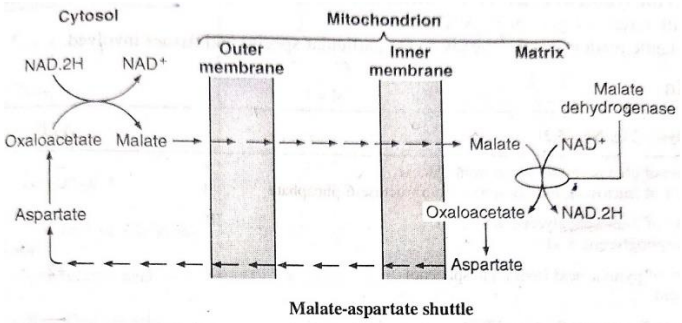
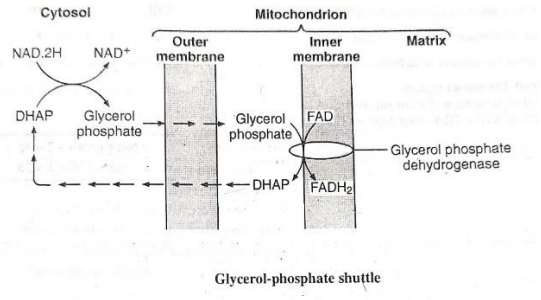
ELECTRON TRANSPORT CHAIN

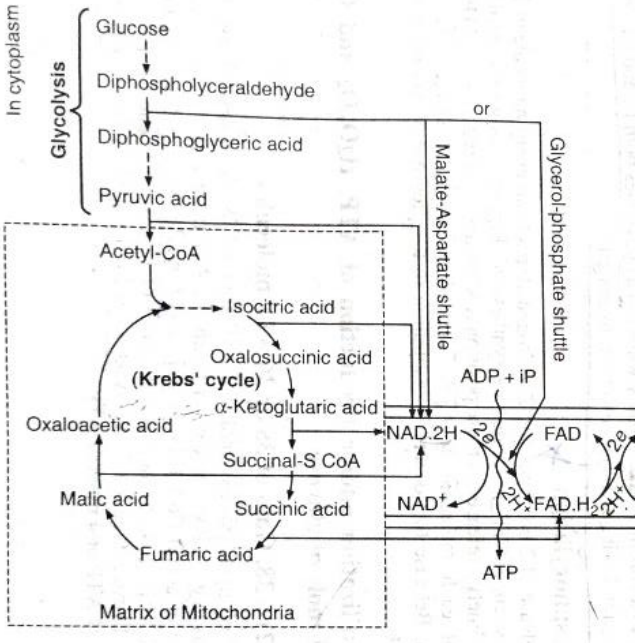
1. **Step-3 Biological oxidation (Electron transport chain)**
   - **Shuttle system**
     - The shuttle system is required because the mitochondrial inner membrane is impermeable to NADH and FADH
     - The **malate-aspartate shuttle** (sometimes simply the **malate shuttle**) is a biochemical system for translocating electrons produced during glycolysis across the semipermeable inner membrane of the mitochondrion for oxidative phosphorylation in eukaryotes
     - The other shuttle is less ambient and results in the reduction of FASD inside the mitochondrion. If this shuttle predominates the electron from NAD2H transferred to FD inside the mitochondrion



Malate-aspartate shuttle



Glycerol-phosphate shuttle

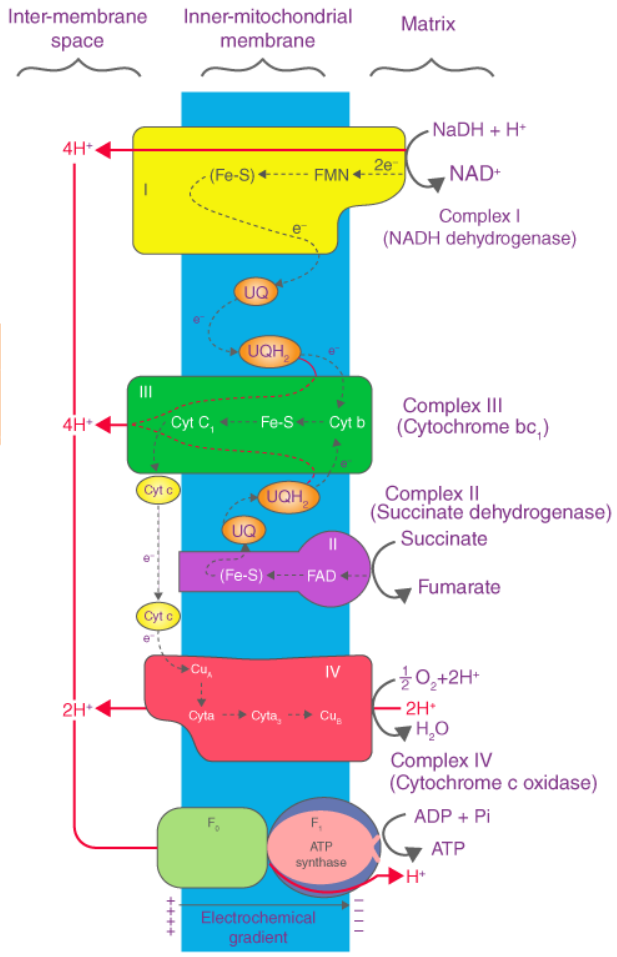


Terminal oxidation- it is the combination of oxygen with electrons and protons released from reduced coenzyme. it produces water called metabolic water.

➢ **Electron transport system (ETS)**

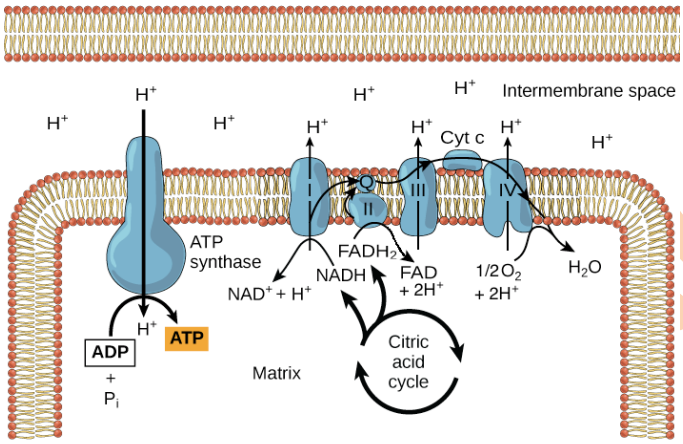
- The metabolic pathway through which the electron passes from one carrier to another is called electron transport system
- It is present in inner mitochondrial membrane in eukaryotes and inner side of plasma membrane in prokaryotes
- The electron carriers are arranged along increasing redox or positive potential or increasing affinity for electrons
- It consists of:-
  - i) Flavins, FeS complex, Quinones (ubiquinones),
  - ii) Cytochromes (cyt b, cyt C, cyt C_1, cyt a and cyt a_3). They contain iron which can undergo $Fe^{2+} \rightarrow Fe^{3+} \rightarrow Fe^{3+}$ during passage of electron.
  - iii) Cyt a_3 additionally contain copper which help in transferring electrons to oxygen

Explanation



- Electrons from NADH produced in the mitochondrial matrix during citric acid cycle are oxidised by an NADH dehydrogenase (complex I), and electrons are then transferred to ubiquinone located within the inner membrane.
- Ubiquinone also receives reducing equivalents via $FADH_2$ (complex II) that is generated during oxidation of succinate in the citric acid cycle.
- The reduced ubiquinone (ubiquinol) is then oxidised with the transfer of electrons to cytochrome *c* via cytochrome *bc*$_1$ complex (complex III). Cytochrome *c* is a small protein attached to the outer surface of the inner membrane and acts as a mobile carrier for transfer of electrons between complex III and IV.
- Complex IV refers to cytochrome *c* oxidase complex containing cytochromes *a* and *a*$_3$, and two copper centres.
- When the electrons pass from one carrier to another via complex I to IV in the electron transport chain, they are coupled to ATP synthase (complex V) for the production of ATP from ADP and inorganic phosphate.
- Oxidation of one molecule of NADH gives rise to 3 molecules of ATP, while that of one molecule of $FADH_2$ produces 2 molecules of ATP.
- Although the aerobic process of respiration takes place only in the presence of oxygen, the role of oxygen is limited to the terminal stage of the process. Yet, the presence of oxygen is vital, since it drives the whole process by removing hydrogen from the system. Oxygen acts as the final hydrogen acceptor.
- **oxidative phosphorylation-** Unlike photophosphorylation where it is the light energy that is utilised for the production of proton gradient required for phosphorylation, in respiration it is the energy of oxidation-reduction utilised for the same process. It is for this reason that the process is called **oxidative phosphorylation.**

- The energy released during the electron transport system is utilised in synthesising ATP with the help of ATP synthase (complex V).
- This complex consists of two major components, F_1 and F_0. The F_1 headpiece is a peripheral membrane protein complex and contains the site for synthesis of ATP from ADP and inorganic phosphate. F_0 is an integral membrane protein complex that forms the channel through which protons cross the inner membrane. For each ATP produced, $4H_+$ passes through F_0 from the intermembrane space to the matrix down the electrochemical proton gradient.



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