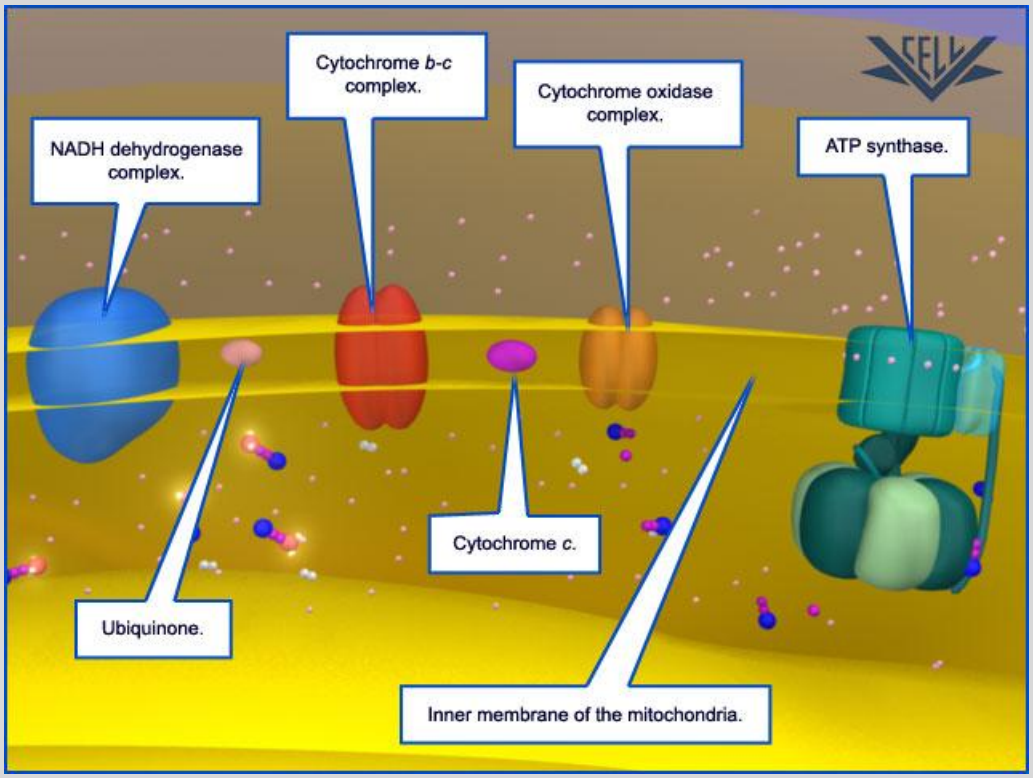
Electron Transport Chain (Respiratory Chain)



Useful link :-

http://www.youtube.com/watch?v=xbJ0nbzt5Kw

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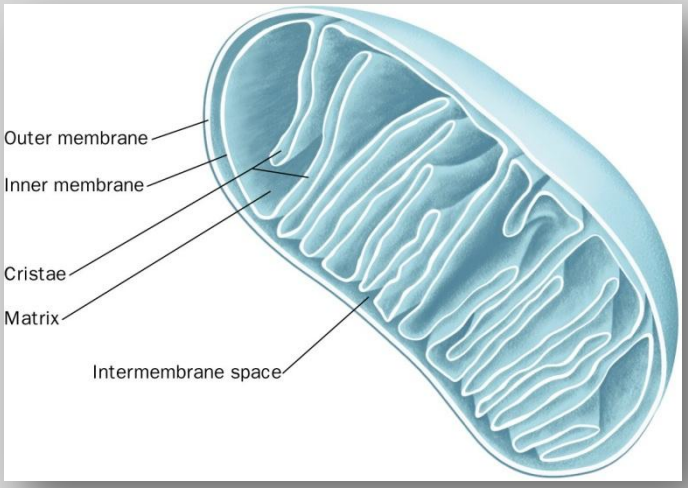
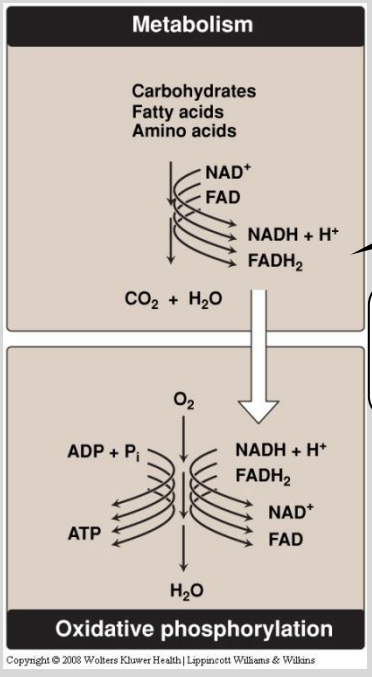
Reviewed by .. Manar AlEid

Electron Transport Chain (ETC)

- A system of electron transport that uses respiratory O_2 to finally produce ATP (energy).
- Located in the **inner** mitochondrial membrane.
- Final common pathway of metabolism.
- Electrons from food metabolism are transported to O_2.
- Uses maximum amount of body's oxygen.



Metabolic breakdown of energy-yielding molecules



Energy-rich reduced coenzymes

Electrons (e^-) lose their free energy

Excess energy generates heat

Components of ETC

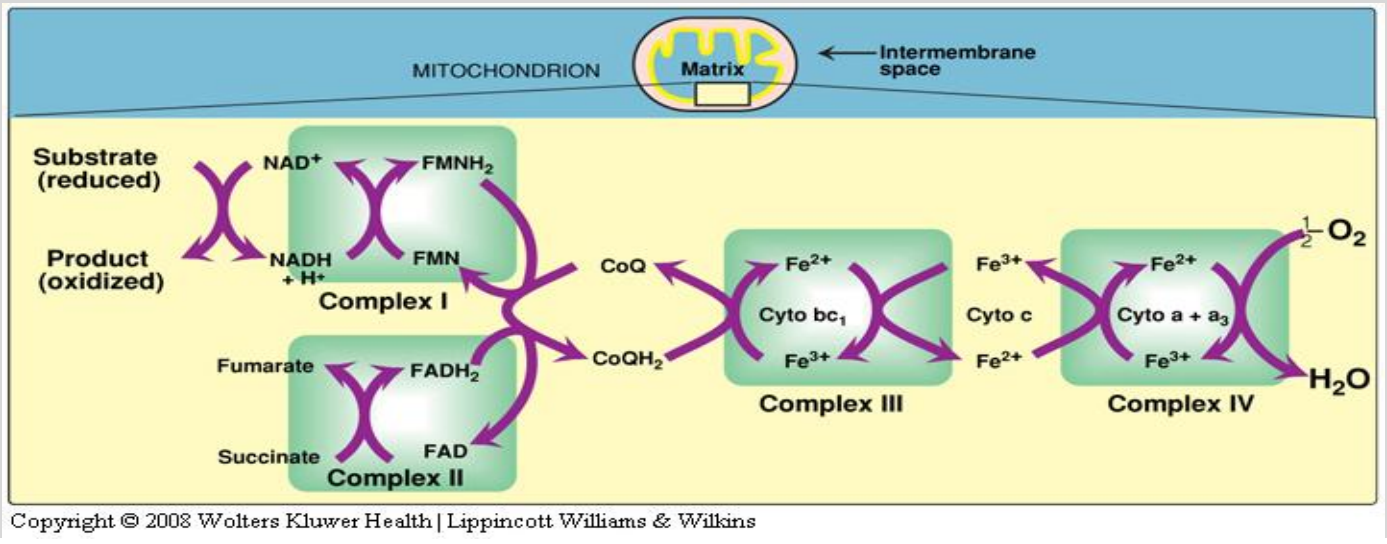
-All members/components are located in the inner mitochondrial membrane (IMM)

- IMM contains 5 complexes and 2 carriers :

Complex I (NADH Dehydrogenase)	**- This complex collects the pair of electrons from NADH and passes them to CoQ**
Complex II (Succinate dehydrogenase)	**- It is also a part of the TCA cycle** **- Transfers electrons to CoQ**
Complex III	**- It is called (Cytochrome bc1)**
Complex IV	**- It is called (Cytochrome a + a_3)**
Complex V	**- ATP synthase: catalyzes ATP synthesis**
CoQ	**- Also called ubiquinone (ubiquitous in biological systems)** **- A non-protein member of the ETC** **- Lipid soluble and mobile**
Cytochrome c	**- Each cytochrome is a protein that contains :** **>Heme group (porphyrin ring + iron in Fe^{3+} state)** **- When cytochromes accept electron :** **>Fe^{3+} (ferric) is converted to Fe^{2+} (ferrous)** **>Fe^{2+} is reoxidized to Fe^{3+} when it donates electrons to the next carrier**

- Complex I, II, III, IV (part of ETC) but complex V (not a part of ETC)

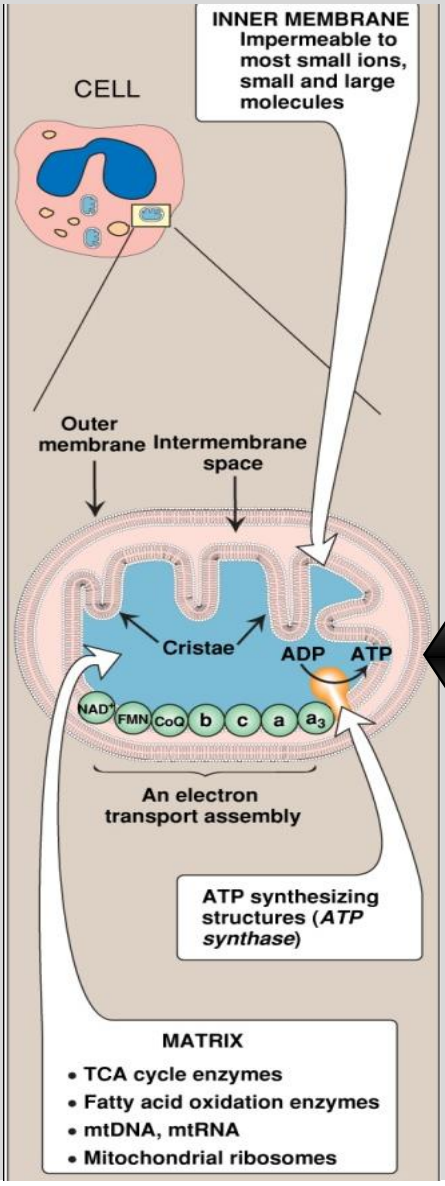
- CoQ & Cytochrome c are mobile electron carriers



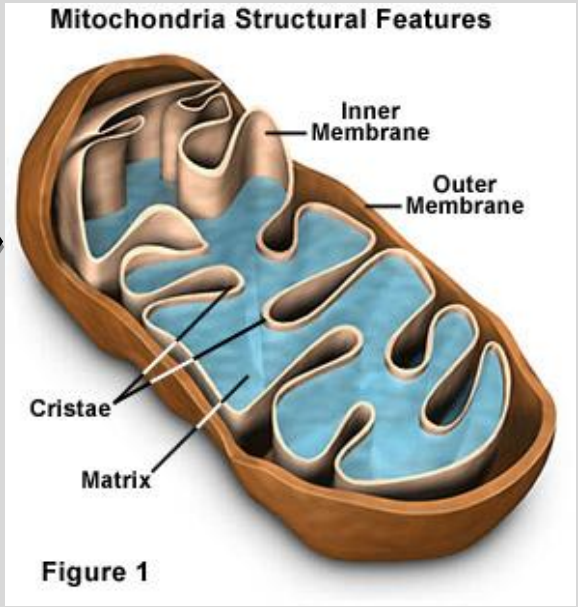
Organization of ETC

- Each complex accepts or donates electrons to mobile carriers.
- Carriers accept electrons from donors and then donate to the next carrier in chain.
- Electrons finally combine with oxygen and protons to form water.
- Oxygen is required as a final acceptor (respiratory chain).

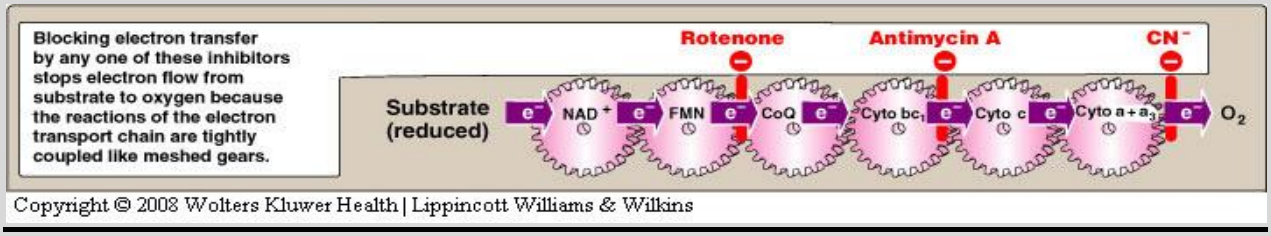
 # Electrons flow from: Complex I & II→ CoQ → Complex III → Cyt. c → Complex IV



Cristae increase the surface area



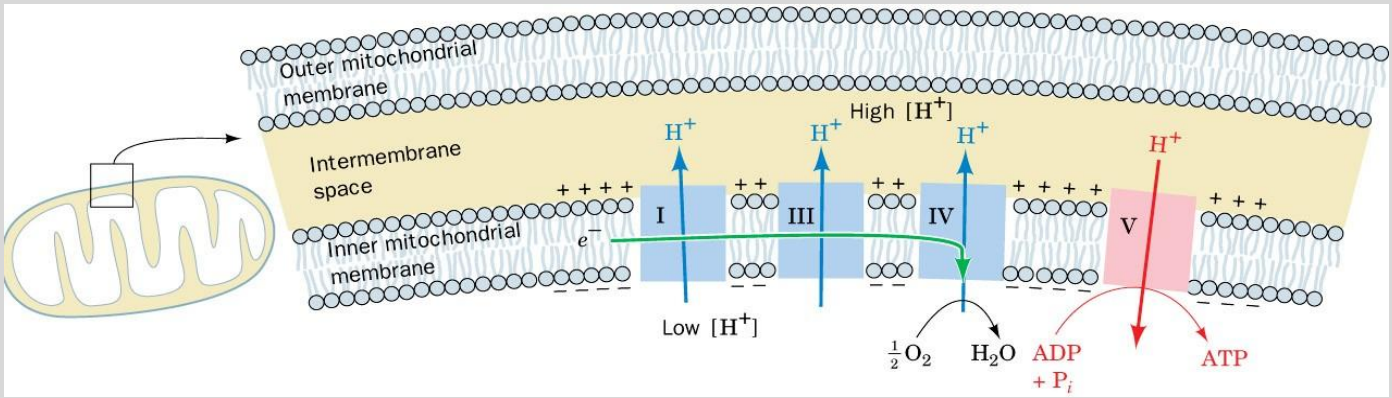
Site-specific inhibitors of ETC



- Rotenone : it inhibits the chain in complex II
- Antimycin A : it inhibits the chain in complex III
- CN (cyanide) : it inhibits the chain in complex IV

ETC is coupled to proton transport for ATP synthesis

- The energy of electron transfer is used to drive the protons out of the matrix
- It is done by complexes I, III and IV (proton pumps)-
- This creates a proton gradient across the IMM to synthesize ATP



ATP synthase

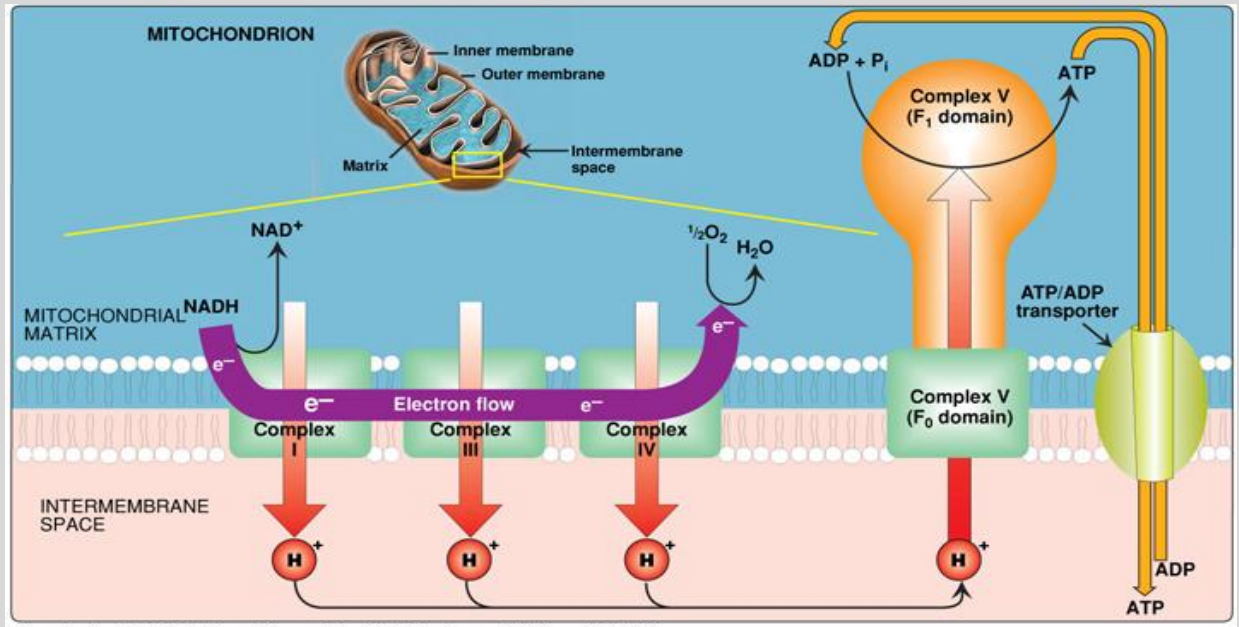
- ATP synthase (Complex V) synthesizes ATP .

- consists of two domains:

>F_0 – membrane spanning domain . (it is in the membrane)

>F_1 – extramembranous domain . (it is in the matrix)

Transport of protons



-Explain for proton transport & ATP synthesize :

The ETC pump the protons (H^+) across IMM → the proton moves to complex I, III and IV to creates electrical gradient[1] & pH gradient[2] → the enzyme complex *ATP* synthase (Complex V) synthesizes ATP using the energy of proton gradient generated by ETC → first it will inter F_0 (then F_0 rotate → then it will moves to F_1 → the energy derived from this movement, will moves the enzyme in a **rotational movement** → in every rotation ADP is convert into ATP → then ATP will transport (release).

#we recommend you to watch this useful video to understand the whole process:

.. Click here ..

Energetics of ATP synthesis

- The energy required for phosphorylation of ADP to ATP = 7.3kcal/mol
- Energy produced from the transport of a pair of electrons from NADH to O_2 = 52.58 kcal
- No. of ATP molecules produced is 3 (NADH to O_2) -
- Excess energy is used for other reactions or released as heat

[1] With more positive charge on the outside of the membrane than on the inside.
[2] The outside of the membrane is at a lower pH than the inside.

P:O ratio

- ATP made per O atom reduced:

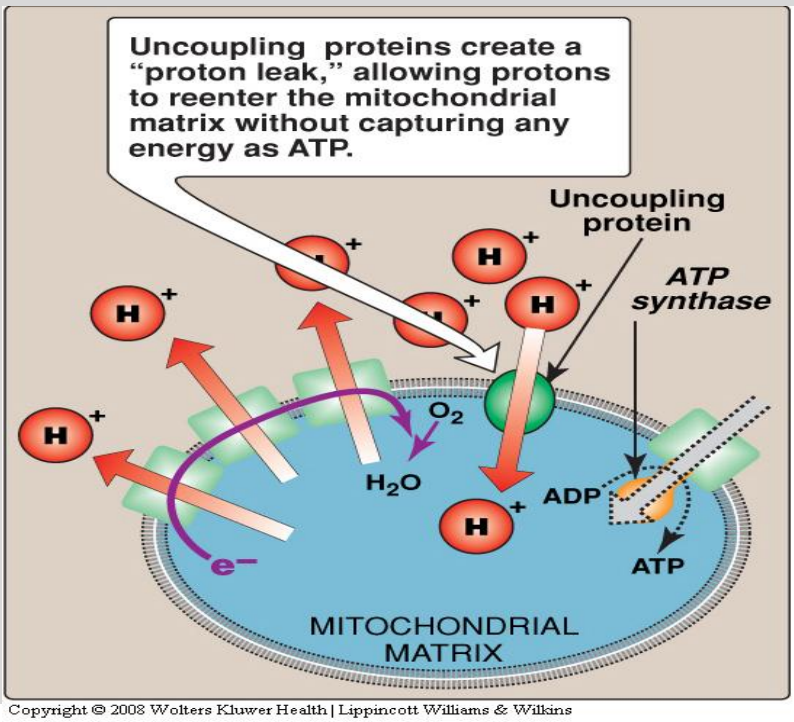
  > for NADH (P:O = 3:1)

  > for FADH2 (P:O = 2:1)

Inhibitors of ATP synthesis

- Oligomycin: (it is a drug)
  > binds to F0 domain of ATP synthase and closes the H+ channel

- Uncoupling proteins (UCPs):
  > Create proton leaks (allow protons to reenter the matrix without ATP synthesis) .
  > Energy is released as heat (nonshivering thermogenesis)



Extra notes :-

- ETC= Respiratory chain.
- In the mitochondria, the outer membrane is highly permeable while the inner membrane is highly impermeable
- The contents of ETC in contact with the matrix.
- All complexes and enzymes are proteins except CoQ
- Every time the electron jumps from one complex to another ,it releases energy which uses in moving protons from matrix to inter membrane space.
- If you block the ETC at certain point :
  Everything before this point will be reduced.
  Everything after this point will be oxidized.
- If ATP is broken to ADP+Pi , it will produce 7.3 kcal/mol as energy.

Quiz :

1- F1 domain in complex V is located in :
   a- Inter membrane space.
   b- Mitochondrial matrix.
   c- Both.
2- The proton pumps are complexes :
   a- I , II , III
   b- I , III , V
   c- II , III , IV
   d- I , III , IV
3- For FADH2 , the P:O ratio is:
   a- 3.1 b- 2.1 c.2.2

Answers:

1	B
2	D
3	B