RESPIRATORY CHAIN

BIOCHEMISTRY TEAM 431

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The team's notes are added in the green color

Electron Transport Chain (ETC): (respiratory chain)

- A system of electron transport that uses respiratory O_2 to finally produce ATP (energy).

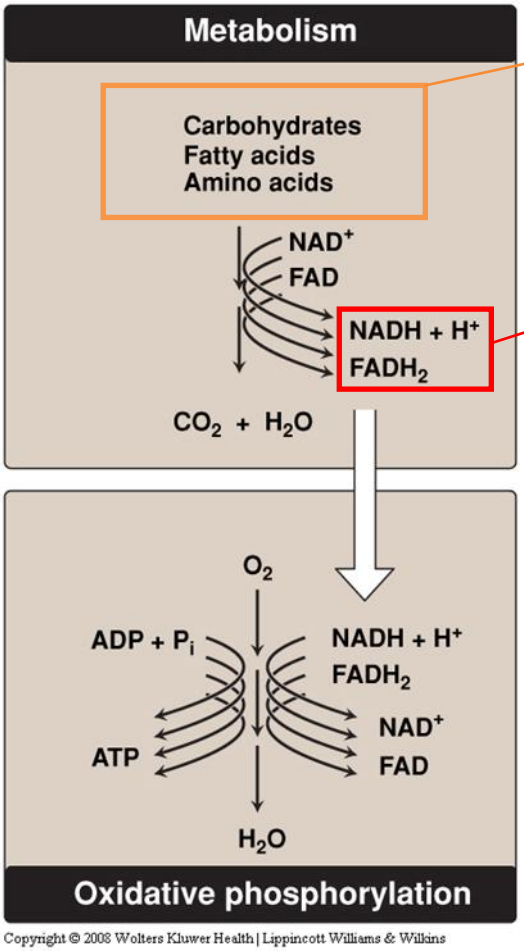
-Electrons from food metabolism are transported to O_2 **(oxygen is the last electron receiver)**

-Final common pathway of metabolism

-Located in the inner mitochondrial membrane

-Uses maximum amount of body's oxygen

Metabolic breakdown of energy-yielding molecules



Molecules that can give out energy

Energy rich reduced coenzymes

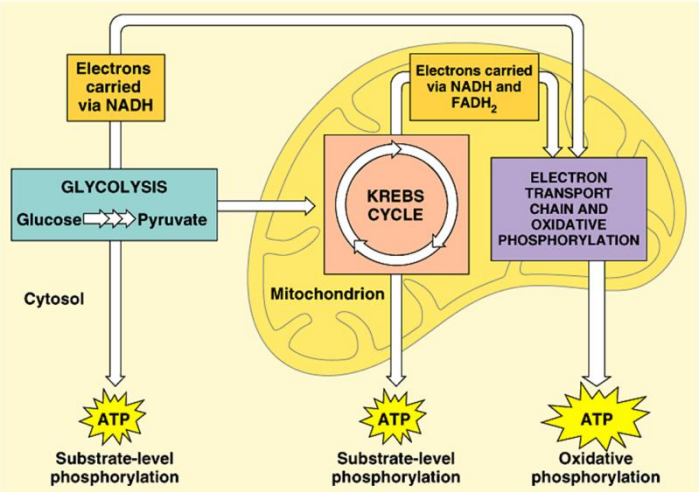
"electron carriers"

As Electrons move down the ETC

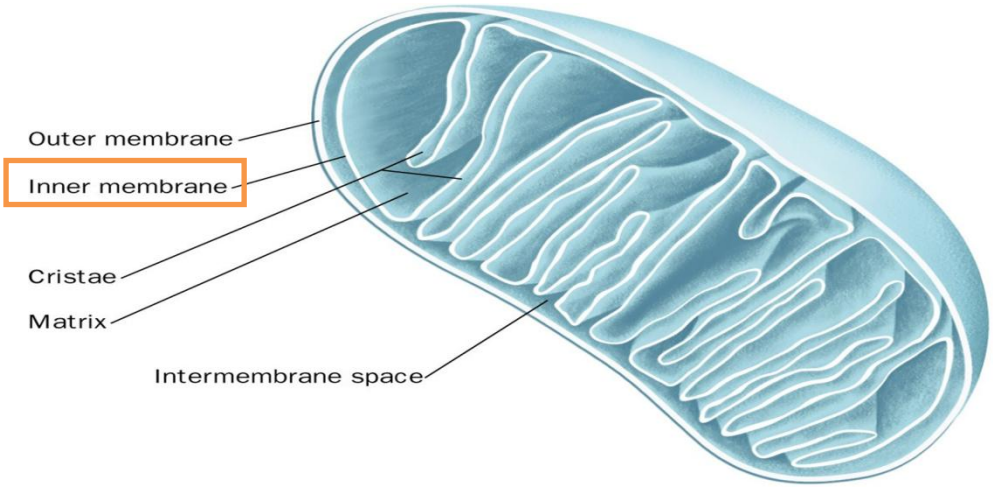
(e^-) lose their free energy

Excess energy generates heat

Cellular respiration



Cutaway diagram of the mitochondria



- Cristae increases surface area

- Inner membrane is impermeable to most small ions and small and large molecules. (Not important)

- Matrix contains citric acid cycle enzymes, fatty acid oxidation enzymes, mtDNA, mtRNA, mitochondrial ribosomes. (Not important)

Components of ETC:

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

-IMM contains 5 complexes:

Complex I, II, III, IV (part of ETC)

-Complex V (ATP synthase, <u>not a component of ETC</u>)

-Mobile electron carriers:

1. CoQ
2. Cytochrome c

} They can move

All these complexes are enzymes .

Organization of ETC:

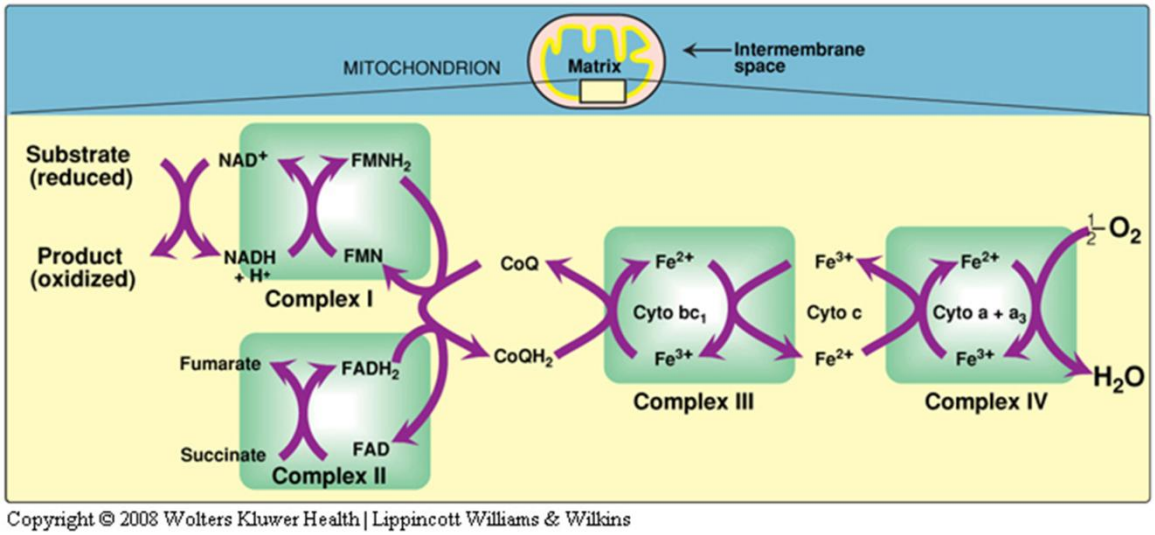
-Each complex accepts or donates electrons to mobile carriers

-Carriers accept electrons from donors and then donate to the next carrier in chain

-Electrons finally combine with oxygen and protons to form water (by reducing oxygen to water "receiving electrons")

-Oxygen is required as a final acceptor (respiratory chain)

Electron transported chain



Complex I – NADH Dehydrogenase:

This complex collects the pair of electrons from NADH and passes them to CoQ. (by oxidizing NADH to NAD+)

Complex II – Succinate dehydrogenase:

- It is also a part of the TCA cycle)

-Transfers electrons to CoQ

TCA cycle : The citric acid cycle or the Krebs cycle . it's the same .

Coenzyme Q (CoQ):

-Also called ubiquinone (ubiquitous in biological systems)

(ubiquitous=present everywhere)

-A non-protein member of the ETC

-Lipid soluble and mobile

Cytochromes:

-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 III and IV:

-Complex III: Cytochrome bc1

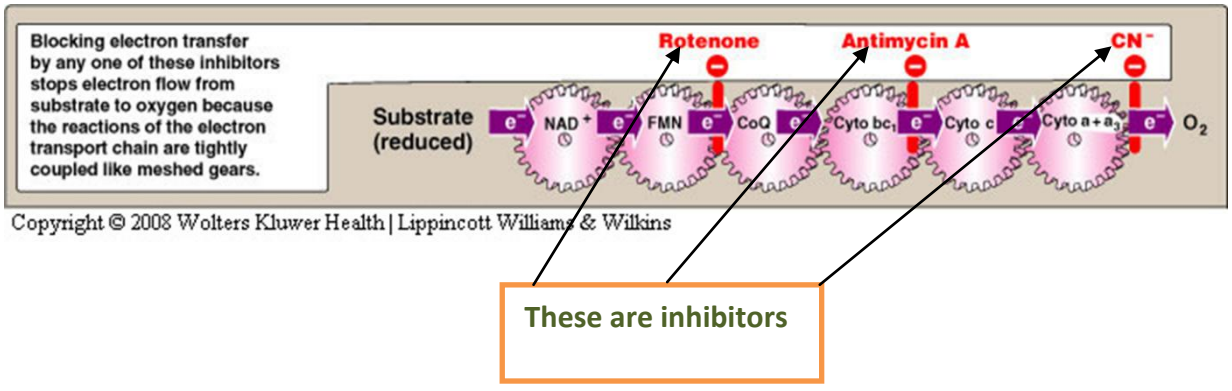
-Complex IV: Cytochrome a + a_3 (cytochrome oxidase)

-Electrons flow from:

CoQ ⟶ Complex III⟶ Cyt. C⟶ Complex IV

For your understanding please read this only once:
http://oi44.tinypic.com/1zlgjgx.jpg

Site-specific inhibitors of ETC



These are inhibitors

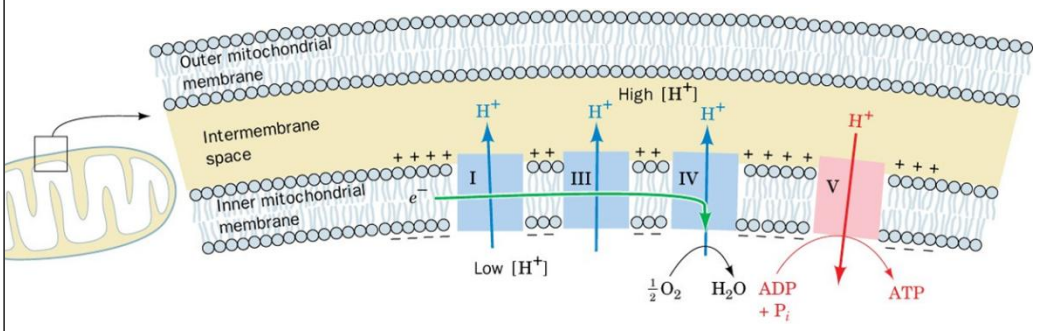
ETC is coupled to proton transport for ATP synthesis:

-The energy of electron transfer is used to drive the protons out of the matrix and into the intermembrane space.

-It is done by complexes I, III and IV (proton pumps)

-This creates a proton gradient across the IMM to synthesize ATP.

It will lead to high proton conc. in the intermembrane space and low proton conc. in the matrix



Coupling of electron transport (green arrow) and ATP synthesis

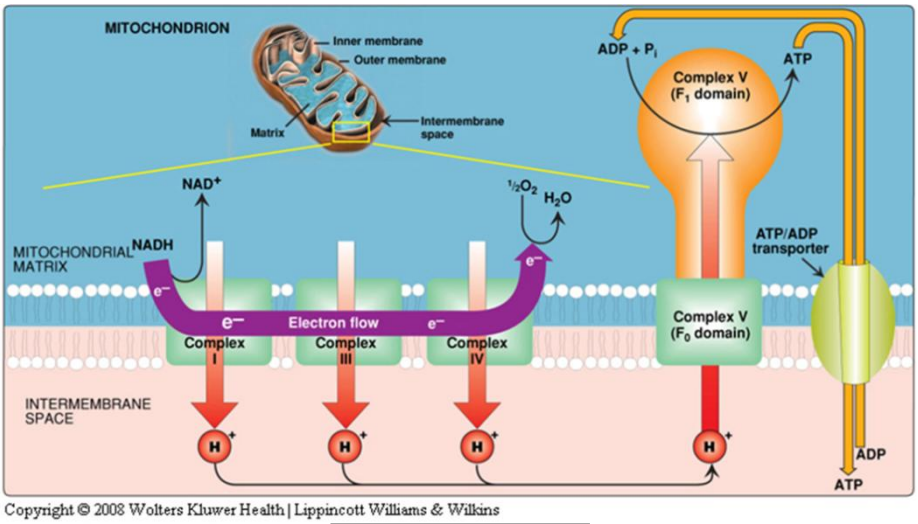
ATP synthase:

-ATP synthase (Complex V) synthesizes ATP

Consists of two domains:

F_0 – membrane spanning domain

F_1 – extramembranous domain (in the matrix)



Transport of protons

Explanation:

The proton enters the F_0 domain which makes it rotate which cause a conformational change in F_1 which produce ATP.

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 O2 = 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

P: O ratio: (P=ATP, O= oxygen)

-ATP made per O atom reduced

-For NADH P:O = 3:1

-For FADH2 P:O = 2:1

Inhibitors of ATP synthesis:

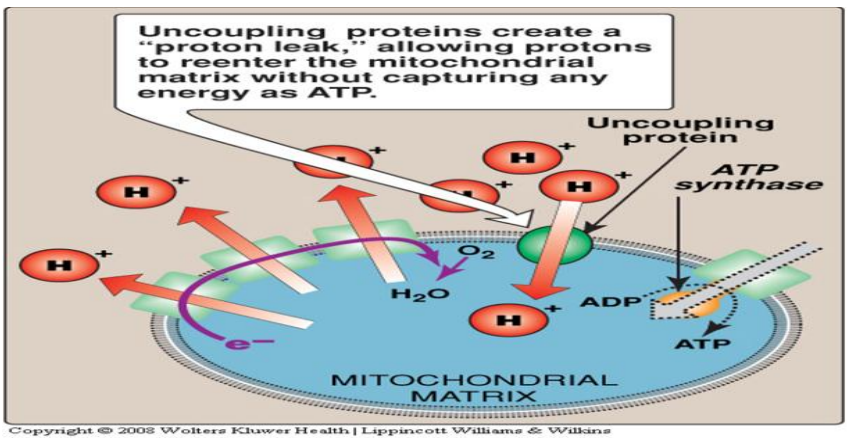
-Oligomycin: It is a drug .

Binds to F_0 domain of ATP synthase and closes the H^+ channel.

-Uncoupling proteins (UCPs):

Create proton leaks (allow protons to reenter the matrix without ATP synthesis) which causes no H^+ gradient difference between the inner mitochondrial membrane

Energy is released as heat (nonshivering thermogenesis) (nonshivering thermogenesis: producing heat without shivering like newborn babies because they have brown fat which generate body heat without shivering)



Quiz

Q1: CoQ receives electrons from:
A) complex I
b) Complex II
c) Complex III
d) Both a and b

Correct answer: D

Q2: these components of the ETC EXCEPT:
A) Complex V
B) Complex II
C) Complex IV
D) Complex I

Correct answer: A

Q3: where does the proton gradient develop?
A) in the matrix
B) in the intermembrane space
C) across the inner mitochondrial membrane
D) across the outer mitochodrial membrane

Correct answer: C

Q4: As the electrons are carried down the ETC they lose some of their free energy, where does that energy go?
A) generate heat
B) used to drive out the H+ into the intermembrane space

Correct answer: B

Q5: Which one of the following is considered as complex V :
A) NADH Dehydrogenase .
B) Succinate dehydrogenase .
C) ATP synthase .
D) None of these .

Correct answer: C