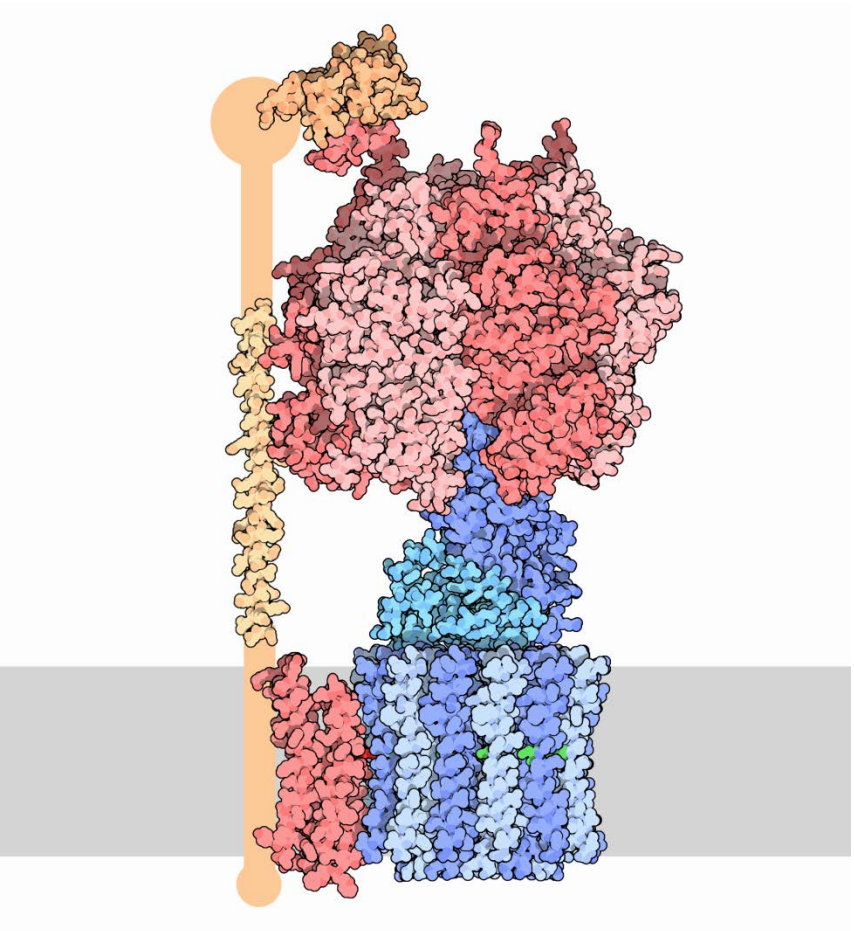
ATP Synthesis & Transport

BIOL 201

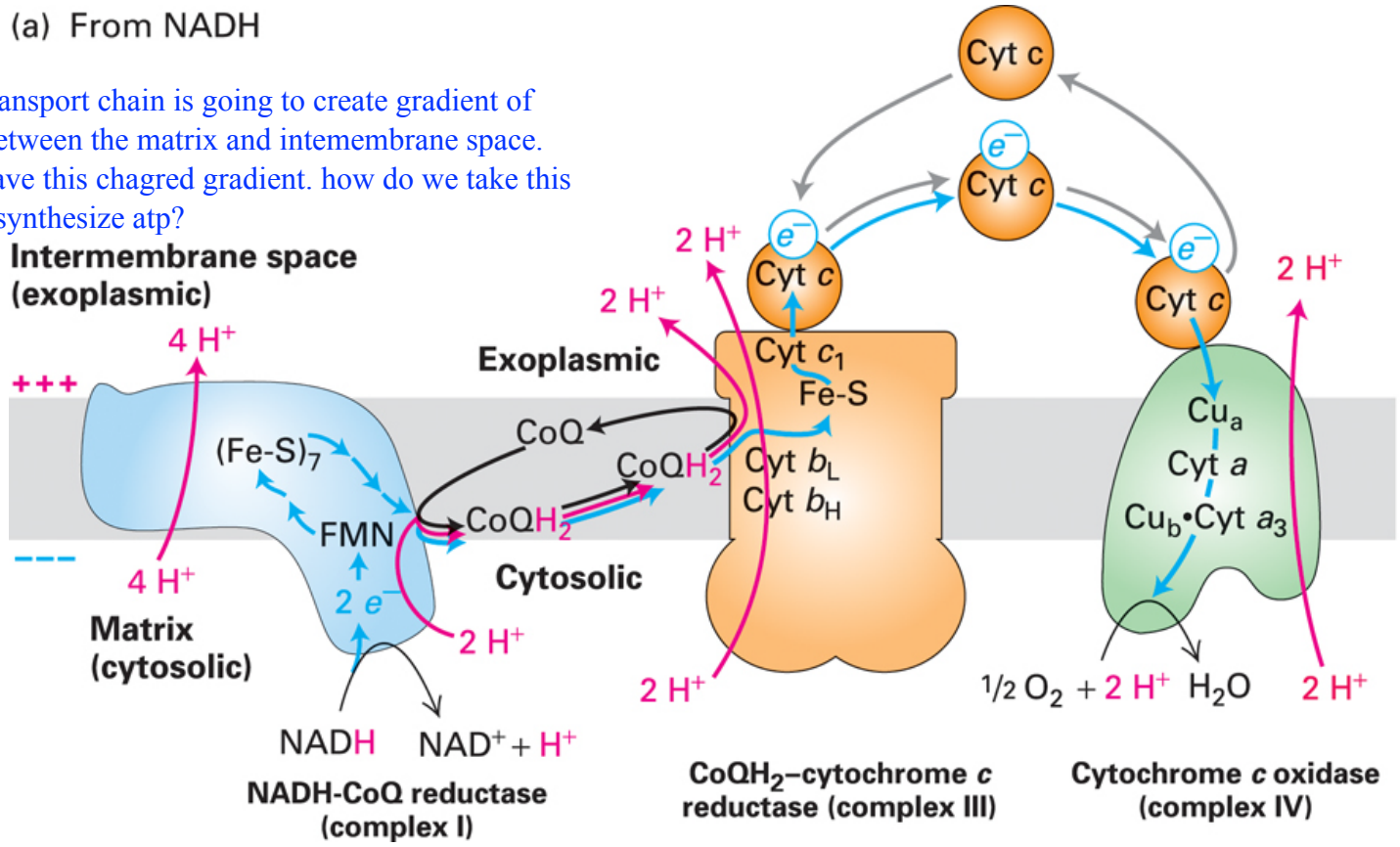
Lecture 13

Gary Brouhard



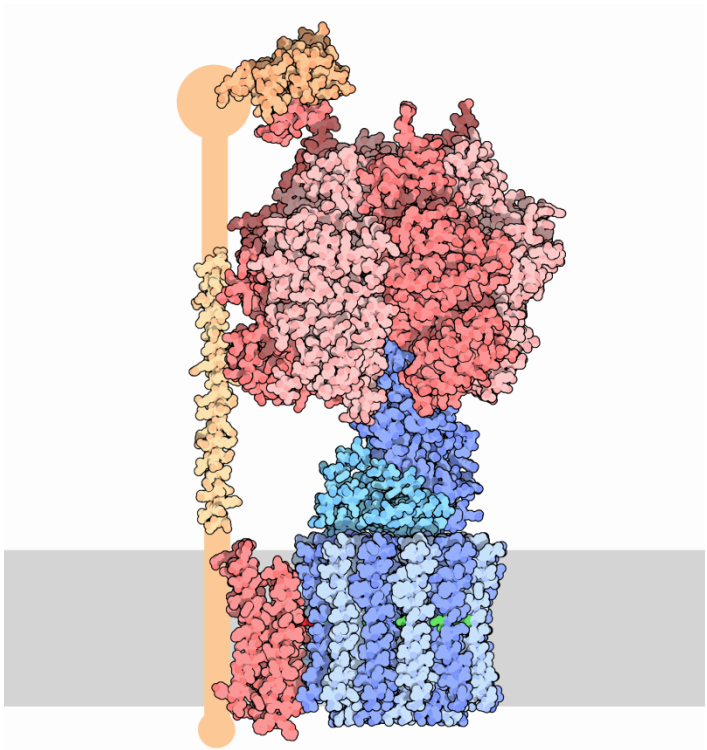
The electron transport chain generates a proton gradient in mitochondria

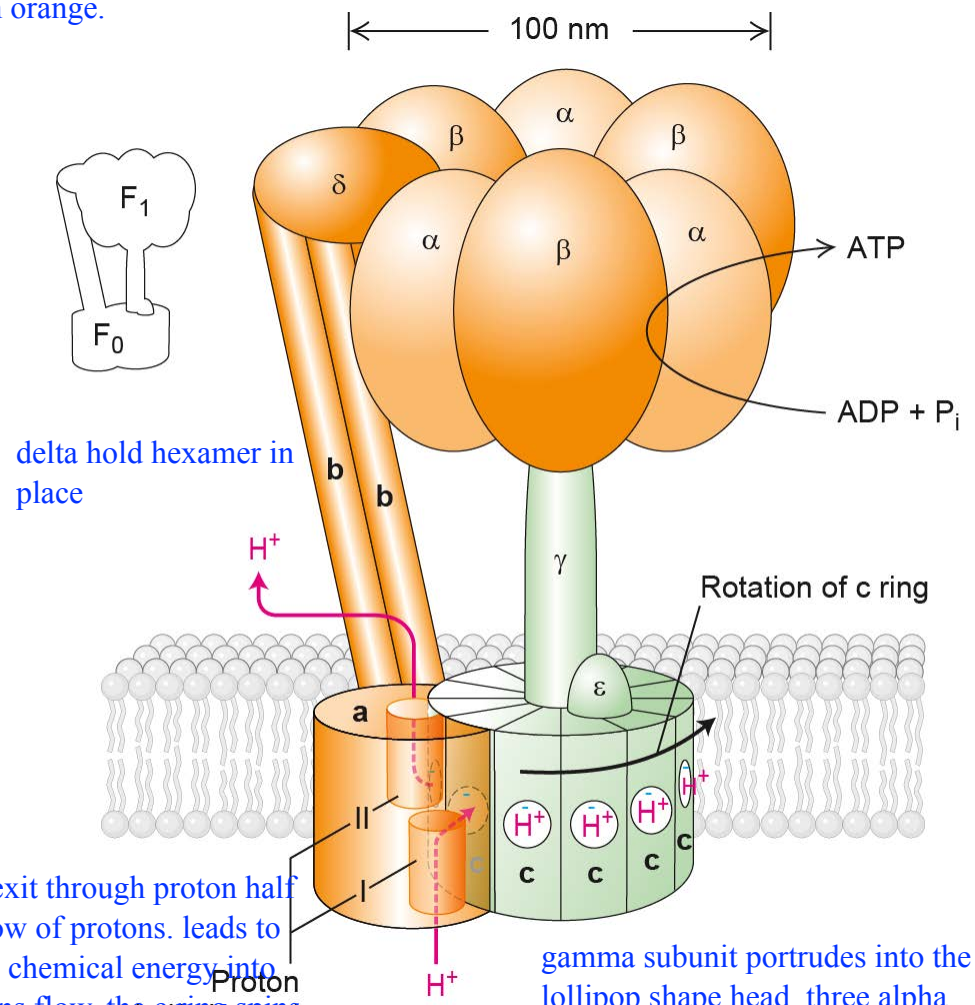
electron transport chain is going to create gradient of proteins between the matrix and intemembrane space. we now have this chagred gradient. how do we take this energy to synthesize atp?



ATP synthase harnesses the proton-motive force to make ATP

moving parts in green, stationaries in orange.





delta hold hexamer in place

Image Source: David Goodsell

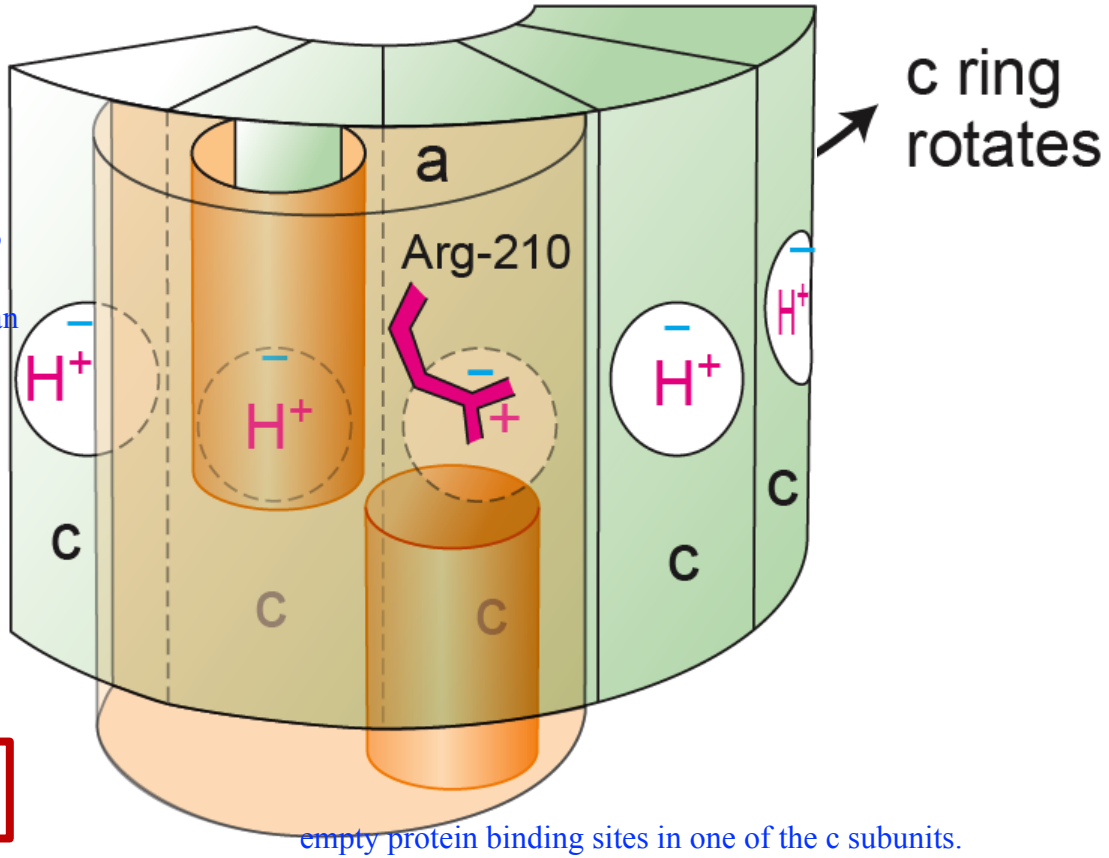
protons are going to enter through proton half channel 1 and exit through proton half channel 2. leads to rotation of c ring subunits - responds to flow of protons. leads to synthesis of atp by beta subunits of the large head. transforms chemical energy into mechanical energy in terms of spinning of the c ring. as protons flow, the c ring spins. rotations of the gamma subunit stalk is going to force the syntehsis of atp in the beta subunits

gamma subunit portrudes into the lollipop shape head. three alpha subunits and hree beta subunits

The F_0 subunit rotates as protons pass through it

proton flows out - argining 210 gets kicked to the left, proton on other side of channel gets popped out

arg210 carries positive charges. the ring actually cant spin most of the time - each of the c subunits actually have a negative charge from an aspartic acid residue. actually have to use alot of energy to force negative charge int o the hydropphpboic space. if the charge is neutralized by a proton it can spin.



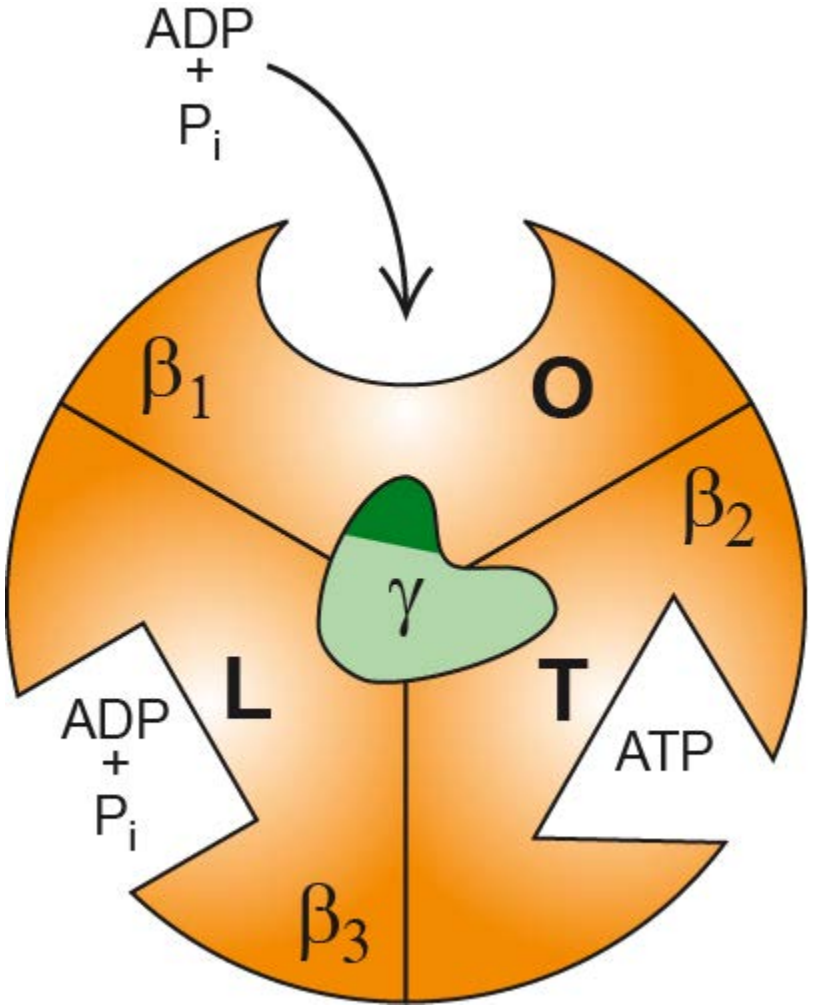
10-14 c subunits

"Brownian Ratchet"

wiggles: rotational diffusion into the membrane is biased to the right

empty protein binding sites in one of the c subunits. proton enters - kicks arginine 210 out, clicks over. positive charge on arg will conflict with proton on the other side of the half channel and the ring can rotate

The F1 subunits exist in 3 discrete conformations



Open

Nucleotides pop in and out

ADP and Pi can come in and binds

Loose

ADP + Pi trapped but non-reactive

grabbed the adp and the pi but not hlding them tightly. jsut have them in the pocket. its trapped but nothing is hapenning reactively

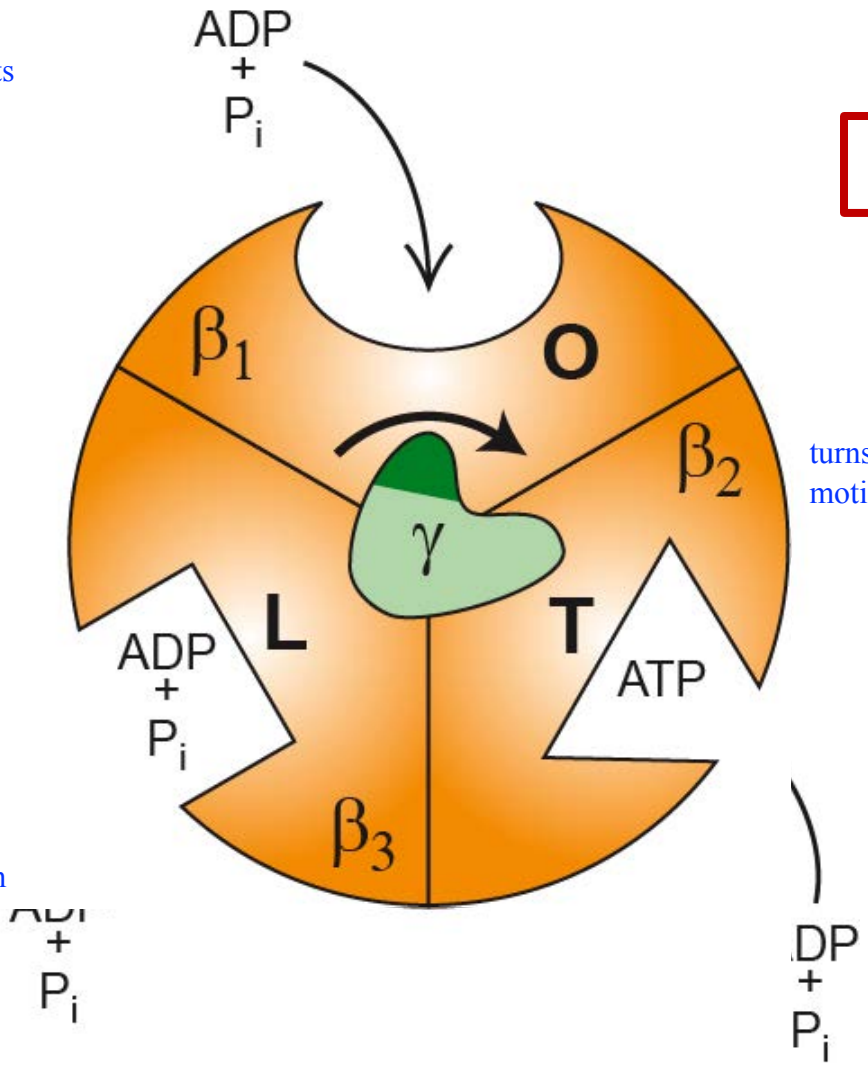
Tight

ADP + Pi converted (reversibly) to ATP

holding so close together that they fuse into AT[and breaking back out into adp and pi.

Rotation of the F_0 γ subunit pushes the F_1 β subunits through their 3-state cycle

dark green lobe forces beta subunits into the o state to l state to t state.



10 H^+ = 3 ATP!

turns rotational motion into linear motion = like a cam

molecule can work both as an atp syntehsis machine and also a proton pump

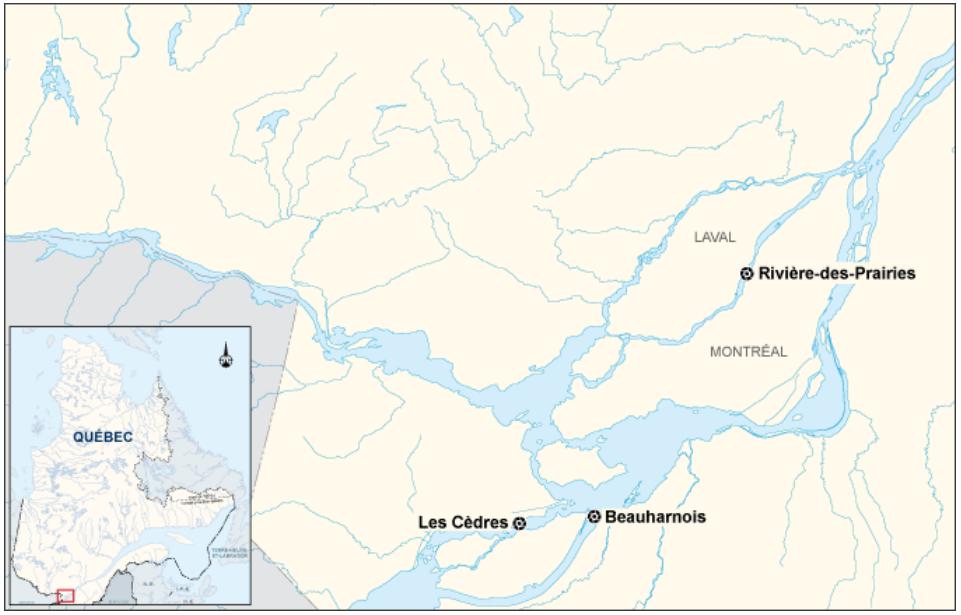
The rotary catalytic mechanism of mitochondrial ATP synthase.

MRC Mitochondrial Biology Unit

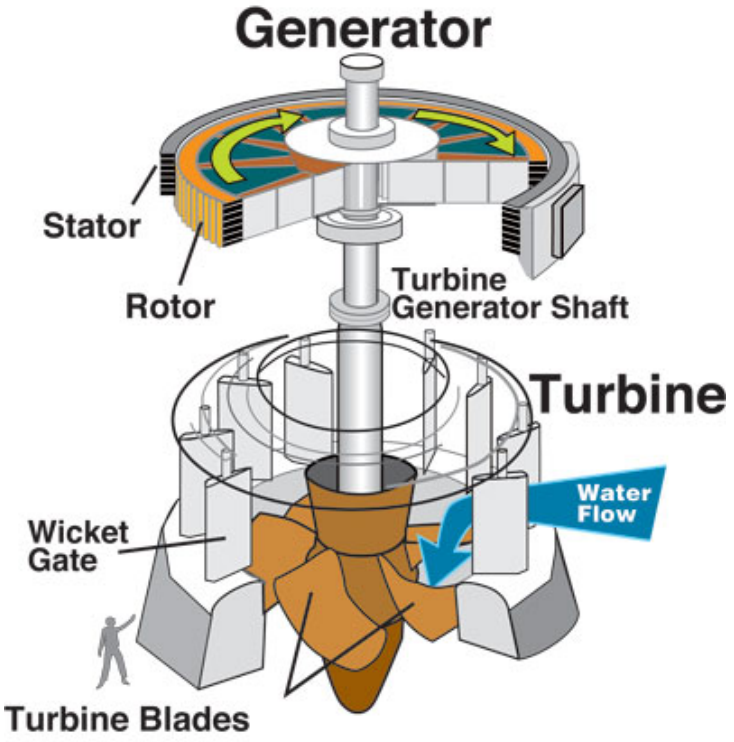
How the rotating γ-subunit imposes conformational states on a β–subunit required for substrate binding, ATP formation and ATP release.

MRC Mitochondrial Biology Unit

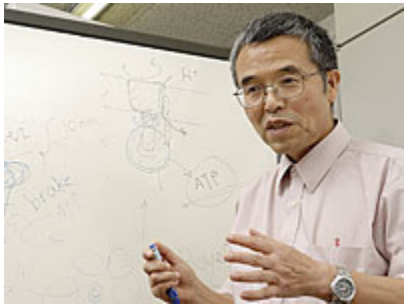
ATP synthase is the world's smallest turbine generator



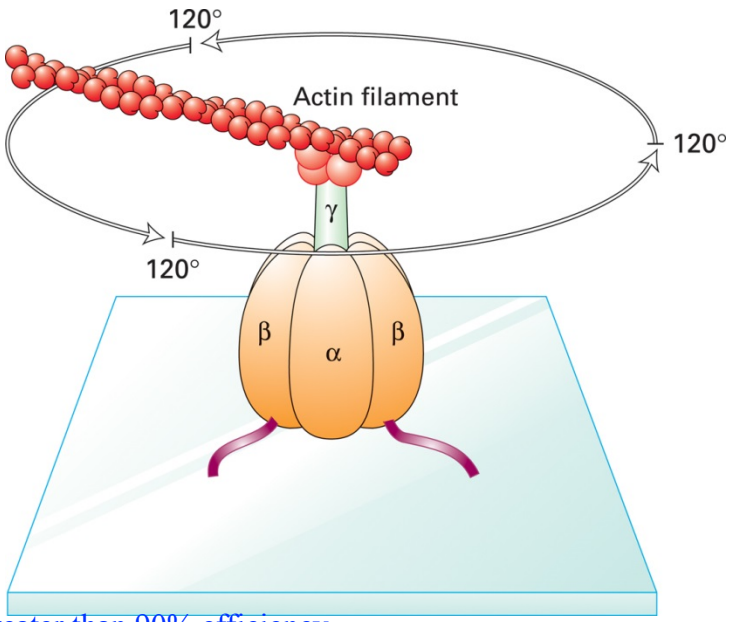
Hydro Québec
Rivière-des-Prairies station



The movement of ATP synthase has been directly visualized



Kazuhiko Kinoshita, Jr.
Masasuke Yoshida



operates at greater than 90% efficiency.

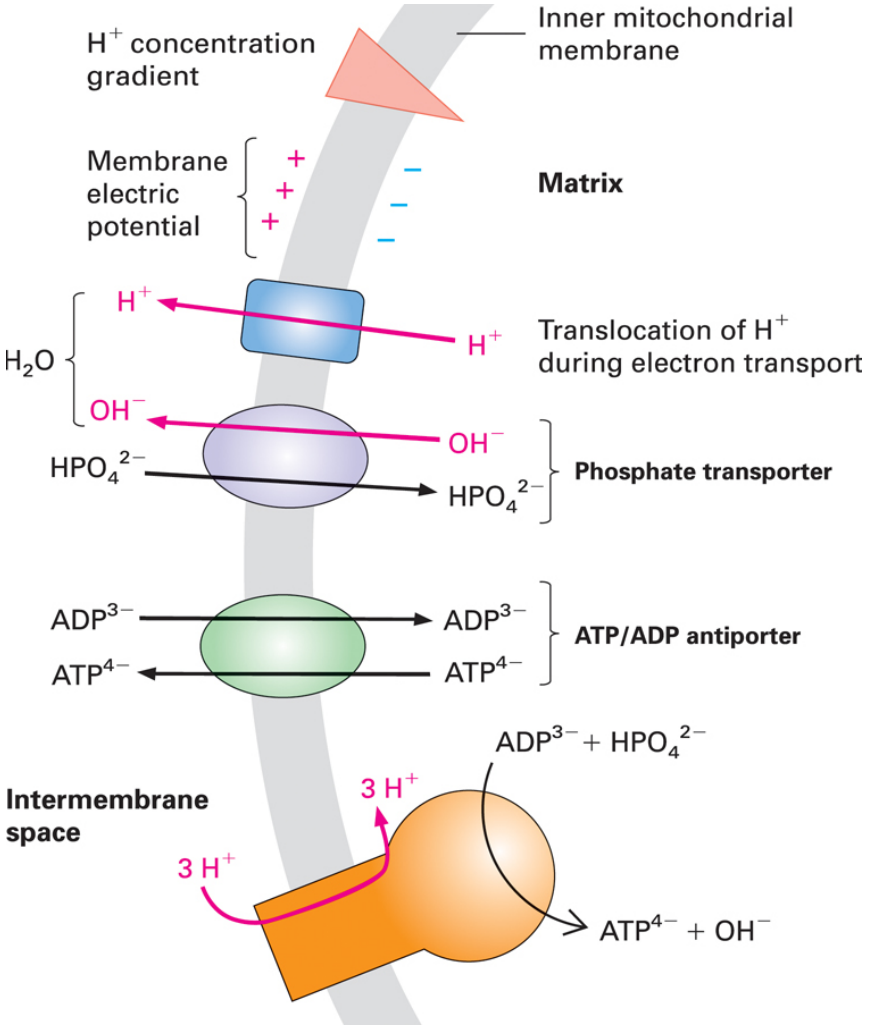
Noji et al., *Nature* 1997

Max Speed: 130 revolutions/sec!!

developed a way to purify fi heads of a bacterial atp syntahse. able to stick the f1 head to a glass and attach a small actin filament (operating as a fluorescent stick) and added a bunch of atp. hydrolyzes atp (in opposite direction) whcih causes the gamma shaft to actually spin.

clones genes out of thermophyllic bacteria - japanese hot springs

ATP escapes the mitochondrial matrix via an ATP/ADP antiporter



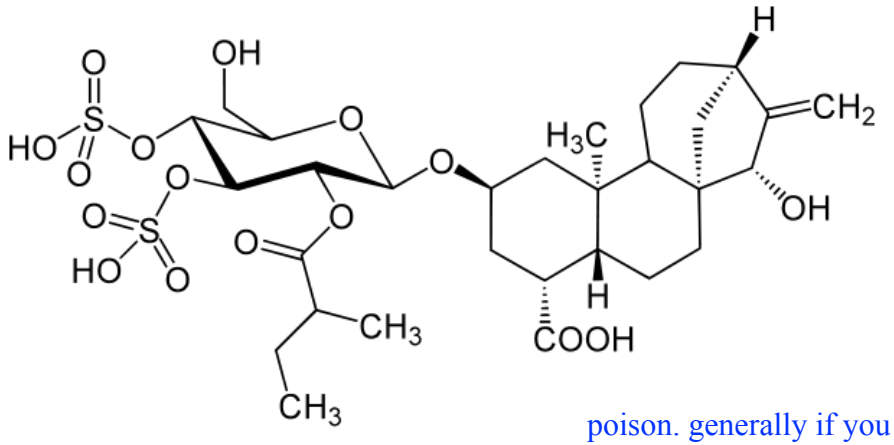
Each ATP needs 1 H+ for transport purposes!

for every atp you syntehsize you need to have brought and adp and a phosphate into the matrix. completed by the two transporters ATP/ADP anitporter.

one spin makes 3 atps.

An African herbal remedy is an inhibitor of the ATP/ADP antiporter

African ox-eye daisy
Callilepis laureola



Atractyloside

poison. generally if you eat them youre going to die

inhibitor

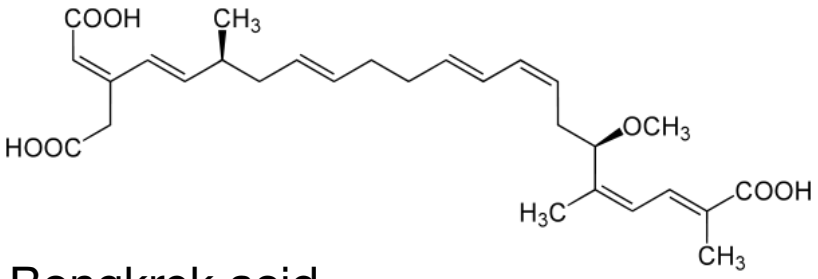
And watch out for funky tempeh!

Tempeh Bongkrek
Fermented soybeans and coconut

Apparently banned but available on black market?

adding coconut allows it to be contaminated by b gladioli which produces the bongkrek acid. you will die because your atp/adp antiporter will be inhibited

Can be contaminated by
B. gladioli



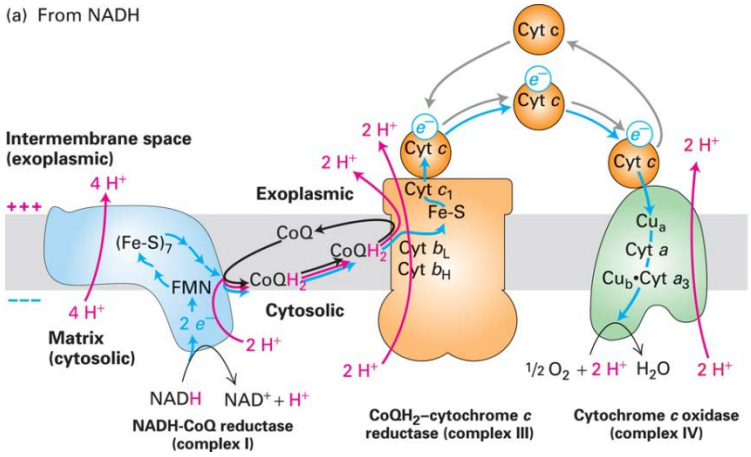
Bongkrek acid
ATP/ADP antiporter inhibitor

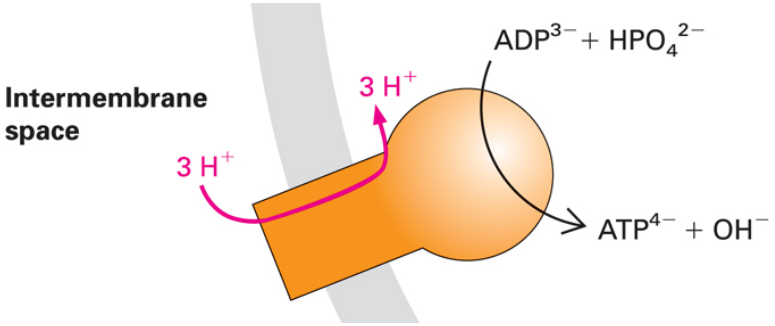
Some accounting…

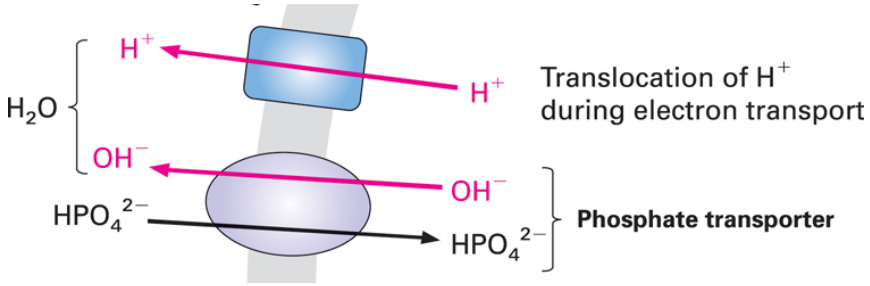
1 NADH reduced = 10 H^+ transferred

4 H^+ = 1 ATP

3 of them used by atp synthase. and one of them is used in the transport process to get phosphate across







1 NADH reduced = 2.5 ATP