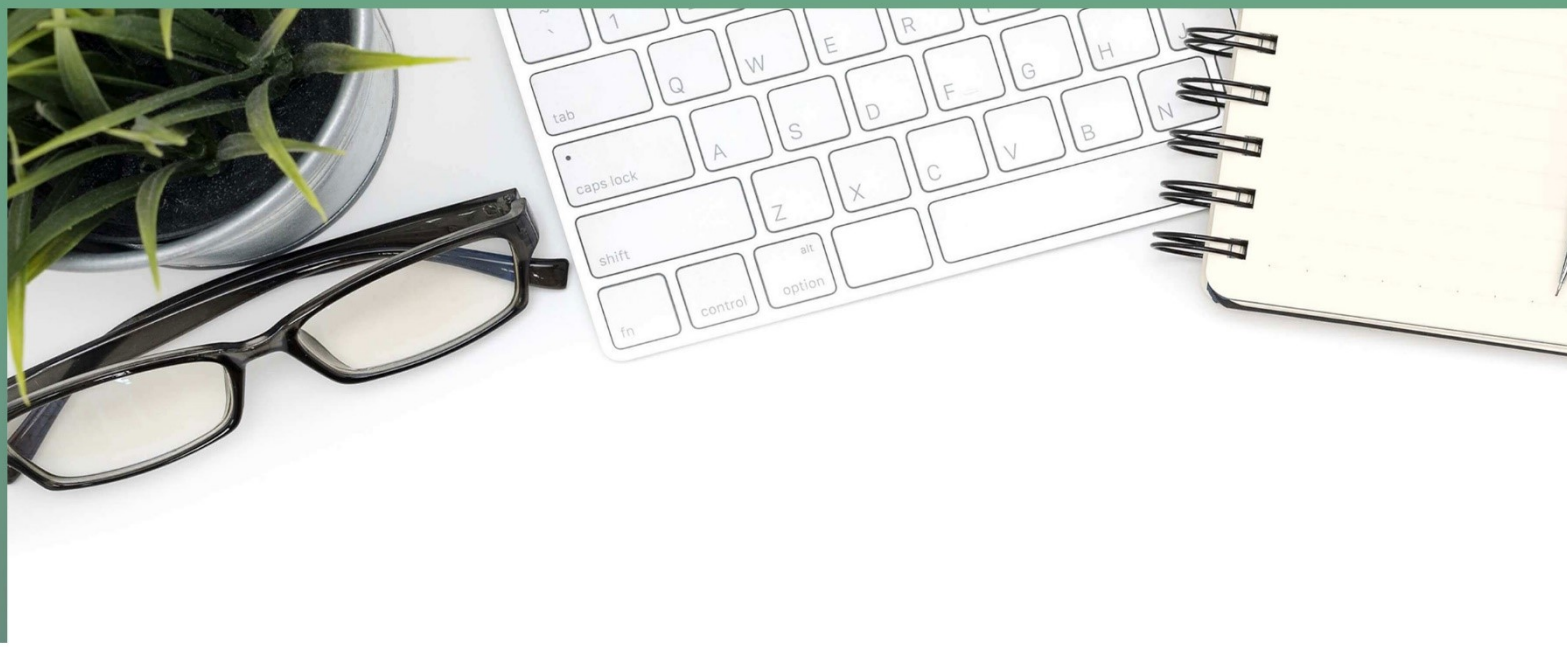

NEET Biology

Short Notes

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Check **Respiration in Plants Notes for NEET 2019 exam**! In medical exams like NEET, AIIMS, and JIPMER there are many questions asked from the Plant Physiology. This is one of the important and Conceptual Unit. Here we are sharing detailed notes on **Glycolysis, Fermentation, Kerb's Cycle** etc. So, Let's begin with a brief introduction of Respiration in Plants.

Respiration in Plants

Plant respiration is the biochemical process in which plant cells use sugars, the by-product of photosynthesis, and oxygen to generate the energy required for growth and development of the plant. Several enzymes catalyse the process and glycolysis is the first step of respiration. The process of respiration can be explained by the following reaction:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_20 + Energy$$

The complete combustion of glucose generates carbon dioxide and water as the end products and energy is released in the form of heat. Respiration can be either of aerobic or anaerobic type. The difference between aerobic and anaerobic respiration is listed below.

- **Table showing the difference between aerobic and anaerobic respiration is shown below:**

Aerobic respiration	Anaerobic respiration
Majority of organisms respire aerobically.	It occurs in few organisms such as yeast.
Oxygen is used and generate CO_2 always.	Oxygen is not required and it may or may not release CO_2.
Glucose is fully oxidized and generates entire energy available in glucose.	Glucose is not fully oxidized and thus release only 5% of energy available in glucose.
It involves five steps; glycolysis, pyruvate oxidation, TCA (Tricarboxylic acid) cycle, ETS (electron transport system), and chemiosmotic synthesis of ATP (adenosine triphosphate).	It involves only two steps; glycolysis and incomplete breakdown of pyruvate.
It takes place in mitochondria and cytoplasm.	It takes place in cytoplasm only.

- In plants, respiration occurs in roots, stems, and leaves. Oxygen present in the interspaces of soil gets diffused into the root cell through root hairs. Air gets diffused through stomata in leaves and stem. In the case of the woody stem, the gaseous exchange is carried out through lenticels.

Glycolysis

The Term glycolysis is derived from two Greek words; glycos meaning sugar and lysis meaning splitting. Otto Mayerhof, J. Parsons, and Gustav gave the scheme of glycolysis. It is a metabolic pathway in which glucose is converted into pyruvate and it occurs in the cytoplasm.

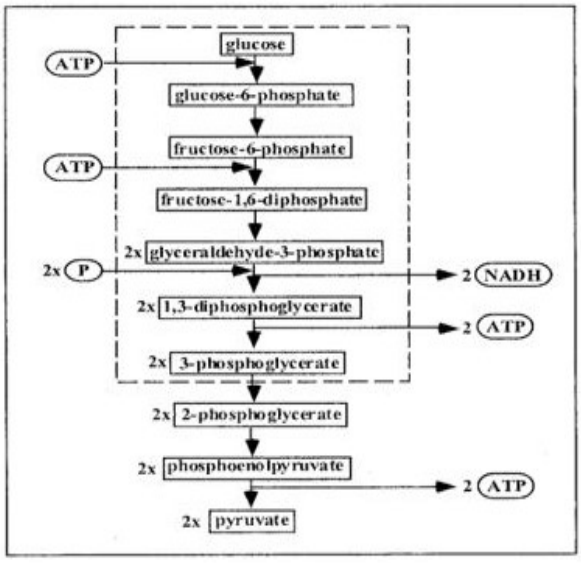

Fig: Schematic illustration of glycolytic pathway

The several steps of glycolysis are illustrated in the figure. It consists of ten enzyme-catalyzed reactions occurring in sequence. The metabolic pathway can be separated into two phases:

1. **Preparatory phase;** at which point ATP is used
2. **Pay off phase;** at which point ATP is produced

Preparatory phase:

The first five steps of glycolysis are considered to be a preparatory phase. This phase consumes energy to convert glucose into two three-carbon sugar phosphates.

- Glucose is phosphorylated to form **glucose 6-phosphate (G6P)** and the reaction is catalyzed by enzymes called **Hexokinases**. This reaction consumes energy in form of ATP.
- G6P is then acted upon by glucose phosphate isomerase and isomerized into **fructose 6-phosphate (F6P).** It is a reversible reaction. Low F6P concentration favours forward reaction and high F6P concentration favours reverse reaction.
- F6P is then converted to **Fructose 1, 6-bisphosphate (F1-6-BP)** and the reaction is catalyzed by **Phosphofructokinase**. The reaction is coupled with hydrolysis and is an irreversible reaction. This step is considered the key regulatory point and also the rate-limiting step.
- F1-6-BP is then split into two triose sugars; GADP (**Glyceraldehyde 3-phosphate**, an aldolase) and DHAP (**Dihydroxyacetone phosphate**, a ketose). This reaction is catalyzed by fructose-bisphosphate aldolase.
- This step includes interconversion of DHAP with GADP, which then may proceed further into glycolysis. This step simplifies the regulation as it directs DHAP down the same pathway as GADP.

Pay off phase

There is a net gain of energy-rich molecules; NADH and ATP. The pay-off phase occurs twice per glucose molecules as a glucose molecule results into two triose sugars in the preparatory phase. Hence, **it yields two NADH and two ATP molecules per glucose from the glycolytic pathway**.

- It involves oxidation of aldehyde groups of the triose sugars and there is an addition of inorganic phosphate resulting into formation of **1,3-bisphosphoglycerate** (1,3BPG).

- There is an enzymatic transfer of phosphate group from 1,3BPG to ADP to form 3-phosphoglycerate (3PG) and ATP. It is catalysed by phosphoglycerate kinase. This step is considered a **substrate-level phosphorylation step.**
- 3PG is then isomerized into 2-phosphoglycerate (2PG) by phosphoglycerate mutase.
- 2PG is then converted into phosphoenolpyruvate (PEP) by **enolase**.
- PEP is then converted to a molecule of pyruvate and a molecule of ATP and the reaction is catalysed by pyruvate kinase. This step is also considered as substrate-level phosphorylation and also serves as an additional regulatory step.

The end product, **Pyruvate**, then enters into the **matrix of mitochondria** and undergoes **oxidative decarboxylation** and **yields acetyl CoA and NADH**. Acetyl CoA then enters into a cyclic pathway called the **Tricarboxylic acid cycle or the Kreb's cycle**.

- **Tricarboxylic acid Cycle:** It is the second stage of cellular respiration. It involves a series of chemical reactions where catabolism of organic fuel molecules such as glucose and sugar takes place and stored energy is released in the form of ATP and carbon dioxide.
- **Electron Transport System and Oxidative phosphorylation:** Electrons pass from one carrier to another in ETS and occur in the inner mitochondrial membrane. NADH and $FADH_2$ from Kreb's cycle carry electrons to ETS and oxygen enters the pathway as electron acceptor at the end of ETS.

Fermentation

Fermentation is the process in which there is incomplete oxidation of glucose.

- It takes place under anaerobic conditions.
- Fermentation, in the same manner as cellular respiration, start off with glycolysis.
- However, in the case of fermentation, pyruvate generated from glycolysis does not undergo the consequent steps of respiration, namely oxidation, citric acid cycle, and the electron transport chain.
- As fermentation does not include the electron transport chain, it is not considered as a type of respiration.

There are two types of fermentation; Lactic acid fermentation and **Alcohol fermentation.**

i. **Lactic acid fermentation:** It occurs in fungi, bacteria, and muscle cells of the animal. In the process, pyruvate molecules generated from glycolysis get reduced to lactate and there is oxidation of NADH to NAD^+. NAD^+ is then replenished and cycles back through glycolysis.

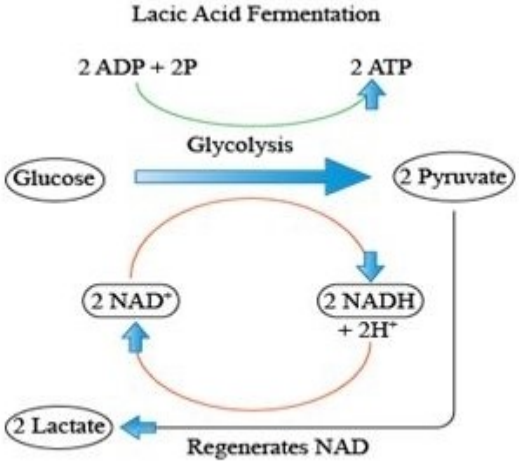

Fig: Lactic acid fermentation

ii. <u>Alcohol fermentation</u>: It occurs in yeast and bacteria. In this process, pyruvate gets reduced to ethanol and along the process generates two molecules of carbon dioxide.

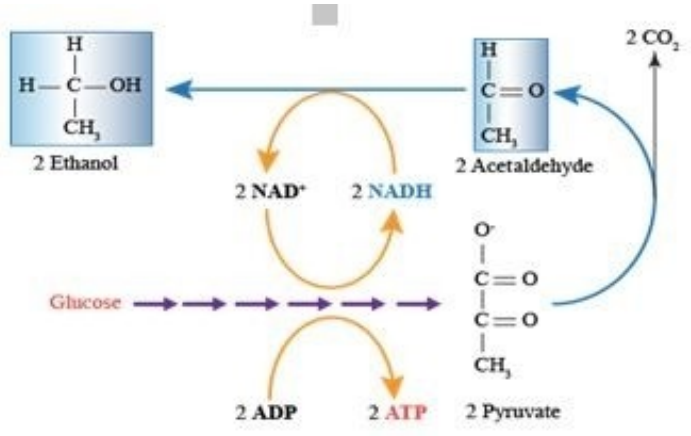

Fig: Alcohol fermentation

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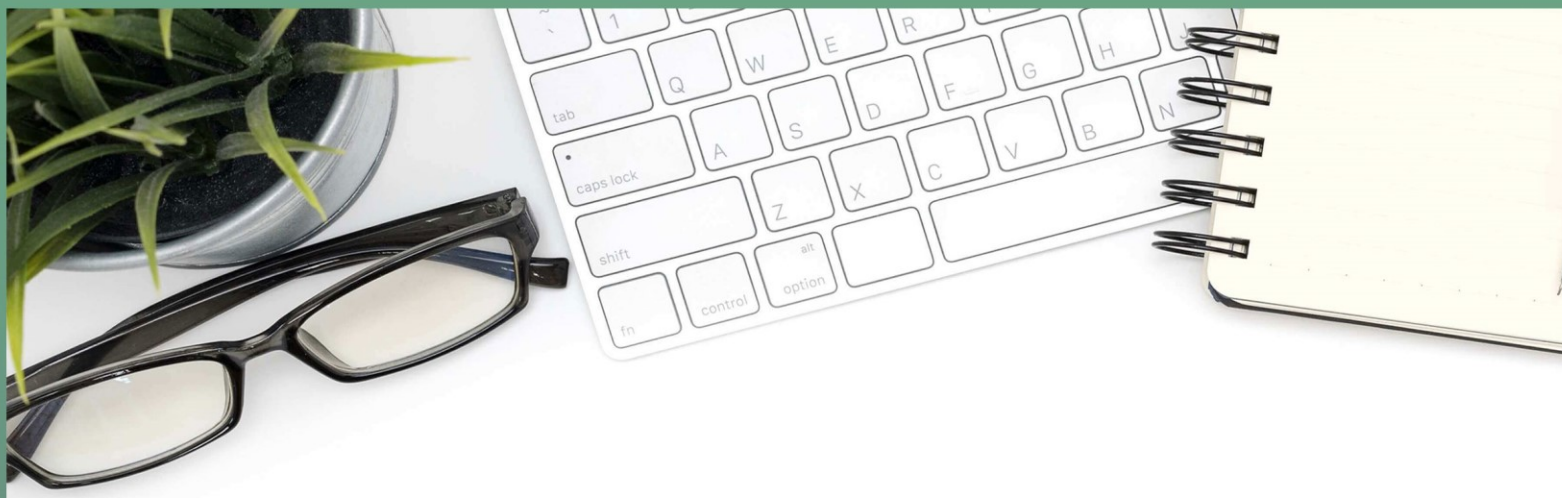

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