(Unit-II) Synthesis of ATP by oxidative electron transport chain

* Oxidative phosphorylation is made up of 2 parts
1) Electron transport chain 2) Chemiosmosis
* Oxidative phosphorylation is a metabolic pathway through which cell release the energy stored in carbohydrates, fats and proteins to produce ATP, the main source of energy for intracellular reactions.

* The process takes place within the mitochondria and involves oxidation-reduction reactions and the generation of an electrochemical gradient by the Electron transport chain

* The electron transport chain (mitochondrial membrane and consists of 4 electron carrier complexes (Complex I-IV) that transfer electrons from NADH and $FADH_2$ to oxygen thereby generating H_2O.

* The electron transport chain is the final component of aerobic respiration and is the only part of glucose metabolism that uses atmospheric oxygen.

* Electron transport chain is a series of redox reactions that resemble a relay race

* The electron transport chain is present in multiple copies in the inner mitochondrial membrane of eukaryotes and plasma membrane of prokaryotes.

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* The details of 4 complexes are describe here:-

1. Complex I

* In this complex, two electrons are carried to the first complex aboard NADH. Complex I is composed of flavin mononucleotide (FMN) and an enzyme containing iron-sulfur (Fe-S).

* FMN, is derived from vitamin B_2, is one of prosthetic groups in the electron transport chain

* The enzyme in complex I is NADH dehydrogenase, a very large protein containing 45 Amino acid chain.

* Complex I can pump 4 hydrogen ions across the membrane from the matrix into the intermembrane space. In this way the hydrogen ion gradient is established and maintain between the 2 compartments separated by the inner mitochondrial membrane.

2. Q and Complex II

* Complex II directly receives $FADH_2$, which does not pass through complex I.

* The compound connecting the first & second complexes to the third is ubiquinone (Q)

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* Q molecule is lipid soluble and freely moves through the hydrophobic core of membrane.
* Once, it is reduced to QH_2, its delivers its electrons to the next Complex in the E.T.C.
* Q receives the electrons derived from NADH from Complex I & the electron derived from $FADH_2$ from Complex II, including succinate dehydrogenase.
* This enzyme and $FADH_2$ form a small complex that delivers electrons directly to the E.T.C, by passing the first complex.
* These electrons bypass, and thus do not energize, the proton pump in the first complex, fewer ATP molecule are made from the $FADH_2$ electrons
* The number of ATP molecules ultimately obtained is directly proportional to the number of protons pumped across the inner mitochondrial membrane

3. Complex III

* The third Complex is composed of Cytochrome B, another Fe-S protein, 2Fe-2S center and cytochrome c protein. This complex is also known as cytochrome oxidoreductase.

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- Cytochrome protein have a prosthetic heme group, it carries electron not oxygen.
- As a result, the iron ion at its core is reduced and oxidized as it passes the electrons, fluctuating between different oxidation state :- Fe^{2+} reduced and Fe^{3+} oxidized.
- Complex III pumps proton through the membrane and passes its electrons to cytochrome c for transport to the complex IV.
- Cytochrome c is the acceptor of electrons from Q; however Q carries pairs of electrons, cytochrome c can accept only one at time.

Complex IV

- It is composed of cytochrome protein c, a and a_3. This complex contains 2 heme groups (one in each of the cytochrome a & a_3) and 3 copper ions.
- The cytochromes hold an oxygen molecule very tightly between the iron and copper ions until the oxygen is completely reduced.
- The reduced oxygen is completely reduced. The reduced oxygen then picks up two hydrogen ions from the surrounding medium to produce water.

$2e^- + H^+ + 1/2\,O_2 \rightarrow H_2O$

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* ATP Synthase uses the proton gradient across the mitochondrial membrane to form ATP.
* It is made up of F_o and F_1 subunits which acts as a rotational motor system
* F_o portion is embedded in the mitochondrial membrane and is protonated and deprotonated repeatedly causing it to rotate.
* This rotation catalyzes the formation of ATP from ADP & Pi.
* The F_1 portion works to hydrolyze the ATP.

Function

* The function of the electron transport chain is to produce a transmembrane proton electrochemical gradient as a result of the redox reaction
* In most of the organism the majority of ATP is generated in electron transport chain.

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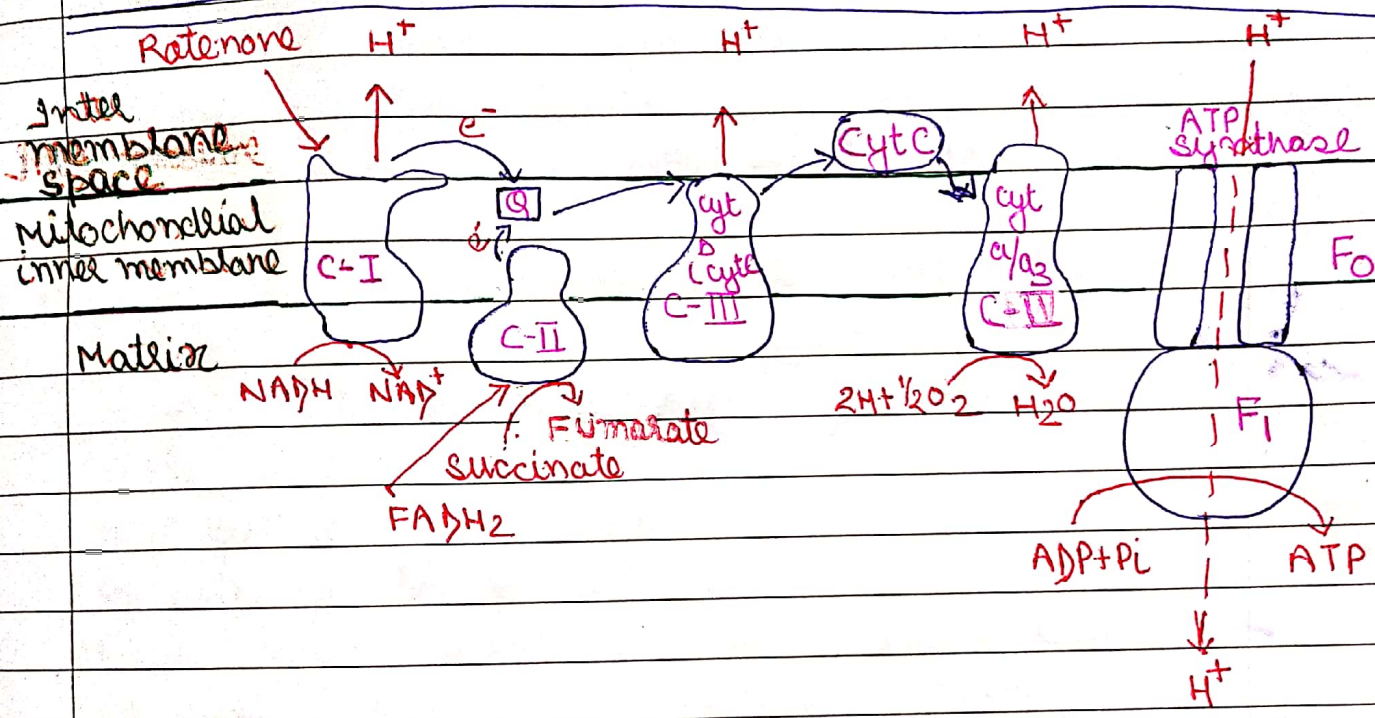

Electron transport Pathway in Mitochondria