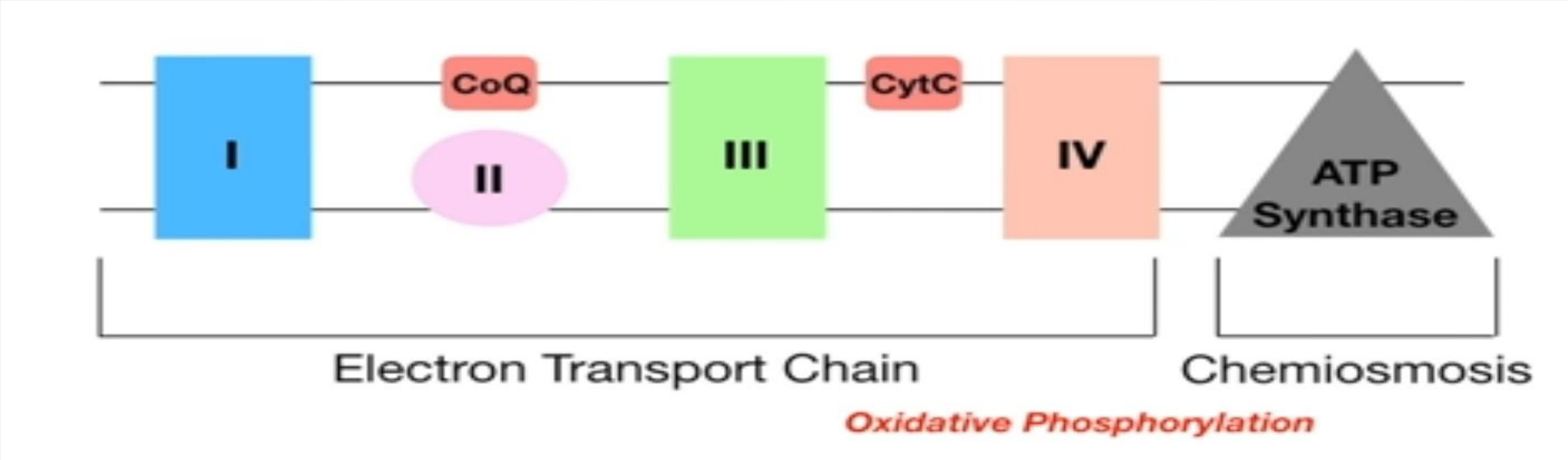

Electron Transport Chain

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Introduction

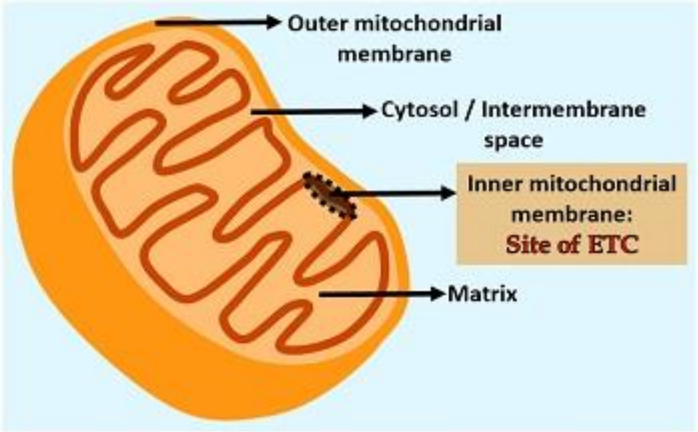
- The electron transport chain (ETC) is a group of proteins and organic molecules found in the inner membrane of mitochondria.
- Each chain member transfers electrons in a series of oxidation-reduction (redox) reactions to form a proton gradient that drives ATP synthesis.

Discovery

- American biochemist, Albert Lehninger, discovered the electron-transport chain in 1961.

Location and Complexes

- In eukaryotes, multiple copies of electron transport chain components are located in the inner membrane of mitochondria.
- The complete ETC was found to have four membrane-bound complexes named complex I, II, III, and IV and two mobile electron carriers, namely coenzyme Q and cytochrome c.



LOCATION OF ELECTRON TRANSPORT SYSTEM

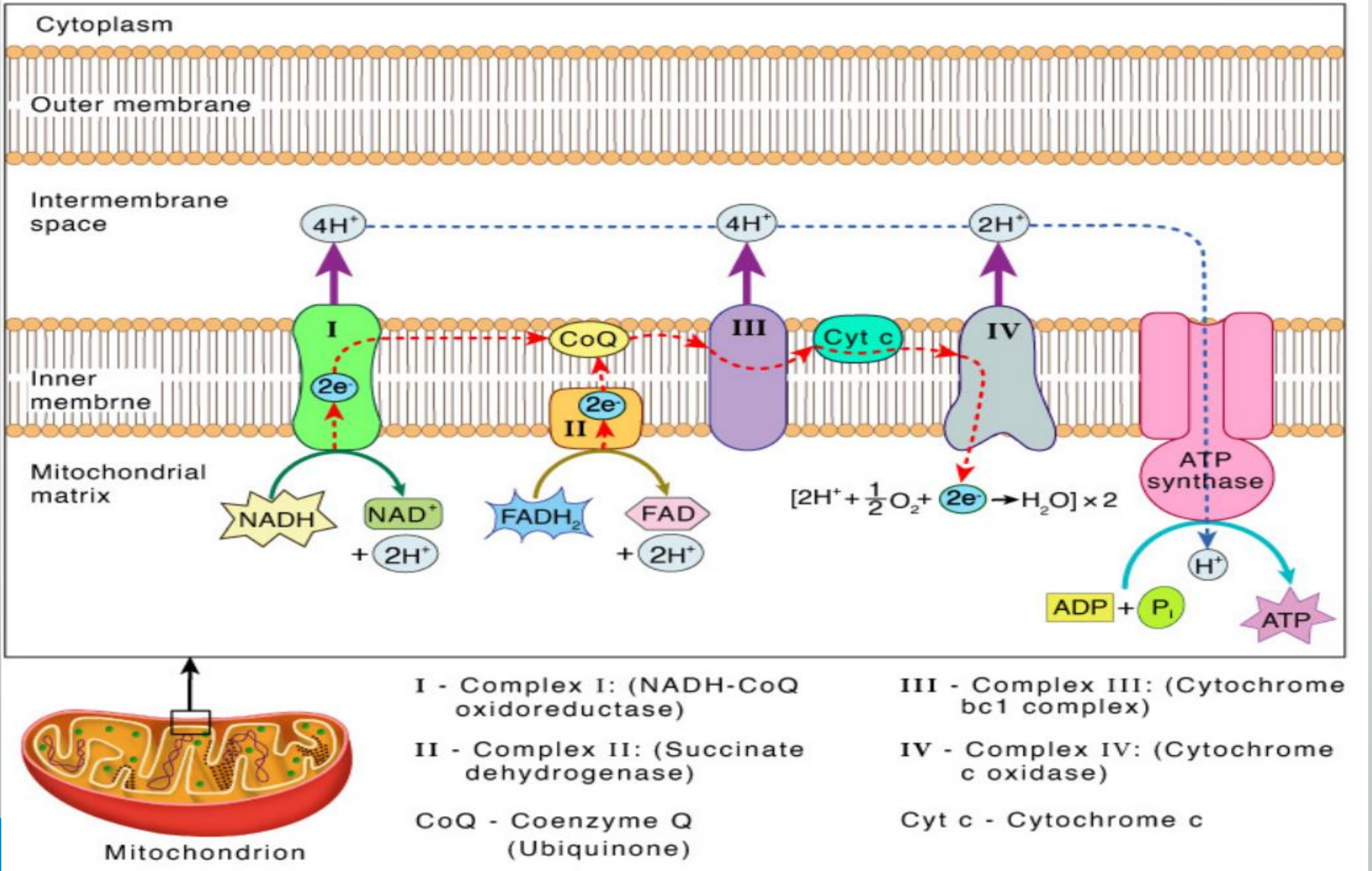
Significance of ETC

- **Regeneration of electron carriers**: Reduced electron carriers NADH and $FADH_2$ pass their electrons to the chain, turning them back into NAD^+ and FAD. This function is vital because the oxidized forms are reused in glycolysis and the citric acid cycle (Krebs cycle) during cellular respiration.

- **Generating proton gradient**: The transport of electron through the chain results in a gradient of a proton across the inner membrane of mitochondria, later used in ATP synthesis.

Critical steps of the electron transport chain

- Donation of electrons by electron carriers NADH and $FADH_2$
- Transfer of electrons by mobile electron carriers and proton pumping
- Splitting of oxygen to form water
- Synthesis of ATP



Cytoplasm
Outer membrane
Intermembrane space
4H+
4H+
2H+
I
CoQ
III
Cyt c
IV
2e-
2e-
II
Inner membrne
Mitochondrial matrix
NADH
NAD+
+ 2H+
FADH2
FAD
+ 2H+
[2H+ + 1/2 O2 + 2e- → H2O] × 2
ATP synthase
H+
ADP + Pi
ATP
Mitochondrion
I - Complex I: (NADH-CoQ oxidoreductase)
II - Complex II: (Succinate dehydrogenase)
CoQ - Coenzyme Q (Ubiquinone)
III - Complex III: (Cytochrome bc1 complex)
IV - Complex IV: (Cytochrome c oxidase)
Cyt c - Cytochrome c

Complex I

- Transfer of Electrons from NADH to Coenzyme Q
- It is found to be composed of one flavin mononucleotide (FMN) and six-seven iron-sulfur centers (Fe-S) as cofactors
- The process starts by catalyzing the oxidation of NADH to NAD^+ by transferring the two electrons
- The above process allows Complex I to pump four protons (H^+) from the mitochondrial matrix to the intermembrane space, establishing the proton gradient.

Complex II

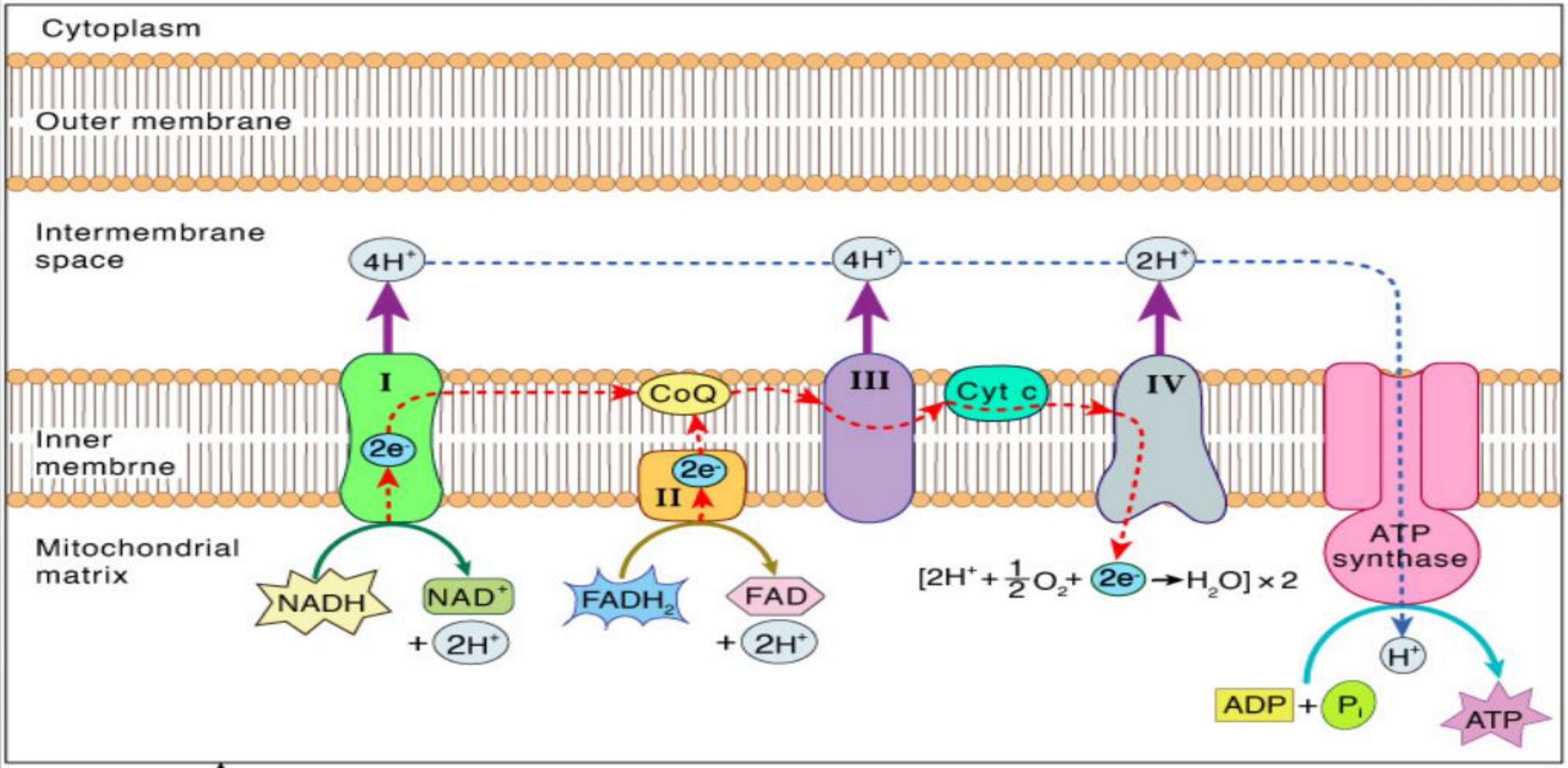
- Transfer of Electrons from $FADH_2$ to Coenzyme Q
- It consists of several Fe-S centers
- $FADH_2 + CoQ \rightarrow FAD^+ + CoQH_2$
- CoQ receives electrons from Complex I and Complex II and gets reduced to $CoQH_2$
- Complex II is thus not a part of creating the proton gradient in the ETC.

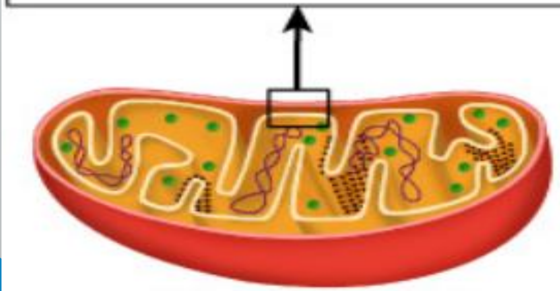
Complex III

- Transfer of Electrons from $CoQH_2$ to Cytochrome c
- It is composed of cytochrome b, c, and a specific Fe-S center
- Complex III catalyzes the transfer of two electrons from $CoQH_2$ to cytochrome c
- $CoQH_2 + 2\ \text{cyt c}\ (Fe^{3+}) \rightarrow CoQ + 2\ \text{cyt c}\ (Fe^{2+}) + 4H^+$
- Complex III is similar to complex I across the inner membrane of mitochondria, thus forming a proton gradient.

Complex IV

- Transfer of Electrons from Cytochrome c to Oxygen
- Complex IV involves transferring two electrons from cytochrome c to molecular oxygen (O_2), the final electron acceptor, thus forming water (H_2O).
- The removal of H^+ from the system pumps two protons across the membrane, forming a proton gradient.
- 4 cyt c (Fe^{2+}) + O_2 $\rightarrow$ 4 cyt c (Fe^{3+}) + H_2O





I - Complex I: (NADH-CoQ oxidoreductase)

II - Complex II: (Succinate dehydrogenase)

CoQ - Coenzyme Q (Ubiquinone)

III - Complex III: (Cytochrome bc1 complex)

IV - Complex IV: (Cytochrome c oxidase)

Cyt c - Cytochrome c

Oxidative Phosphorylation

- The proton gradient is formed within the mitochondrial matrix, and the intermembrane space is called the proton motive force.
- ATP synthase is somewhat similar to a turbine in a hydroelectric power plant, which is run by H+ while moving down their concentration gradient.
- As ATP synthase turns, it catalyzes the addition of phosphate to ADP, thus forming ATP.

Chemical Equation

$6O_2 + C_6H_{12}O_6 + 38\ ADP + 39Pi \rightarrow 38\ ATP + 6CO_2 + 6H_2O$

Reactants (Inputs)

- ✔ NADH
- ✔ $FADH_2$
- ✔ O_2

End Products (Outputs)

- ✔ NAD^+
- ✔ FAD
- ✔ H_2O
- ✔ ATP

Thankyou