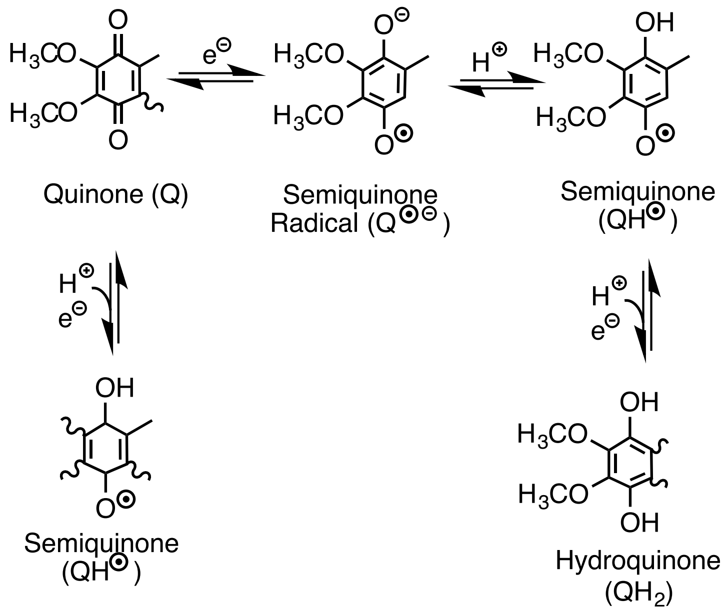
Session 13 - The Q-Cycle - A Proton Pump

A

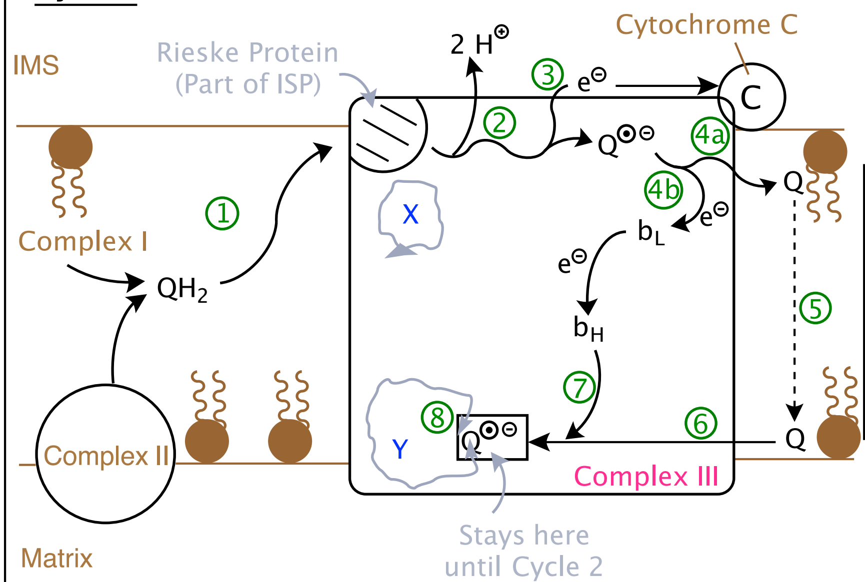
-- Works by a redox-loop mechanism

Players



Cycle 1

B



net 1st half-reaction

-- Two H⊕ translocated

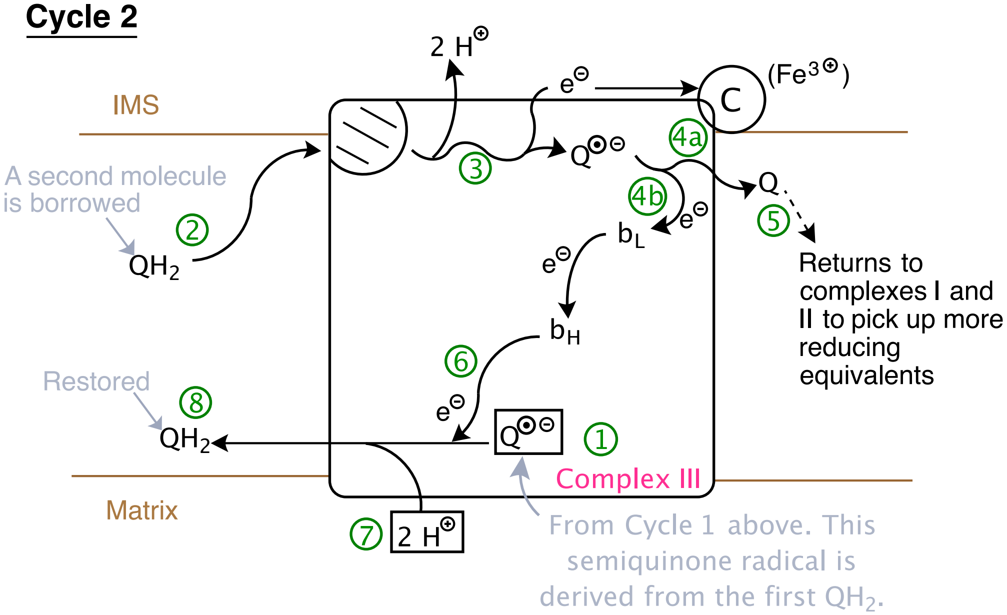
-- One CytoC-(Fe^{3+}) reduced

ISP = Iron-sulfur protein

X = Q_Δ site
Y = Q_i site

Cycle 2

C



net 2nd half-reaction

-- Another two H⊕ translocated (Step ③)

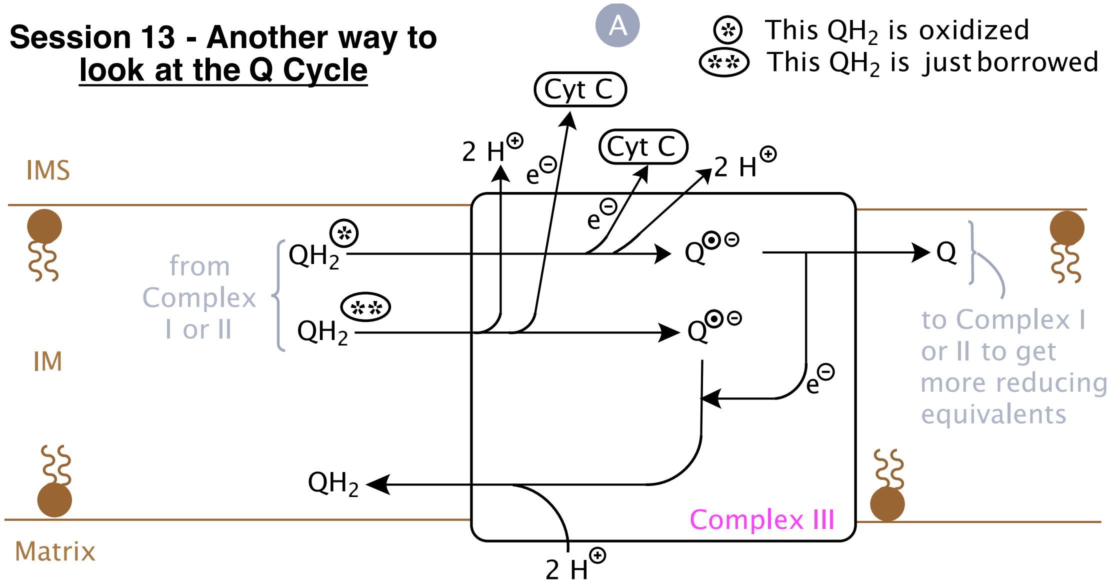
-- Another One CytoC-(Fe^{3+}) reduced (Step ③)

D

So, for each QH_2 oxidized, you translocate 4 H⊕ -- and move two electrons via CytC(Fe^{2+}) to Complex IV.

Session 13 - Another way to look at the Q Cycle

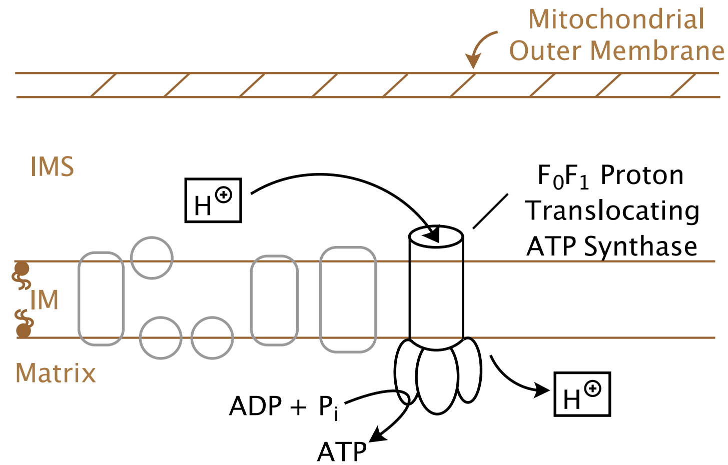
A



Note: The previous 2-cycle presentation is more chemically accurrate - but this way of looking at the cycle might help. Look at both versions but the previous page is the operative mechanism.

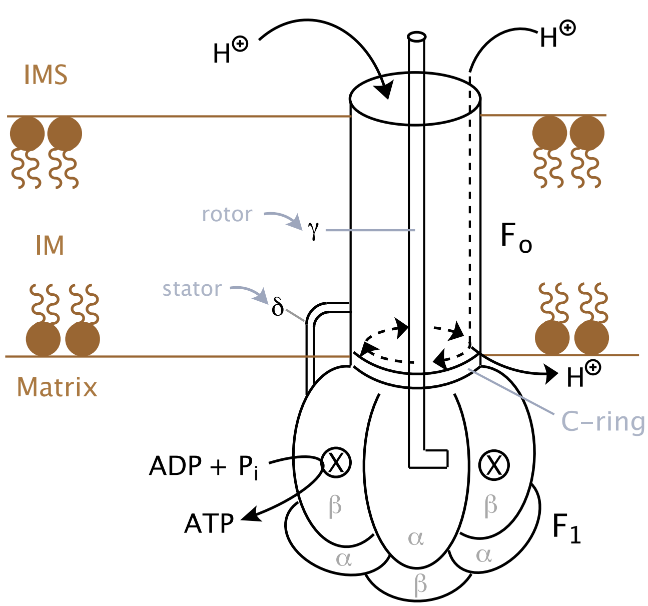
B

We have converted the e⊖ transfer potential of NADH/FADH$_2$ into a proton gradient -- Next we want to convert the proton gradient into the phosphate transfer potential of ATP ⟹ "oxidative phosphorylation"



Coupling Proton Transport with ATP Synthesis

C



As drawn here:

-- shaft rotates CW when it pumps H⊕

-- CCW when it hydrolyzes ATP (see book)

-- α3β3 stays fixed (by δ) while γ rotates

-- C-ring rotates

ⓧ = Active Site

Making ATP

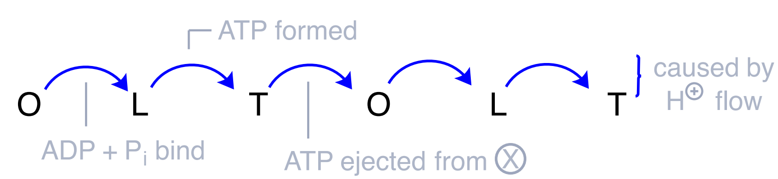
D

-- The C-Ring and γ spin when H⊕ are pumped

-- This causes conformational change in β subunit active site (ⓧ) that favors ADP + P$_i$ ⟶ ATP

-- Three conformations at ⓧ:

O = Open (nothing bound)
L = Loose (ADP + P$_i$ bound)
T = Tight (ATP bound)



Key Point - flow of protons starts with binding of ADP

Physiological Scenario

A

1.) Stress-muscle intensive situation

2.) ATP ⟶ ADP + P_i [ADP]↑ in matrix

3.) ADP binds to ⊗ ⟶ protons flow

4.) T ⟶ O ⟶ L } ATP released and continuously made

5.) pH in Inner Membrane Space ↑ because of lost protons

6.) Electron Transport Chain responds by oxidizing NADH at elevated rate - trying to maintain ΔpH across the mitochondrial IM

B

7.) Concentration of NADH drops in matrix

8.) Note that NADH "product inhibits" the TCA cycle + PDH steps that make it (there also is an allosteric component)

9.) The ↑ [NADH] boots up the TCA cycle to make more of it - letting you continue to make ATP

10.) It all starts with ADP production. This is called "acceptor control" where ADP is the "acceptor" of P_i

11.) Eventually with a persistent dog, you become O_2 limited

C

12.) Glycolysis boots up

13.) The Lactate-Pyruvate (homo-lactic fermentation) shuttle boots up

14.) Lactate acidifies the blood

15.) Bohr effect reduces affinity of Hb for O_2

16.) More O_2 delivered to tissues

17.) Respiration boots up again, because O_2 is available

The Respiratory Apparatus

D