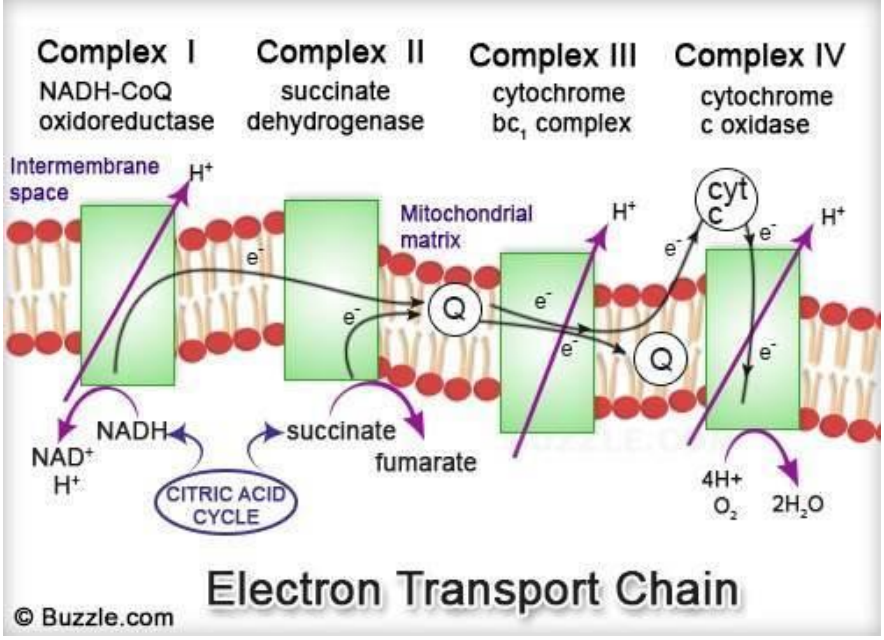
ELECTRON TRANSPORT CHAIN

"The electron transport chain (aka ETC) is a process in which the NADH and [$FADH_2$] produced during glycolysis, β-oxidation, and other catabolic processes are oxidized thus releasing energy in the form of ATP." The mechanism by which ATP is formed in the ETC is called chemiosmosis phosphorylation.

Or

"It is a series of reaction which undergoes transport of electron from donor (electron donor) to electron acceptor."



Occurrence: Inner mitochondrial membrane

Carriers: NADH

$FADH_2$

Introduction

The byproducts of most catabolic processes are NADH and [$FADH_2$] which are the reduced forms. Metabolic processes use NADH and [$FADH_2$] to transport electrons in the form of hydride ions (H^-). These electrons are passed from NADH or [$FADH_2$] to membrane bound electron carriers which are then passed on to other electron carriers until they are finally given to oxygen resulting in the production of water. As electrons are passed from one electron carrier to another hydrogen ions are transported into the intermembrane space at three specific points in the chain. The

transportation of hydrogen ions creates a greater concentration of hydrogen ions in the intermembrane space than in the matrix which can then be used to drive ATP Synthase and produce ATP (a high energy molecule).

Protein Complexes in the Chain

There are **four** protein complexes that are part of the electron transport chain that functions to pass electrons down the chain. A fifth protein complex serves to transport hydrogen ions back into the matrix. These complexes are embedded within the inner mitochondrial membrane.

Complex I (**NADH dehydrogenase**)

NADH transfers two electrons to Complex I resulting in four H^+ ions being pumped across the inner membrane. NADH is oxidized to NAD^+, which is recycled back into the Krebs cycle. Electrons are transferred from Complex I to a carrier molecule ubiquinone (Q), which is reduced to ubiquinol (QH2). Ubiquinol carries the electrons to **Complex III**.

Complex II (**Succinate dehydrogenase**)

$FADH_2$ transfers electrons to Complex II and the electrons are passed along to ubiquinone (Q). Q is reduced to ubiquinol (QH2), which carries the electrons to Complex III. No H^+ ions are transported to the intermembrane space in this process.

Complex III (**cytochrome bc_1 complex**)

The passage of electrons to Complex III drives the transport of four more H^+ ions across the inner membrane. QH2 is oxidized and electrons are passed to another electron carrier protein cytochrome C.

Complex IV(**cytochrome c oxidase**)

> Cytochrome C passes electrons to the final protein complex in the chain, Complex IV. Two H^+ ions are pumped across the inner membrane. The electrons are then passed from Complex IV to an oxygen (O_2) molecule to produce water within the mitochondria matrix.

ATP Synthase

ATP Synthase: An integral protein consisting of several different subunits. This protein is directly responsible for the production of ATP via chemiosmotic phosphorylation. It uses the proton

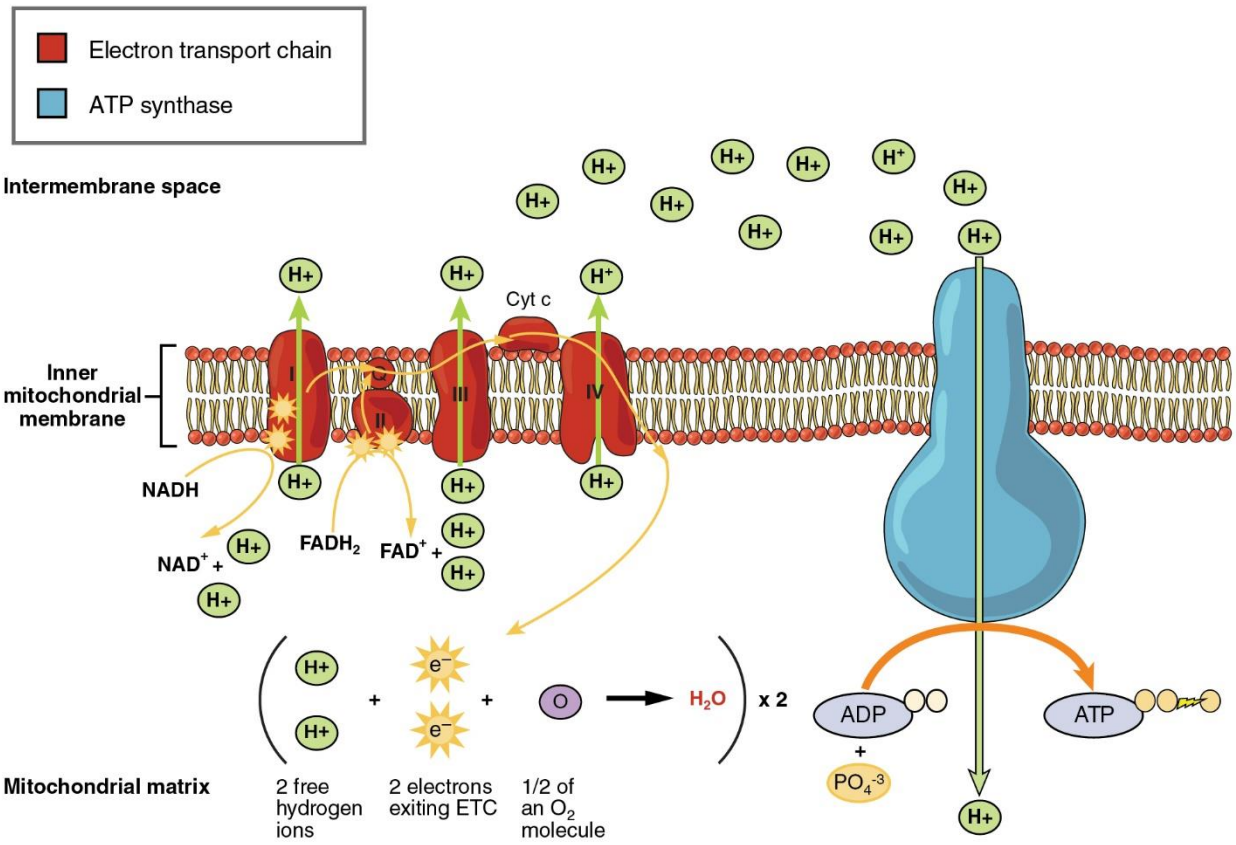
gradient created by several of the other carriers in the ETC to drive a mechanical rotor. The energy from that rotor is then used to phosphorylate ADT to ATP.

ATP synthase moves H^+ ions that were pumped out of the matrix by the electron transport chain back into the matrix. The energy from the influx of protons into the matrix is used to generate ATP by the phosphorylation (addition of a phosphate) of ADP. The movement of ions across the selectively permeable mitochondrial membrane and down their electrochemical gradient is called chemiosmosis.

NADH generates more ATP than $FADH_2$. For every NADH molecule that is oxidized, 10 H^+ ions are pumped into the intermembrane space. This yields about three ATP molecules. Because $FADH_2$ enters the chain at a later stage (Complex II), only six H^+ ions are transferred to the intermembrane space. This accounts for about two ATP molecules. A total of 32 ATP molecules are generated in electron transport and oxidative phosphorylation.

Components of ETC

Complex	Name	No. of Proteins	Prosthetic Groups
Complex I	NADH Dehydrogenase	46	FMN, 9 Fe-S cntrs.
Complex II	Succinate-CoQ Reductase	5	FAD, cyt b_{560}, 3 Fe-S cntrs.
Complex III	CoQ-cyt c Reductase	11	cyt b_H, cyt b_L, cyt c_1, Fe-S_{Riesle}
Complex IV	Cytochrome Oxidase	13	cyt a, cyt a_3, Cu_A, Cu_B


Electron transport chain
ATP synthase
Intermembrane space
Inner mitochondrial membrane
Cyt c
I
II
III
IV
NADH
NAD+ +
FADH2
FAD+ +
H+
e−
O
H2O
x 2
ADP
+
PO4-3
ATP
Mitochondrial matrix
2 free hydrogen ions
2 electrons exiting ETC
1/2 of an O2 molecule