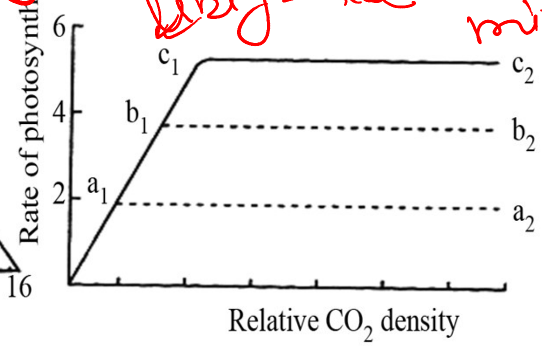
(7) Enzyme

Role of Limiting Factor in Photosynthesis

In 1905, Blackman proposed the 'Law of limiting factor' theory on the basis of law of minimum. According to this theory, when the rapidity of a physiological process is dependent on some different factors, then the slowest factor limits the rate of that process. According to Blackman, when a process is conditioned as to its rapidity by a number of separate factors, the rate of the process is limited by the pace of the slowest factor. According to the principle of limiting factor, photosynthesis is limited by a single factor at a specific time. The rate of photosynthesis is proportional to that factor. So photosynthesis rate increases when that factor is increased and vice versa.







Photosynthesis rate/quotient

In photosynthesis, sunlight is converted into chemical energy to produce carbohydrate by reducing CO_2. In this process, CO_2 is released. The amount of the released CO_2 is almost equal to the amount of absorbed CO_2 in this process. The ratio of amount of O_2 and CO_2 in photosynthesis at a specific time is called photosynthesis quotient. Briefly it is termed as PQ. Photosynthesis quotient is measured by the following equation.

$$PQ = \frac{\text{Amount of } O_2 \text{ released}}{\text{Amount of } CO_2 \text{ aecepted}} = \frac{1}{1} = 1$$

Respiration

The biochemical process which oxidizes complex organic compounds within living cells and as a result, transforms the potential energy of organic compounds into kinetic energy is called respiration. Energy released in respiration is consumed in different energy requiring activity of organisms. If glucose is assumed as the primary respiratory substance, then the chemical formula of respiration would be-

$$C_6H_{12}O_6 + 6O_2 + 6H_2O + 38ADP + 38Pi \xrightarrow[\text{Co−enzyme, activators etc}]{\text{Different enzymes}} 6CO_2 + 12H_2O + 38ATP$$

Respiratory organs and Respiratory material

Respiratory organs: Respiration is taking place in each living plant cell 24 hours a day. Cellular cytoplasm and mitochondria are the main organs of respiration. Because of absence of mitochondria in many prokaryotic cells (bacteria, cyanobacteria), respiration is performed with the help of cytoplasmic enzymes.

Respiratory material: Compounds which are oxidized to simple substances by respiration are called respiratory substances. Carbohydrates, proteins, lipids and organic acids are consumed as respiratory substances. Light energy of the sunlight is stored as chemical potential energy in these substances which is released as kinetic energy by respiration. So, light energy is the main source of all other energies.

Types of Respiration

Respiration can be classified into 2 types based on the necessity of oxygen, such as:

(A) Aerobic respiration and

(B) Anaerobic respiration.

Aerobic respiration : Respiration that needs free oxygen is called aerobic respiration

Anaerobic respiration: respiration that occurs in absence of oxygen is called anaerobic respiration.

Aerobic Respiration

The respiration process which requires free oxygen and which completely oxidizes respiratory substances to produce CO_2, H_2O & huge amount of energy is called aerobic respiration.

$$C_6H_{12}O_6 + 6O_2 + 6H_2O + 36ADP + 36Pi \longrightarrow 6CO_2 + 12H_2O + 36ATP \text{ (38 ATP নয়)}$$

Although aerobic respiration is a sequential process, it can be divided into 3 sequential steps or phases according to the site of reaction and nature of action. These are as follows:

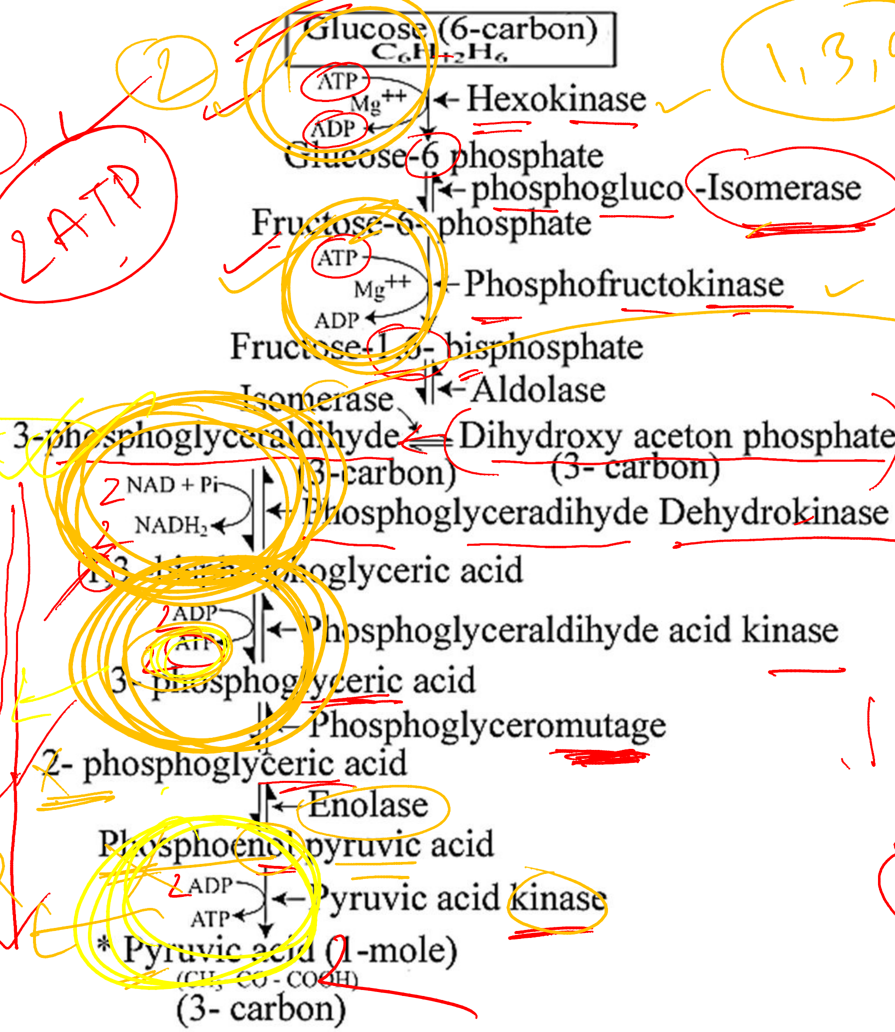
1. **Glycolysis**
2. **Krebs cycle**
3. **Electron transport chain phase.**

Glycolysis

- The process by which one molecule of glucose is oxidized through different chemical reactions into two molecules of pyruvic acid is called glycolysis. Glycolysis is also called EMP (according to the names of the three founder scientists of this process- Embden, Meyerhof and Parnas) pathway, common pathway of respiration or cytoplasmic respiration.

- No oxygen is required for this process. Glycolysis is the first step of both aerobic and anaerobic respirations.

The process of glycolysis



Poll Question-01

- Where Glycolysis takes place?

  (a) Mitochondria

  (b) Cytoplasm*

  (c) Plastid

  (d) Ribosome

Krebs cycle

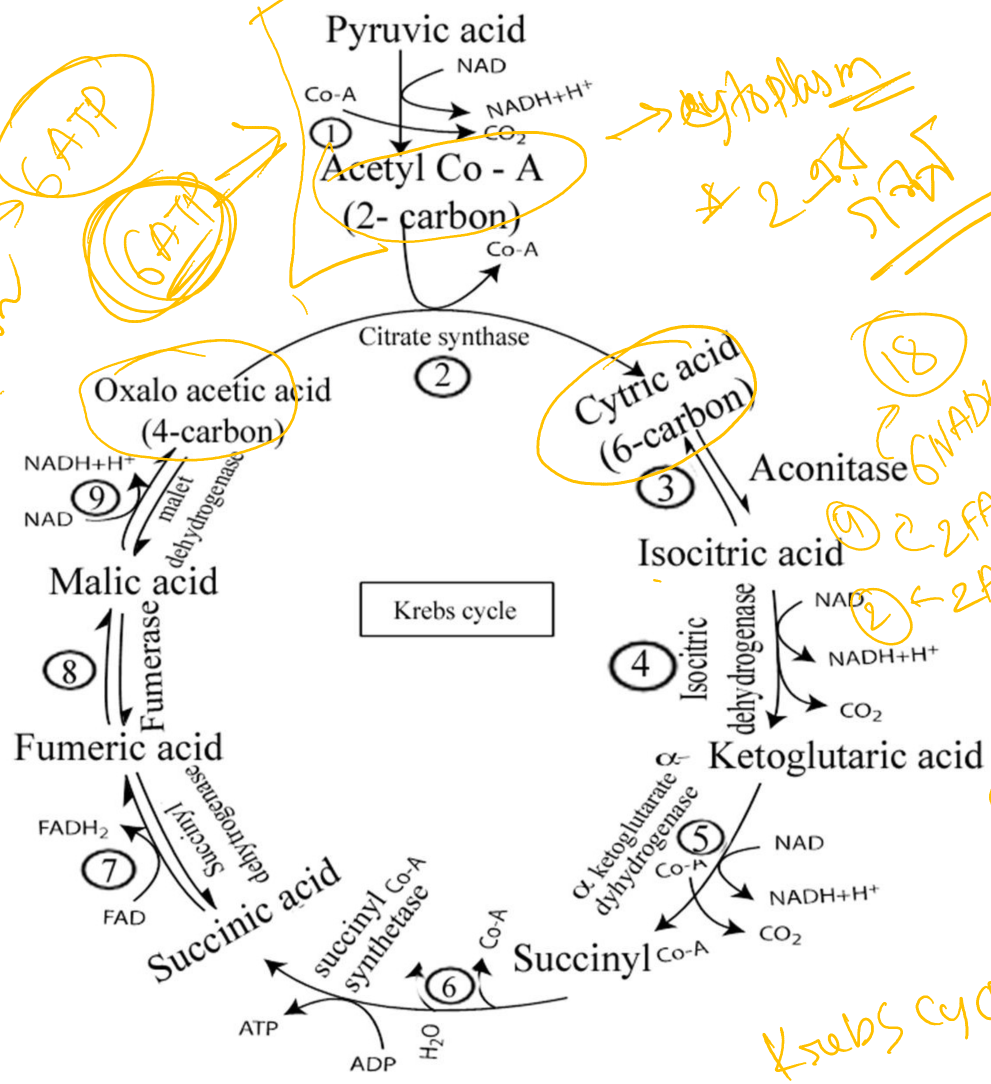


Fig: Krebs cycle

3^{rd} step: Transfer of electrons and production of ATP

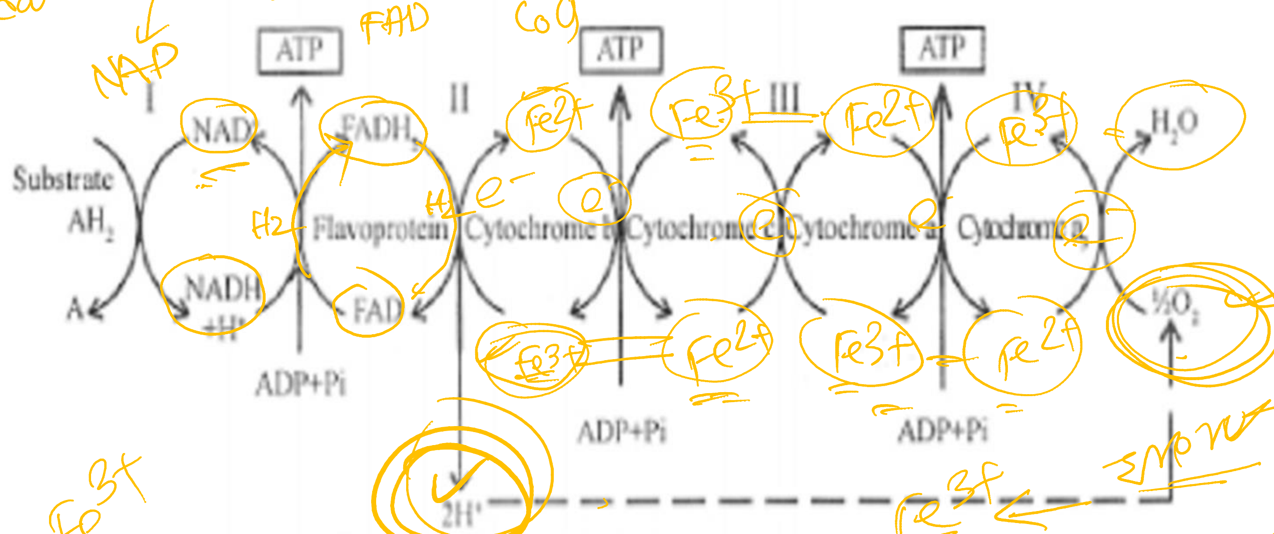


Fig. Electron transport system

3rd step: Transfer of electrons and production of ATP

Energy produced by complete oxidation of one molecule glucose into CO_2 and water:

Glycolysis	Production of acetyl Co-A	Krebs Cycle	ETS	Total ATP
2ATP..........	....	....	....	2ATP
2NADH + H^+.....	....	....	4ATP	= 4ATP
(one ATP is is lost converting into $FADH_2$ white entering mito chondrial matrix from cytoplasm	2NADH + H^+ While producing acetyl Co-A		6ATP	= 6ATP
		4NADH + H^+	18ATP	= 18ATP
		$2FADH_2$	4ATP	= 4ATP
		2ATP	....	2ATP
			32ATP	36ATP

Energy produced by complete oxidation of one molecule glucose into CO_2 and water:

It should be mentioned here that, 686 kcal energy is released if 1 mole glucose is burnt but only 380 kcal (from 38 ATP) energy is obtained in biological system and the rest are wasted as heat energy.

A total of 380 kcal energy from 38 ATPs are supplied through different energy absorbing chemical reactions (10 kcal energy from each ATP) i.e. only 380 kcal energy is obtained from 686 kcal,

so the working efficiency is-

$\frac{380 \times 100}{686}$ = 55.393586 = 55.4% (almost) Mary opines 22%.

Anaerobic Respiration

No free oxygen is needed in anaerobic respiration. The respiration which occurs in absence of oxygen is called anaerobic reparation.

$$C_2H_5OH \longrightarrow C_6H_{12}O_6 + 2CO_2 + 20 \text{ kcal energy}$$

2ATP

Anaerobic respiration can be divided in two steps: 1. Glycolysis and 2. Partial oxidation of pyruvic acid.

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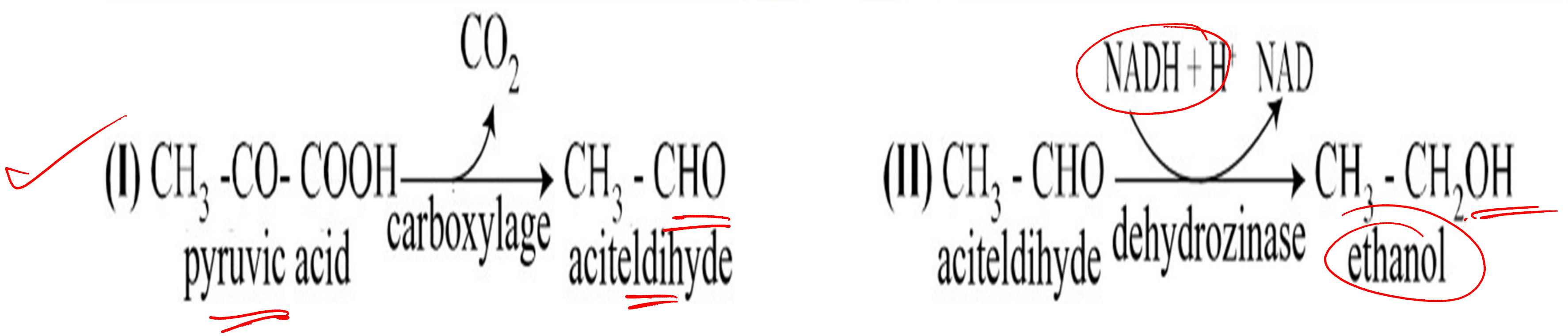
Anaerobic Respiration

1. **Glycolysis:** It is similar to the glycolysis of aerobic respiration. Glycolysis is the first step of both types of respiration. In this step, 2 molecules of pyruvic acid, 2 molecules of NADH + H^+ and 2 molecules of ATP are produced from one molecule of glucose.

2. **Production of ethanol or lactic acid from pyruvic acid:** In this process, pyruvic acid is partially oxidized to produce ethanol and CO_2 or only lactic acid.

Production of Ethanol



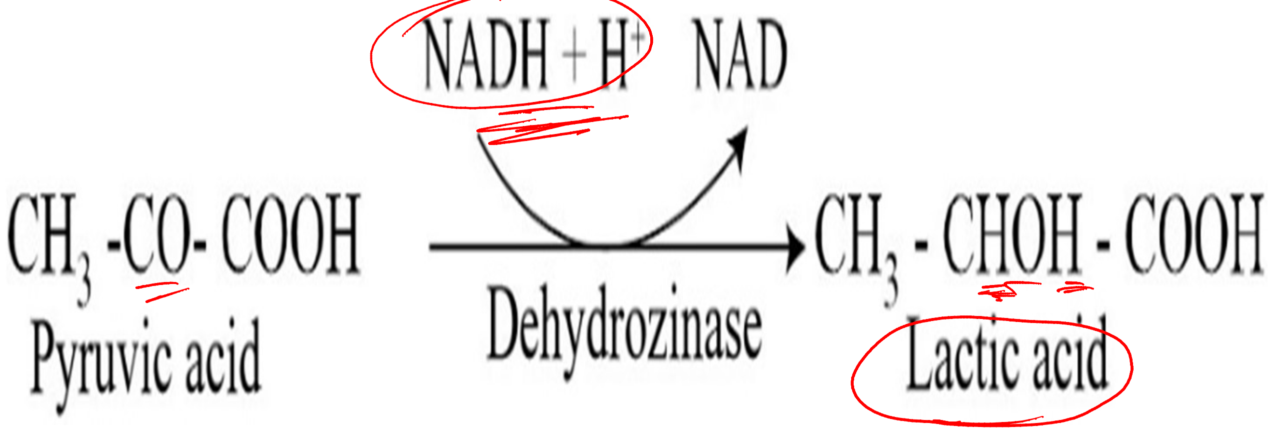
In anaerobic respiration, one molecule of glucose breaks down into 2 molecules of ethyl alcohol and 2 molecules of CO_2.

$$C_6H_{12}O_6 \longrightarrow 2CO_2 + 2C_2H_5OH + 20 \text{ kcal energy}$$

Glucose   Ethyl alcohol

NADH + H^+ that was produced in glycolysis of anaerobic respiration is consumed here. So, the two ATP stored during glycolysis is the only source of energy in anaerobic respiration. Finally, $10 \times 2 = 20$ kcal energy is obtained from 2 ATP.

Formation of lactic acid



In anaerobic repiration, 2 molecules of lactic acid are produced from one molecule of glucose.

$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3 + 20$ kcal energy

Glucose — Lactic acid

Poll Question-02

- Which one is not the product of Aerobic Respiration Resction?

(a) Acetaldehyde

(b) Lactic acid

(c) Citric acid*

(d) Ethanol

Site of respiration in prokaryotes and eukaryotes

Eukaryotes	Prokaryotes
(a) Outside mitochondrion (cytoplasm) 1. Glycolysis 2. Fermentation (b) Inside the matrix of mitochondrion: 3. Krebs cycle in inner membrane 4. Electron transport system	(a) In cytoplasm- 1. Glycolysis 2. Fermentation 3. Krebs cycle (b) Inner surface of plasma membrane- 4. Electron transport system

Poll Question-03

- Which one is the Respiratory Quotient of malic acid?

  (a) 1

  (b) 1.33*

  (c) 0.71

  (d) 0.33

Application of anaerobic respiration in many industries

(i) Bakery:

(ii) Liquor Industry:

(iii) Alcohol Production

(iv) Dairy Industry:

(v) Herbal Medicine Industry:

(vi) Processing of tea

(vii) Meat Industry:

(viii) Vitamin Production:

(ix) Vinegar Production:

(x) In soft drink industry:

Respiratory Quotient

The ratio of released CO_2 and consumed O_2 during respiration of plants is called Respiratory quotient/R.Q. Respiratory quotient: Respiratory quotients are different for different respiratory substances. For example, if glucose is the respiratory substance, then it releases 6 molecules of CO_2 and receives 6 molecules of O_2 by aerobic respiration. So, its R.Q. = 1.

Following equation is used to calculate the R.Q. in this case.

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

So, R.Q. of aerobic respiration = number of molecules of released CO_2 / number of molecules of consumed O_2.

$$\therefore R.Q = \frac{6CO_2}{6O_2} = \frac{6}{6} = 1$$

Carbohydrate, organic acid, fat and protein are oxidized as respiratory materials in respiration. R.Q. varies according to the type of respiratory material and respiration. For example-

R.Q. of malic acid $= \frac{4CO_2}{3O_2} = \frac{4}{3} = 1.33$

R.Q. of oleic acid $= \frac{36CO_2}{51O_2} = \frac{36}{51} = 0.71$

Amount of O_2 is less in protein and if protein is used as respiratory material, then value of R.Q. becomes less than 1.

Factors affecting Respiration

(a) External factors:

1. Temperature:
2. Oxygen:
3. Water:
4. Light:
5. Concentration of CO_2:

Factors affecting Respiration

Reading

(b) Internal factors:

1. Compound foods:
2. Enzyme:
3. Age of Cells:
4. Inorganic cellular salts:
5. Cellular water:
6. Inorganic salts in soil:

Importance of Respiration

1. Supply of energy in organism.
2. Production of food.
3. Absorption of minerals.
4. Cell division and physical growth.
5. Production of enzyme and organic acid.
6. Maintenance of balance of CO_2 & O_2 in atmosphere.
7. Usage in industries.
8. Bakery and dairy industry.

লেগে থাকো সৎ ভাবে,
স্বপ্ন জয় তোমারই হবে।