Electron Transport Chain and Phosphorylation

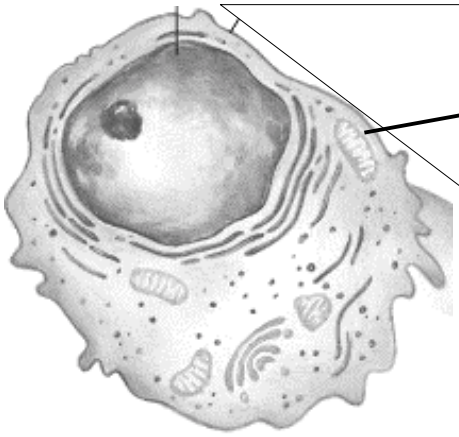


Diagram of a typical cell

Fig 02-01.GIF

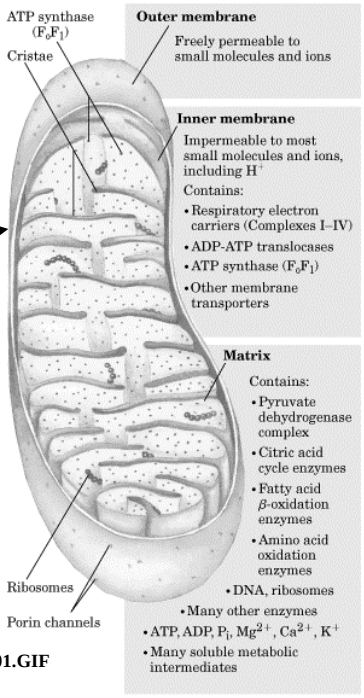


Fig 19-01.GIF

Introduction to Membranes - Functions

MEMBRANES

FUNCTIONS:

- selective, semipermeable barrier
- provides a nonpolar environment for special processes (photosynthesis, electron transport,
- provides outside surface for cell recognition, receptors

FEATURES:

- contains phosphoglycerides as main building blocks (sphingomyleins in nerve tissue)
- contains proteins that carry out wide variety of different functions of membrane

On the average: 40 % by weight lipid
60 % by weight protein

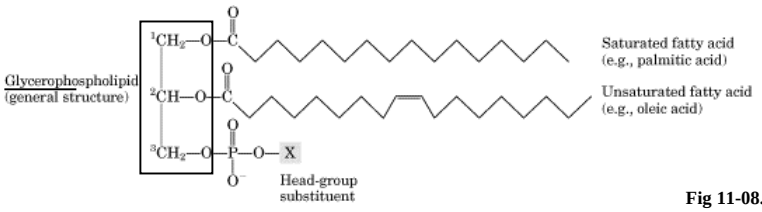
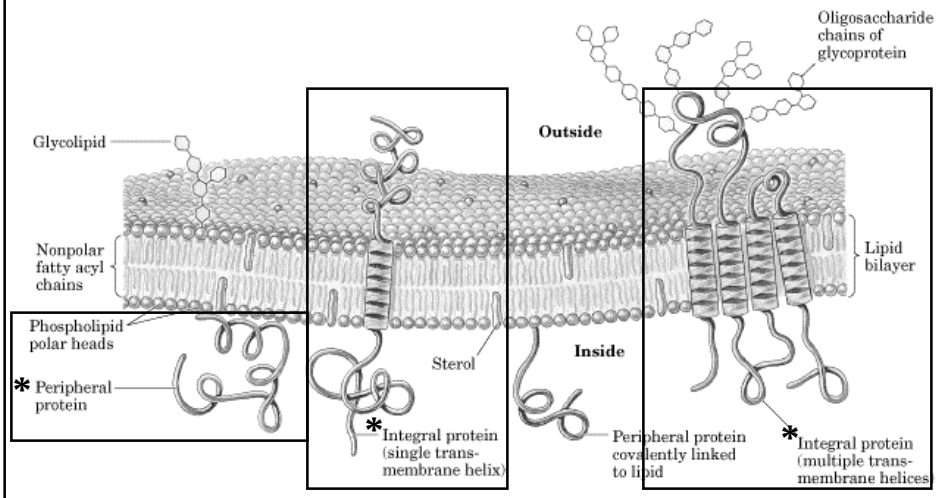


Fig 11-08.GIF

Introduction to Membranes – Fluid Mosaic Model



Inner Mitochondrial Membrane

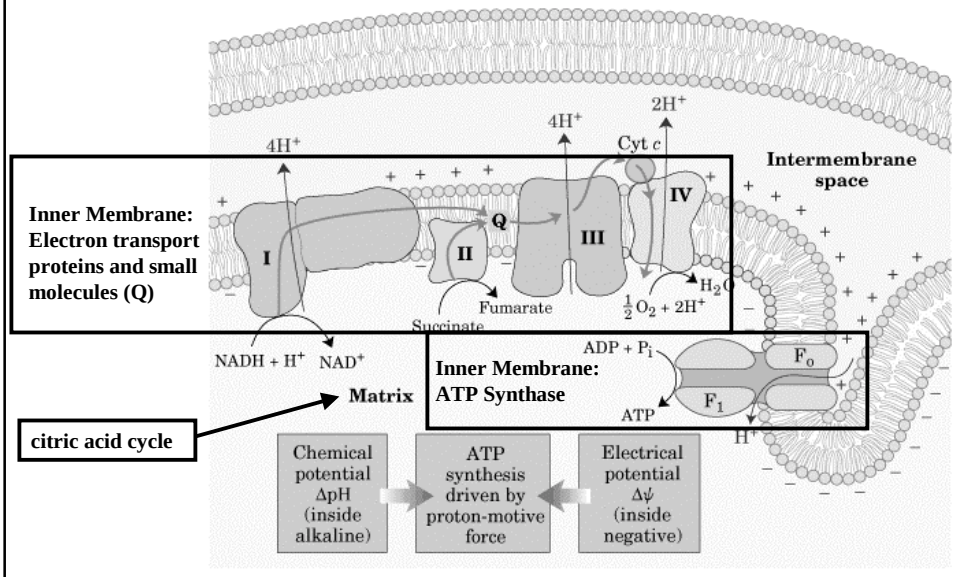


Fig 19-16.GIF

Electron Transport Chain and Phosphorylation

Oxidative Phosphorylation:

Process of oxidation of NADH and $FADH_2$ using the energy of oxidation to make ATP. Electrons from NADH and $FADH_2$ are transferred to O_2.

Oxidation:

Process of oxidation of NADH and $FADH_2$ by carriers in the electron transport chain

Phosphorylation

Process of synthesis of ATP

ADP + Pi → ATP + H_2O

Oxidation

COMPLEXES I, II, III, IV

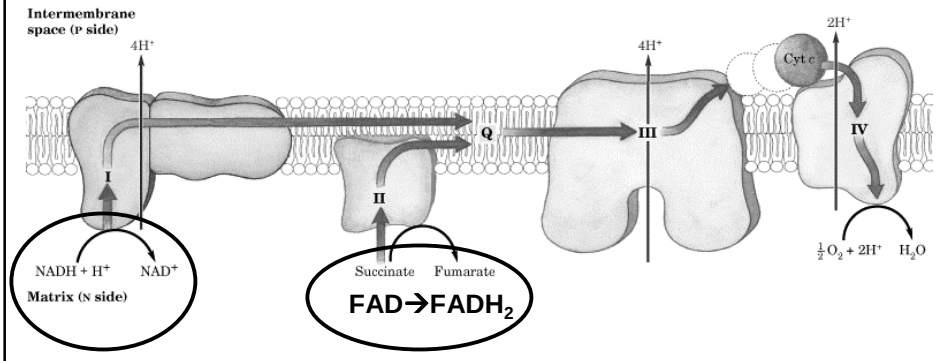


Fig 19-14.GIF

Actual e⁻ carriers

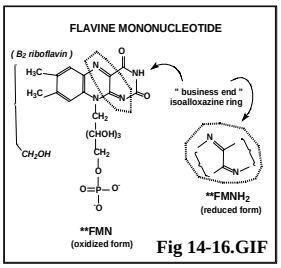


Fig 14-16.GIF

Iron-Sulfur ClustersFig 19-5.GIF

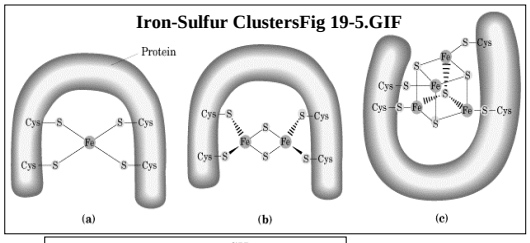
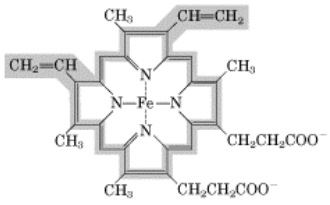
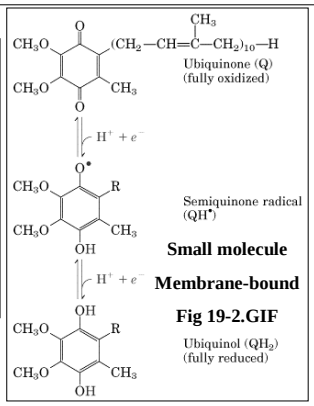


Fig 19-3.GIF





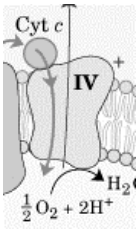
Small molecule

Membrane-bound

Fig 19-2.GIF

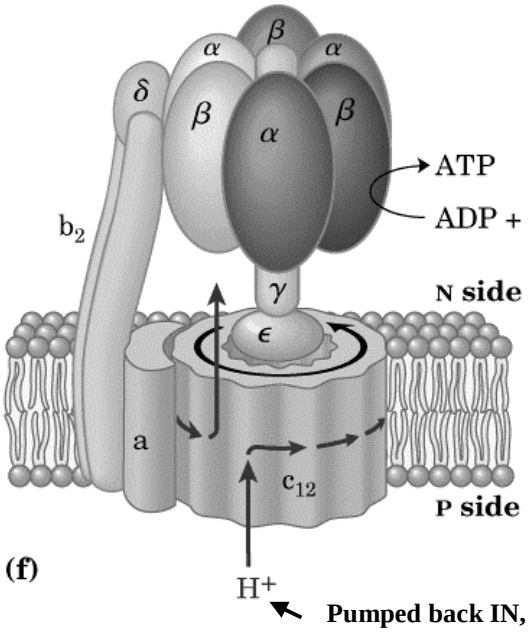
Cu^{2+}/Cu^{+} centers

Special Fe^{2+}/Cu^{+} pair: site of O_2 binding



Phosphorylation

ATP Synthase



matrix space

intramembrane space

Pumped back IN, destroying gradient in local area

Fig 19-22f.GIF

Try this link at www.csun.edu/~hcchm001/ATP synthase:
http://www.biologie.uni-osnabrueck.de/Biophysik/Junge/pictures/Synthase.MOV

Binding Change Mechanism: ATP Synthase

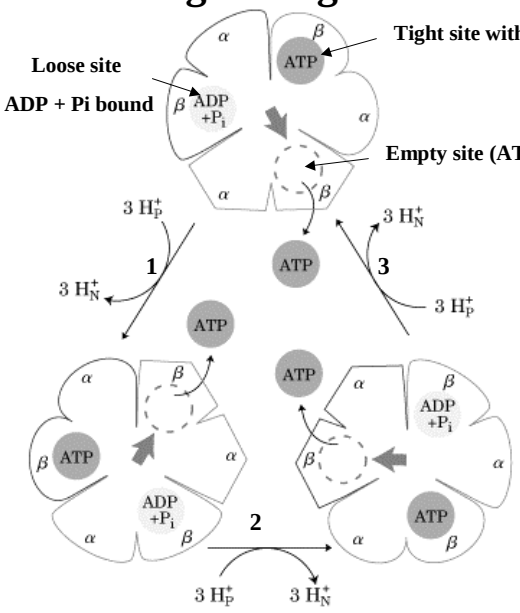


Fig 19-23.GIF

Steps 1, 2, 3:

The pumping of H^+ through the membrane-bound subunits (F_0) results in the rotation of the γ-subunit.

Each of the three active sites (in F_1) undergoes a different conformational change depending upon whether it is an empty, loose, or a tight site.

Binding Change Mechanism: ATP Synthase

Loose site **ADP + Pi bound**	**H^+ (out)** **H^+ (in)**	**Loose site → Tight site** **ADP + Pi → ATP + H_2O**
Tight site **preformed ATP**		**Tight site → Empty site** **bound ATP → free ATP**
Empty site **ATP dissociated** **ADP + Pi to enter**		**Empty site → Loose site** **(empty) → Bound ADP + Pi**

Oxidation and Phosphorylation are Tightly Coupled -1

Coupling "Mechanism": H^+ gradient

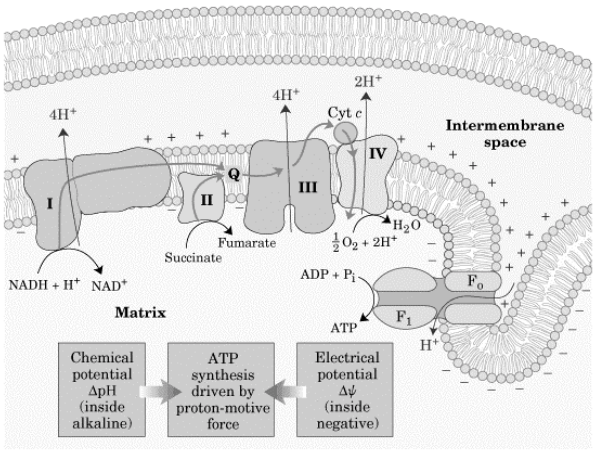


Fig 19-16.GIF

Oxidation of NADH and $FADH_2$ is accompanied by pumping H^+ OUT across the inner mitochondria membrane.	**The H^+ gradient causes conformational changes in the ATP synthase (F_0) that results in 1) the pumping of H^+ back IN and 2) the synthesis of ATP.**

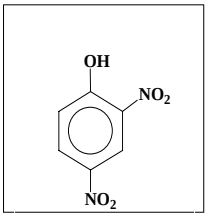
Oxidation and Phosphorylation are Tightly Coupled- 2

Uncoupling and Inhibition of Mitochondrial Oxidative Phosphorylation

Uncouplers of Mitochondrial Oxidative Phosphorylation:

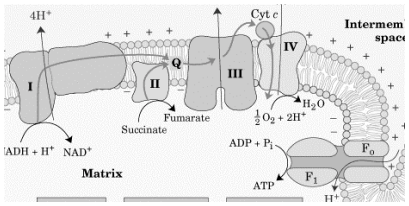
For 462: Spring 2002

Dinitrophenol carries H^+



- destroy the pH gradient because they bring H^+ back in by passive diffusion
- allow H^+ transport out through complexes I, II, III, IV
- oxidation of NADH and $FADH_2$ can continue
- prevent the synthesis of ATP because no pH gradient can be established
- CAC and β-oxidation continue
- G → 2 LAC ↑ in attempt to get needed ATP

** Because these uncouplers allow H^+ transport to occur within complexes I, II, III, IV, the of NADH and $FADH_2$ can proceed as "normal". Because the gradient is destroyed, no ATP can be made.



Oxidation and Phosphorylation are Tightly Coupled- 3

Inhibitors of Oxidation/Reduction:

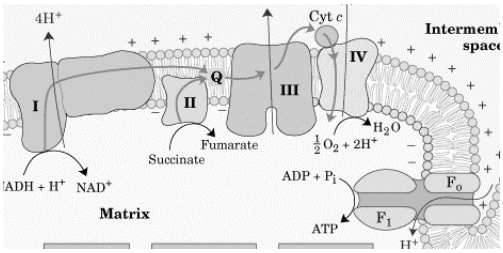
Fe^{3+} ····· Cu^{2+}

CN^-

(cyanide inhibition of complex IV)

- Bind to various metal ions & other active sites, in I, II, III, IV
- Reduced forms of carriers build up on the "NADH" side of the inhibition site
- prevent H^+ transport out
- pH gradient cannot be established
- ATP cannot be made
- NADH ↑, CAC ↓, β-oxidation ↓
- G →2 LAC ↑ in attempt to get needed ATP

** Because these types of inhibitors prevent electron transport, they also prevent H^+ transport out through the complex where the inhibition is occurring. The oxidation of NADH and $FADH_2$ cannot proceed and the reduced forms of the carriers build up. Because the gradient is cannot be established, no ATP can be made.



Oxidation and Phosphorylation are Tightly Coupled- 4

Inhibitors of Phosphorylation:

Oligomycin binds to F_o portion of ATP synthase

- Bind to F_o or F_1 portion of ATP synthase (F_oF_1-ATPase)
- Prevent H^+ transport back into the mitochondria
- Gradient remains intact "locally"
- Gradient prevents further H^+ transport out of mitochondria
- NADH and $FADH_2$ oxidation inhibited
- NADH ↑, CAC ↓, β-oxidation ↓
- G →2 LAC ↑ in attempt to get needed ATP

** Because these types of inhibitors prevent the transport of H^+ back into the mitochondria, they prevent the conformational changes necessary to allow the F_1 portion of the ATP synthase to make ATP. Therefore no ATP can be made even though the gradient may be present. Because the gradient is present, no further H^+ transport out of mitochondria is possible. The oxidation of NADH and $FADH_2$ cannot continue, reduced forms of carriers build up and no further ATP can be made.