-: Biological Oxidation :-

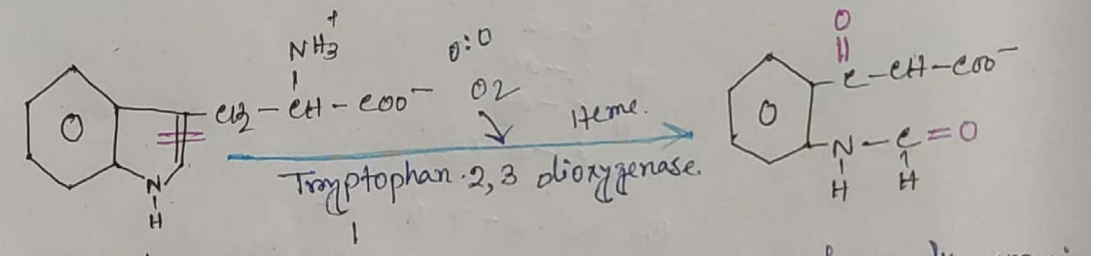
Role of Oxygenases:- Oxygenases are group of enzymes may Oxidizes substrate by removing reducing equivalents (H^+ and electrons) from the substrate by using O_2.

For example:-

1. Dioxygenases.
2. Mono oxygenases or Hydroxylase.

1. Dioxygenases:-

This enzyme cleave the molecular chain of substrate by adding both atoms of O_2.



Tryptophan

N-formylkynurenine

Fig:- Action of Dioxygenases

2. Mono oxygenases or Hydroxylase:-

Mono oxygenases incorporates one oxygen atom of O_2 into the substrate to form a Hydroxyl group and other oxygen atoms is reduce to H_2O by reducing equivalents (H^+ and e) from electron donar cosubstrate and coenzyme like NADPH, Tetrohydrobiopterin, cytochrome P_{450}. Simultaneously this enzyme further oxydises the nascent products.

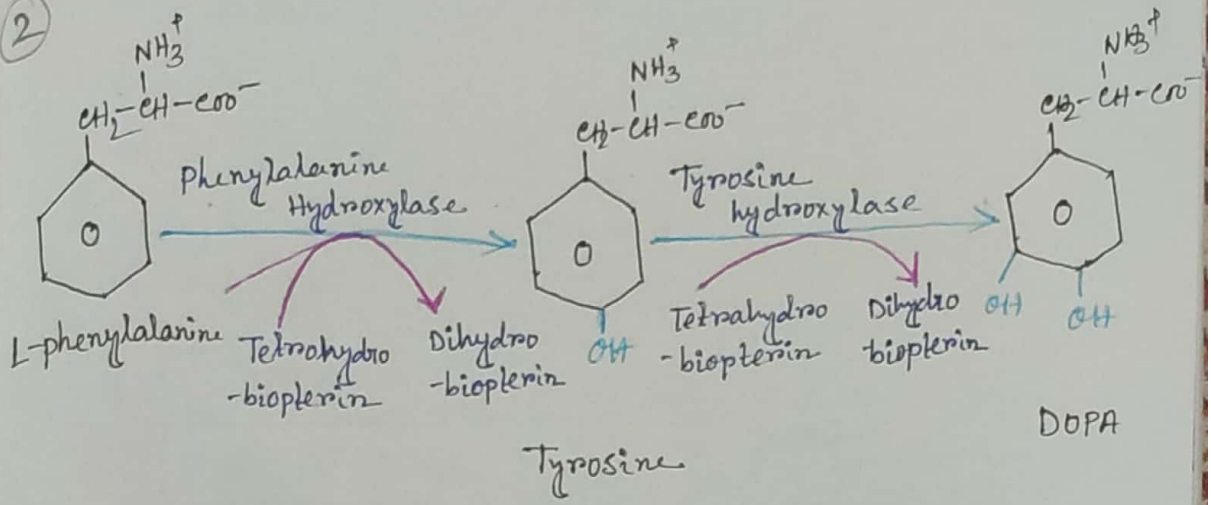


Fig:- Action of Mono oxygenase

Role of Oxidases:-

1. Cytochrome oxidases oxidises the substrate by transfering reducing equivelants (H^+ and e^-) from the substrate to molecular O_2 directly in mitocondrial membrane.

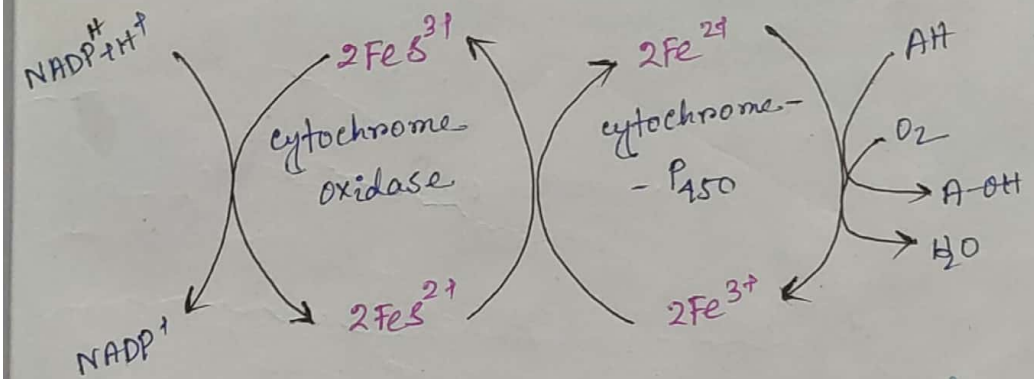


Fig:- Role of cytochrome oxidase

2. Flavoprotein Oxidases:-

This enzymes tightly bound with FAD or FMN and oxidises substrates (AH_2) by ~~except~~ reducing equivalents (H^+ and e^-) and reduces FMN or FAD to $FMNH_2$ or $FADH_2$. Thereby, $FMNH_2$ or $FADH_2$ oxidises to FMN or FAD by donating reducing equivalent directly to molecular O_2 and forming H_2O

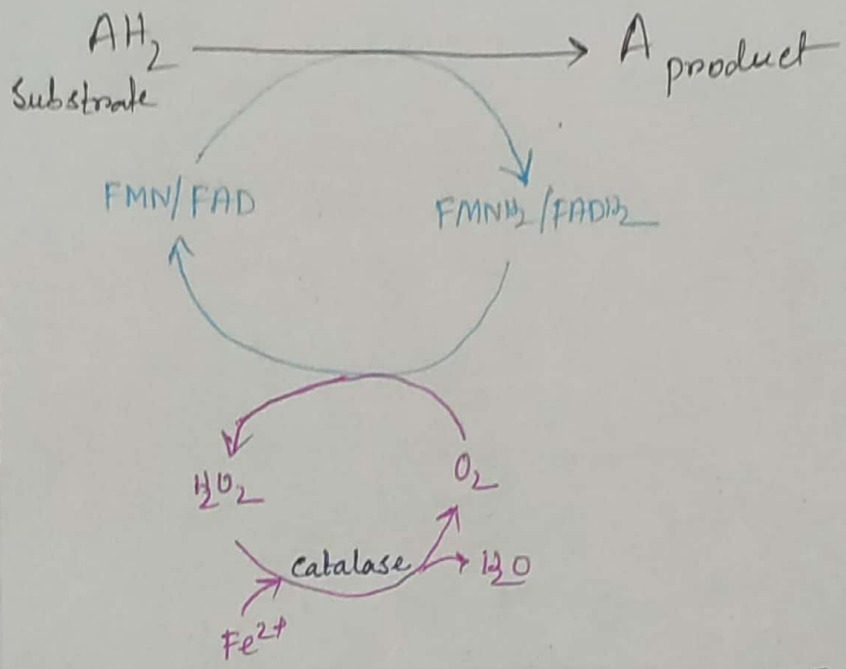


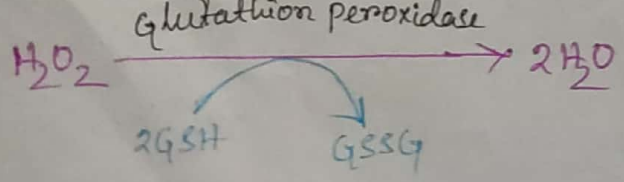
Fig:- Role of Flavoprotein oxidase

Role of Hydroperoxidases:—

Hydroperoxidases are redox active Hemoproteins may transfer reducing equivalents (H^+ & e^-) from specific electron donar substrate into peroxides such as H_2O_2, Fatty acid peroxides and other organic hydroperoxides to neutralise peroxides. Hydroperoxidases include glutathione peroxidases, amino acid oxidase, xanthine oxidase, Super oxide dismutase (SOD) etc occur in hepatic and renal peroxisomes, erothrocyte, granulocytes, platelets and many other tissues.

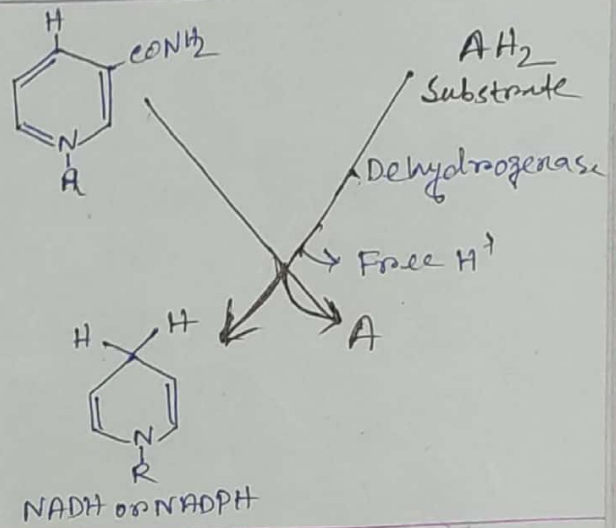
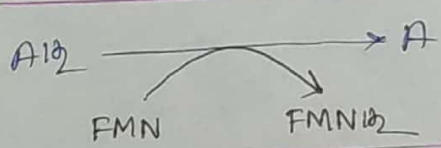
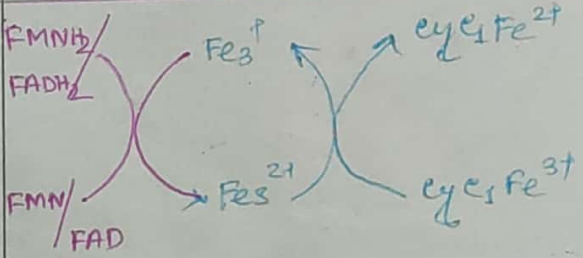
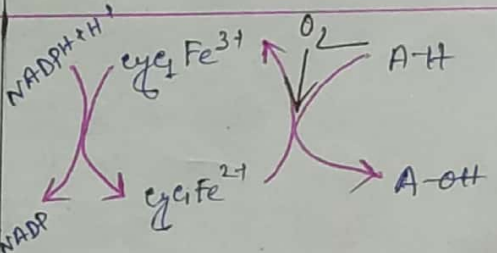
② Role of Glutathione peroxidases:—

It is a selenoprotein acting as an antioxidant and protecting from strace full effects of Reactive oxygen species (ROS) in tissues. Glutathione peroxidase uses reduce glutathion (GSH) as the electron donar in reducing H_2O_2 to Water and GSSG (oxidised glutathione).



Role of Dehydrogenases :—

This enzymes can't transfer electrons from the substrate to molecular O_2 directly. This enzymes transfer electron to other electron acceptor. The role some dehydrogenases mention below in table :——

Dehydrogenases	Name of the electron acceptors	Reaction Sequences
1. Pyridine-linked dehydrogenases	NAD^+ and $NADP^+$	
2. Flavin linked dehydrogenases	FMN or FAD	
3. Iron-Sulfer proteins	Fe^{3+}	
4. Cytochromes	cytochrome b_{560}, b_L, b_H, c and c_1	

Redox Potential (E_0') :— The electron affinity of a substance is expressed as its redox potential (E_0') or oxidation reduction potential. An oxidizing and reducing agent exists in two form ——

(5)

Oxidizing or reducing Agent

(1) The oxidant accepts electrons from a substrate to oxidize.

(2) The reductant, which donates electrons to a substrate to reduce.

So, the electron acceptor oxidant form and the electron donar reductant form of a substant constitute a redox couple eg; $NAD^+/NADH$, FMN/$FMNH_2$, Ferricytochrome/Ferrocytochrome redox pairs.

	E_0' Volts
$NAD^+ + 2e + 2H^+ \rightleftharpoons NADH + H^+$	−0.315
$FMN + 2e + 2H^+ \rightleftharpoons FMNH_2$	−0.30
$cyc\,Fe^{3+} + e \rightleftharpoons cyc\,Fe^{2+}$	+0.235

1. What is Nernst equation?

⇒ The electron transfer potential (E) of a redox couple is discribed by the Nernst equation which expresses E as a function of a ratio of molar Concentration of the oxident (ox) and its conjugate reductant (Red).

Nernst equation is, —

$$E = E_0' + \frac{0.059}{n} \log \frac{[ox]}{[red]}$$

Where,
- E = Electron Transfer potential
- E_0' = Redox potential
- n = Number of electron transfer.

The Nernst equation is, indicates that a rise in the relative Concentration of the oxidant raises the electron transfer potential with a concequent increase in its electron affinity and oxidizing capacity.

Mitochondrial Respiratory chain / Electron Transport chain (ETC) and its mechanism :—

The inner mitochondrial membrane carries an electron transport chain (ETC) or Mitochondrial respiratory chain forms the final path for electron flow from tissue substrate to molecular O_2 in this chain electrons flow from the reductant of a redox couple (a lower redox potential) to the oxidant of another redox couple (a higher redox potential) the free energy liberated during the flow of electrons along this chain by forming high energy bonds of ATP.

The chain contains the following components as the principle electron carriers —

— Co-enzyme Q, cytochrome c, b_L, b_H, b_{560}, c_1, a and a_3.

Mechanism :—

Respiratory chain complexes :—

There are four complex – I, II, III, IV catalyses electron transfer from NADH to coenzyme Q.

Respiratory chain complex

Complex I	Complex II	Complex III	Complex IV
or, NADH CoQ oxidoreductase	or, Succinate CoQ reductase	or QH_2 cytochrome c reductase	or, cytochrome oxidases

1. **Complex I :—**

NADH CoQ oxidoreductase binds with FMN and iron sulfur clusters (Fe_2S_2 and Fe_4S_4) as prosthetic group.

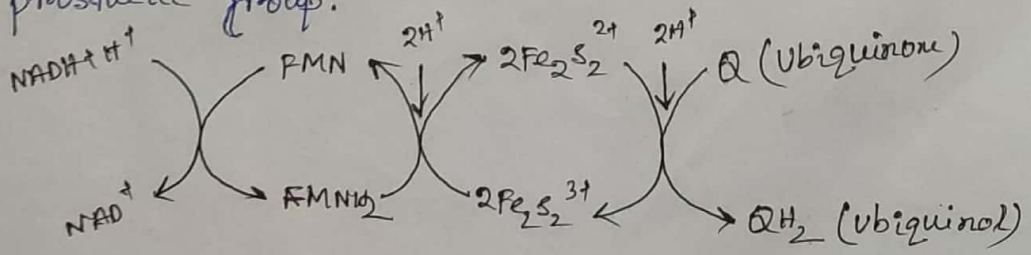


Fig:- Overall action of NADH-CoQ reductase

2. Complex II :— Succinate CoQ reductase binds with FAD and Fe_2S_2 as prosthetic group and oxidises Succinate to Fumarate.

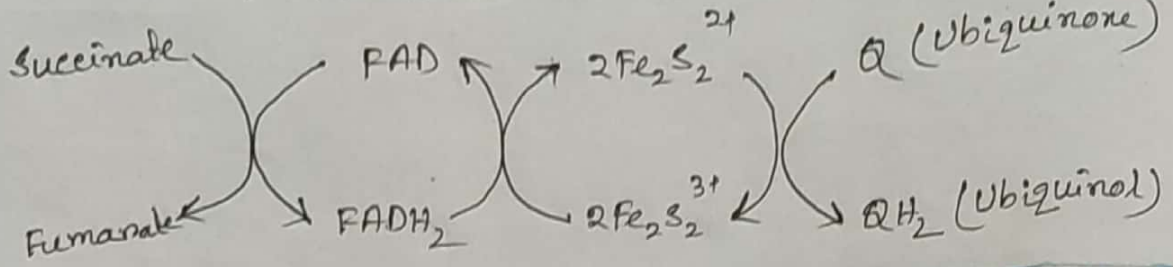


Fig:- Overall action of Succinate CoQ reductase

3. Complex III :— QH_2 cytochrome c reductase binds with heme b_L, heme b_H, heme c and nonheme Fe_2S_2 as prosthetic group transfers electron from QH_2 to Q.

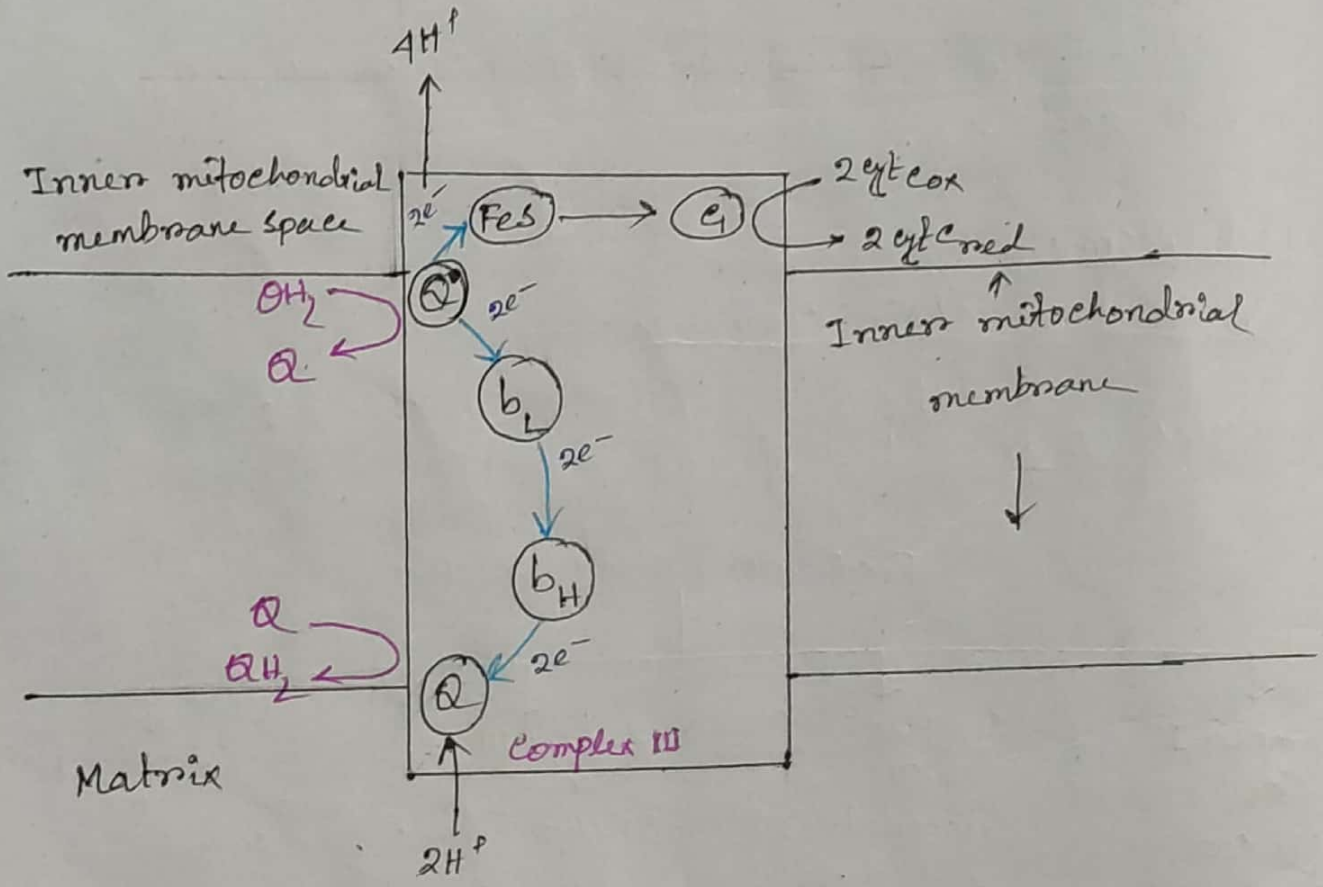


Fig:- Q cytochrome c

4. Complex IV :— cytochrome oxidased bind with Ferrocytochrome c ($cyt\,c\,Fe^{2+}$), Cu_A, Cu_B, $cyt\,a$ and $cyt\,a_3$ transfer from mitochondrial matrix to inner membrane spaces.

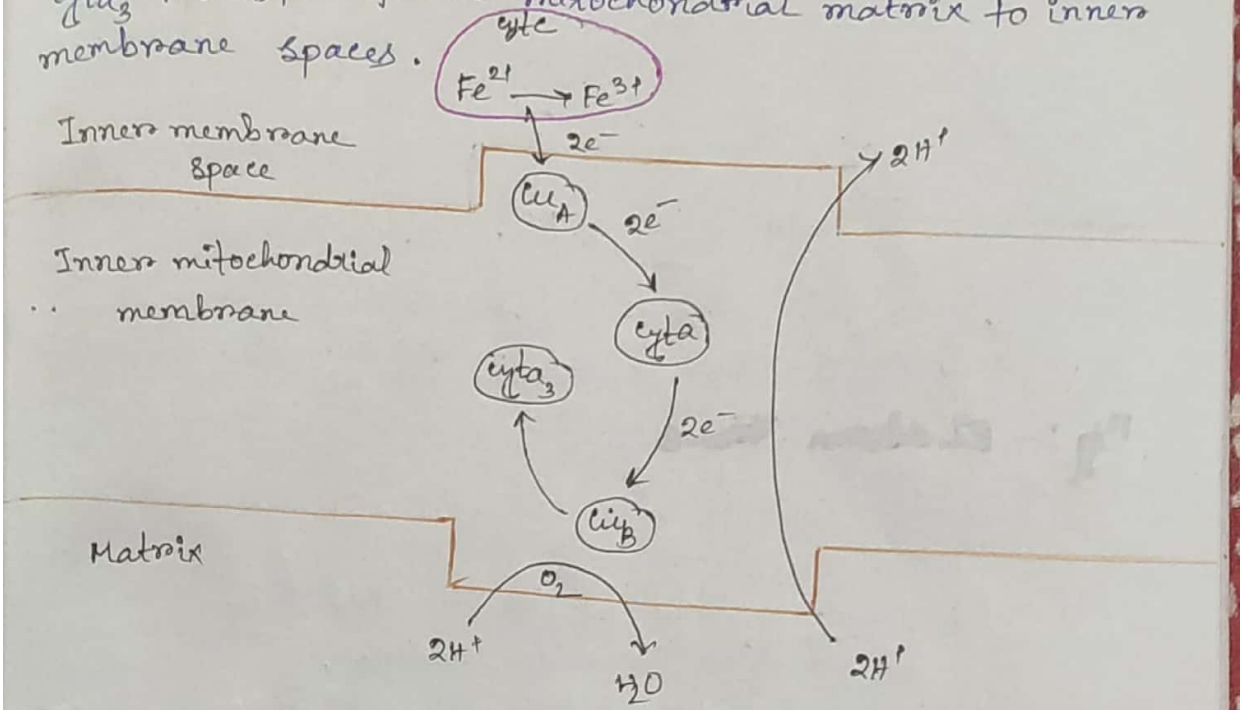


Fig:— Role of cytochrome oxidases

Oxidative Phosphorylation

Oxidative phosphorylation := Oxidative phosphorylation is the formation of ATP by the phosphorylation of ADP with pi during mitochondrial aerobic oxidation. Transport of electrons along with Redox potential (E_0') of the component in the complexes I, II, III, IV creates formation of a high energy phosphoric anhydride bond of ATP by the endergonic reaction and exergonic reaction. ATP synthesis catalyses endergonic phosphorylation of ADP to ATP and release free energy during electron flow. There are many theory regarding ATP synthesis out of these chemiosmotic theory is accepted.—

Chamiosmotic theory of ATP synthesis :—

In this theory peter Mitchell proposed that, ATP synthesis catalyses the phosphorylate coupling with mitochondrial electron transport to release free energy during translocation of protons from the matrix to mitochondrial inner membrane space across the inner membrane. This proton translocation maintains a higher H^+-concentration outside

the inner membrane to generate 0.14V electron negative membrane potential. By this potential energy ATP Synthesis phosphorylates ADP to ATP.

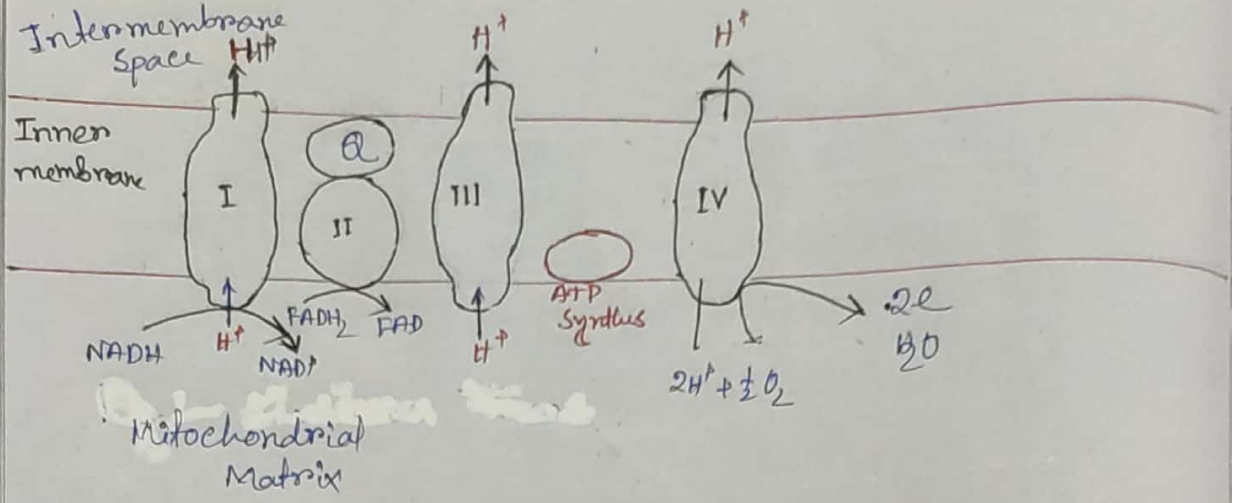


Fig:- Electron transport during oxidative phosphorylation in mitochondria.

Substrate level phosphorylation

☑ Substrate level phosphorylation:- It is a metabolic reaction of transfer a phosphoryl (PO_3) group to ADP or GDP to form ATP or GTP. PO_3 group is transfer from another phosphorylated compound during this phosphorylation released chemical energy called the Gibbs free energy. Substrate level phosphorylation occurs in the cytoplasm of cell during glycolysis and in mitochondria during Krebs cycle.

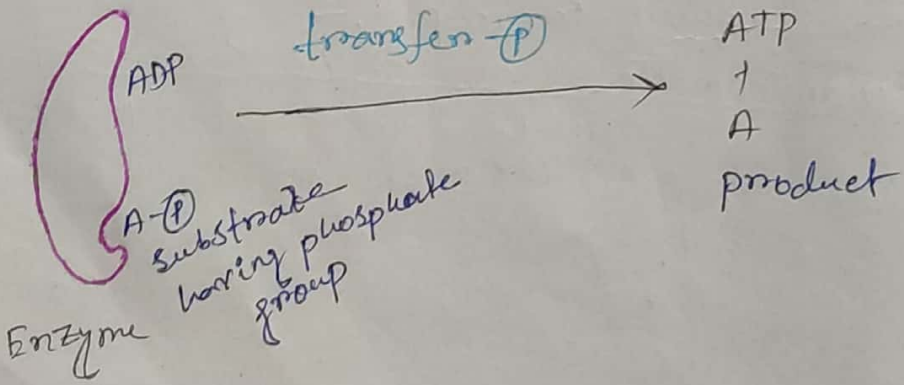


Fig:- Substrate level phosphorylation.

What is oxidative stress:—

Oxidative stress is an imbalance between reactive oxygen species (ROS) and antioxidant in the cells and tissues. Some (ROS) Reactive oxygen species are superoxide anion (O_2^-), Hydroperoxyl radical ($HO_2^{\cdot}$), hydrogen peroxide (H_2O_2) and Hydroxyl radical ($O^{\cdot}H$).

Under normal condition cells are able to balance the production of oxidants and antioxidants but When Reactive oxygen species (ROS) are excess in the cell posses oxidative stress. In humans, oxidative stress may cause cancer, parkinson's disease. Athero selerosis, diabetic, Alzheimer's disease etc.