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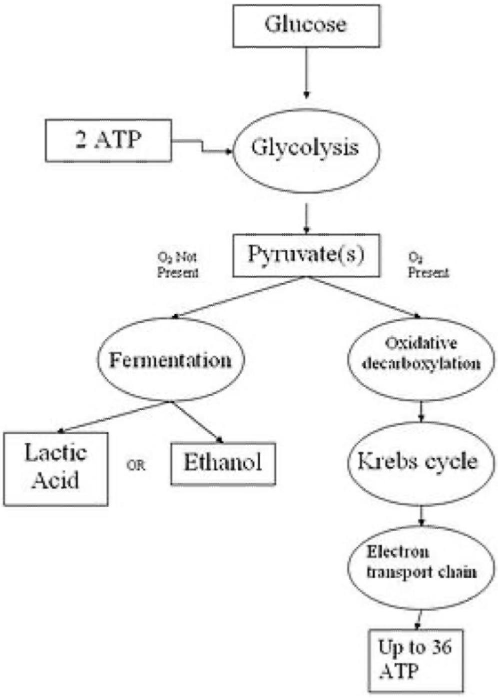
18/mhs01/301
MEDICAL LABORATORY SCIENCE
Assignment

Question
Describe the mechanism in aerobic respiration .

Answer
Aerobic respiration, the process that does use oxygen, produces much more energy and doesn't produce lactic acid. It also produces carbon dioxide as a waste product, which then enters the circulatory system . The carbon dioxide is taken to the lungs, where it is exchanged for oxygen. The simplified formula for aerobic cellular respiration is:
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy (as ATP)

Aerobic cellular respiration has four stages. Each is important, and could not happen without the one before it. The steps of aerobic cellular respiration are:

- Glycolysis(the break down of glucose)
- Kreb cycle
- Terminal oxidation



Glycolysis:
It is also called EMP pathway because it was discovered by three German scientists Embden, Meyerhof and

Parnas. Glycolysis is the process of breakdown of glucose or similar hexose sugar to molecules of pyruvic acid through a series of enzyme mediated reactions releasing some energy (as ATP) and reducing power (as NADH2). It occurs in the cytoplasm. It takes place in the following sub steps.

1. Phosphorylation: Glucose is phosphorylated to glucose-6-phosphate by ATP in the presence of enzyme hexokinase (Meyerhof, 1927) or glucokinase (e.g., liver) and Mg2+.

2. Isomerization: Glucose-6-phosphate is changed to its isomer fructose-6-phosphate with the help of enzyme phosphohexose isomerase.

Fructose-6-phosphate can also be produced directly by phosphorylation of fructose with the help of enzyme fructokinase.

3. Phosphorylation: Fructose-6-phosphate is further phosphorylated by means of ATP in presence of enzyme phosphofructo-kinase and Mg2+. The product is Fructose-1, 6 diphosphate.

4. Splitting: Fructose-1, 6-diphosphate splits up enzymatically to form one molecule each of 3-carbon compounds, glyceraldehyde 3-phosphate (= GAP or 3-phosphoglyceraldehyde = PGAL) and dihydroxy acetone 3-phosphate (DIHAP). The latter is further changed to glyceraldehyde 3-phosphate by enzyme triose phosphate isomerase (= phosphotriose isomerase).

$$\text{Fructose-1, 6-diphosphate} \xrightleftharpoons{\text{Aldolase}} \text{Glyceraldehyde 3-phosphate (GAP) or Phosphyglyceraldehyde (=PGAL)} + \text{Dihydroxyacetone 3-phosphate}$$

$$\text{Dihydroxy acetone 3-phosphate} \xrightleftharpoons[\text{isomerase}]{\text{Triose phosphate}} \text{Glyceraldehyde 3-phosphate}$$

5. Dehydrogenation and Phosphorylation:
In the presence of enzyme glyceraldehyde phosphate dehydrogenase, glyceraldehyde 3-phosphate loses hydrogen to NAD to form NADH2 and accepts inorganic phosphate to form 1, 3-diphosphoglyceric acid.

$$\text{Glyceraldehyde 3-phosphate} + H_3PO_4 + NAD^+ \xrightleftharpoons[\text{Dehydrogenase}]{\text{Glyceraldehyde Phosphate}} \text{1,3-diphosphoglyceric acid} + NADH + H^+$$

6. Formation of ATP: One of the two phosphates of diphosphoglyeerie acid in linked by high energy bond. It can synthesise ATP and form 3-phosphoglyceric acid. The enzyme is phosphoglyceryl inase. The direct synthesis of ATP from metabolites is called substrate level phosphorylation.

$$\text{1, 3-diphosphoglyceric acid} + ADP \xrightleftharpoons[\text{Kinase } + Mg^{2+}]{\text{Phosphoglyceryl}} \text{3-phosphoglyceric acid} + ATP$$

7. Isomerization:
3-phosphoglyceric acid is

changed to its isomer 2-phosphoglyceric acid by zyme phosphoglyceromutase.

$$\text{3-diphosphoglyceric acid} \xrightleftharpoons{\text{phosphoglyceromutase}} \text{2-phosphoglyceric acid}$$

8. Dehydration:
Through the agency of enzyme enolase, 2-phosphoglyceric acid is converted to phosphoenol pyruvate (PEP). A molecule of water is removed in the process. Mg2+ is required.

$$\text{2-Phosphoglyceric acid} \xrightleftharpoons[Mg^{2+}]{\text{Enolase}} \underset{\text{(PEP)}}{\text{Phosphoenol Pyruvate}} + H_2O$$

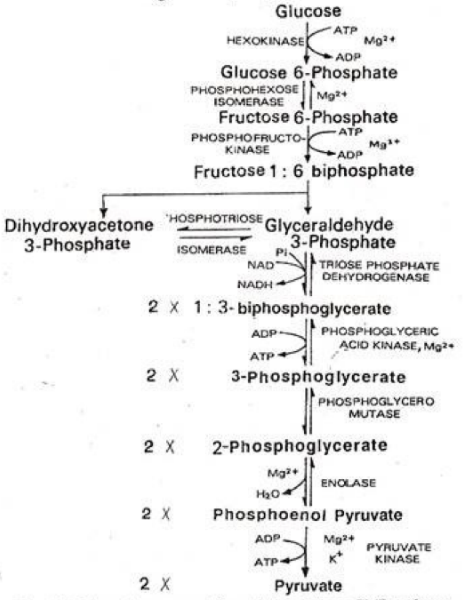


Fig. 1.18 Schematic representation of glycolysis or EMP pathway.

9. Formation of ATP:
During formation of phosphoenol pyruvate the phosphate radical picks

up energy. It helps in the production of ATP by substrate level phosphorylation. The enzyme is pyruvic kinase. It produces pyruvate from phosphoenol pyruvate.

Net Products of Glycolysis:

In glycolysis two molecules of ATP are consumed during double phosphorylation of glucose to form fructose-1, 6 diphosphate. In return four molecules of ATP are produced by substrate level phosphorylation (conversion of 1, 3 diphosphoglyceric acid to 3-phosphoglyceric acid and phosphenol pyruvate to pyruvate). Two molecules of NADH2 are formed at the time of oxidation of glyceraldehyde 3-

phosphate to 1, 3-diphosphoglyceric acid. The net reaction is as follows:

Glucose+2NAD+ +2ADP+2H3PO4+2H3PO4 -> 2 Pyruvate+2NADH+2H+ +2ATP

Krebs Cycle:

The next phase of aerobic respiration is the citric acid cycle, also known as the Kreb's cycle, named for the biochemist who discovered it. To prepare for this stage, the pyruvate molecules from glycolysis are converted to a 2-carbon compound called Acetyl CoA. What happened to the third carbon? You just exhaled it in the form of carbon dioxide!

With each turn of the cycle, the Acetyl CoA is broken down and rebuilt into carbon chains. The purpose is to extract electrons from them and generate more ATP, similar to the more simple process of glycolysis. NAD+ is used again to pick up the electrons released, as is another acceptor molecule, FADH, which becomes FADH2 when reduced. These acceptor molecules get loaded up with electrons, like cargo trucks, and carbon dioxide is released as the carbon chains are broken down and new Acetyl CoA comes in.

Terminal Oxidation:
It is the name of oxidation found in aerobic respiration that occurs towards the end of catabolic process and involves the passage of both electrons and

protons of reduced coenzymes to oxygen.

$$FADH_2 \rightleftharpoons FAD + 2H^+ + 2e^-$$
$$\frac{1}{2}O_2 + 2H^+ + 2e^- \longrightarrow H_2O$$

Terminal oxidation consists of two processes-electron transport and oxidative phosphorylation.