University of Fallujah
College of Medicine

Electron Transport Chain and Oxidative Phosphorylation

Lecture : 4&5

Stage : 2nd Stage

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Learn Objectives

-What is Electron Transport Chain ?

-Electron Transport Chain Complex

-Monophosphate Shunt (HMP) ?

Electron Transport Chain : This is the **final common pathway in aerobic** cells by which electrons derived from various substrates are **transferred to oxygen in mitochondria**.

• **Energy-rich molecules**, such as **ATP** " is generated as a result of the energy produced when electrons **transport from NADH and FADH2 are passed to oxygen** by a series of electron carriers, collectively **known as the electron transport chain.**

•The components of the chain include: **FMN** (Flavin mononucleotide), **Fe-S** centers, **coenzyme Q**, and a series of **cytochromes** (b, c1, c and aa3).

The ***electron transport chain in the mitochondrial membrane has been separated on four (4) complexes****, their components as follows:*

1- ***Complex I : NADH – CoQ reductase****.*

This system has two functions:

1-Electron transfer.

2-Acts as a proton pump.

$NADH + H_+ + FMN \rightarrow FMN.H_2 + NAD_+$

2- ***Complex II: Succinate – CoQ Reductase.***

Flow of ***electrons from succinate to CoQ occurs via FAD.H₂.***

$Succinate + CoQ \rightarrow Fumarate + CoQ.H_2$

3- Complex III: CoQ – Cyt.C Reductase.

Function as:

*1- **Proton pump**, and*

*2- **Catalyzes transfer of electrons.***

2- Fe^{+3} accepts electron and is oxidized to Fe^{+2}

4- ***Complex IV: Cyt.C oxidase.***

The system functions:

1- ***As proton pump.***

2- ***Catalyzes transfer of electrons from Cyt.C to molecular O_2 to form H_2O via Cyt.a****, Cu^{+2} ions and Cyt. A_3*

Note: Cyt. C does not form a part of any complexes. It is mobile and acts as a shuttle between complex – III and complex – IV to transfer e^- (electron).

• The energy derived from the transfer of electrons through the electron transport chain is used to pump protons across the inner mitochondrial membrane from the matrix to the cytosolic side. An electrochemical gradient is generated, consisting of a proton gradient and a membrane potential.

****ATP is transported from the mitochondrial matrix to the cytosol in exchange for ADP (the ATP-ADP antiport system)***.

*- The oxidation of **NADH** generates approximately (**3 ATP**), while the oxidation of one **$FADH_2$** **g**enerates approximately (**2 ATP**).*

- Because energy generated by transfer of electrons through the electron transport chain to O_2 is used in the production of ATP, the overall process is known as oxidative phosphorylation.

Clinical correlations:

- Cyanide poisoning:

Cyanide binds to Fe^{+3} in cytochrome aa_3. As a result, O_2 can not receive electrons, respiration is inhibited, energy production is halted, and death occurs rapidly.

After cyanide poisoning, the electron transport chain can no longer pump electrons into the intermembrane space. The pH of the intermembrane space would increase, and ATP synthesis would stop

-Acute myocardial infarction:

Coronary arteries frequently become narrow because of atherosclerotic plaques. If coronary occlusions occur, regions of heart muscle may be deprived of blood flow and, therefore, of oxygen for prolonged periods of time. Lack of oxygen causes inhibition of the processes of electron transport and oxidative phosphorylation, which results in a decreased production of ATP.

Heart muscle, suffering from a lack of energy required for contraction and maintenance of membrane integrity, becomes damaged. Enzymes from the damaged cells leak into the blood. If the damage is relatively mild, the person may recover. If heart function is severely compromised, death may result

Monophosphate Shunt (HMP)

An **alternate pathway** for oxidation of glucose.

It is also called HMP pathway or **Pentose –phosphate pathway** (pp-pathway) or called Pentose cycle and finally may called phosphogluconate pathway.

Biomedical Importance

-it is oxidationenergy of glucose, but not meant for energy.

-provide NADPH which is required for various reductive synthesis in metabolic pathways.

-provides pentoses required for nucleic acid synthesis.

Deficiency of a particular enzyme leads to hemolytic anemia, which is of great clinical importance.

Major differences with Embden–Meyerhof pathway

1- This pathway occurs in certain **specialized tissues** only to serve specific functions. e.g. *liver, adipose tissue, RB cells, tests and ovary, adrenal cortex and lactating mammary glands, also lens and cornea of eyes*. **It is unimportant for skeletal muscle.**

2- It is a **multicyclic process, 3 molecules of G-6-P enter the cycle, producing 3 mols of CO_2 and 3 mols of 5-C residues, which rearrange to give 2 mols of G-6-P and one mol of glyceraldehyde-3-P**.

3- Oxidation is achieved by **dehydrogenation**, **but NADP+ *is used as* . +not NAD*hydrogen acceptor and***

4- **CO_2 is produced** in this pathway which is never produced in E.M. pathway.

Similarity: The only similarity is that enzymes are extra mitochondrial (Cytosolic) and it operates in cytosol.

NOTE: *NADP: Nicotinamide adenine dinucleotide phosphate.*
NAD: Nicotinamide adenine dinucleotide.