Part II Chemiosmotic Coupling

How is the *G* of e^- flow converted into energy for ATP synthesis?

During the transport of e^-, H^+ are removed from the matrix (inside inner membrane) and transported into the space between the inner and outer mitochondrial membranes by Complexes I, III, IV.

This **electrochemical work** is done using the G released during e^- flow.

A **chemical / pH gradient** is built up across the inner membrane with OH^- in the matrix and H^+ in the space.

An **electrical gradient** is also built up across the inner membrane as positive and negative charges are separated. The matrix becomes negative, the inter-membranous space, positive.

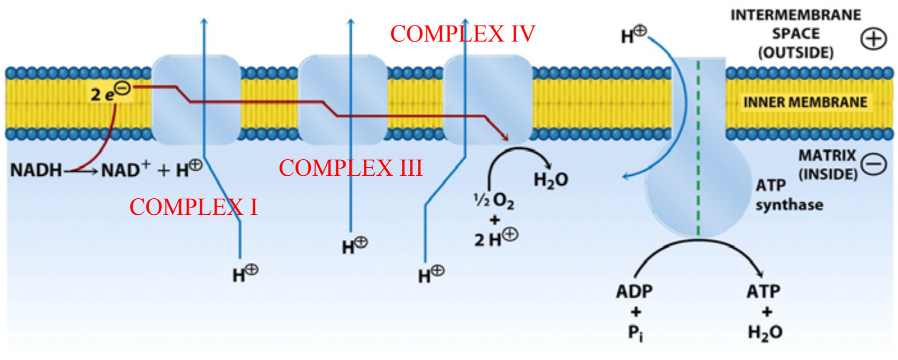


Figure 14-1 Principles of Biochemistry, 4/e

This results in an electrical potential difference of 0.15 – 0.2 Volts ($\Delta\psi$).

Combined pH and electrical gradients serve as the energy reservoir to drive ATP formation.

The *G* stored in the electric and chemical gradients could be released if the H^+ were permitted to diffuse back into the mitochondrion.

The return of H^+ into the matrix would provide enough *G* for the synthesis of ATP.

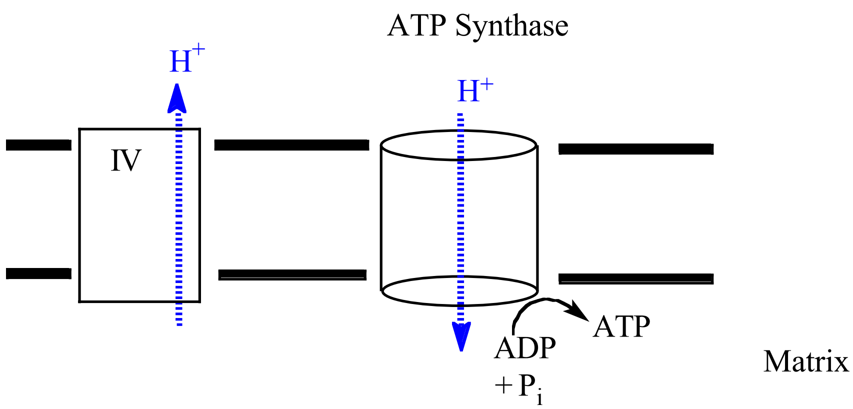
The H^+ gradient-electrical gradient is coupled to ATP synthesis by the **F_oF_1 ATP Synthase complex (Complex V)**.

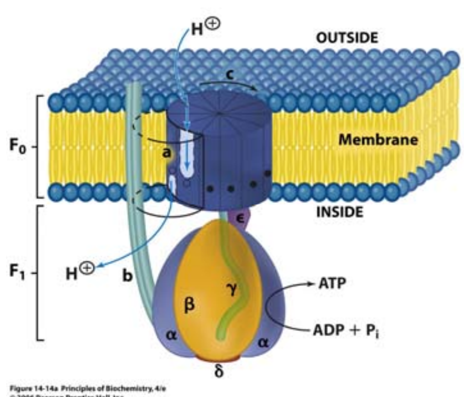
Complex V (ATP synthase) catalyzes the reaction ADP + Pi → ATP

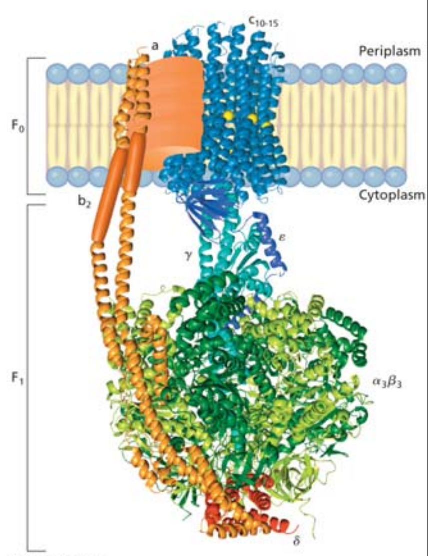
The reaction is driven by the proton/electrical gradient generated during membrane-associated electron transport.

H^+ flow through F_o releases *G* that is used to make ATP.

Electron transport and oxidative phosphorylation are tightly **coupled** so inhibition of one, shuts down the other process.







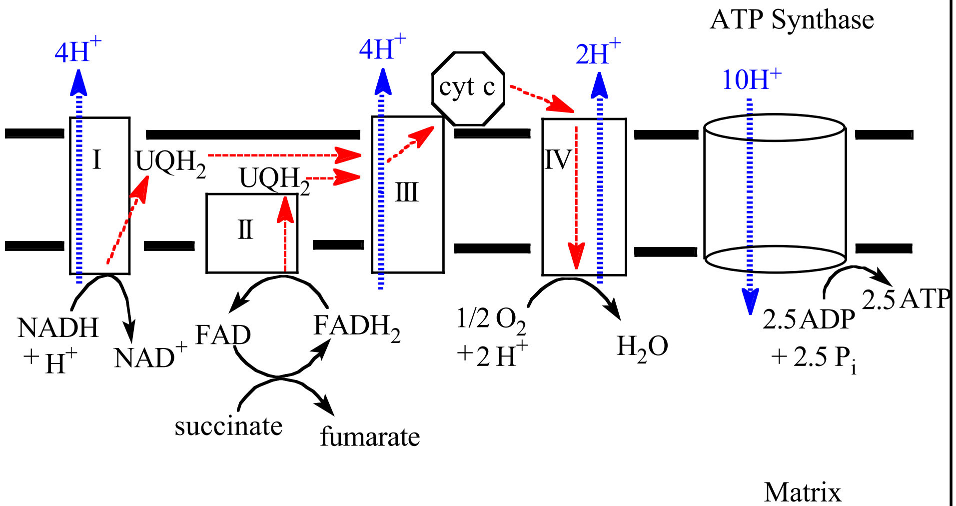
F_o is a tetrameric integral membrane protein channel for H^+. Composition $a_1b_2c_{10\text{-}15}$.

F_1 is a peripheral membrane protein with subunits $\alpha_3\beta_3\gamma\delta\varepsilon$. It contains the ATP synthesis activity.

Oxidative phosphorylation is regulated by the supply of ADP and phosphate.

The enzyme ***ATP / ADP translocase*** moves ATP into the cytoplasm and ADP into the mitochondrion.

Summary



Stoichiometry is for 2 electrons from NADH.

The Nobel Prize in Chemistry 1997
Paul D. Boyer, John E. Walker, Jens C. Skou

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The Nobel Prize in Chemistry 1997

Paul D. Boyer
Prize share: 1/4

John E. Walker
Prize share: 1/4

Jens C. Skou
Prize share: 1/2

The Nobel Prize in Chemistry 1997 was divided, one half jointly to Paul D. Boyer and John E. Walker *"for their elucidation of the enzymatic mechanism underlying the synthesis of adenosine triphosphate (ATP)"* and the other half to Jens C. Skou *"for the first discovery of an ion-transporting enzyme, Na+, K+ -ATPase".*

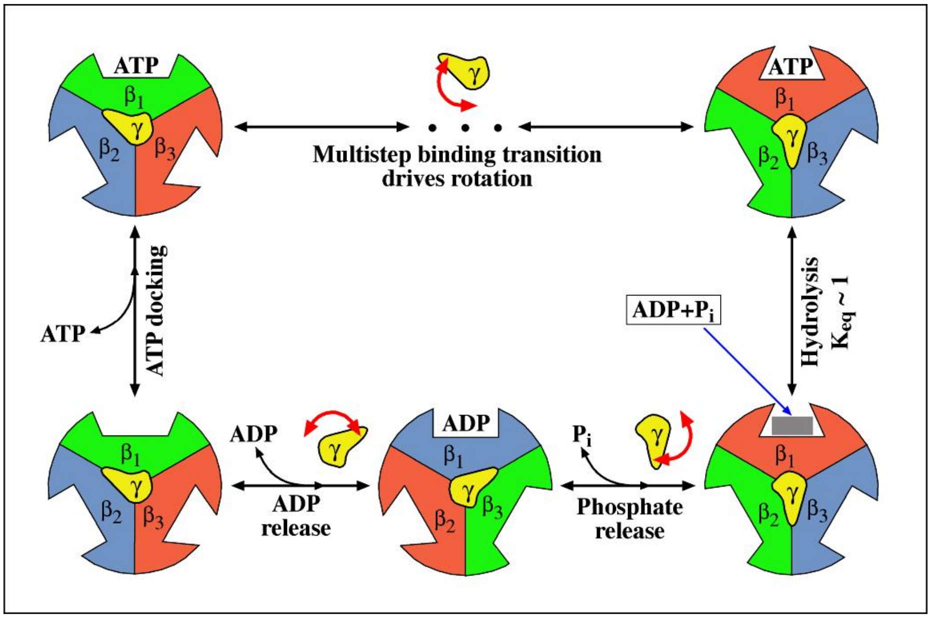
Model for ATP synthesis (Paul Boyer 1979)

1. A molecule of ADP and one Pi bind to an open catalytic site (there are three catalytic sites).

2. Rotation of the gamma shaft causes all three sites to change conformation between open, loose and tight. Rotation occurs at 10 rev/sec.

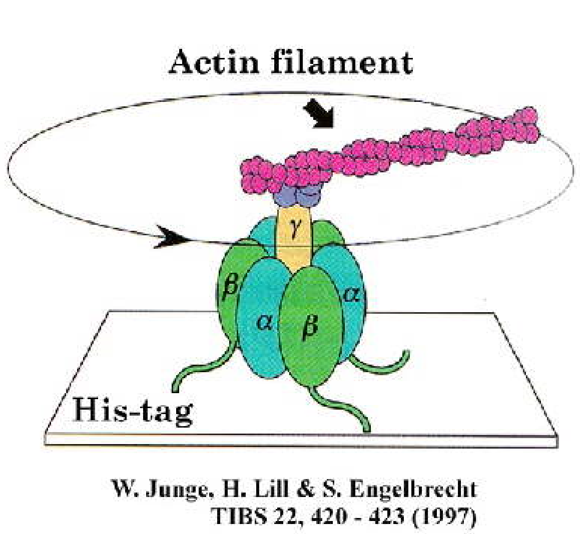
   open: ATP formed can be released and new ADP, Pi can bind.
   loose: bound ADP, Pi cannot be released.
   tight: ADP, Pi are bound very tightly, causing condensation and formation of ATP

3: ATP is released from the open site and the site fill again with ADP and Pi.



See Figure 14.23

http://users.soe.ucsc.edu/~hongwang/Images/Binding_Zipper.jpg



http://www.youtube.com/watch?v=0y7n-vK1AJE

See Figure 14.24

THE END!