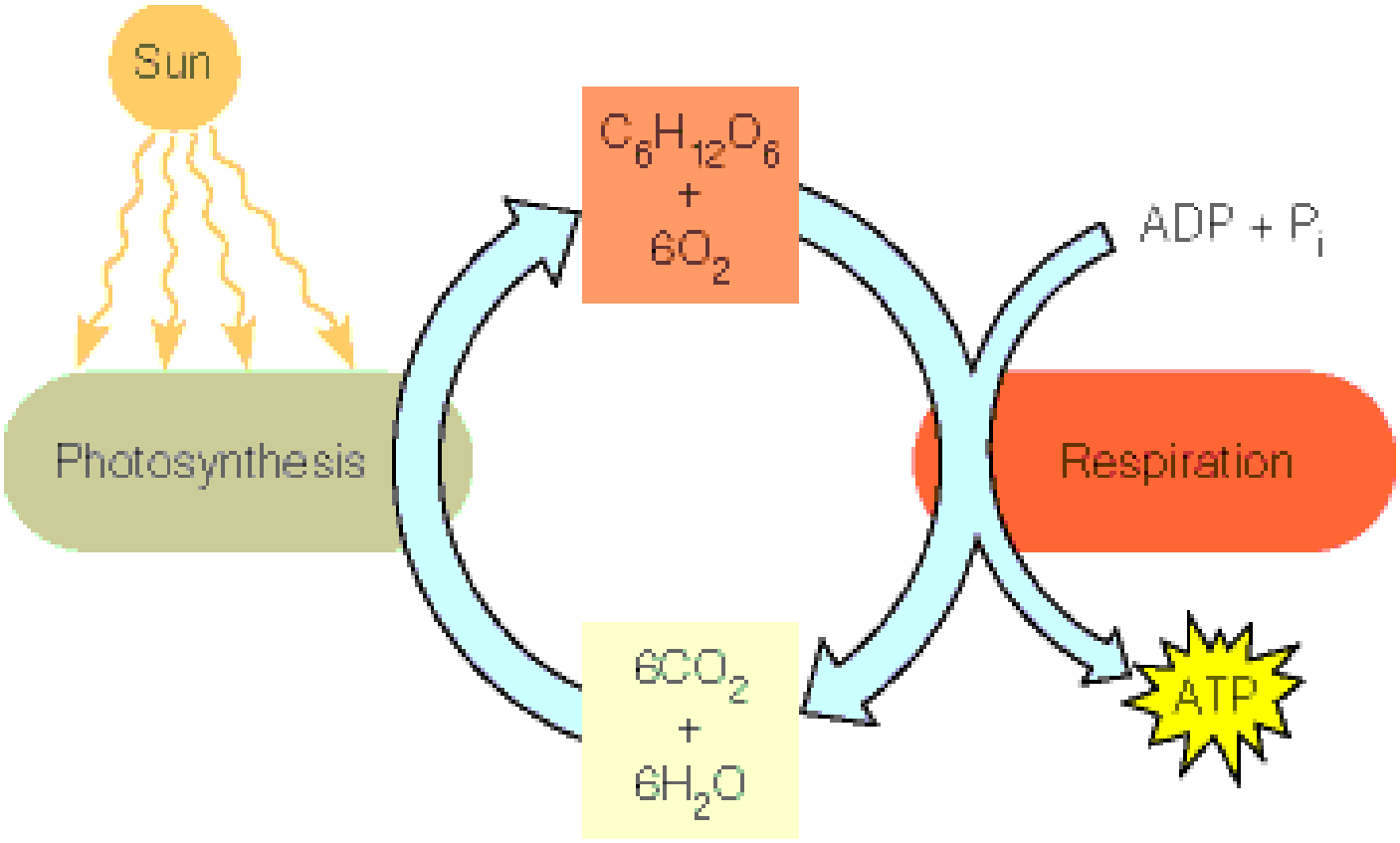
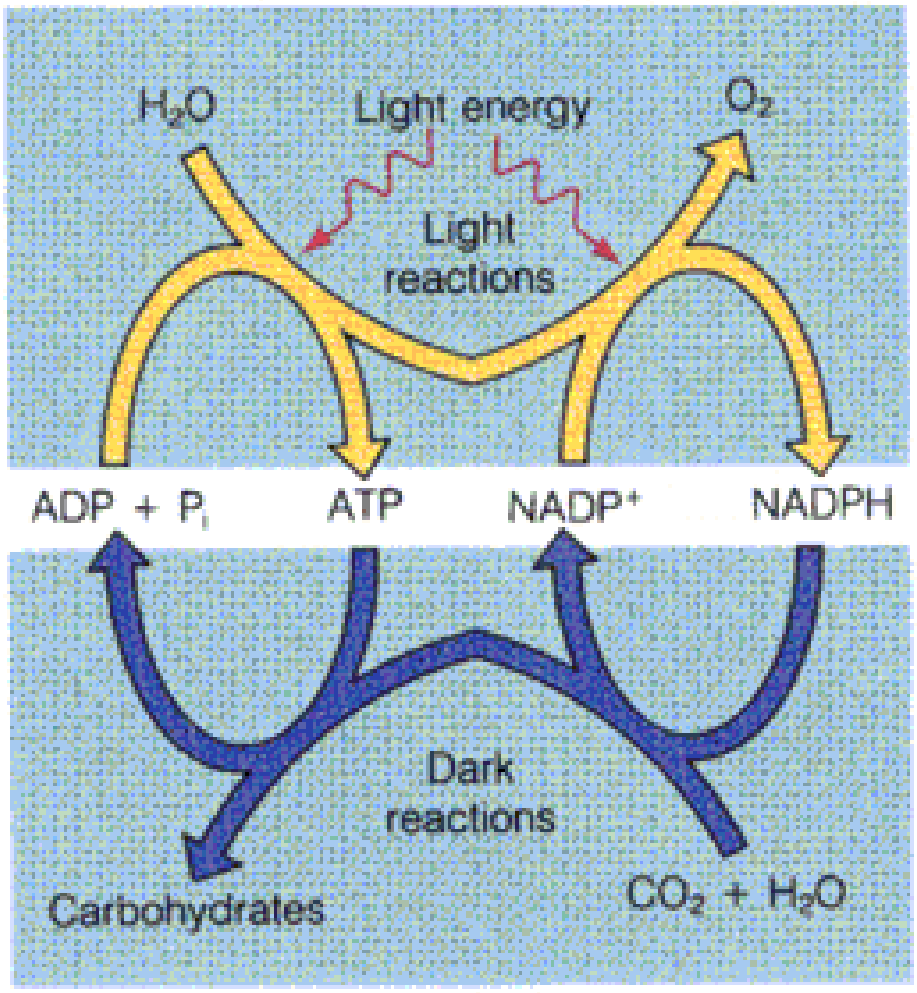
Chapter 17

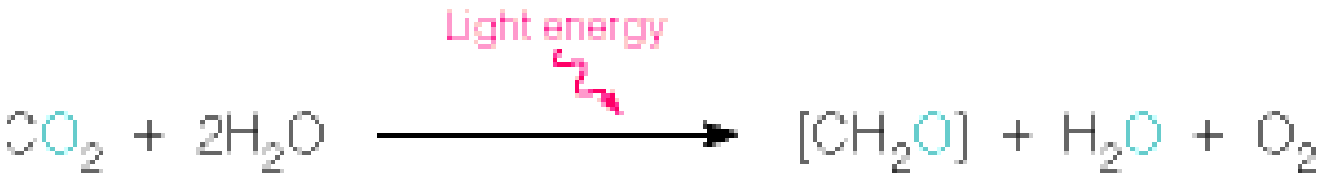

Sun
$C_6H_{12}O_6$ + $6O_2$
ADP + P_i
Photosynthesis
Respiration
$6CO_2$ + $6H_2O$
ATP



Light energy fuels production of ATP and reduced NADPH.

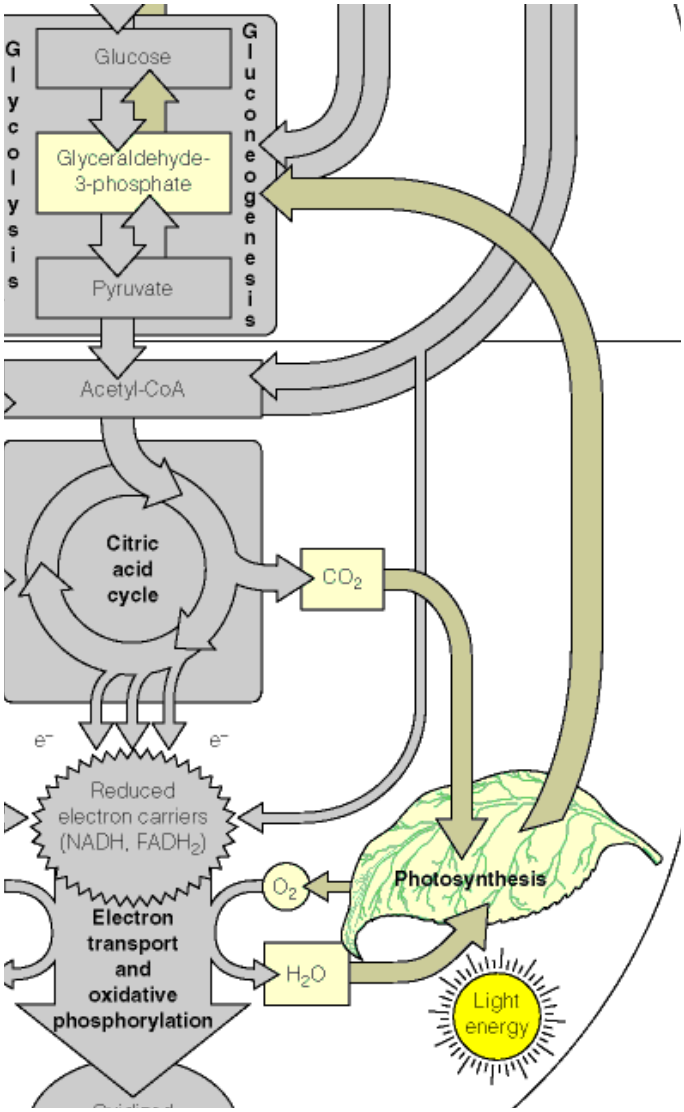
Notice parallels with respiration and ATP synthase.

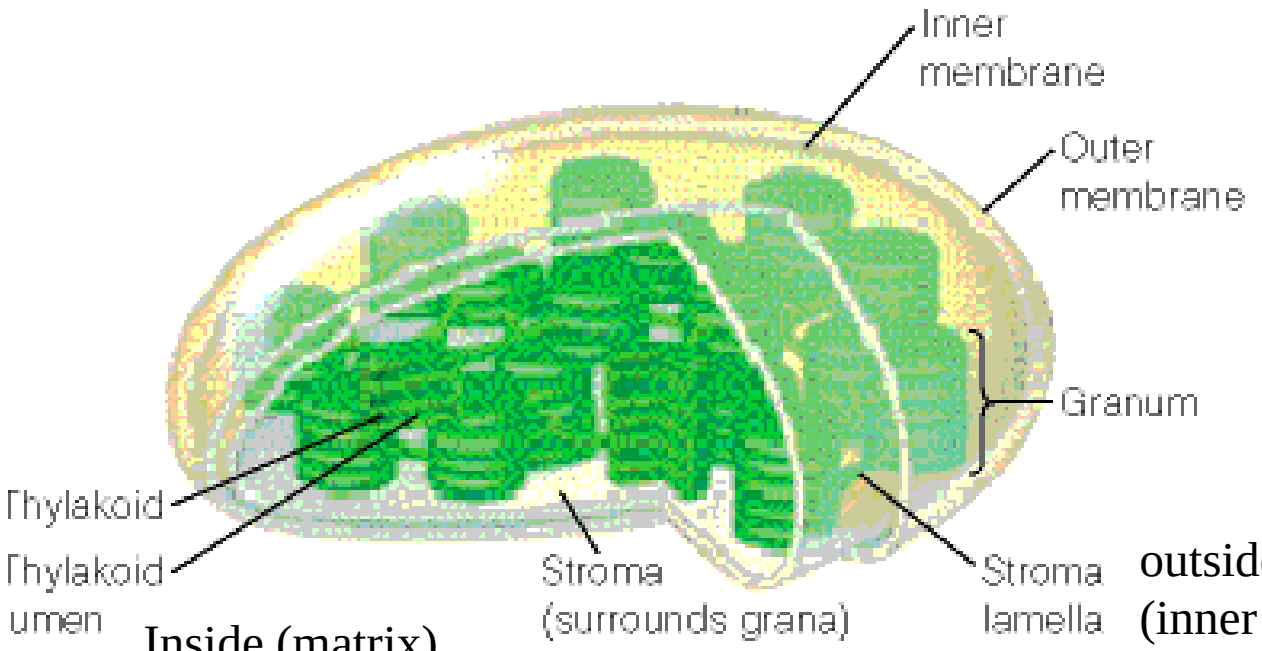
Dark reactions don't require light and produce carbohydrates.



Organisms	Reductant	Reaction
Plants, algae, cyanobacteria	H_2O	$CO_2 + 2H_2O \longrightarrow [CH_2O] + H_2O + O_2$
Green sulfur bacteria	H_2S	$CO_2 + 2H_2S \longrightarrow [CH_2O] + H_2O + 2S$
Purple sulfur bacteria	$[HSO_3^-]$	$CO_2 + H_2O + 2[HSO_3^-] \longrightarrow [CH_2O] + 2[HSO_4^-]$
Nonsulfur photosynthetic bacteria	H_2 or many other reductants,	$CO_2 + 2H_2 \longrightarrow [CH_2O] + H_2O$

Water (and other substances--H_2, H_2S provide electrons). Labeling experiments show that the CO_2 O does not end up in O_2.


Glycolysis
Gluconeogenesis
Glucose
Glyceraldehyde-3-phosphate
Pyruvate
Acetyl-CoA
Citric acid cycle
CO_2
e⁻
e⁻
Reduced electron carriers ($NADH$, $FADH_2$)
Electron transport and oxidative phosphorylation
O_2
H_2O
Photosynthesis
Light energy



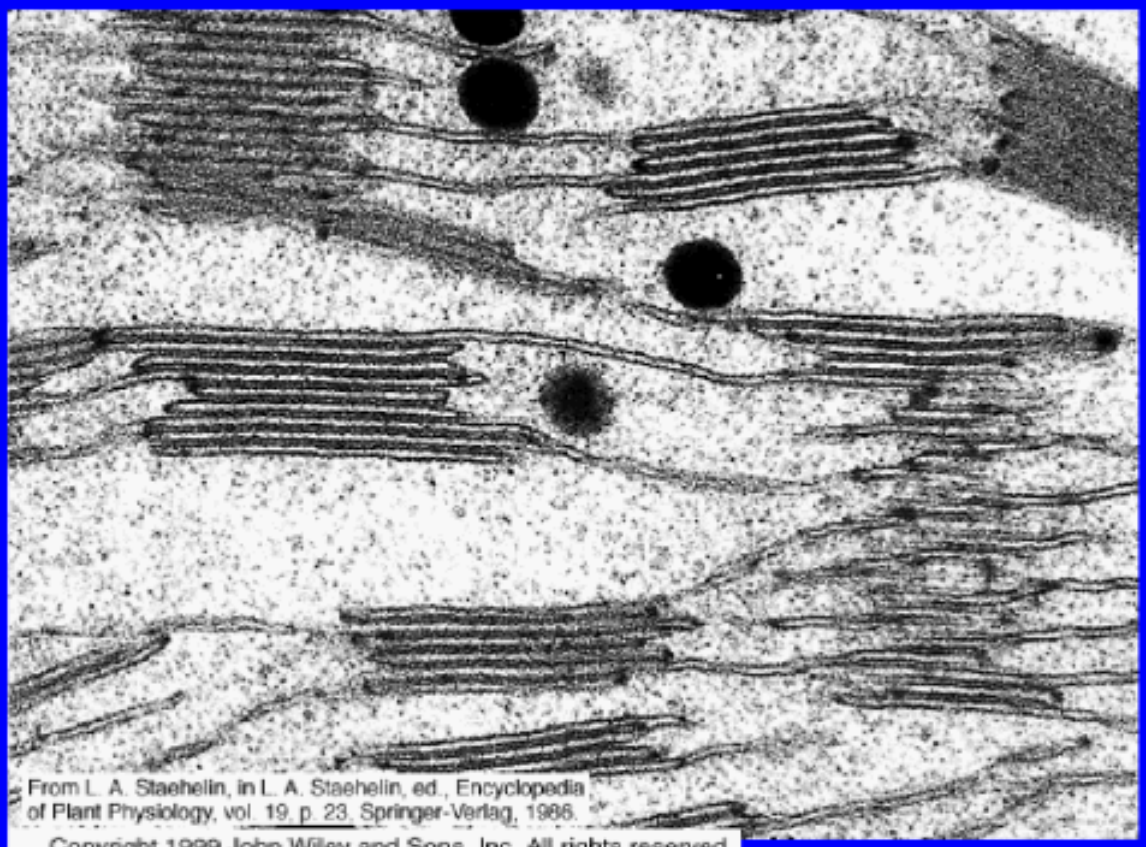
Inside (matrix)

outside (inner Membrane)

c)

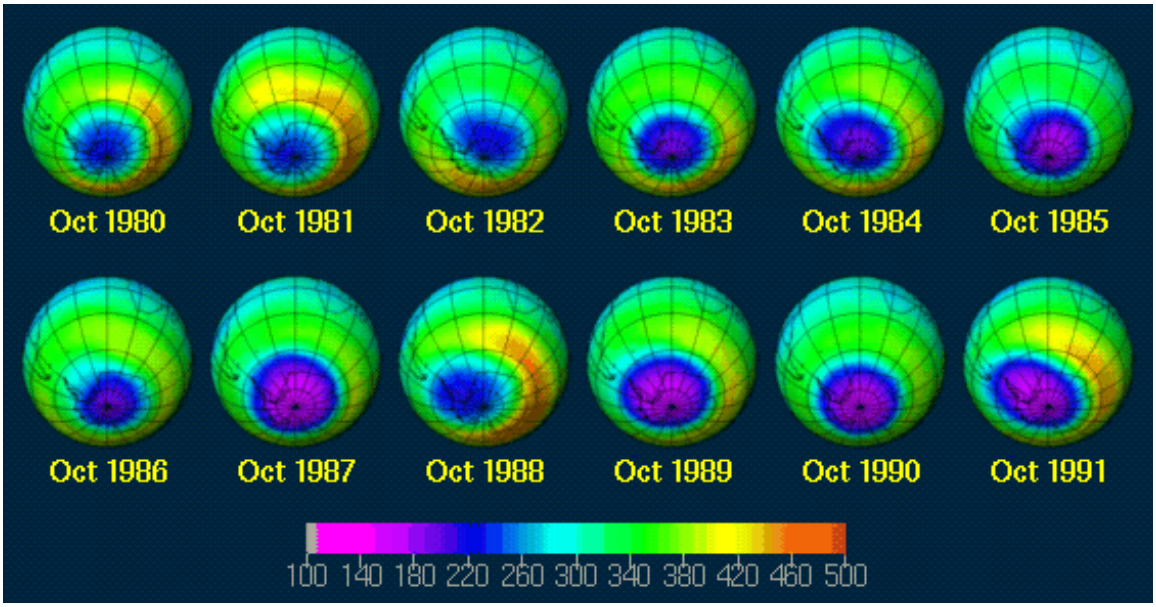
Chloroplasts--similar to mitochondria
(origin free-living photosynthetic bacteria, with DNA, ribosomes)
PhotoSystems I & II and CF0/CF1 embedded in
Thylakoid membrane

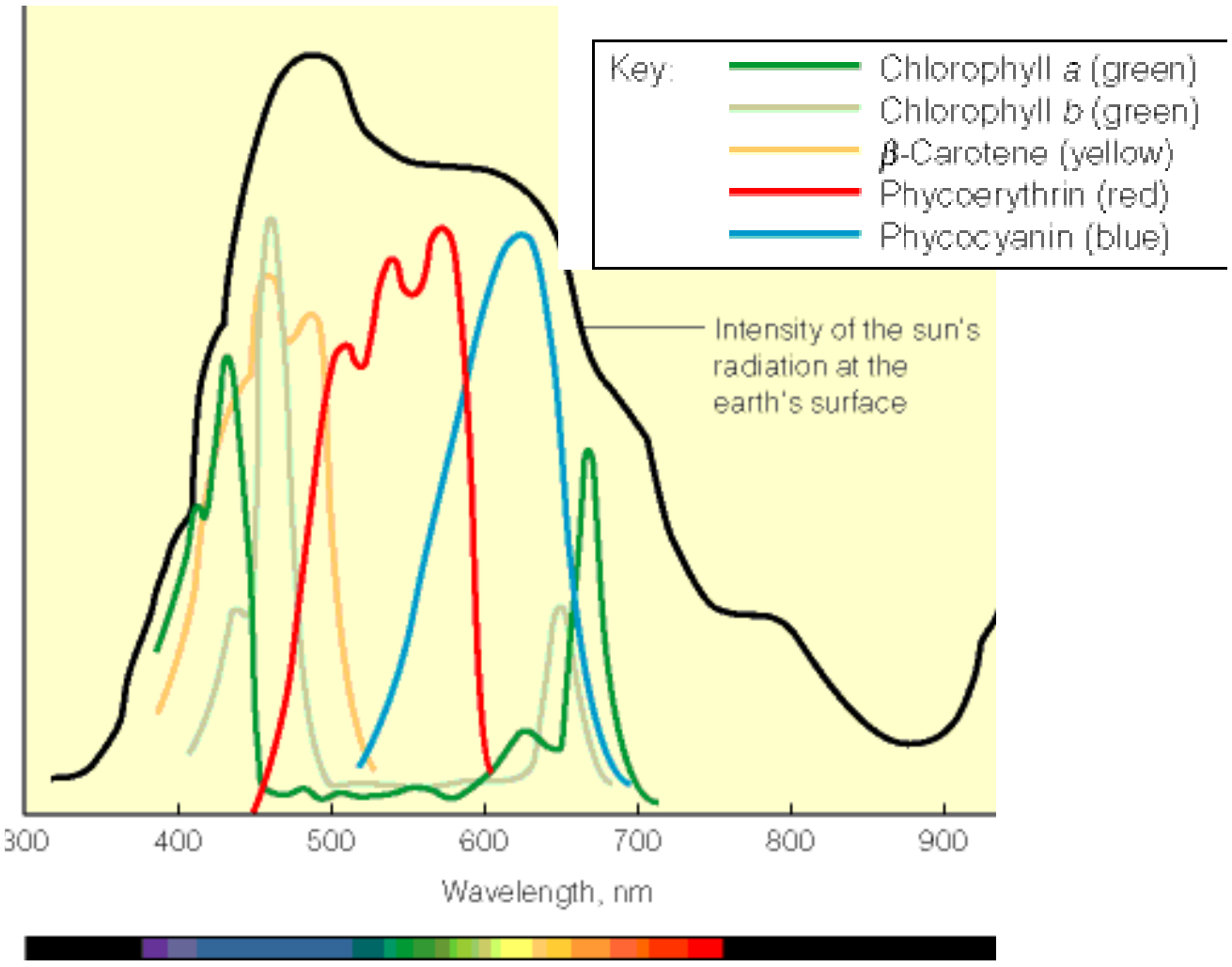
THYLAKOID STRUCTURE

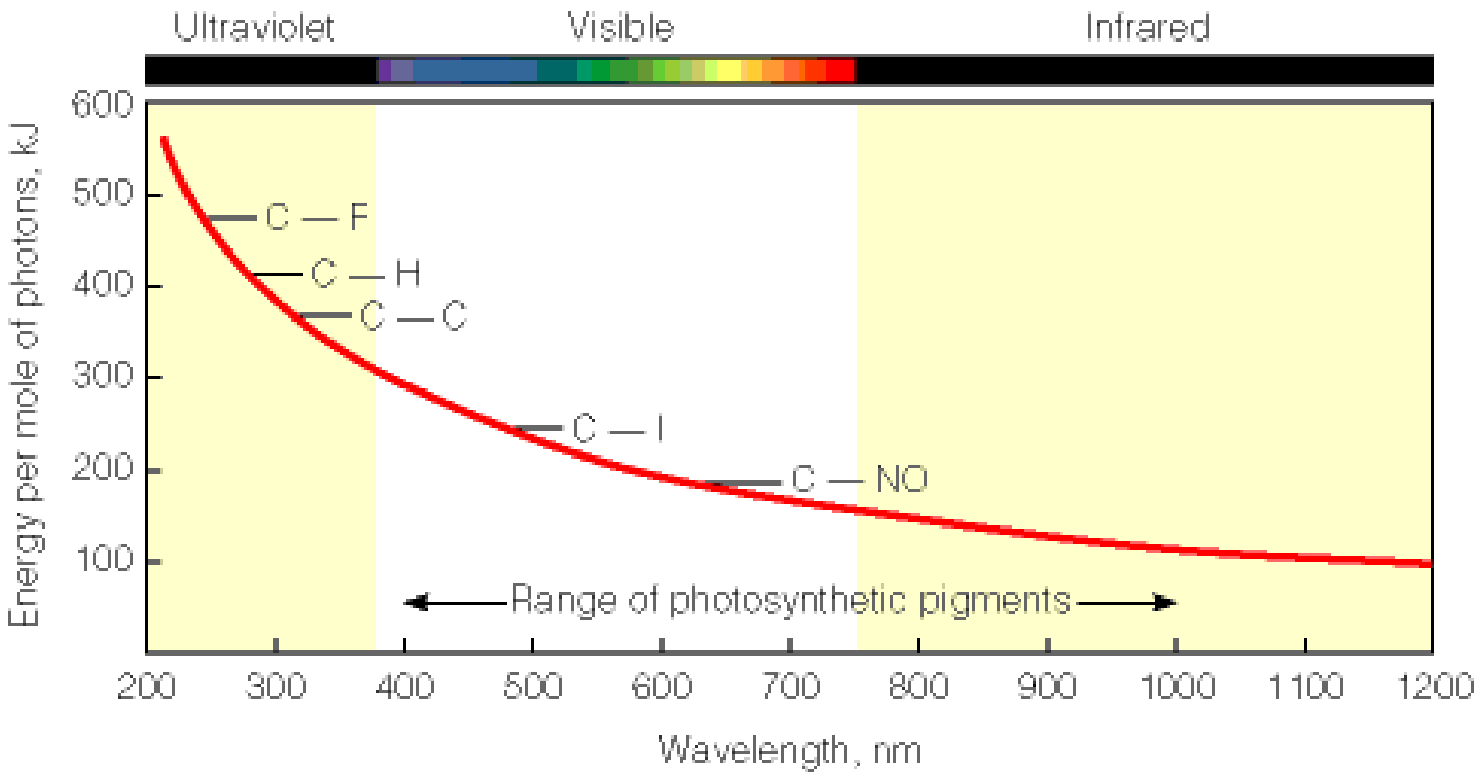


From L. A. Staehelin, in L. A. Staehelin, ed., Encyclopedia of Plant Physiology, vol. 19, p. 23, Springer-Verlag, 1986.

UV light, whose photons have sufficient energy to break covalent bonds, is normally screened out by the ozone layer. Photosynthetic organisms take advantage of all frequencies of visible light.

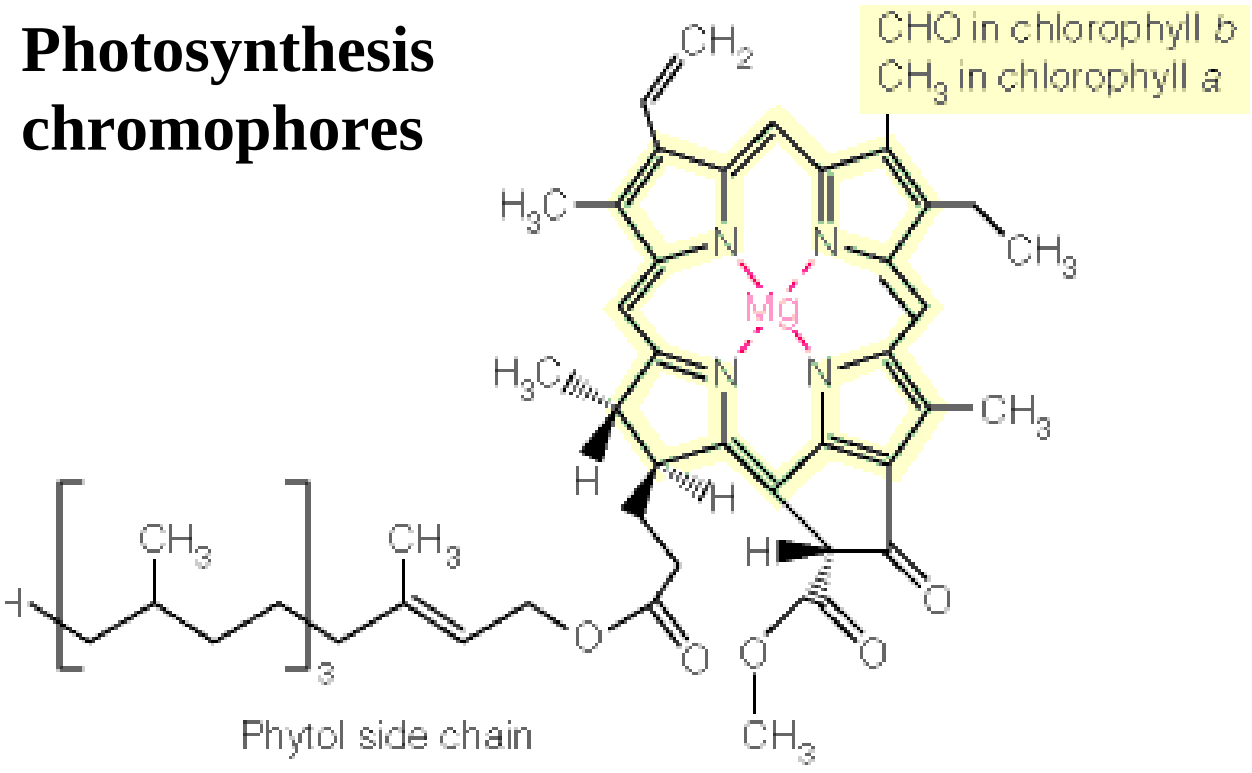



Key:
Chlorophyll a (green)
Chlorophyll b (green)
β-Carotene (yellow)
Phycoerythrin (red)
Phycocyanin (blue)
Intensity of the sun's radiation at the earth's surface
300
400
500
600
700
800
900
Wavelength, nm

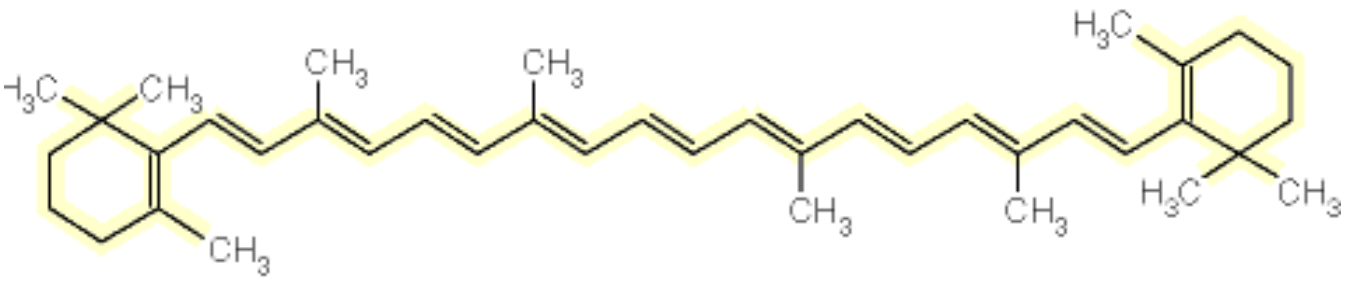


Visible light provides energy without breaking biologically important covalent bonds.

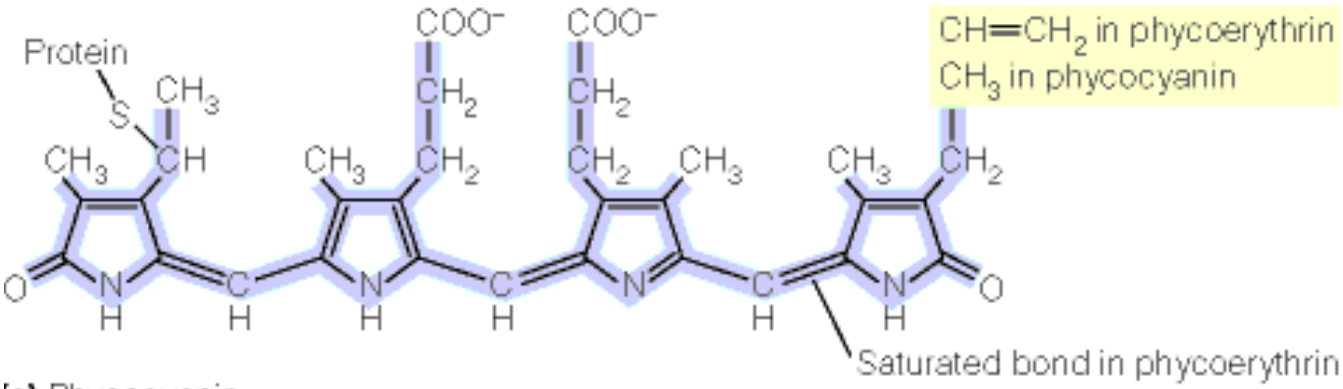
Photosynthesis chromophores



(a) Chlorophylls *a* and *b*

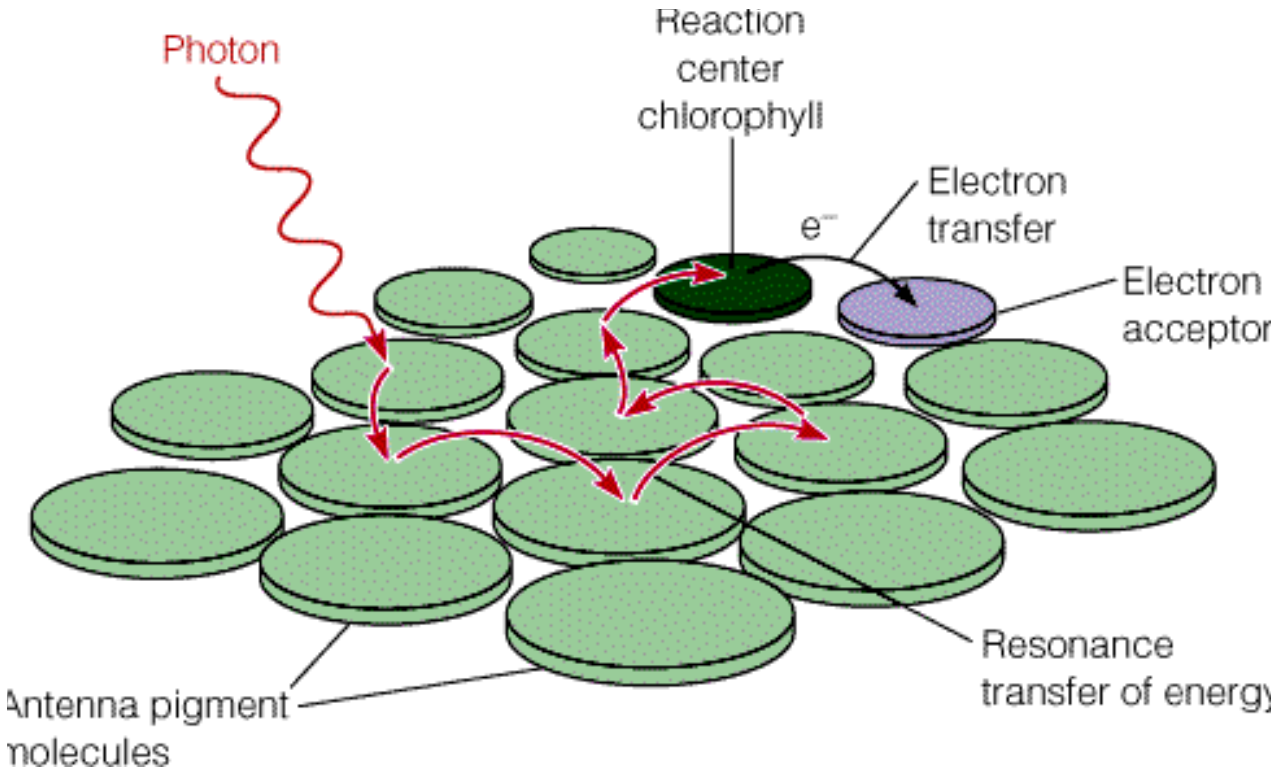


(b) β-Carotene



(c) Phycocyanin

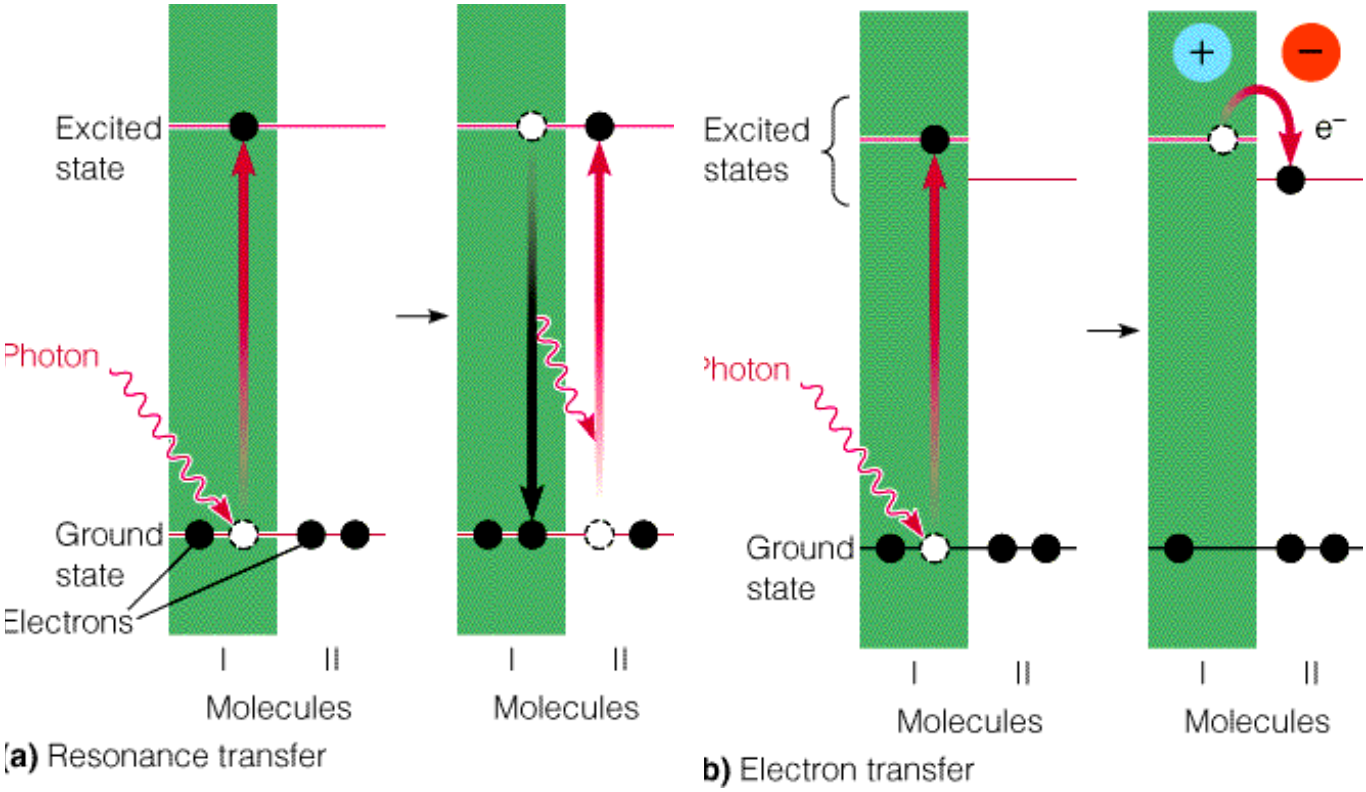
More chromophores (pigments)



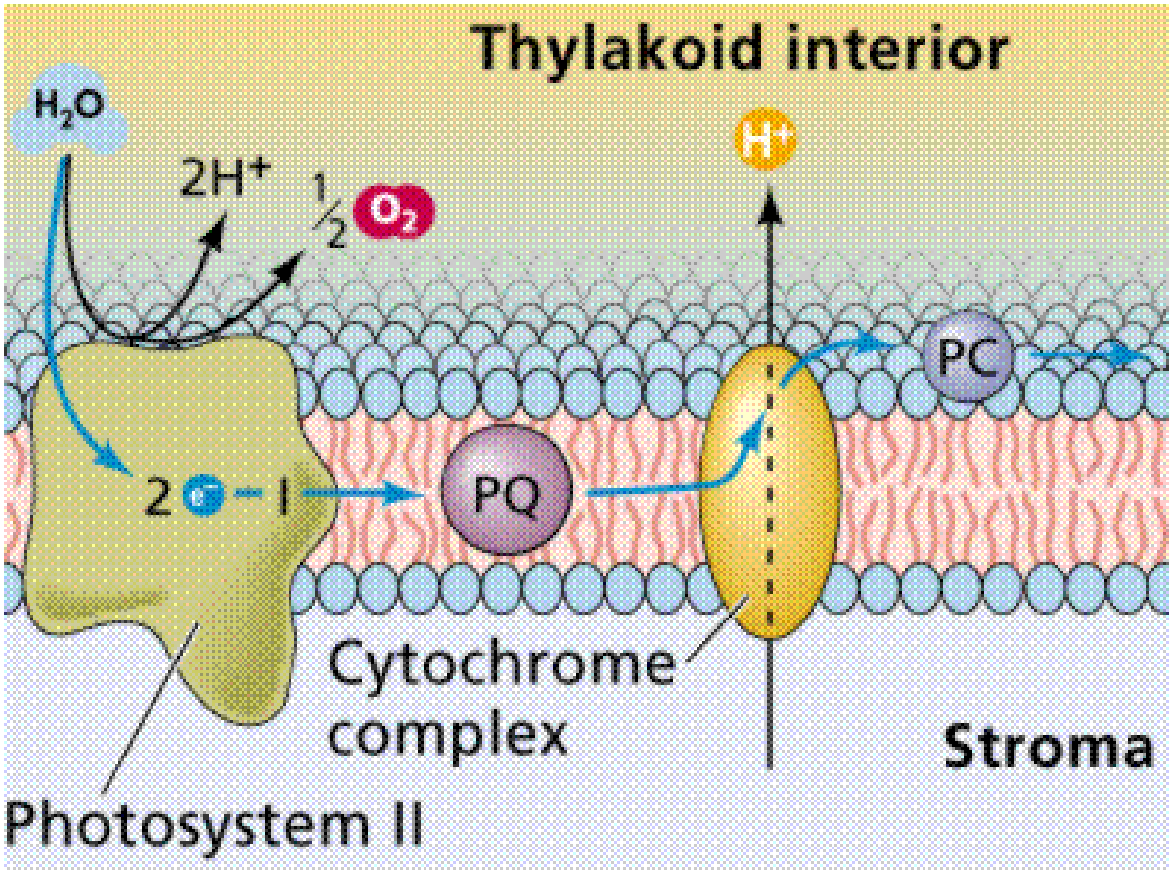
Electrons “funnel” into ‘special” reaction center

another antenna

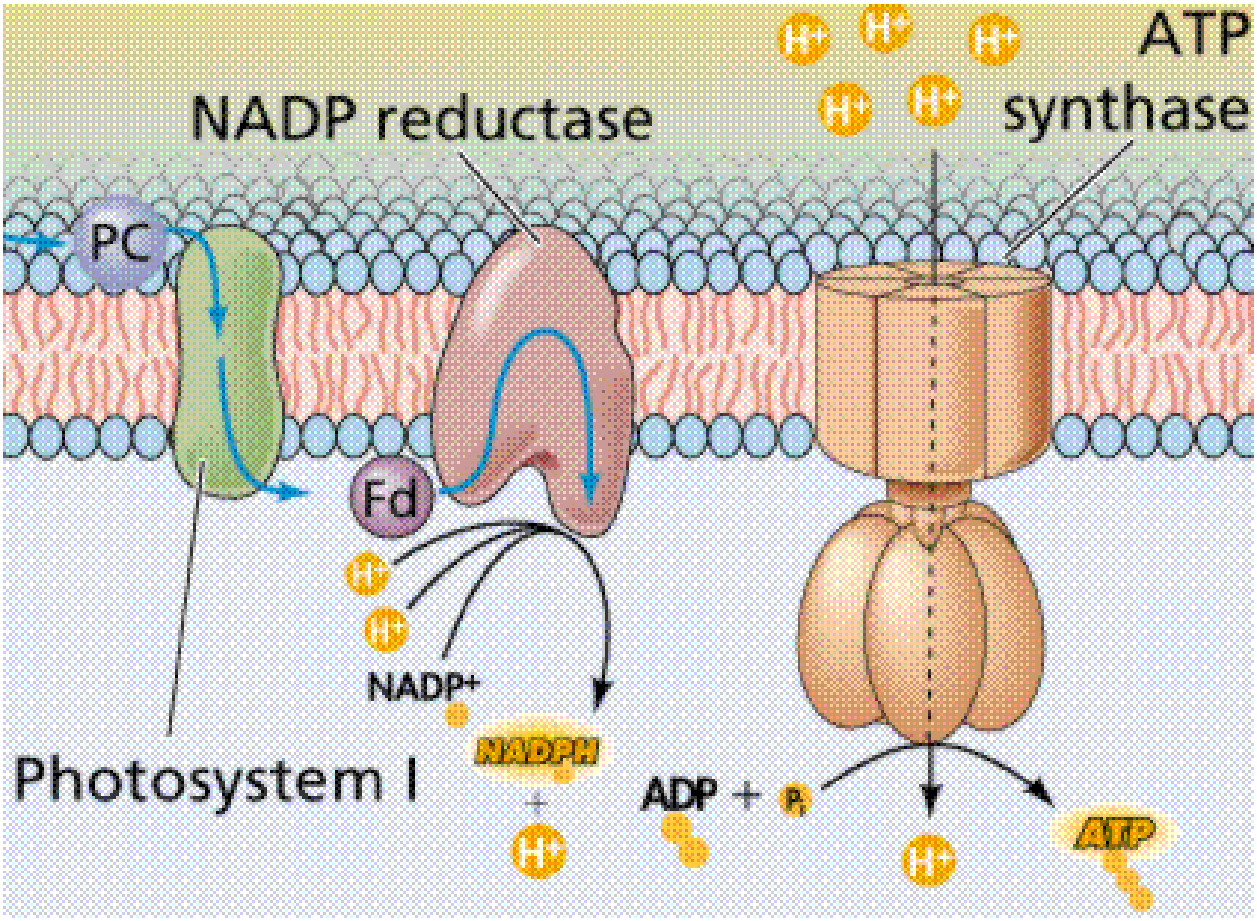
special



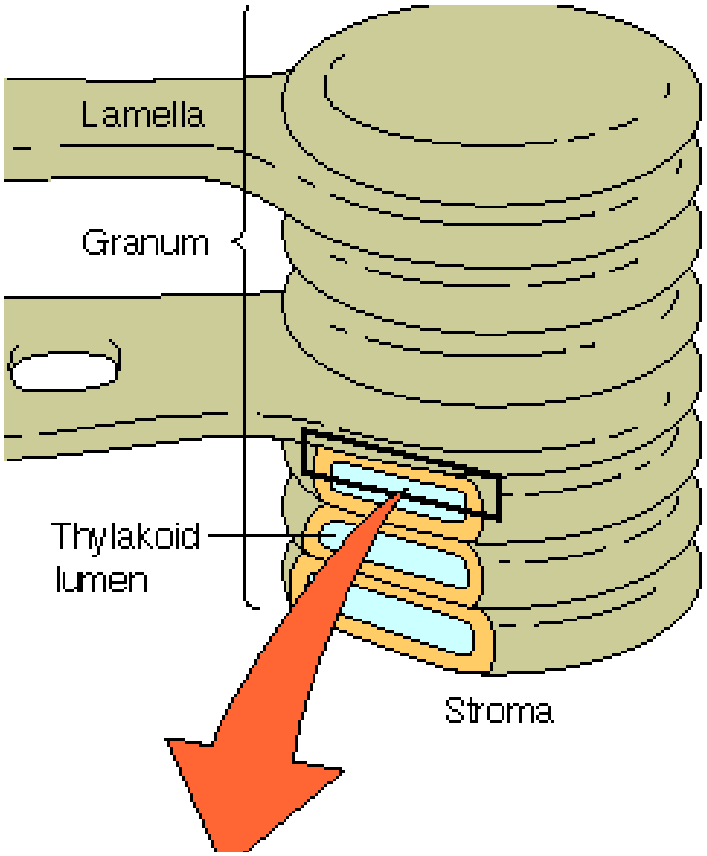
Photon Absorption



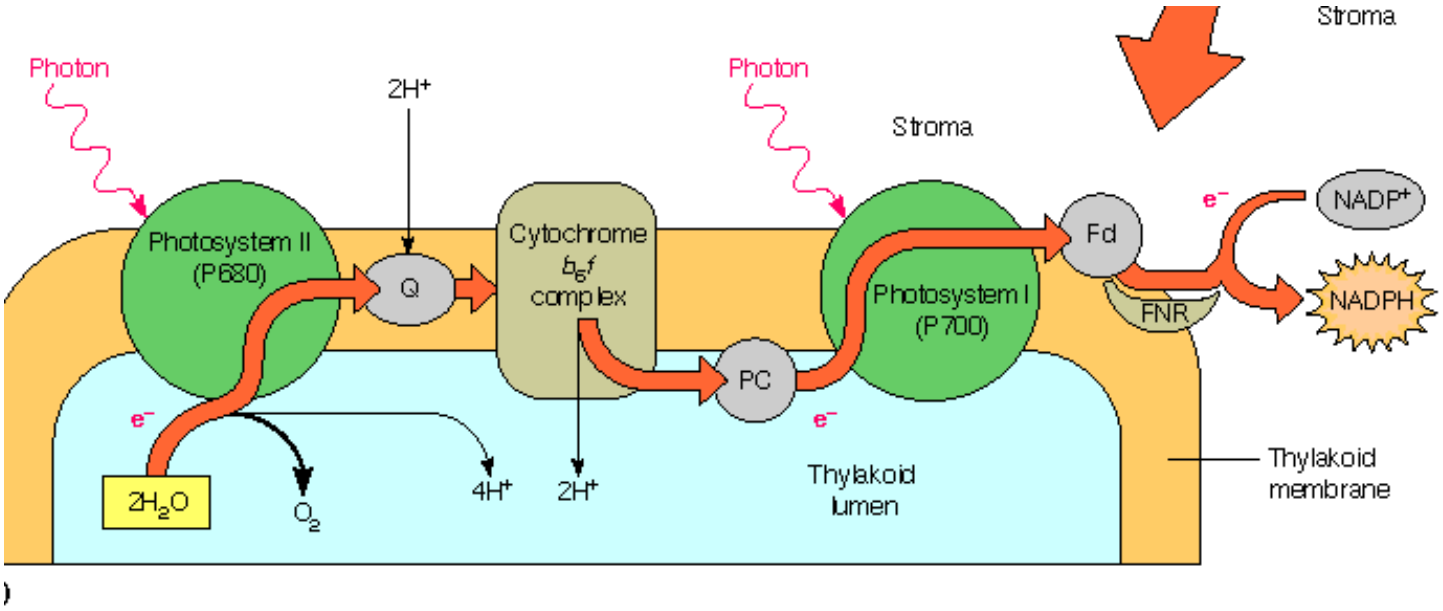
Photosystem II comes first (and was discovered second!)



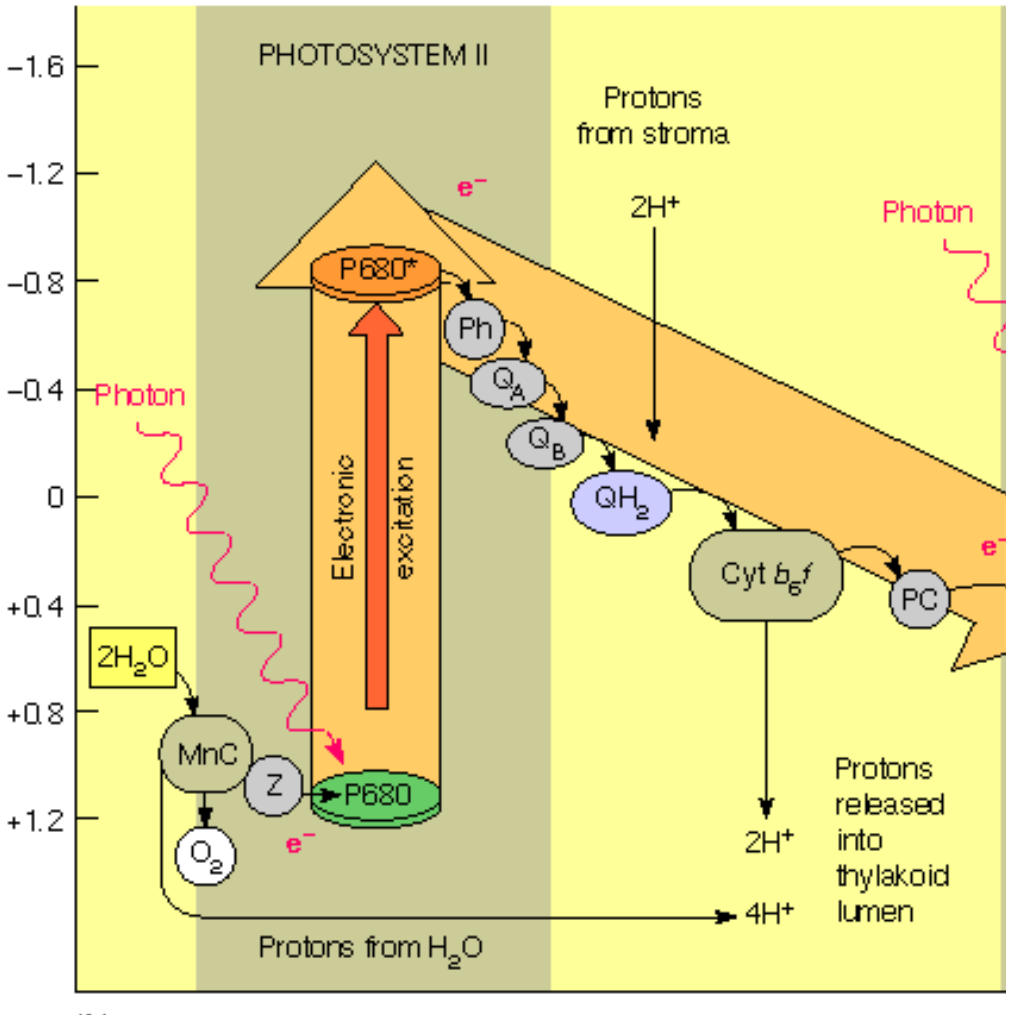
Photosystem I



Zooming in on photon/ electron journey



Complexes are named for longest effective wavelength.



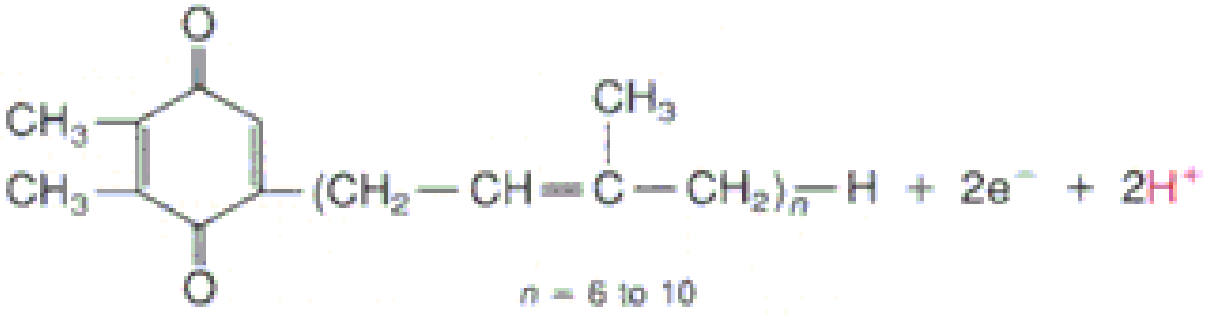
Photosystem II

Excited Electron is Passed to

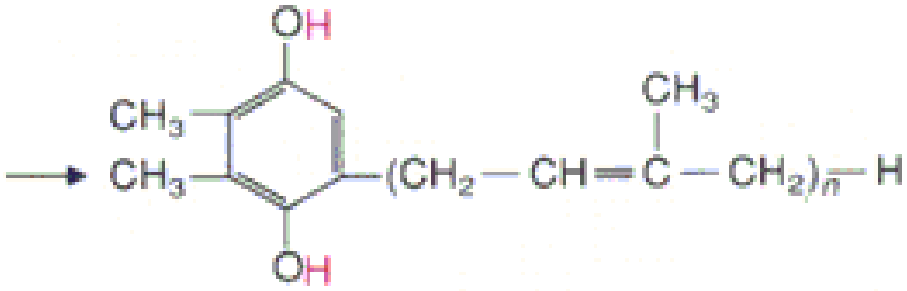
Phytins
Quinones
Cytochrome
Plastocyanin

Protons are Pumped.

Water supplies Electron to P680



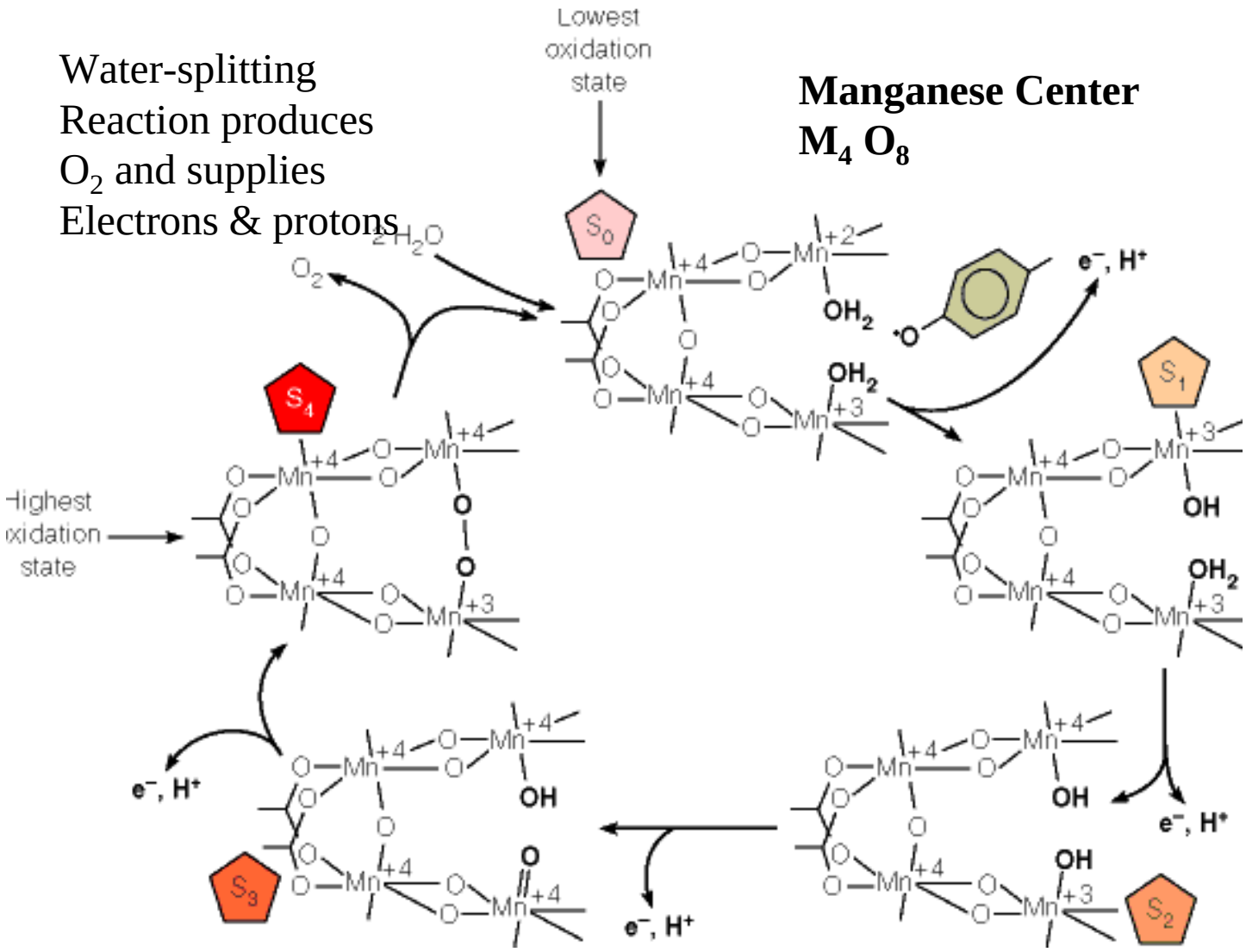
Plastoquinone

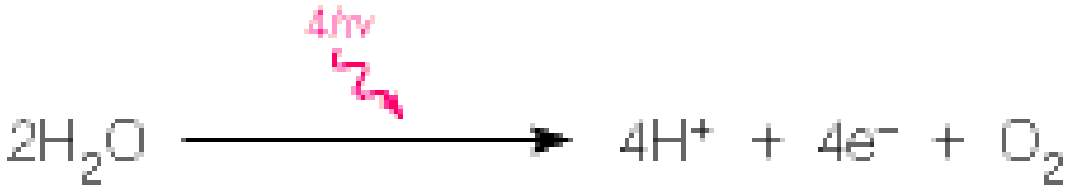


Plastoquinol

Water-splitting
Reaction produces
O_2 and supplies
Electrons & protons

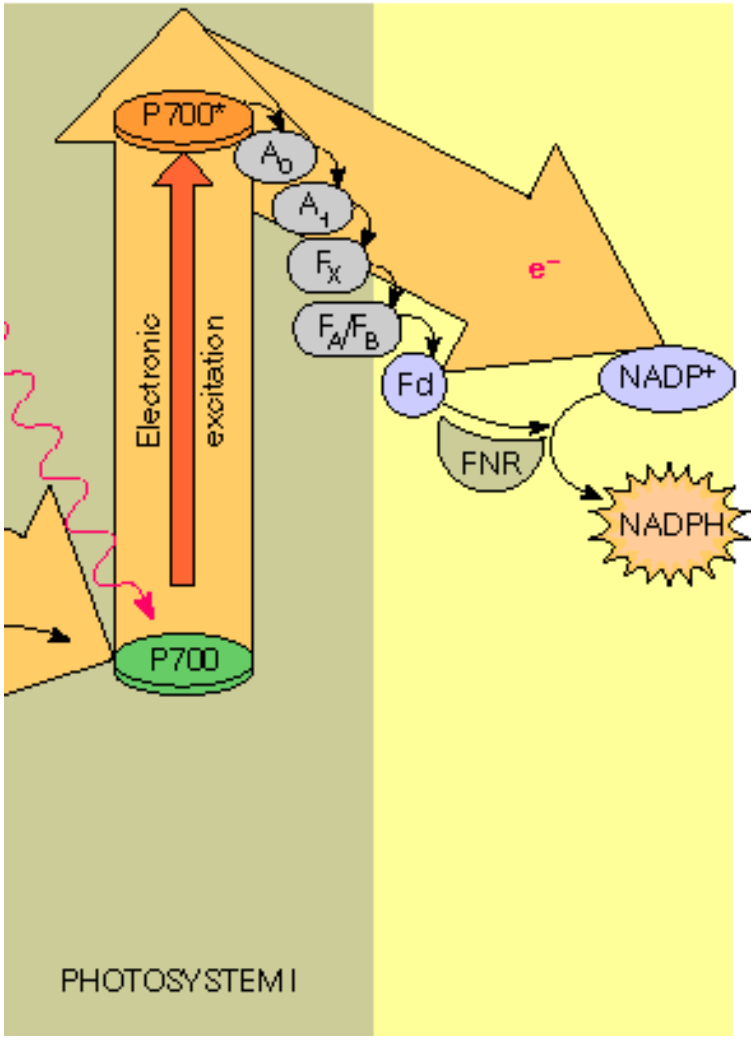
Manganese Center
M_4 O_8





Tryosine cycles between OH and O. free radical state

Mn oxidation states are poorly understood



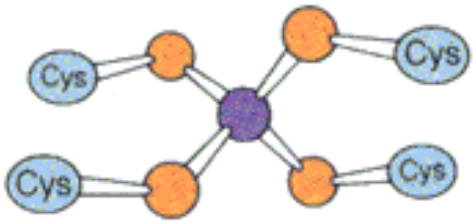
Photosystem I P700

Electron transport to

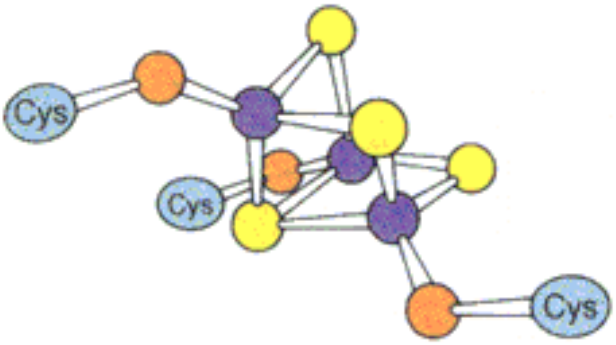
Chlorophyll
Quinones
Iron Sulfur Clusters
Ferrodoxin

Ferrodoxin NADP
Oxidoreductase

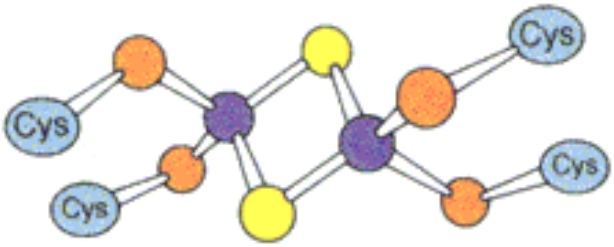
Protons are pumped
And NADPH is made.



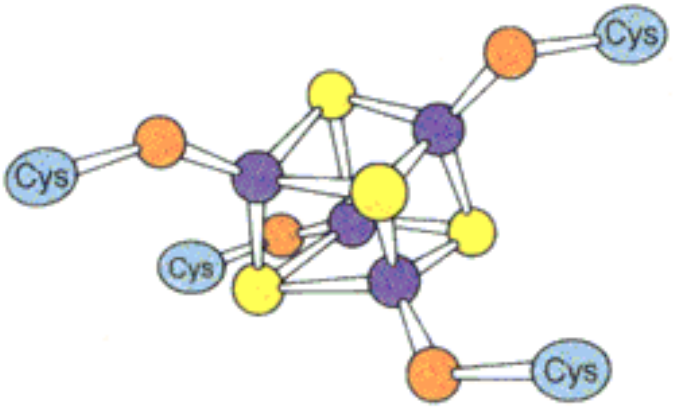
FeS



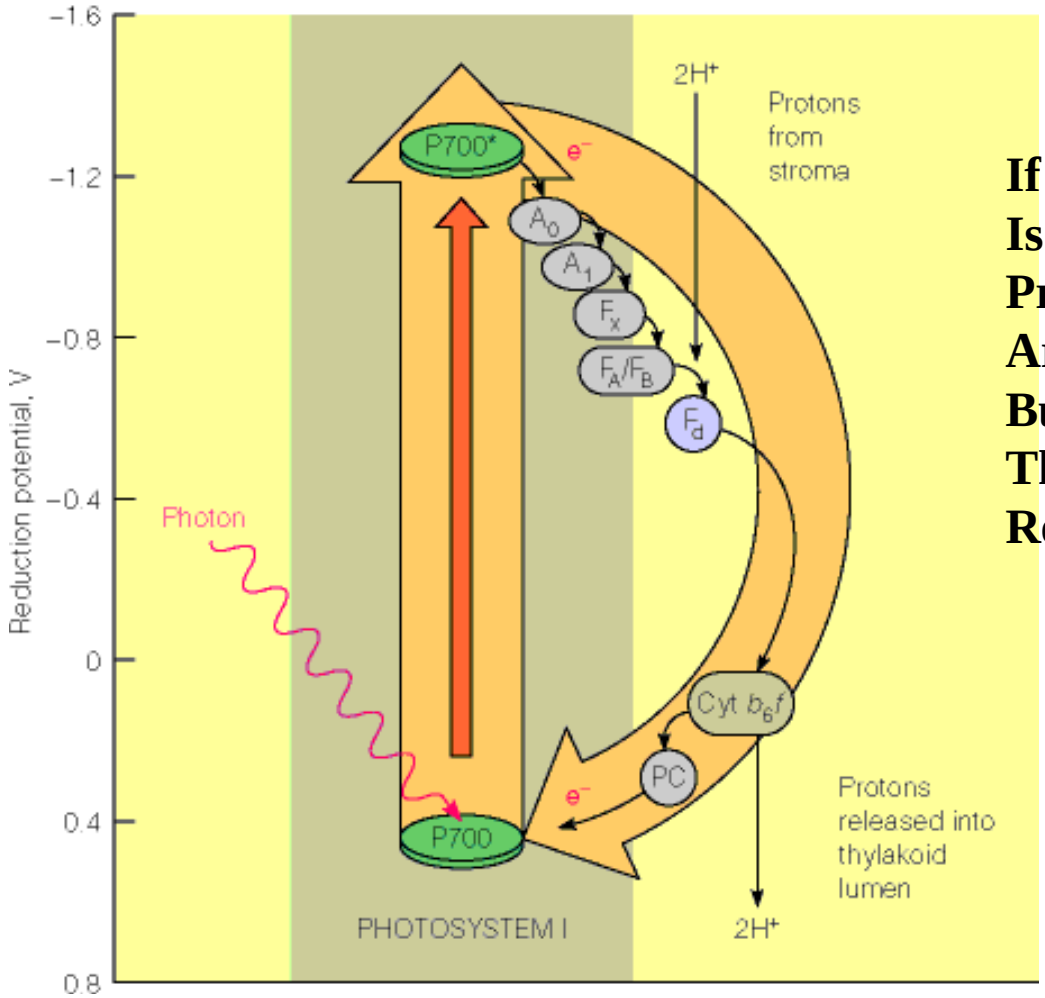
Fe_3S_4



Fe_2S_2

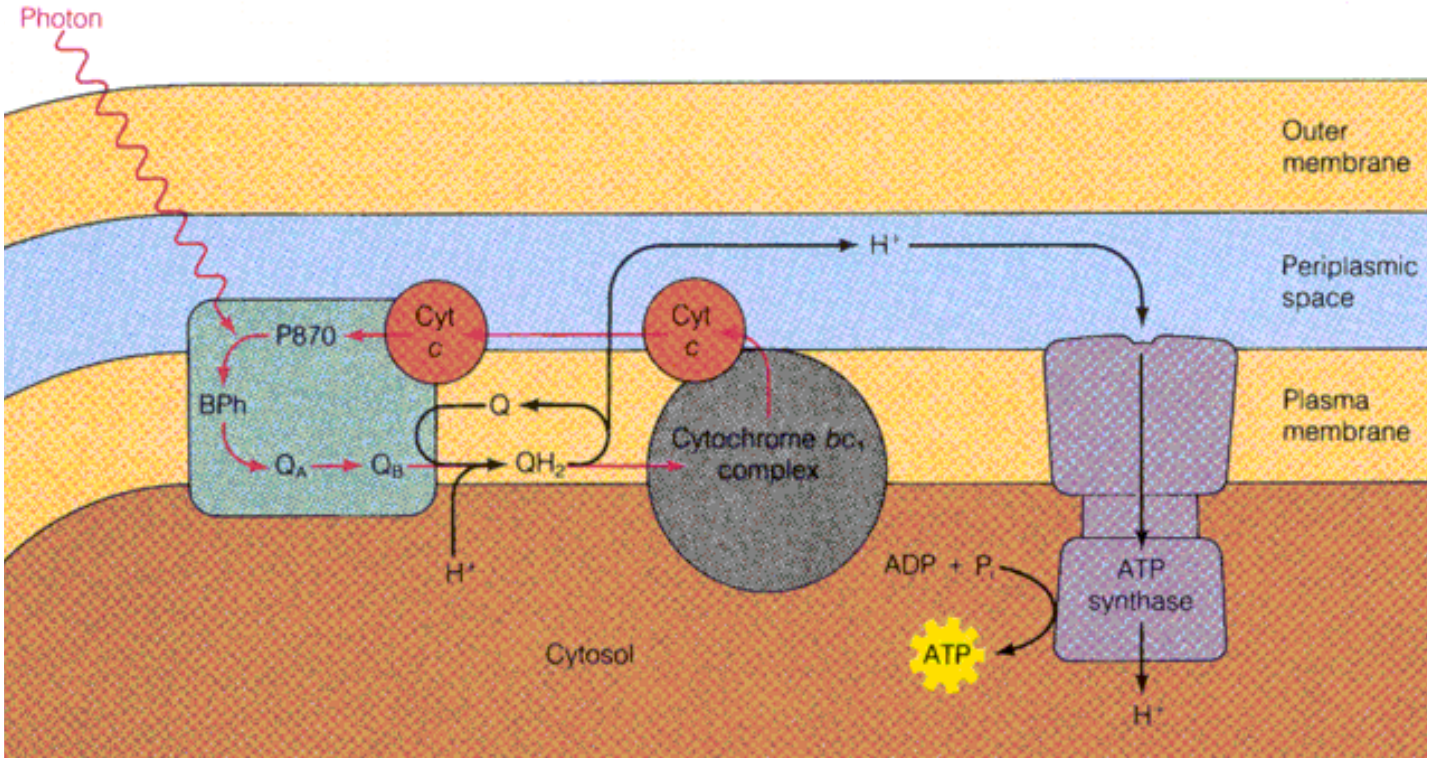


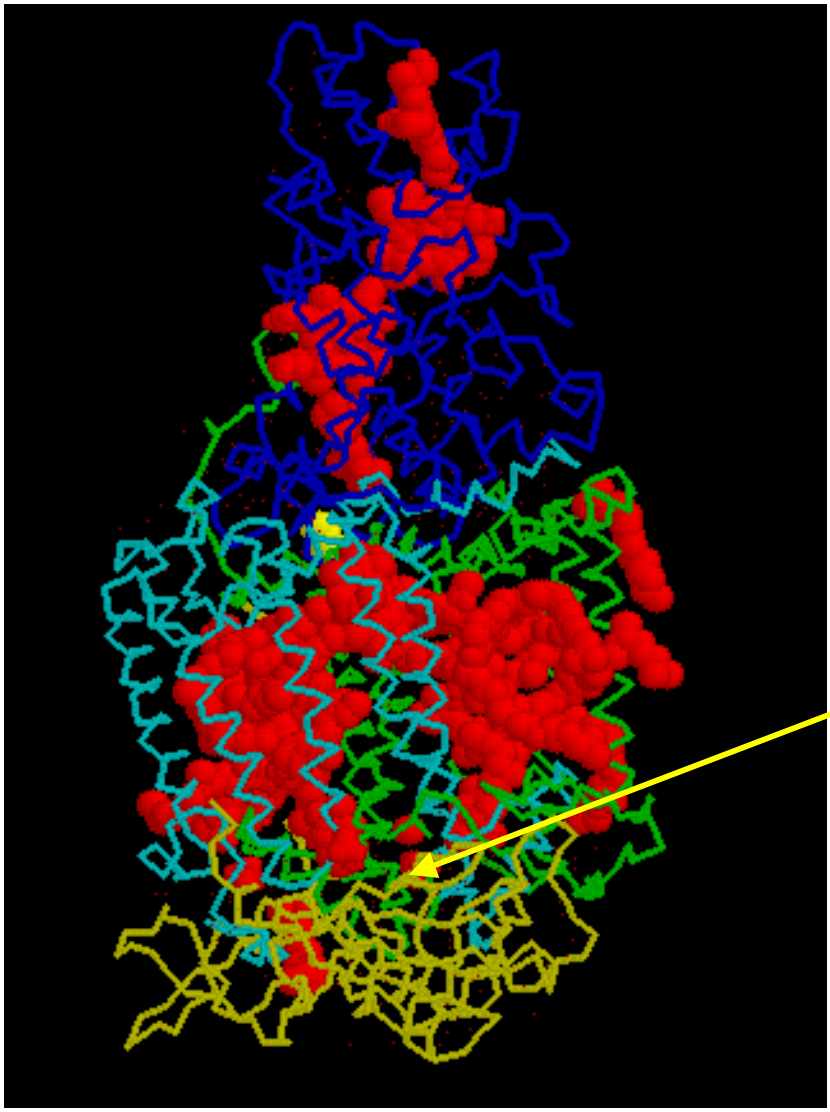
Fe_4S_4



If NADPH
Is not needed
Protons
Are pumpled
But
The electron
Returns to P700

Bacterial Photosynthesis





Bacterial Rxn Center

Top--cytochrome subunit (blue) (4 hemes)

Middle--membrane Embedded protein
4 chlorophylls,
2 phytins
2 quinones
1 Fe

Bottom--
subunit H (yellow)

Bacterial Rxn Center

(Rhodobacter viridis)

Structure by
Deisenhofer and Michel
Nobel Prize 1988

Photosynthesis vs Respiration

- Electron transport
- From high to low potential
- Via series of membrane protein/cofactors
- Some moblile e carriers (PC)
- Proton gradients
- Similar ATP synthases

- Respiration reduced high potential electron
- Photon excites electron to high energy
- Proton gradients are opposite direction

Practical Reasons to Study Photosynthesis

Artificial Photosynthesis
Solar Energy