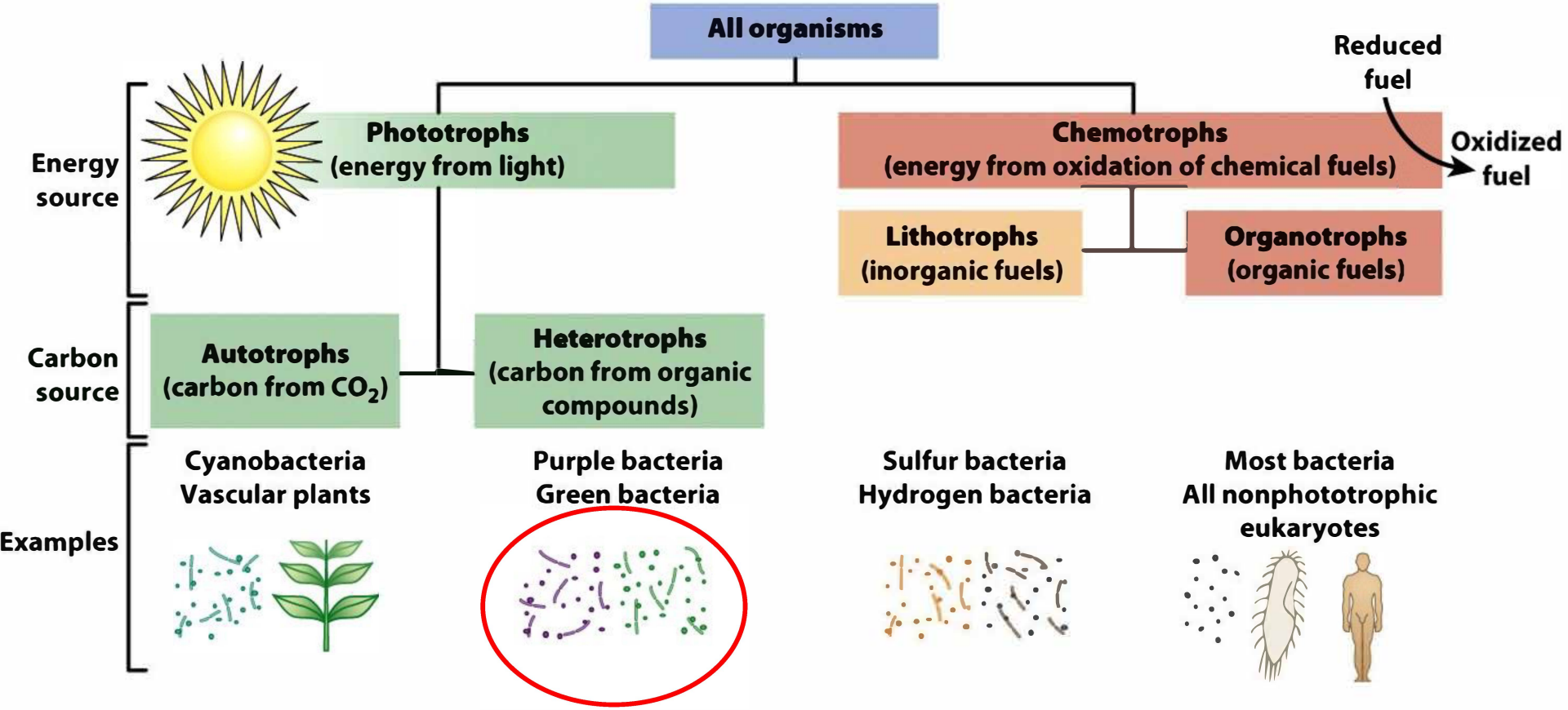
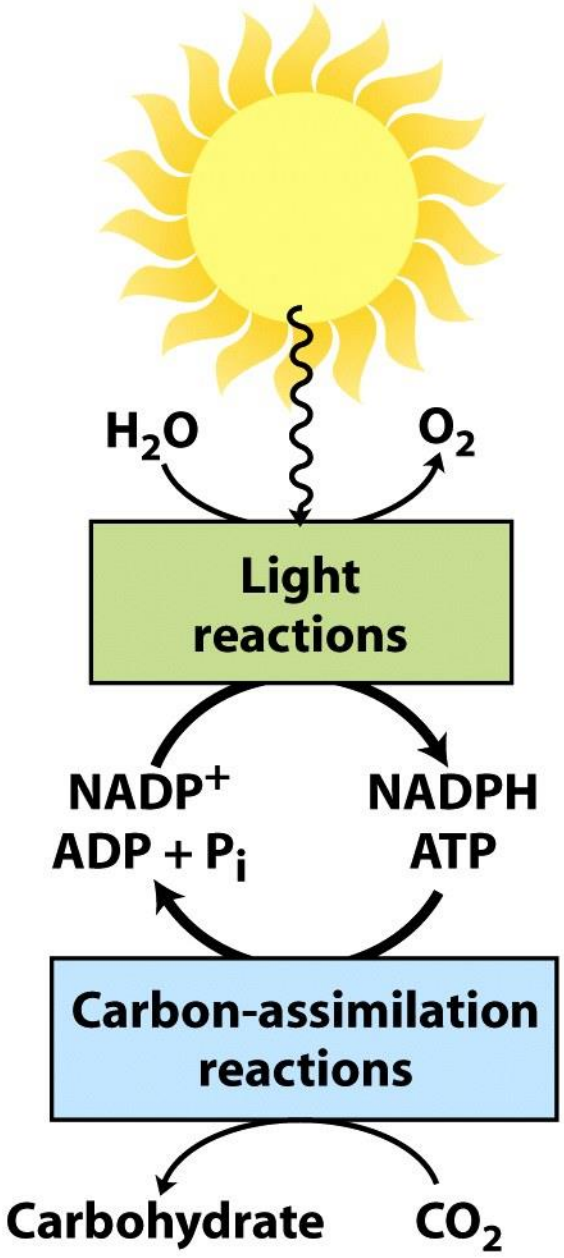
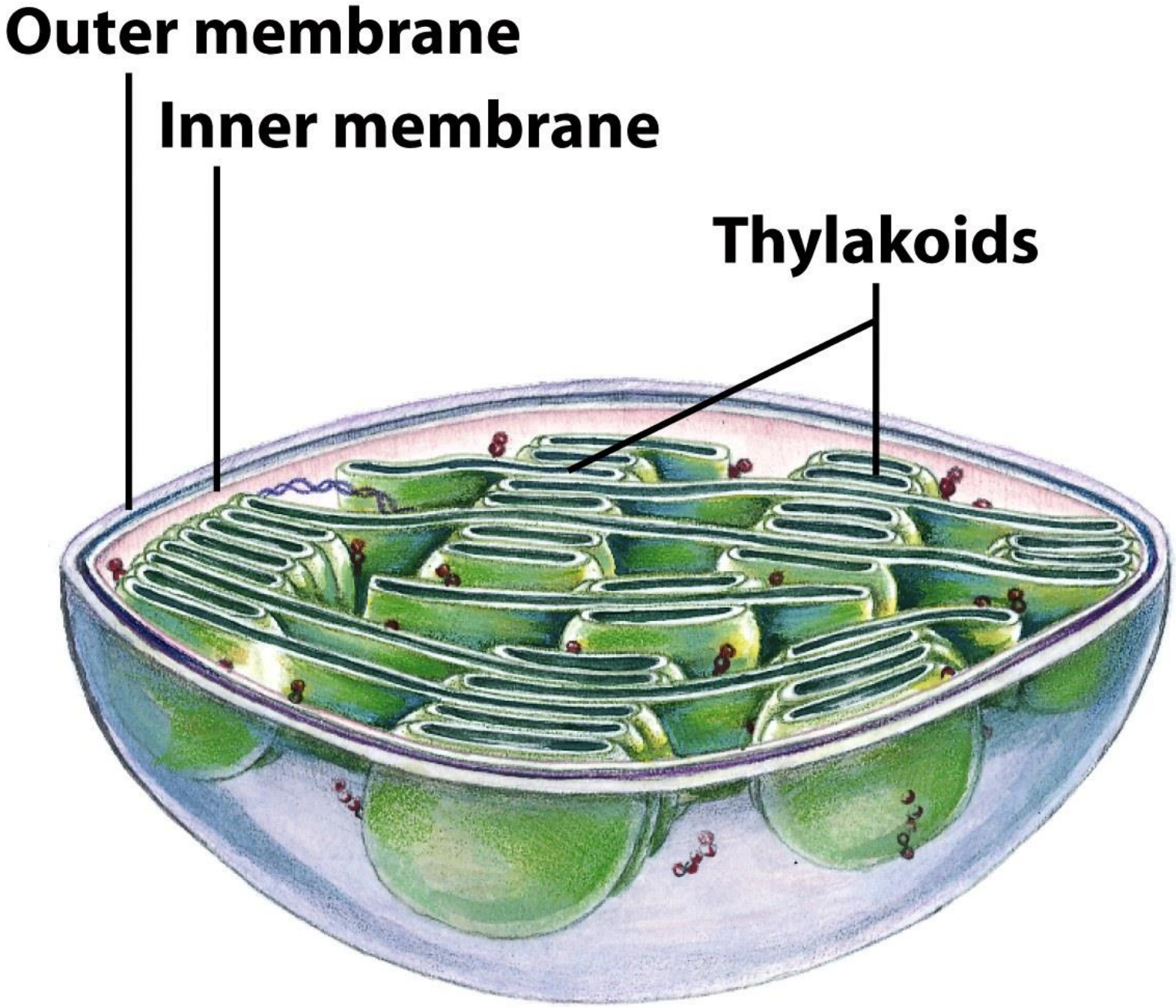
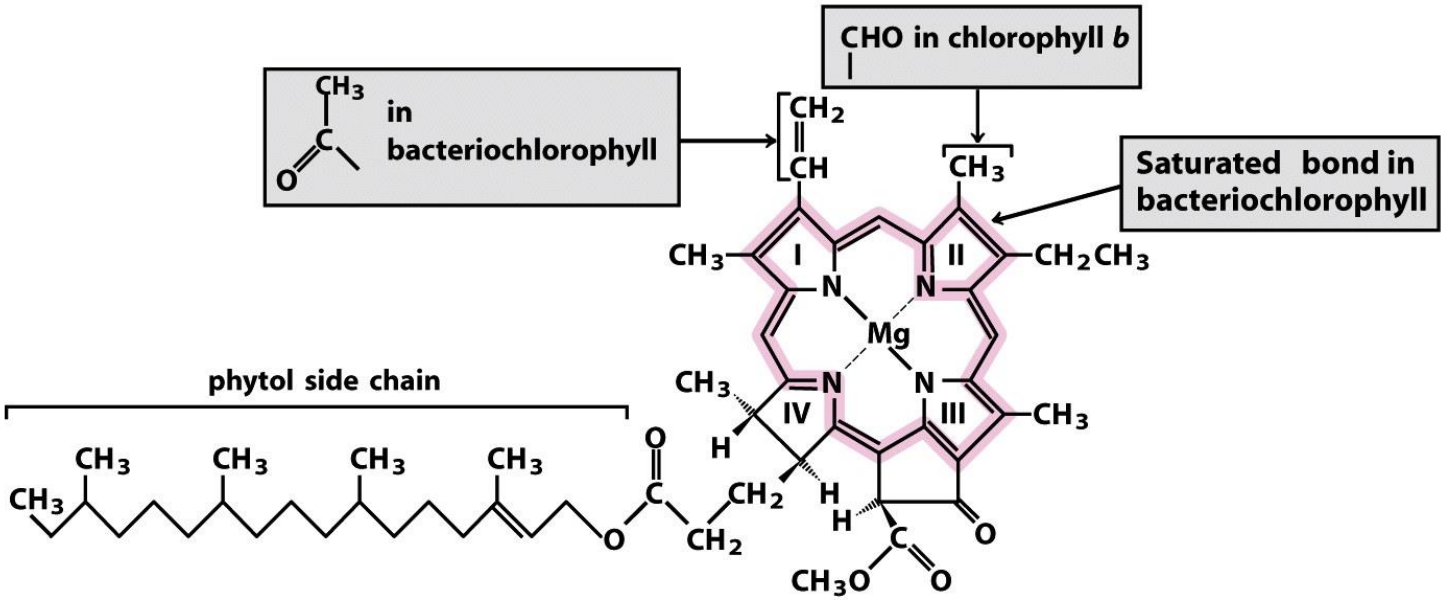
Photosynthesis (Part I)

slides are from Lehninger, 5th and 6th ed.

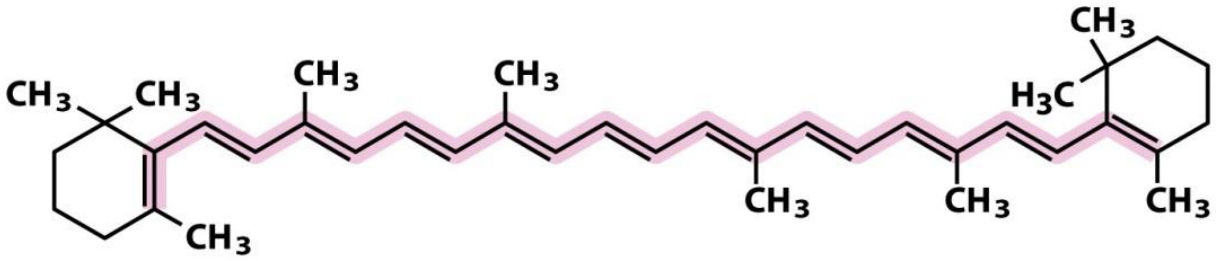

All organisms
Reduced fuel
Oxidized fuel
Energy source
Phototrophs (energy from light)
Chemotrophs (energy from oxidation of chemical fuels)
Lithotrophs (inorganic fuels)
Organotrophs (organic fuels)
Carbon source
Autotrophs (carbon from CO_2)
Heterotrophs (carbon from organic compounds)
Examples
Cyanobacteria
Vascular plants
Purple bacteria
Green bacteria
Sulfur bacteria
Hydrogen bacteria
Most bacteria
All nonphototrophic eukaryotes


H_2O
O_2
Light reactions
$NADP^+$
$ADP + P_i$
NADPH
ATP
Carbon-assimilation reactions
Carbohydrate
CO_2

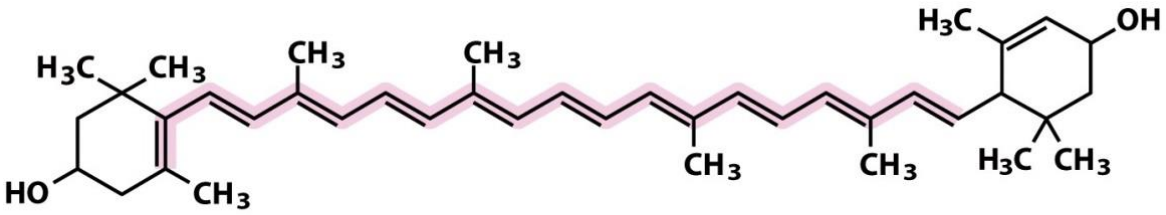

Outer membrane
Inner membrane
Thylakoids



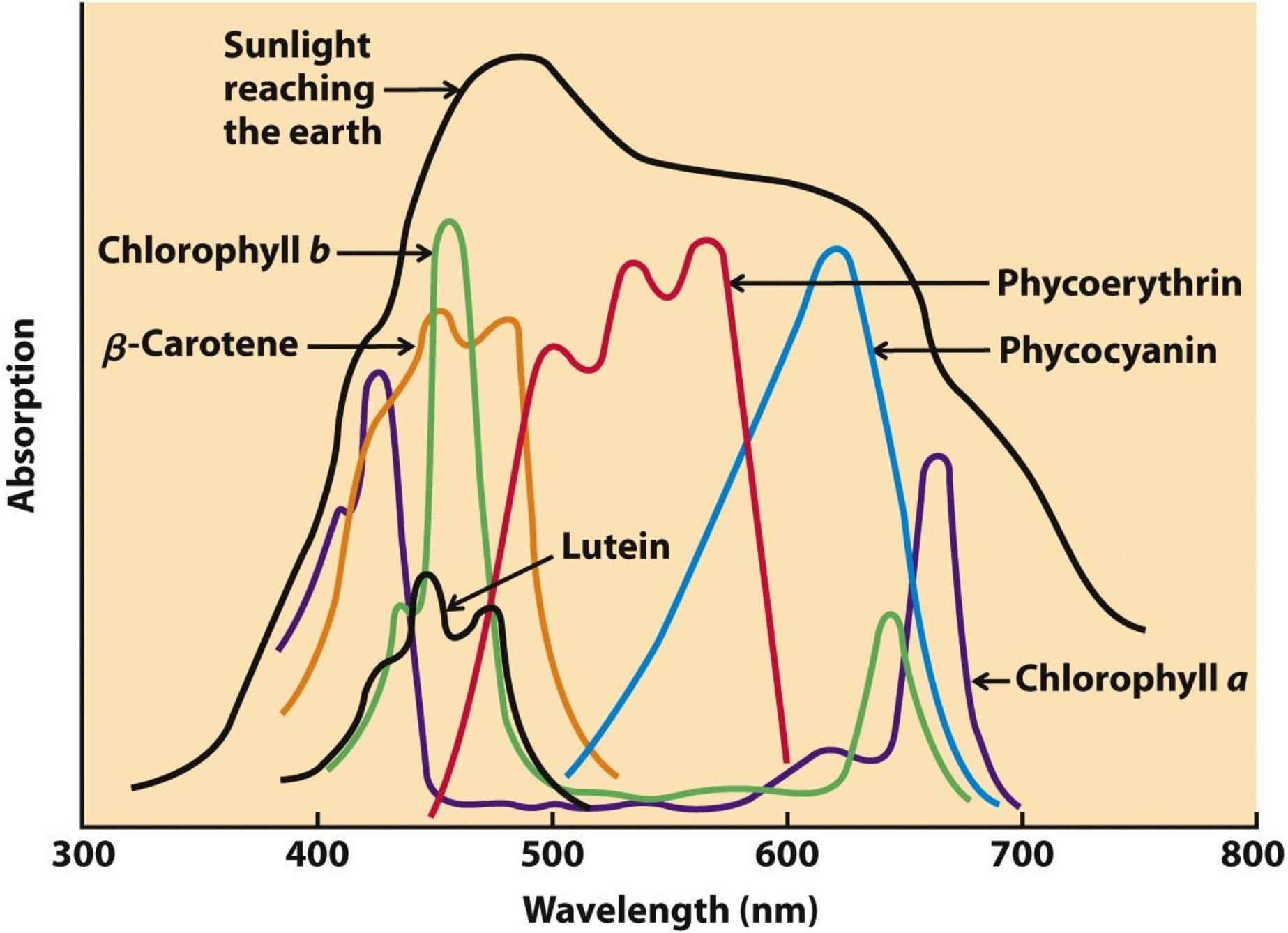
Chlorophyll *a*

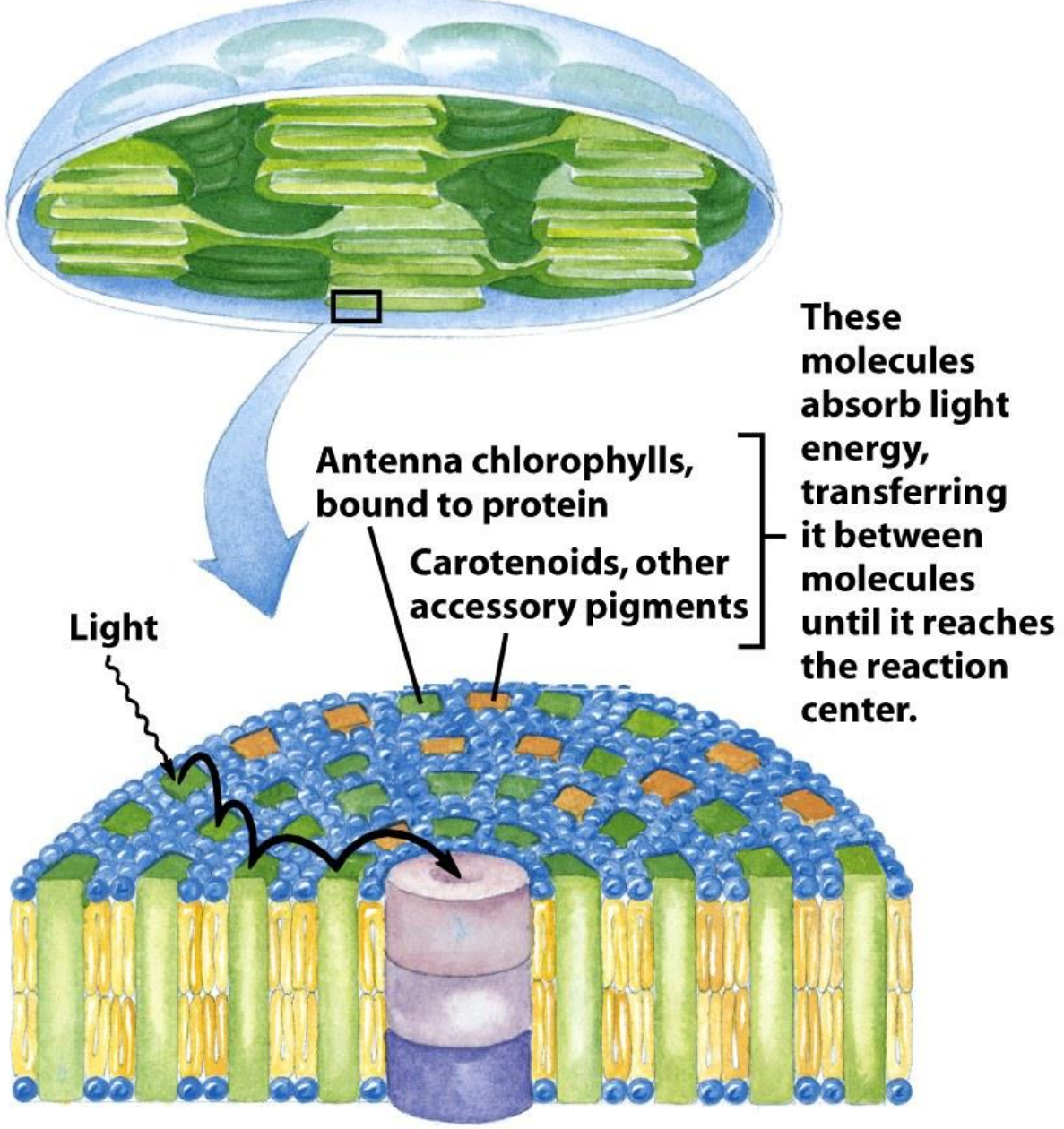


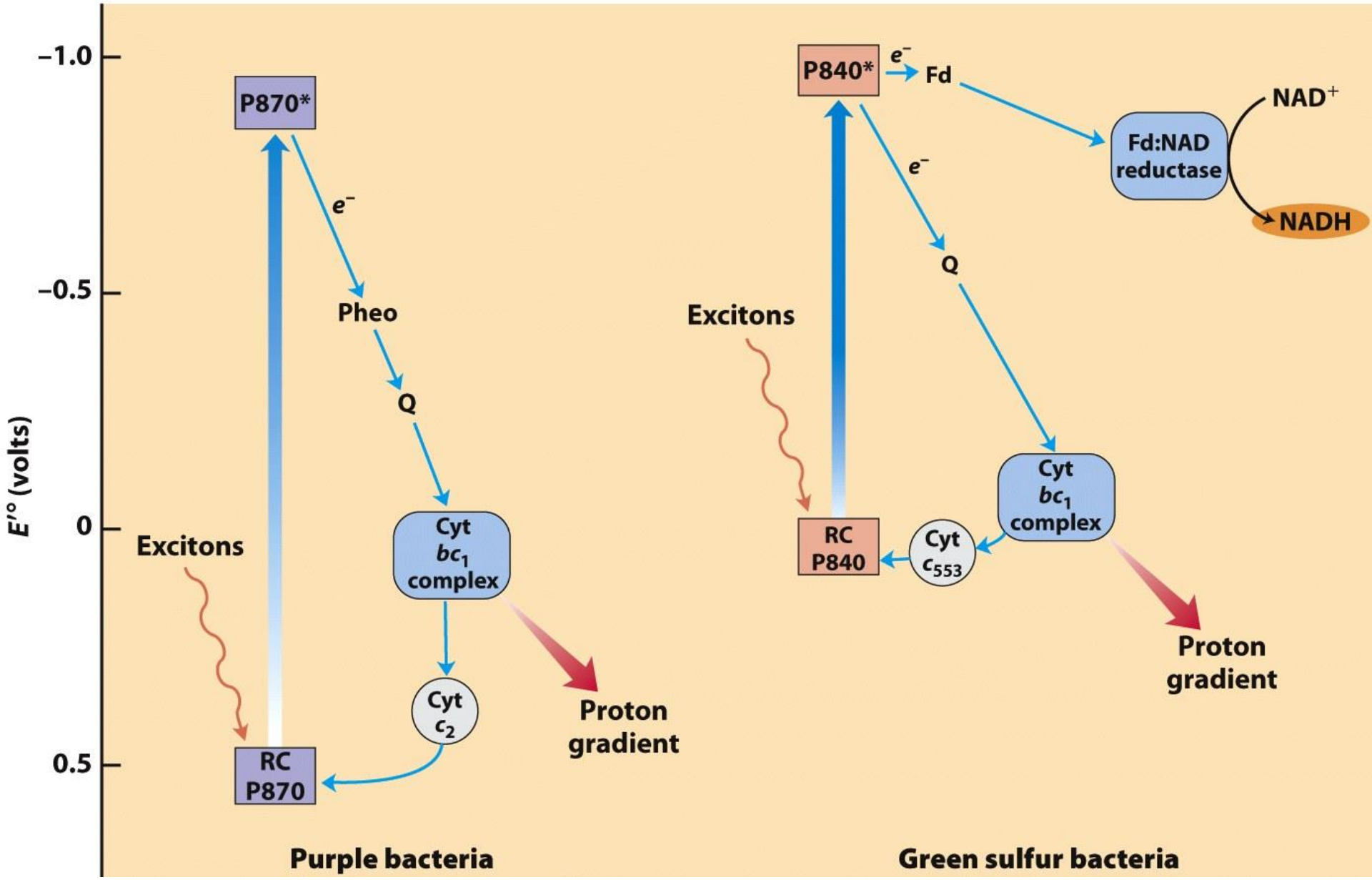
β-Carotene

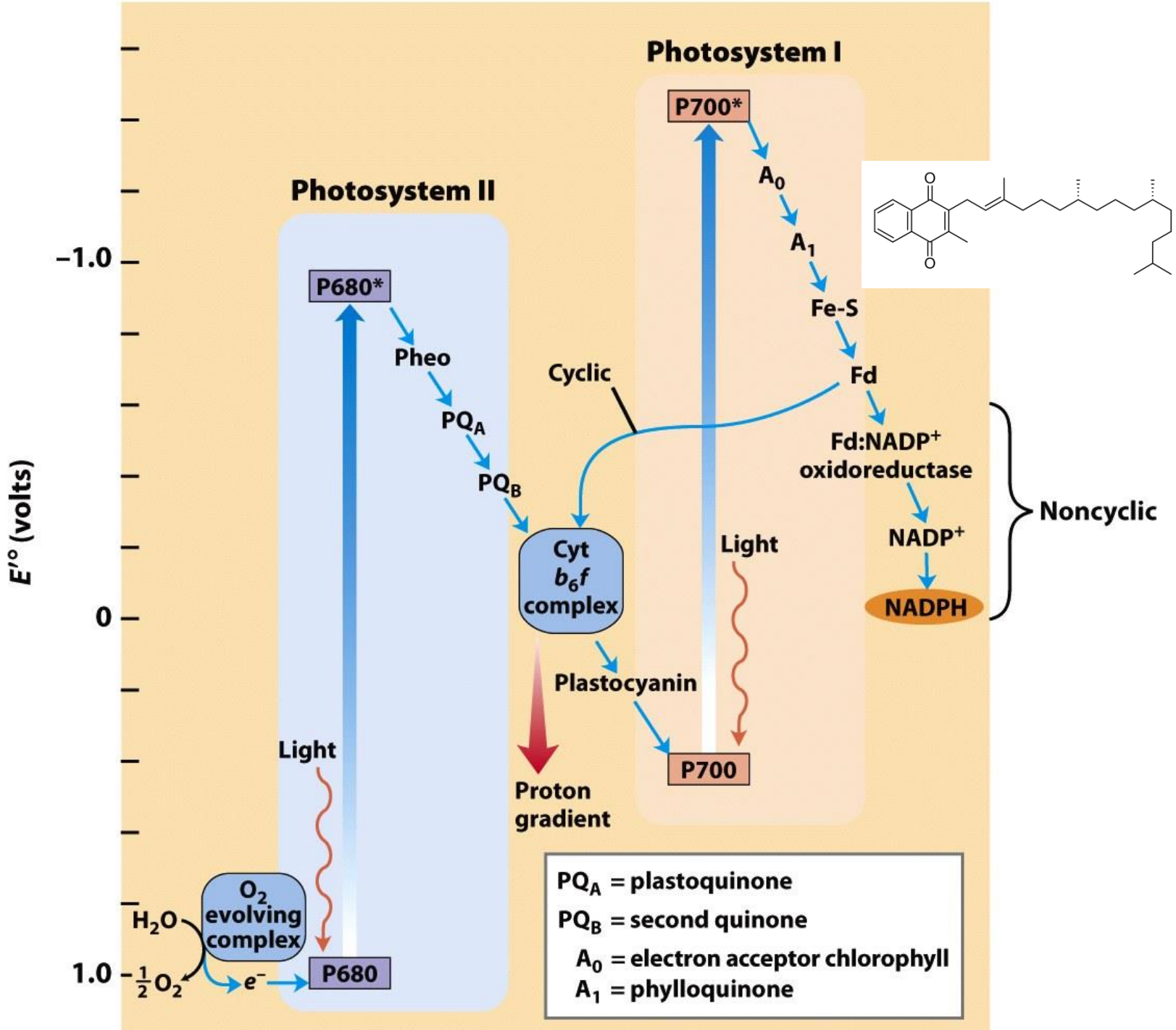


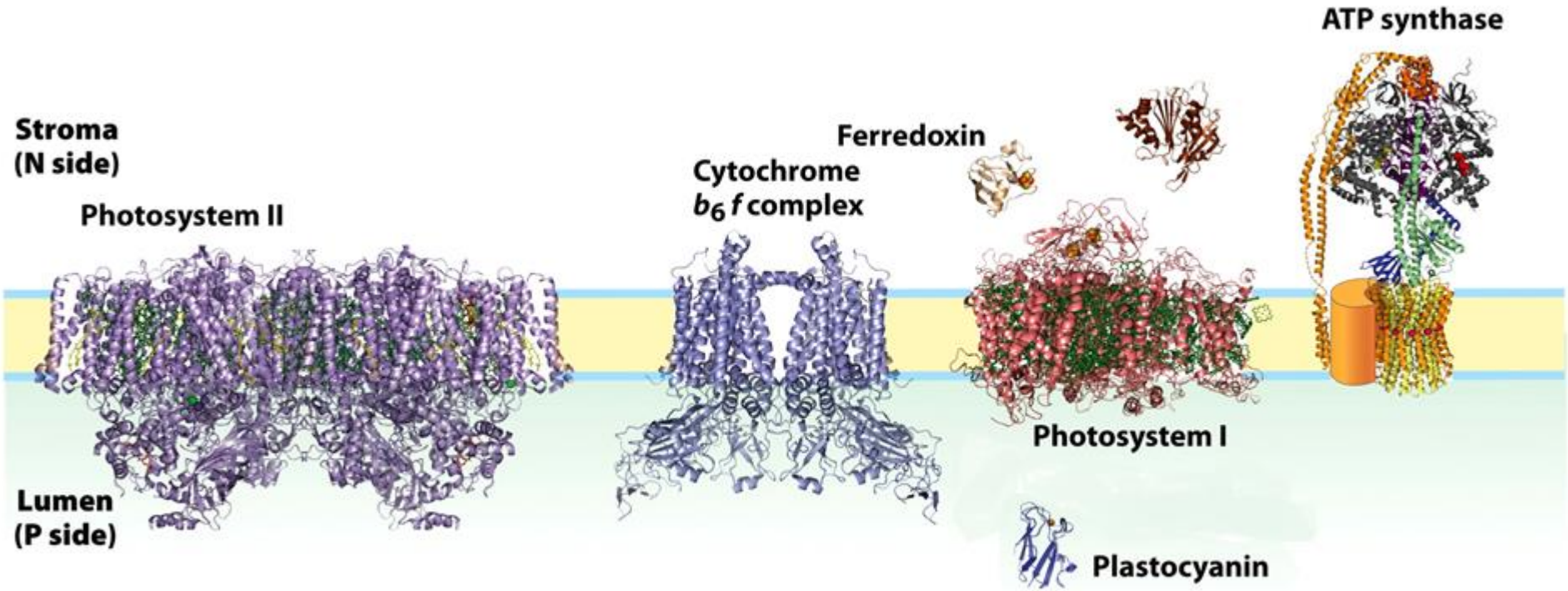
Lutein (xanthophyll)

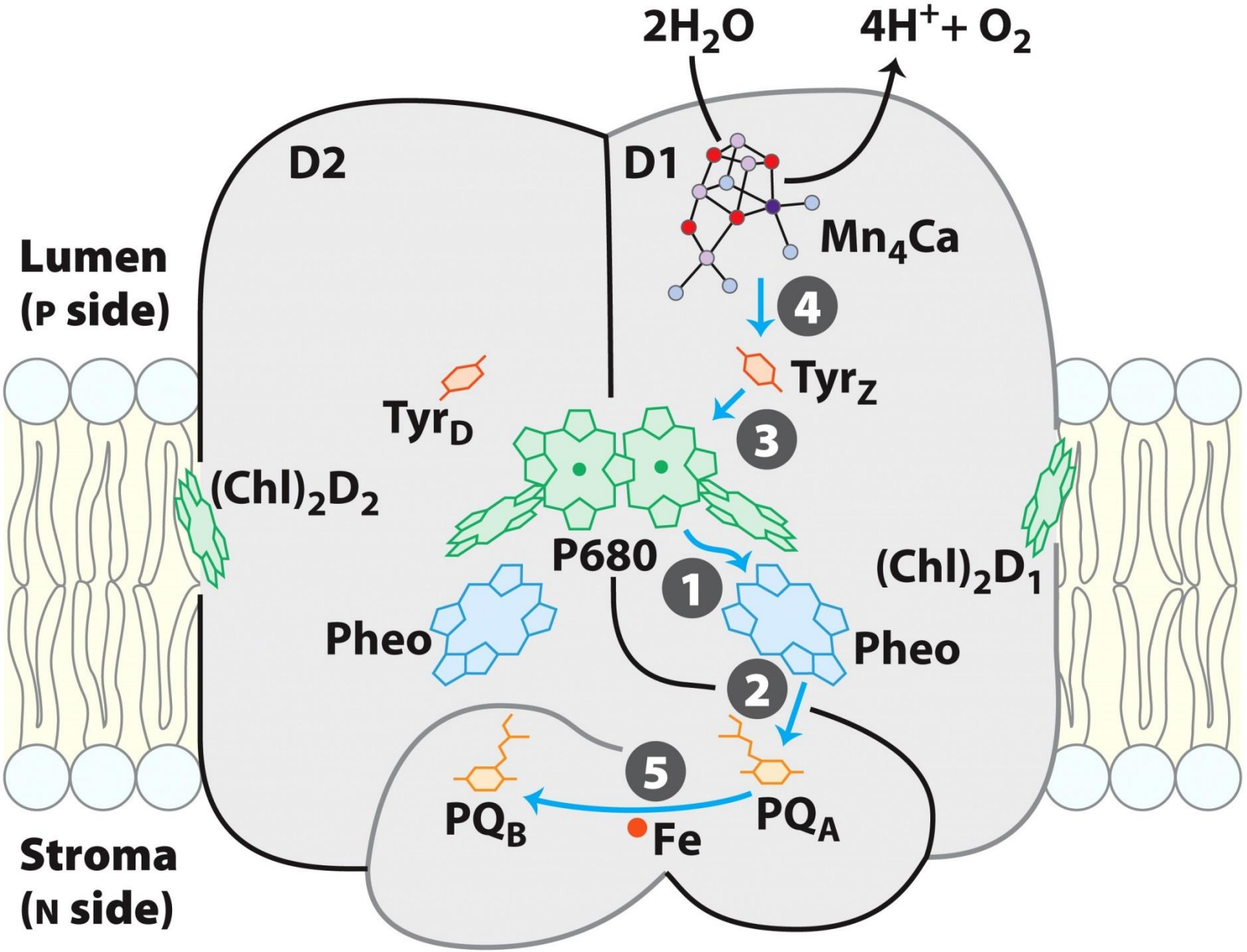

Sunlight reaching the earth
Chlorophyll b
β-Carotene
Phycoerythrin
Phycocyanin
Lutein
Chlorophyll a
Absorption
300
400
500
600
700
800
Wavelength (nm)

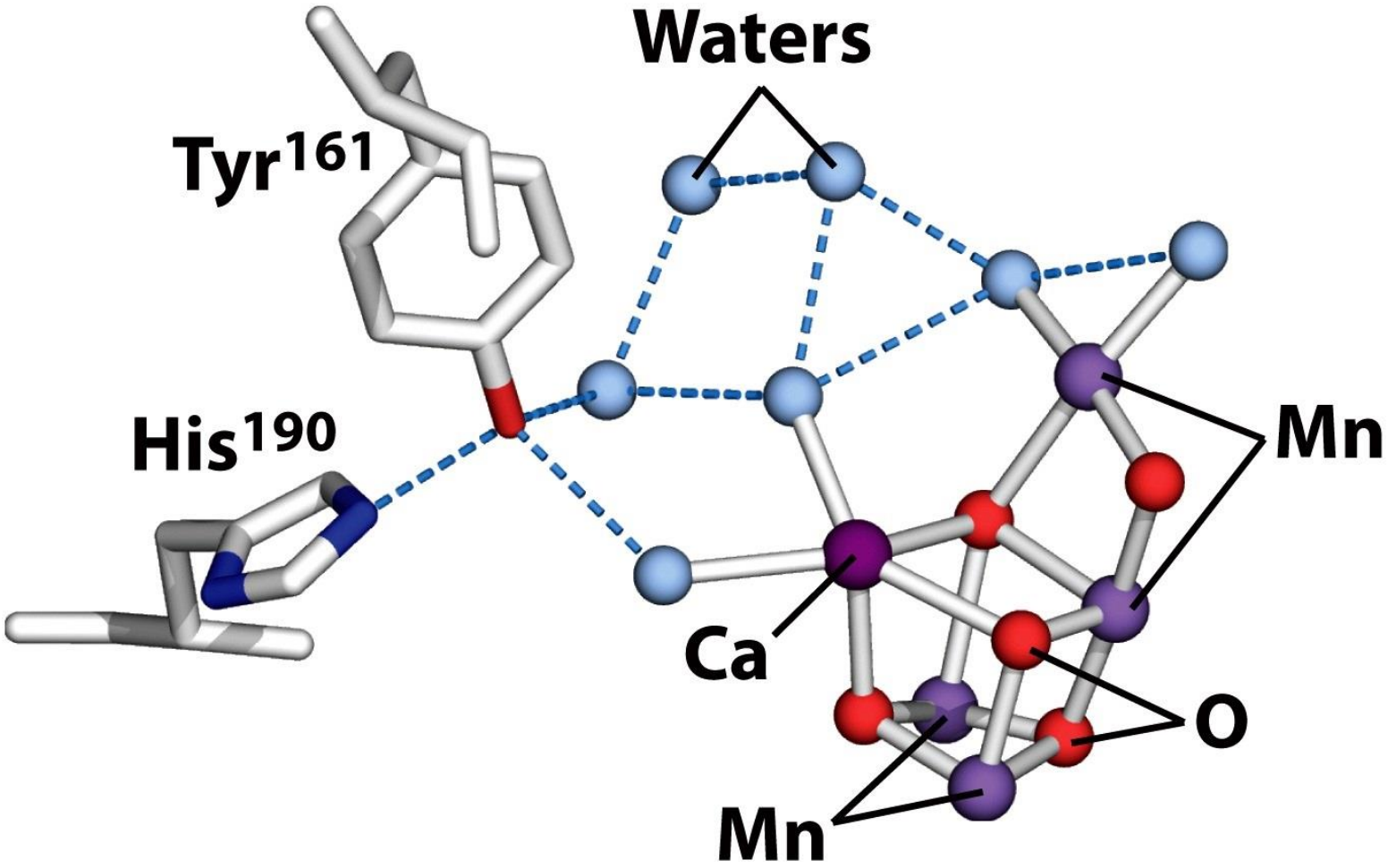

These molecules absorb light energy, transferring it between molecules until it reaches the reaction center.
Antenna chlorophylls, bound to protein
Carotenoids, other accessory pigments
Light
Reaction center
Photochemical reaction here converts the energy of a photon into a separation of charge, initiating electron flow.

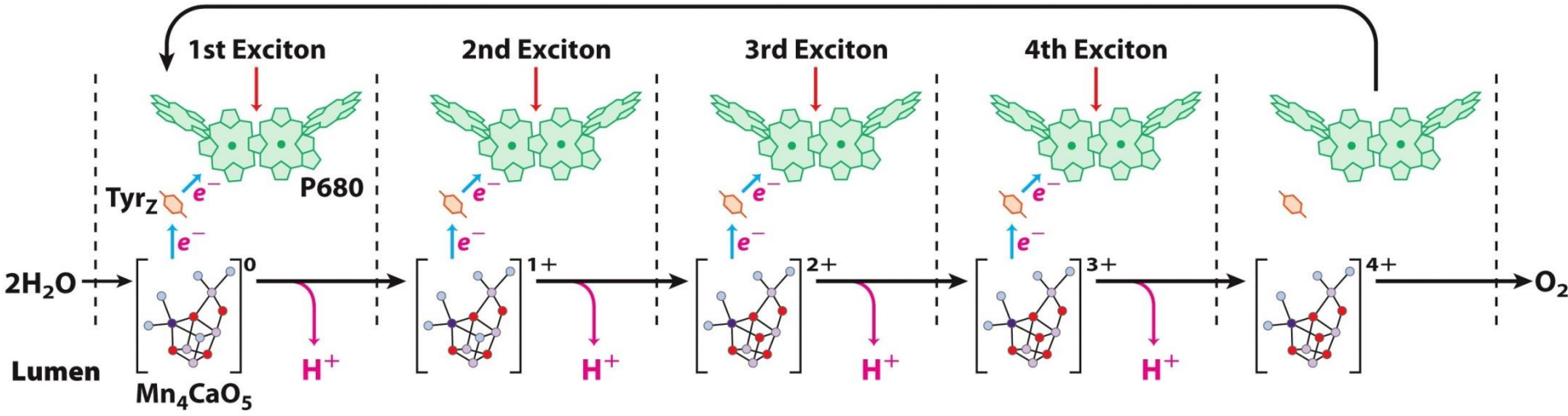

E'° (volts)
−1.0
−0.5
0
0.5
P870*
e⁻
Pheo
Q
Excitons
Cyt bc1 complex
Cyt c2
RC P870
Proton gradient
Purple bacteria
P840*
e⁻
Fd
Fd:NAD reductase
NAD+
NADH
e⁻
Q
Excitons
Cyt bc1 complex
RC P840
Cyt c553
Proton gradient
Green sulfur bacteria


Photosystem I
Photosystem II
P700*
A0
A1
Fe-S
Fd
Fd:NADP+ oxidoreductase
NADP+
NADPH
Noncyclic
Cyclic
Light
P700
Plastocyanin
Cyt b6f complex
Proton gradient
P680*
Pheo
PQA
PQB
Light
O2 evolving complex
H2O
½ O2
e−
P680
E'° (volts)
−1.0
0
1.0
PQA = plastoquinone
PQB = second quinone
A0 = electron acceptor chlorophyll
A1 = phylloquinone


ATP synthase
Stroma
(N side)
Ferredoxin
Cytochrome
$b_6 f$ complex
Photosystem II
Photosystem I
Lumen
(P side)
Plastocyanin

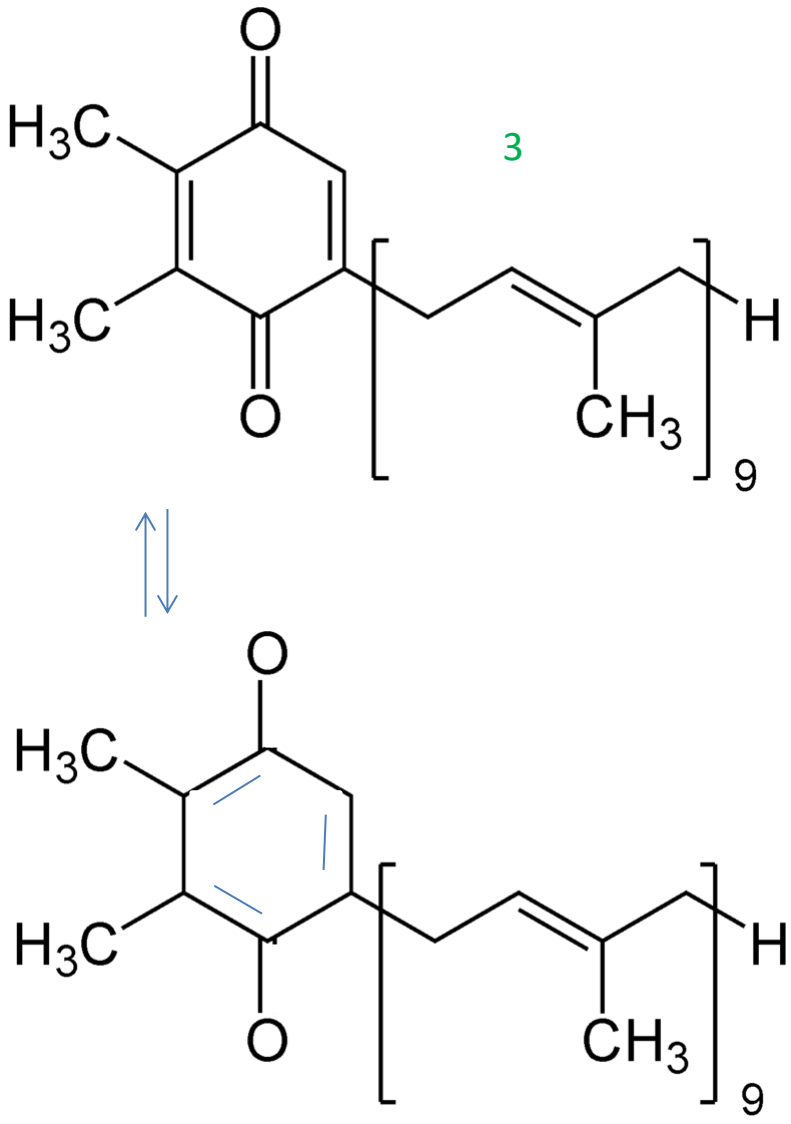

2H2O
4H+ + O2
D2
D1
Mn4Ca
Lumen
(P side)
4
TyrZ
TyrD
3
(Chl)2D2
P680
1
(Chl)2D1
Pheo
Pheo
2
5
PQB
Fe
PQA
Stroma
(N side)

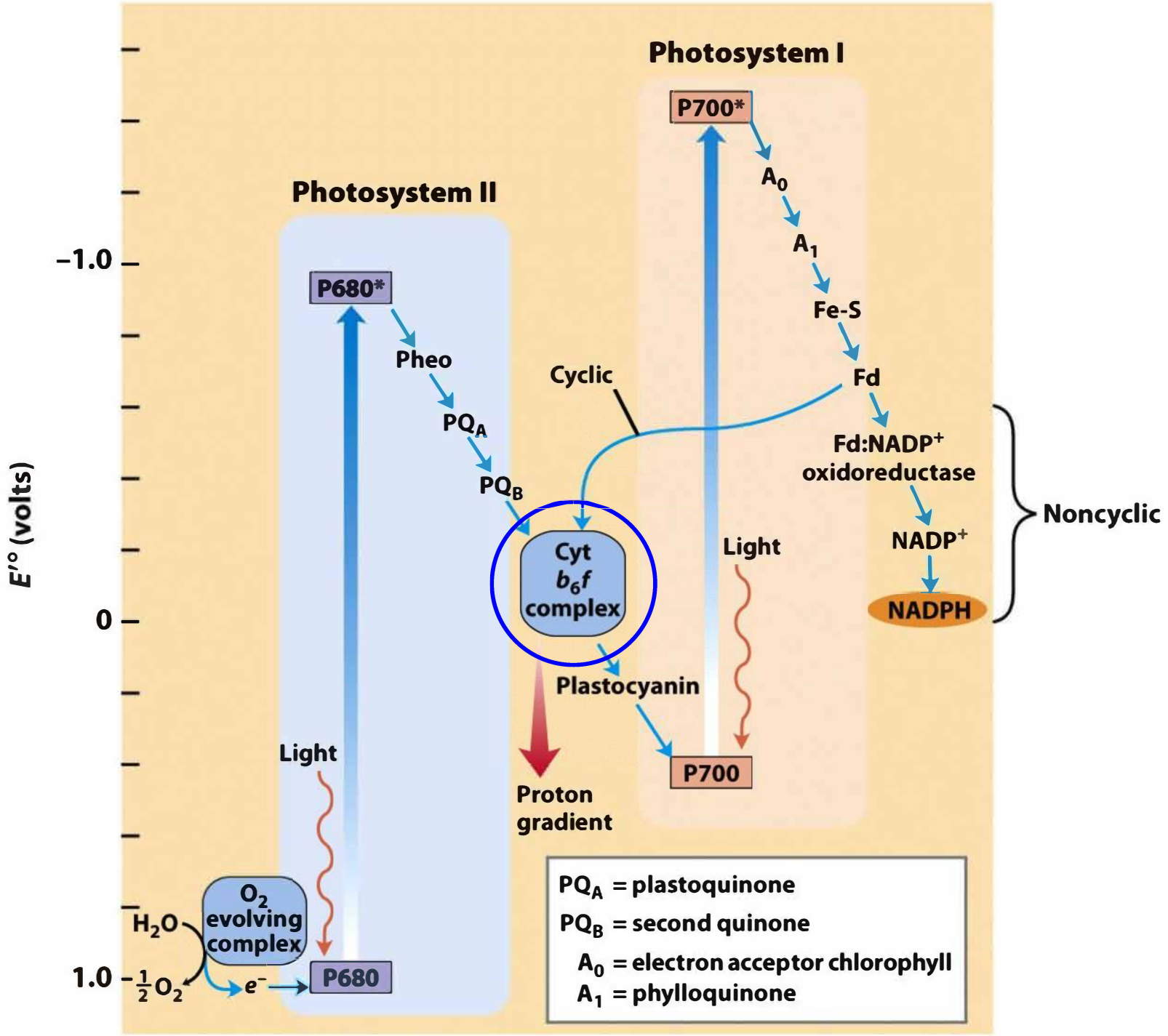

Waters
Tyr161
His190
Mn
Ca
O
Mn

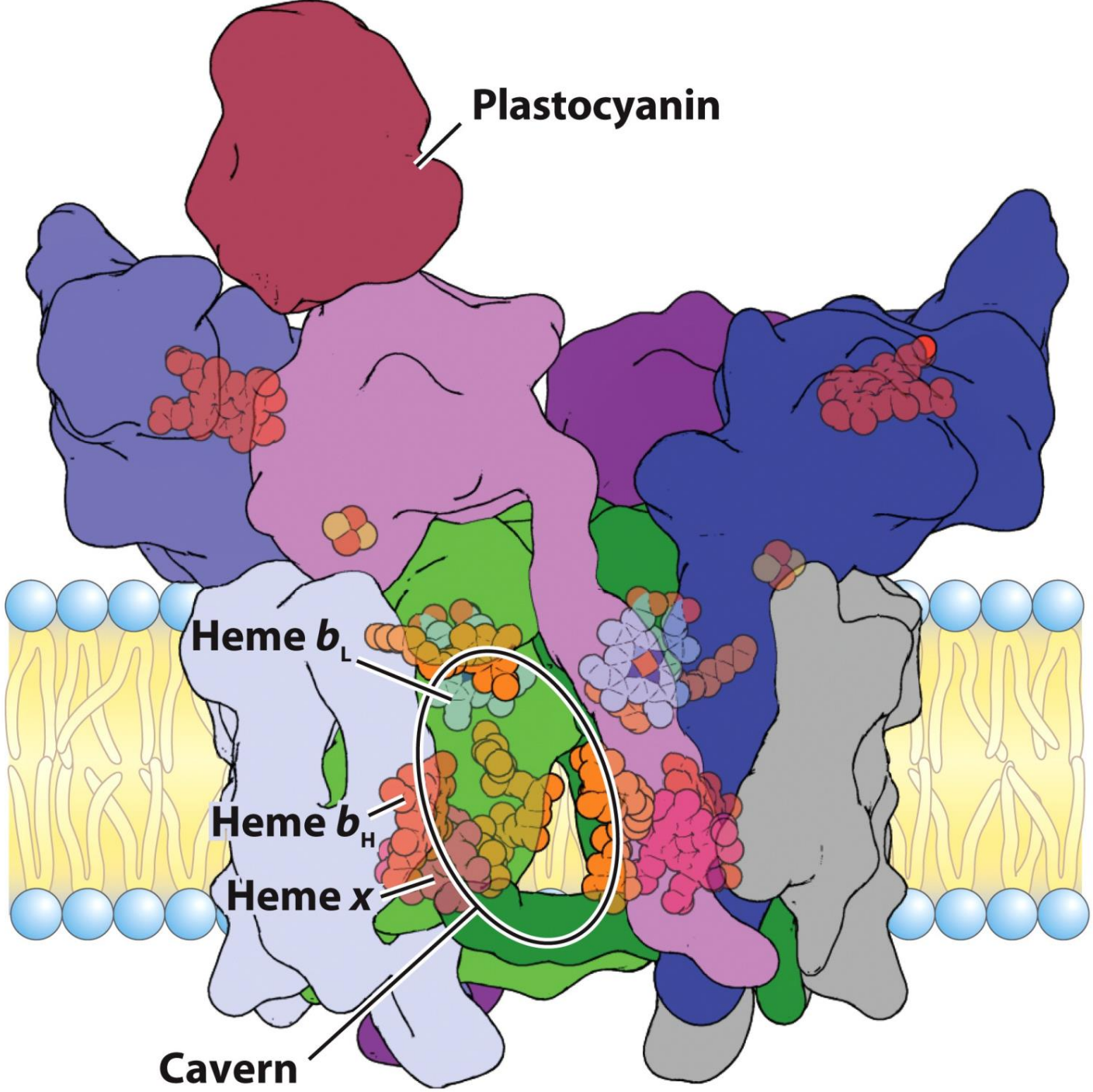


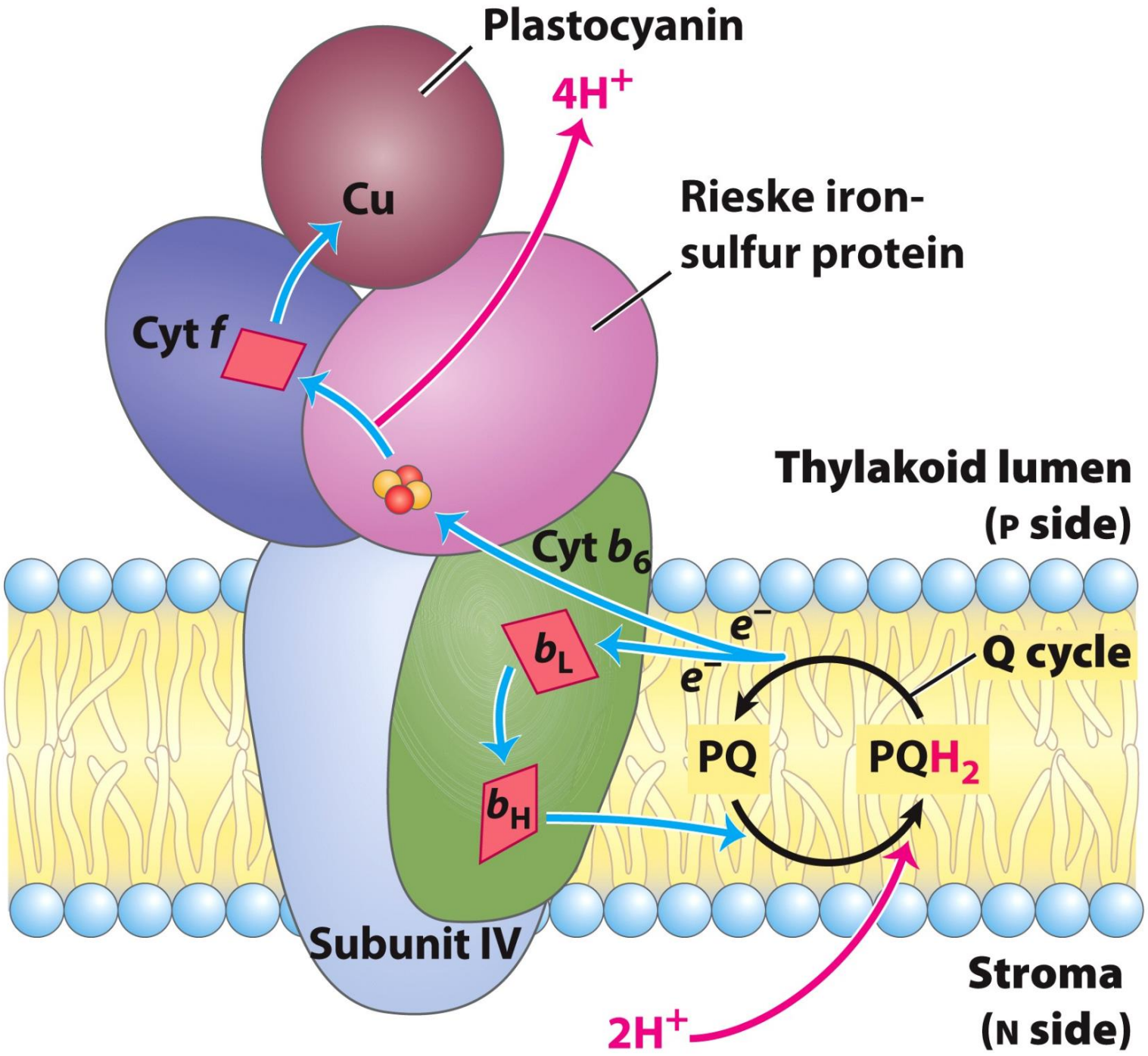
Note that absorbance of light at the P680 reaction center not only sent an electron to pheophytin, but also created a strong oxidant in the chlorophyll dimer of P680 ($P680^+$). This strong oxidant takes an e^- from Tyr_z which then takes one from the Mn_4 complex. Eventually, the Mn_4^{+4} complex takes electrons from water. How the Mn complex does this is unknown.

Plastoquinone (PQ)




Photosystem I
Photosystem II
P700*
A0
A1
Fe-S
Fd
Fd:NADP+ oxidoreductase
NADP+
NADPH
Noncyclic
Cyclic
P680*
Pheo
PQA
PQB
Cyt b6f complex
Plastocyanin
P700
Light
Light
Proton gradient
O2 evolving complex
H2O
½O2
e−
P680
E'° (volts)
−1.0
0
1.0
PQA = plastoquinone
PQB = second quinone
A0 = electron acceptor chlorophyll
A1 = phylloquinone


Plastocyanin
Heme b_L
Heme b_H
Heme x
Cavern


Plastocyanin
4H+
Cu
Rieske iron-sulfur protein
Cyt f
Thylakoid lumen (P side)
Cyt b6
e−
e−
bL
Q cycle
PQ
PQH2
bH
Subunit IV
Stroma (N side)
2H+