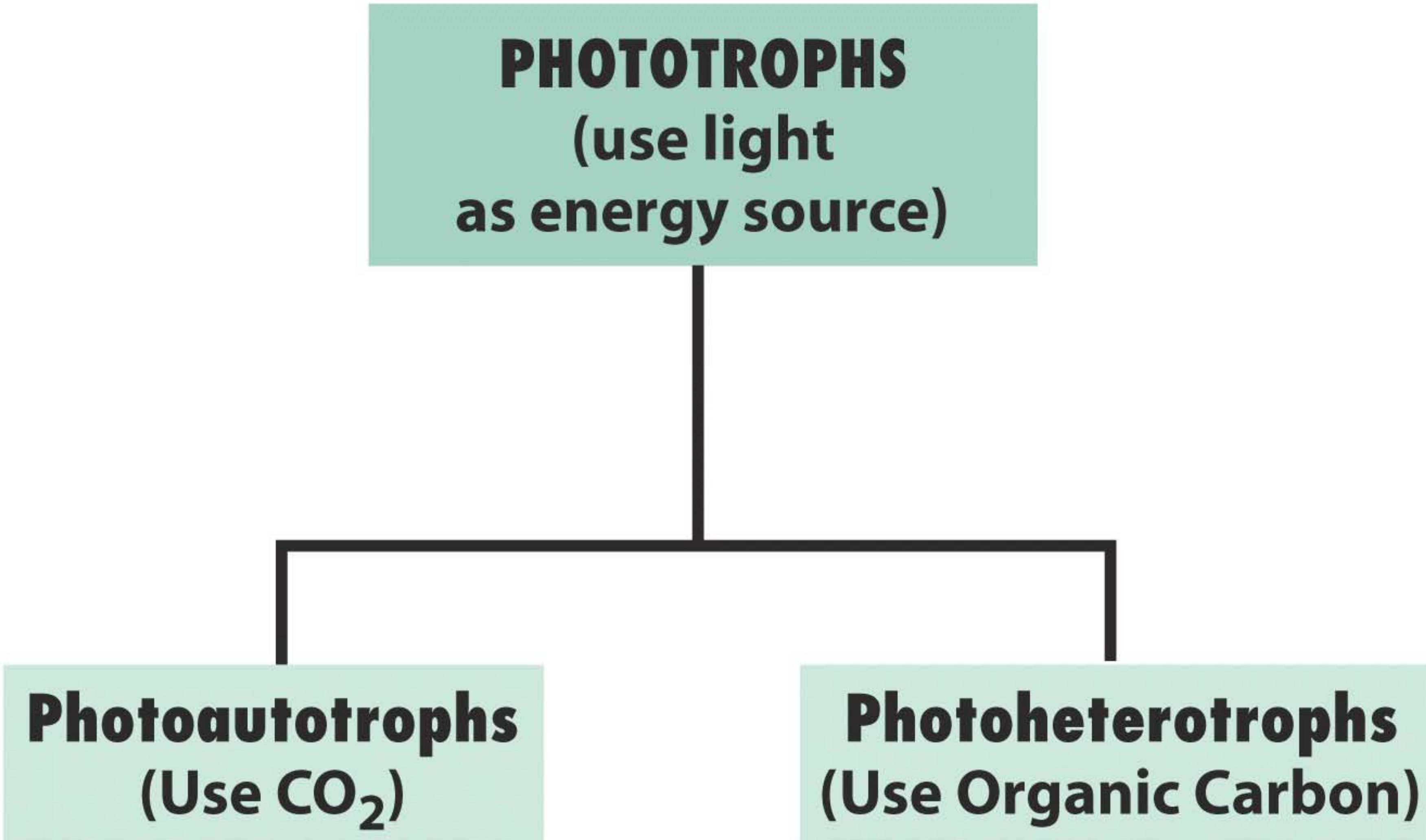
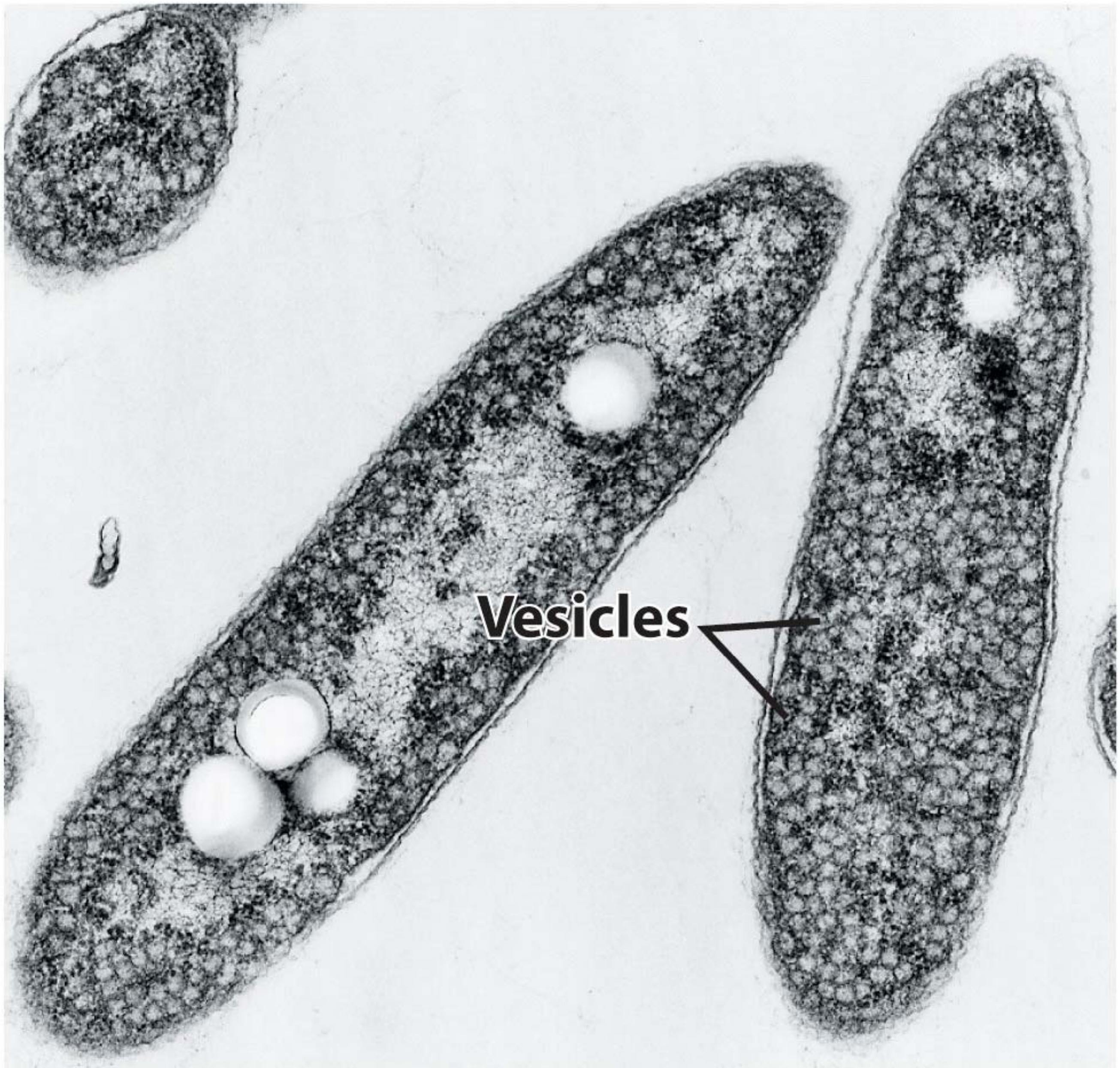
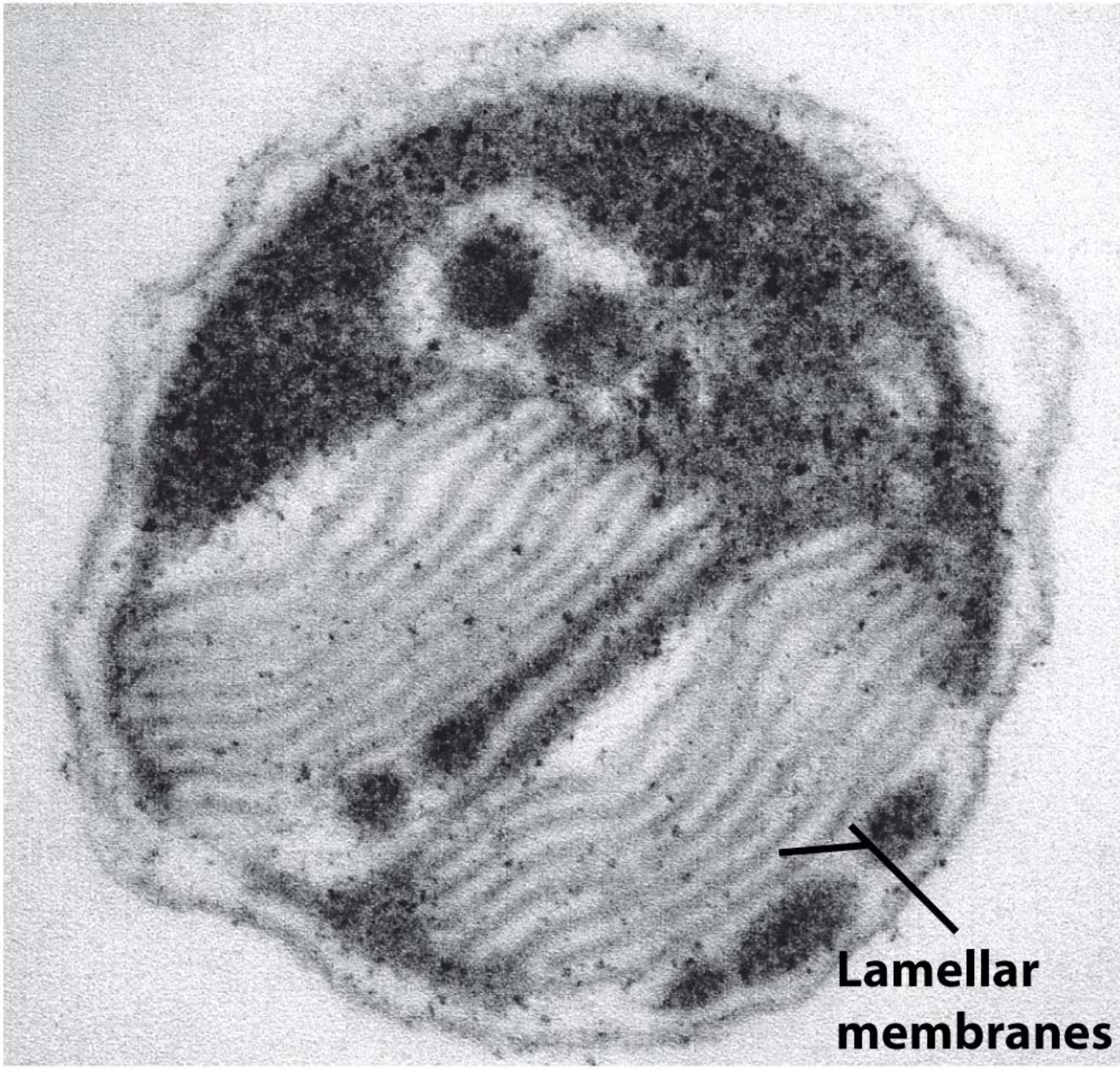
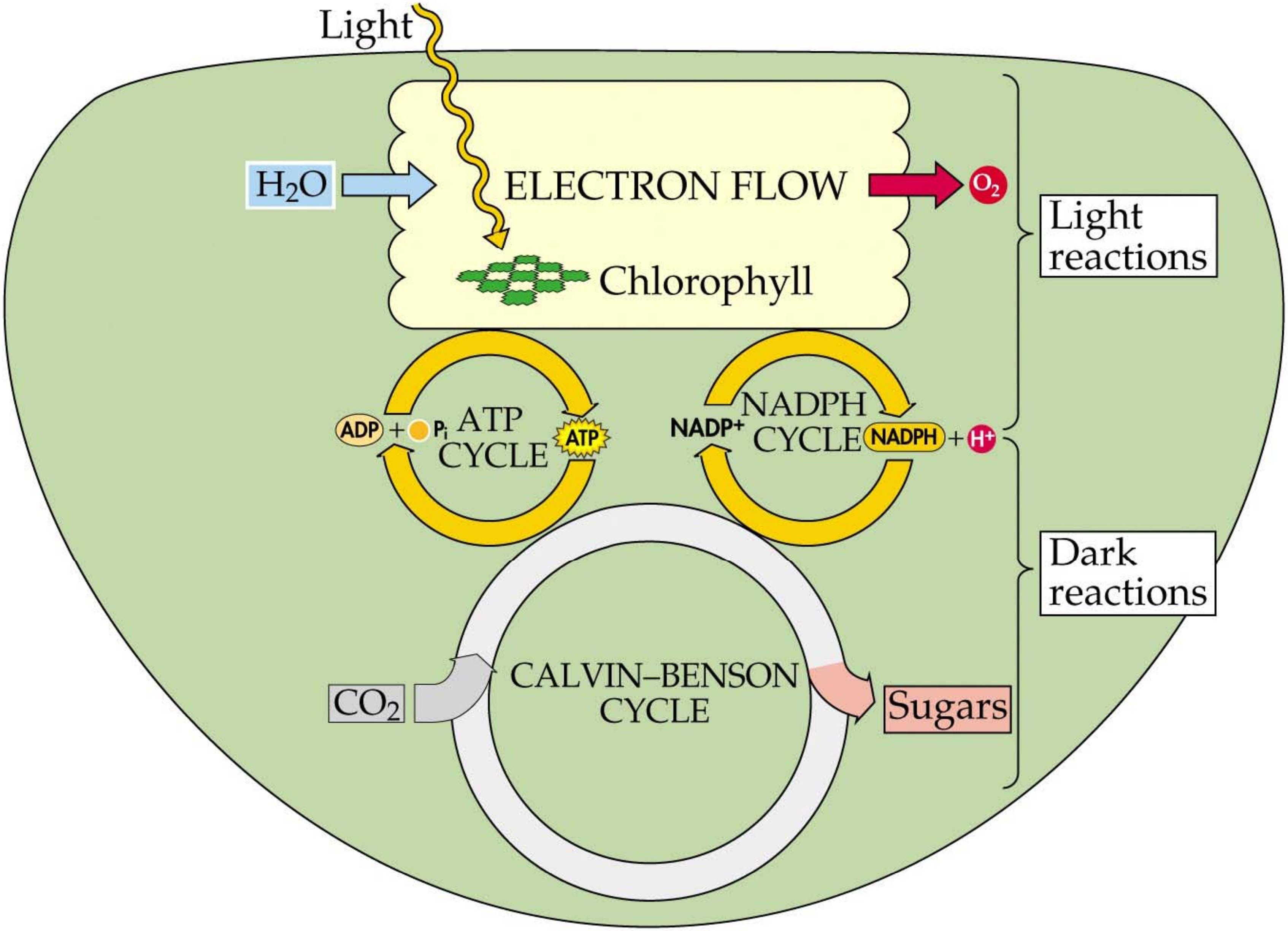
More on Phototrophic Potential

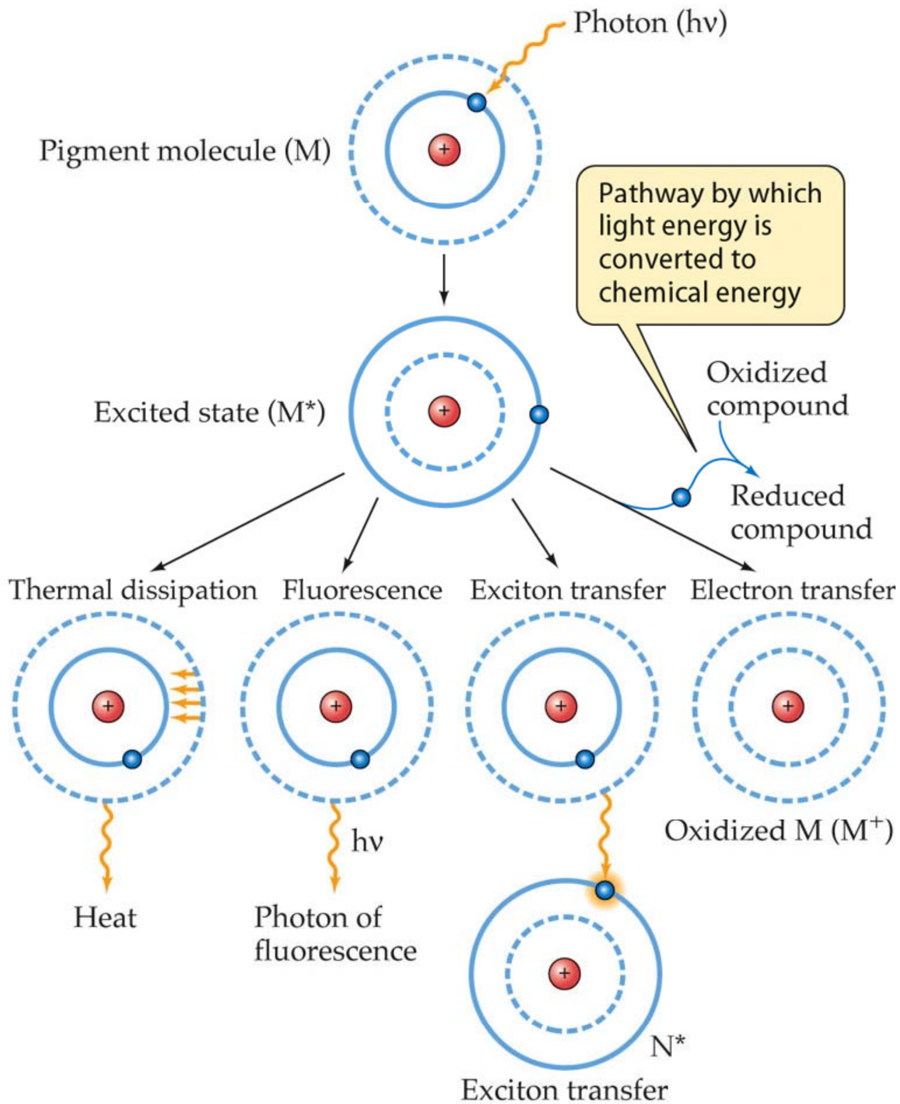

PHOTOTROPHS
(use light
as energy source)
Photoautotrophs
(Use CO_2)
Photoheterotrophs
(Use Organic Carbon)

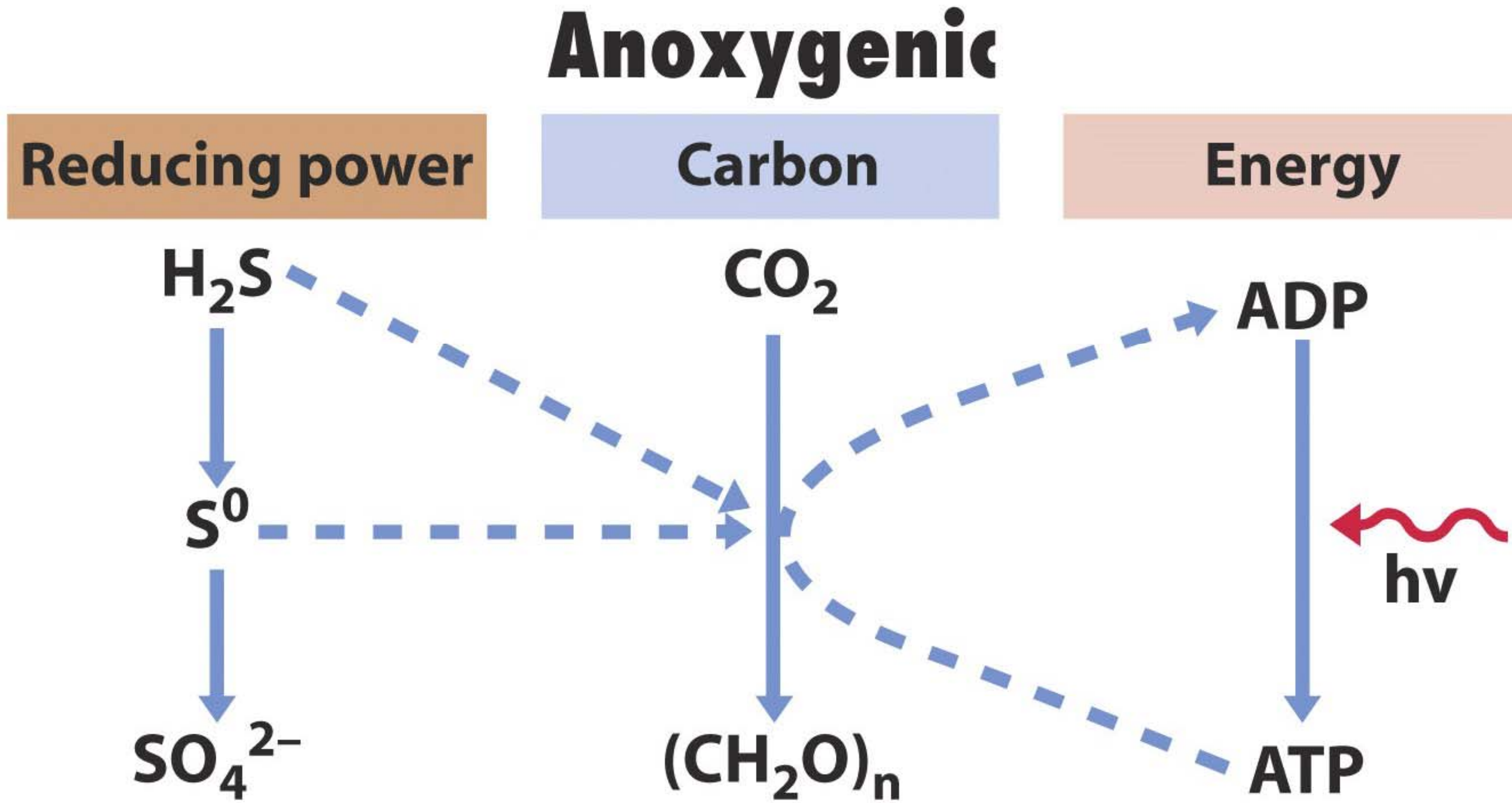

Vesicles


Lamellar
membranes

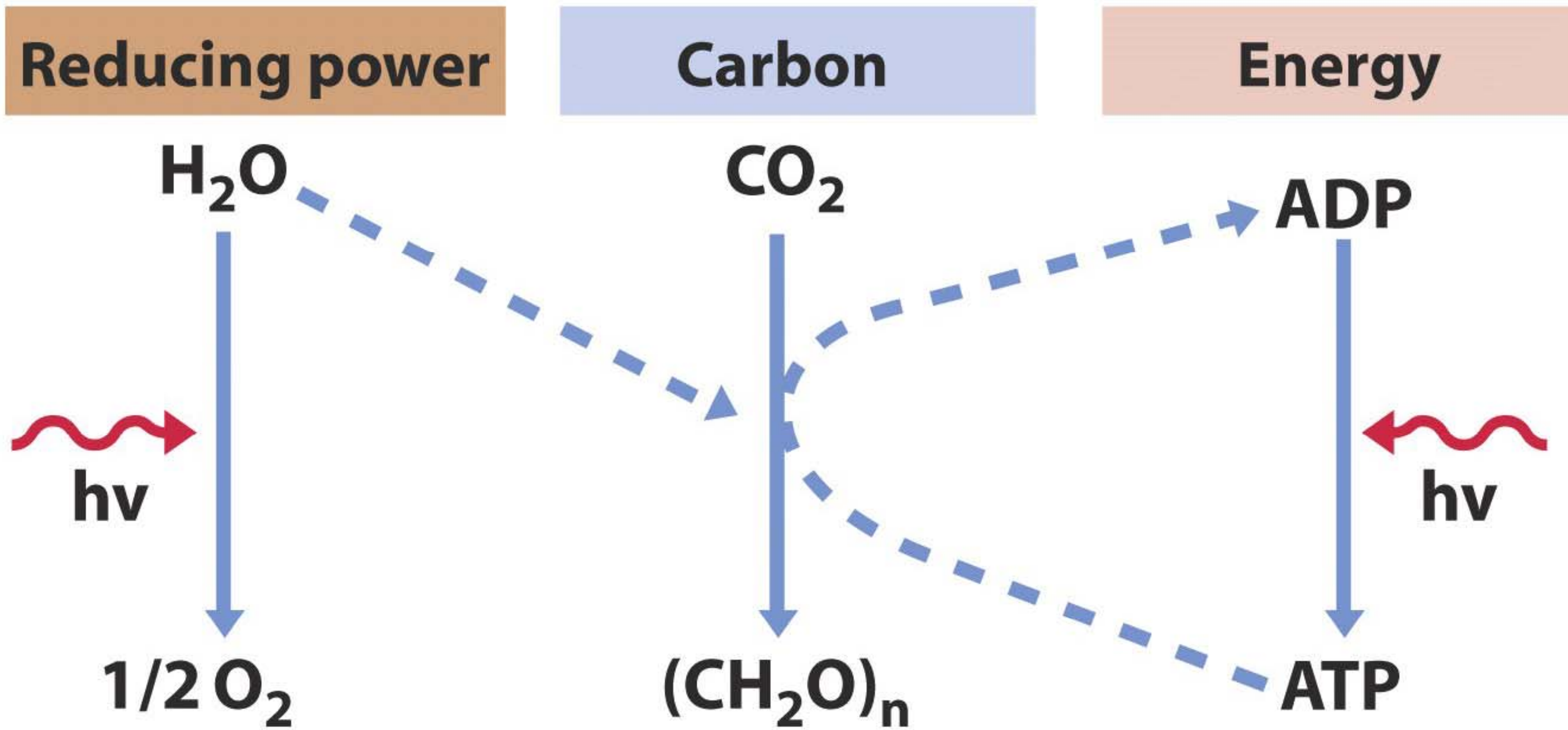

Light
H_2O
ELECTRON FLOW
O_2
Chlorophyll
Light reactions
ADP + P_i
ATP CYCLE
ATP
NADP+
NADPH CYCLE
NADPH + H+
Dark reactions
CO_2
CALVIN–BENSON CYCLE
Sugars

The possible fates of an excited electron




Anoxygenic
Reducing power
Carbon
Energy
H_2S
S^0
SO_4^{2-}
CO_2
$(CH_2O)_n$
ADP
ATP
hv

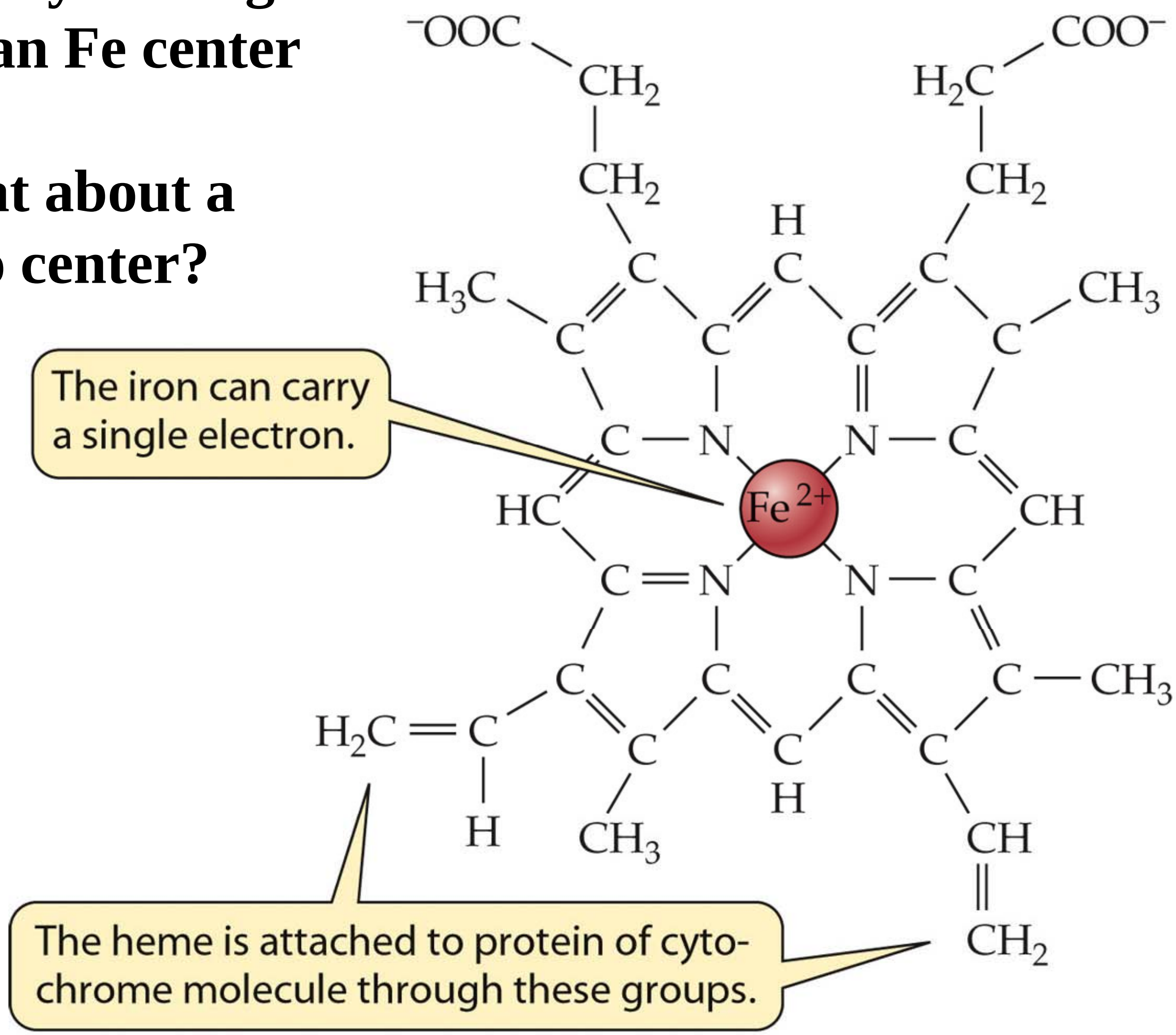
Oxygenic

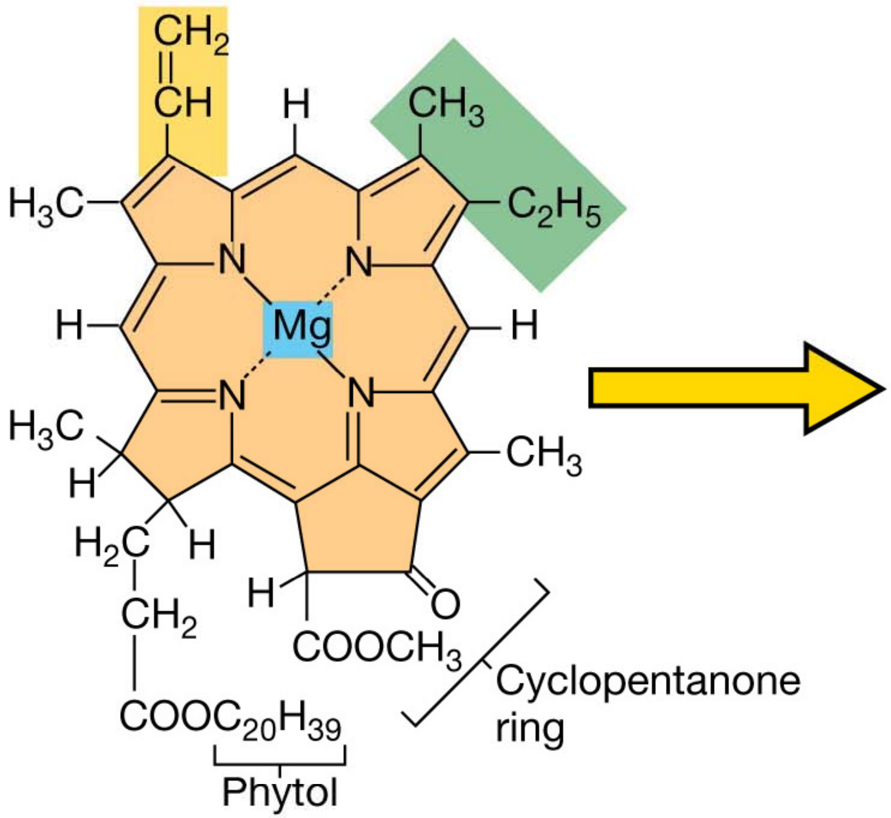


Wow!

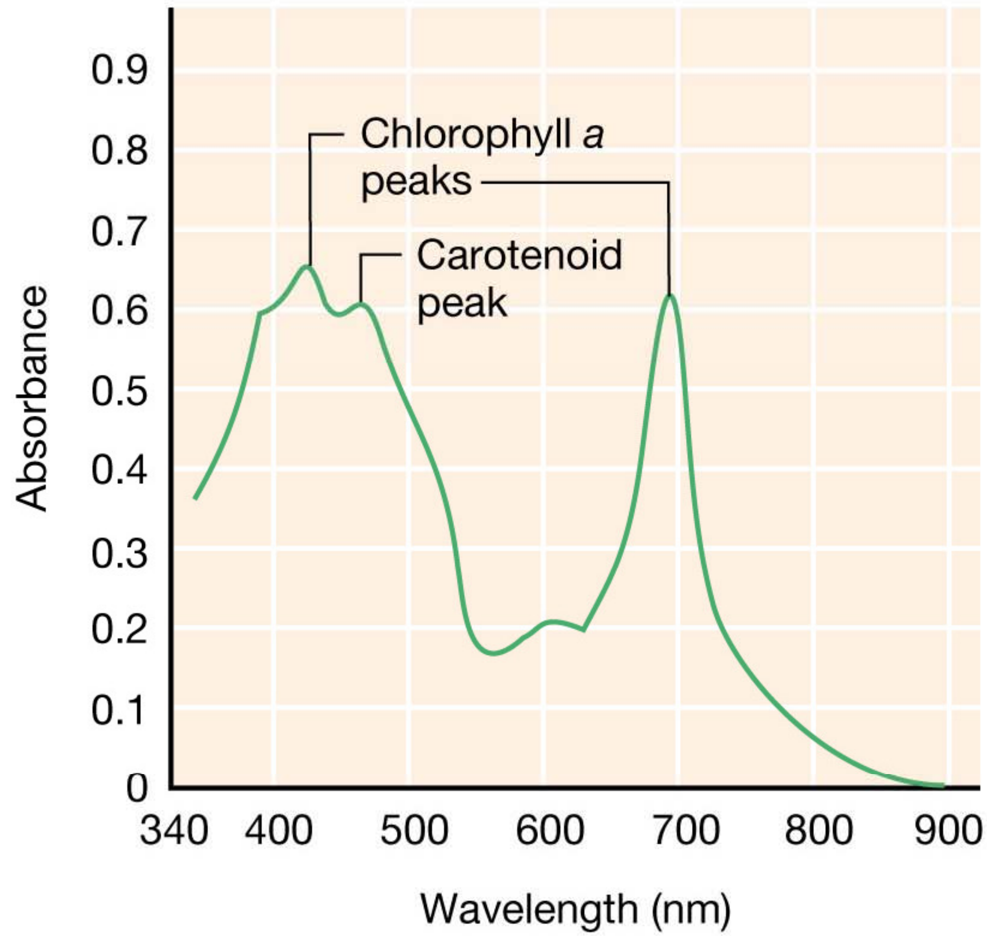
Porphyrin ring with an Fe center

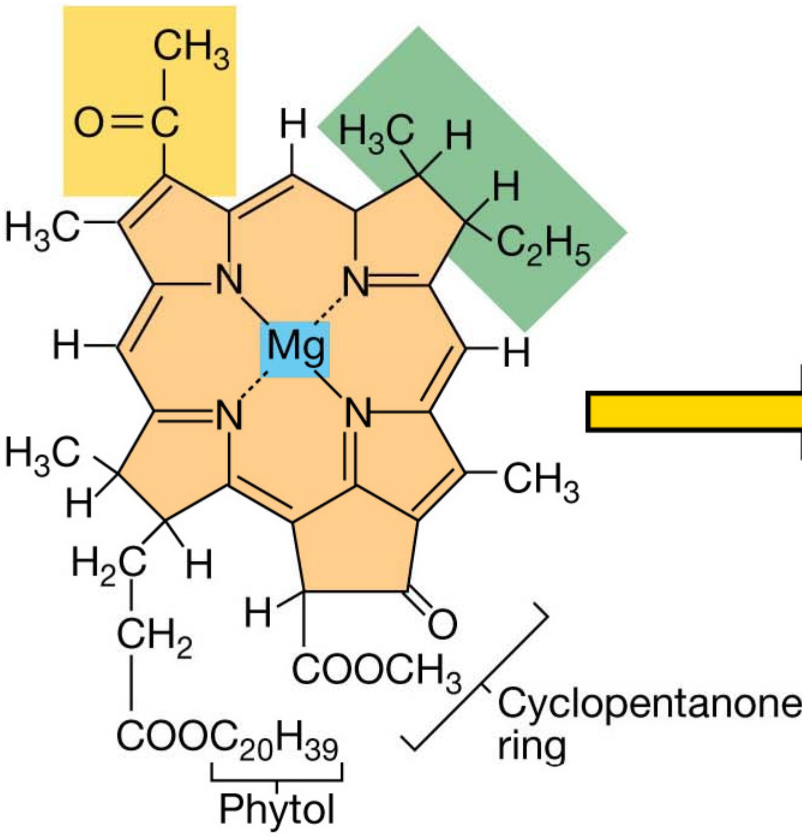
What about a Co center?



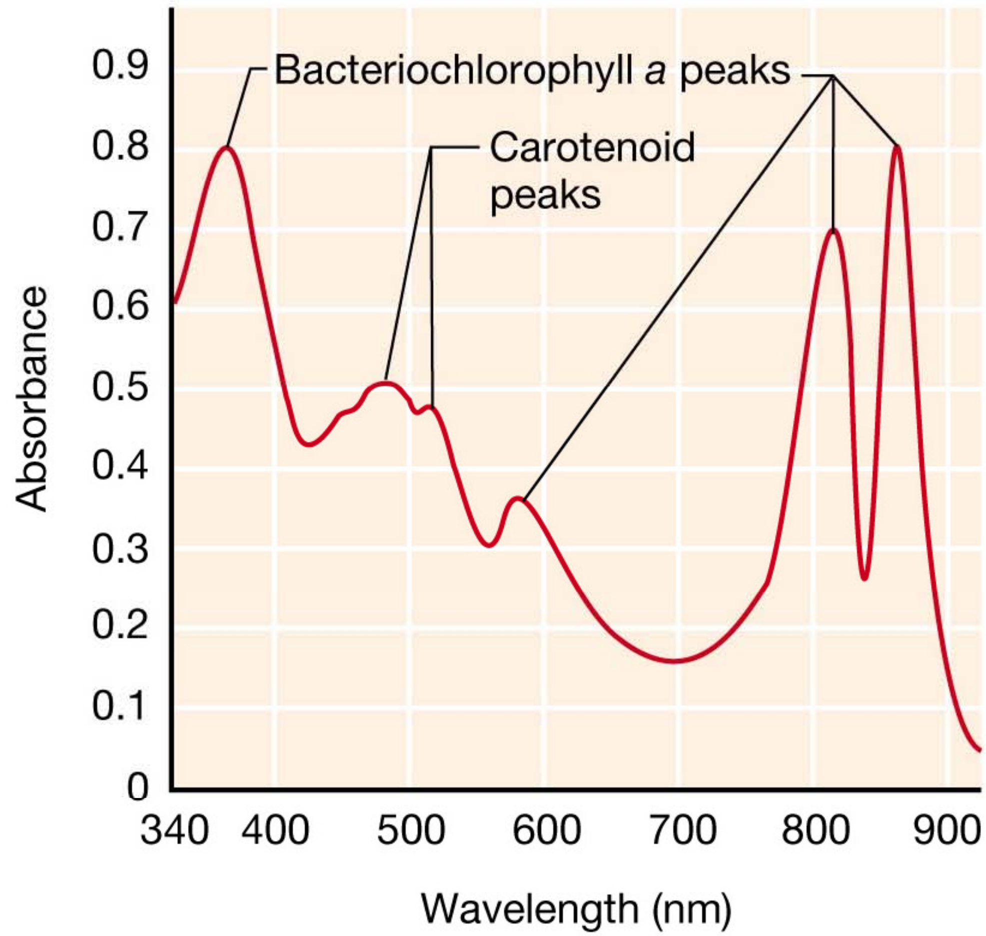


Chlorophyll *a*



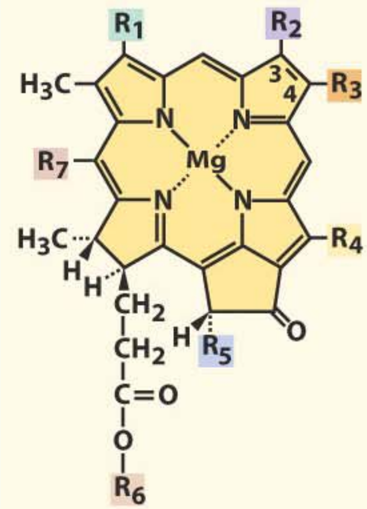


Bacteriochlorophyll *a*



Bacteriochlorophyll Structures

Pigment/Absorption maxima (*in vivo*)	R_1	R_2	R_3	R_4	R_5	R_6	R_7
Bchl *a* (purple bacteria)/ 805, 830–890	$-C(=O)-CH_3$	$-CH_3$[b]	$-CH_2-CH_3$	$-CH_3$	$-C(=O)-O-CH_3$	P/Gg[a]	$-H$
Bchl *b* (purple bacteria)/ 835–850, 1020–1040	$-C(=O)-CH_3$	$-CH_3$[c]	$=C(H)-CH_3$	$-CH_3$	$-C(=O)-O-CH_3$	P	$-H$
Bchl *c* (green sulfur bacteria)/745–755	$-C(H)(OH)-CH_3$	$-CH_3$	$-C_2H_5$ $-C_3H_7$[d] $-C_4H_9$	$-C_2H_5$ $-CH_3$	$-H$	F	$-CH_3$
Bchl *c_s* (green nonsulfur bacteria)/740	$-C(H)(OH)-CH_3$	$-CH_3$	$-C_2H_5$	$-CH_3$	$-H$	S	$-CH_3$
Bchl *d* (green sulfur bacteria)/705–740	$-C(H)(OH)-CH_3$	$-CH_3$	$-C_2H_5$ $-C_3H_7$ $-C_4H_9$	$-C_2H_5$ $-CH_3$	$-H$	F	$-H$
Bchl *e* (green sulfur bacteria)/719–726	$-C(H)(OH)-CH_3$	$-C(=O)-H$	$-C_2H_5$ $-C_3H_7$ $-C_4H_9$	$-C_2H_5$	$-H$	F	$-CH_3$
Bchl *g* (heliobacteria)/ 670, 788	$-C(H)=CH_2$	$-CH_3$[b]	$-C_2H_5$	$-CH_3$	$-C(=O)-O-CH_3$	F	$-H$



[a] P, Phytyl ester ($C_{20}H_{39}O-$); F, farnesyl ester ($C_{15}H_{25}O-$); Gg, geranylgeraniol ester ($C_{10}H_{17}O-$); S, stearyl alcohol ($C_{18}H_{37}O-$).

[b] No double bond between C_3 and C_4; additional H atoms are in positions C_3 and C_4.

[c] No double bond between C_3 and C_4; an additional H atom is in position C_3.

[d] Bacteriochlorophylls *c*, *d*, and *e* consist of isomeric mixtures with the different substituents on R_3 as shown.

Chloroplast Structure

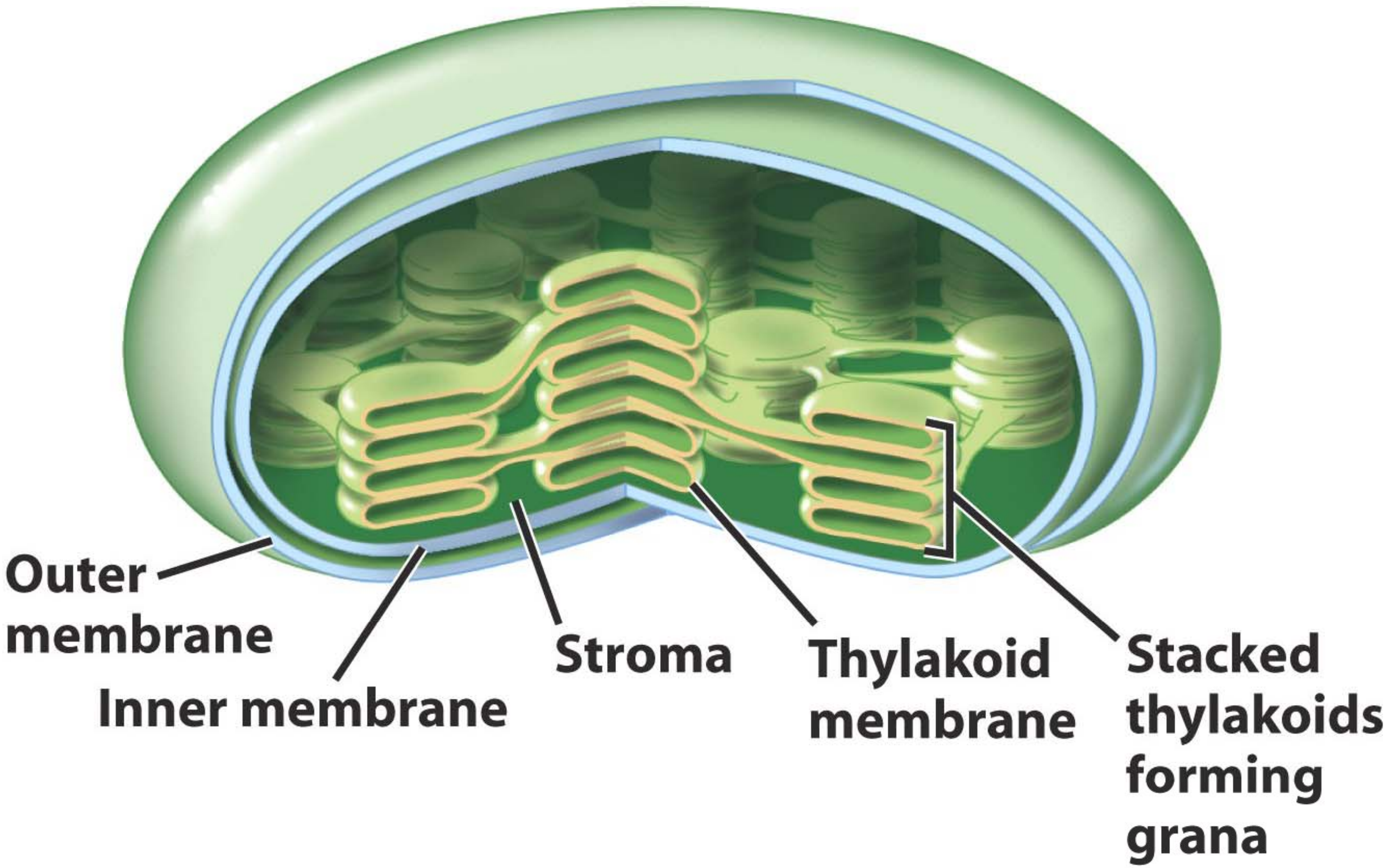
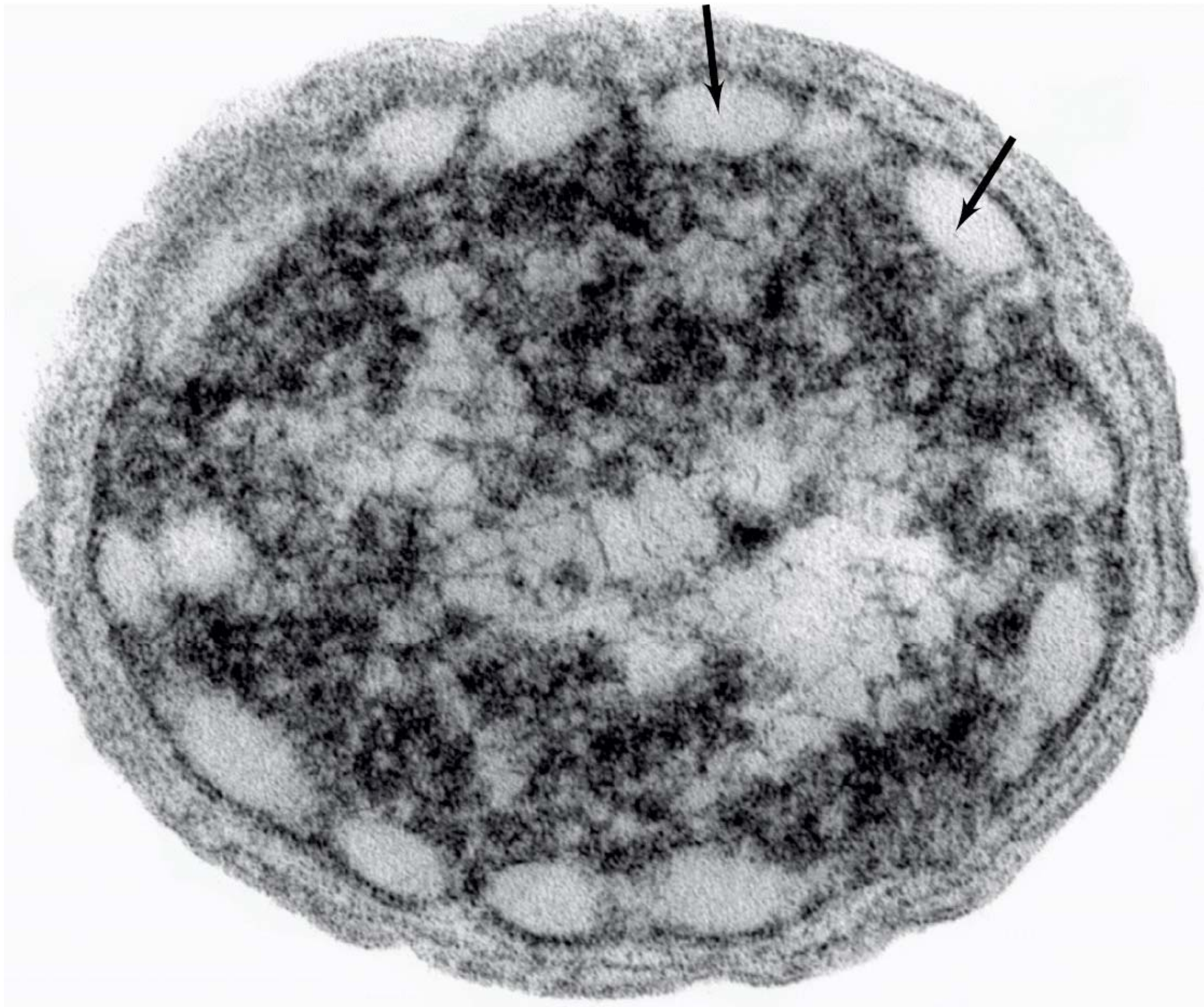


Table 9.1 Some general properties of the various photosynthetic bacteria

	Nonsulfur Purple Bacteria	Purple Sulfur Bacteria	Green Sulfur Bacteria	Cyanobacteria	Heliobacteria
Source of reducing power (e^-)	H_2, reduced organic	H_2S	H_2S	H_2O	Lactate, organic
Oxidized product	Oxidized organic	SO_4^{2-}	SO_4^{2-}	O_2	Oxidized organic
Source of carbon	CO_2 or organic	CO_2	CO_2	CO_2	Lactate pyruvate
Heterotrophic growth	Common	Limited[a]	Limited[a]	Limited[a]	Required

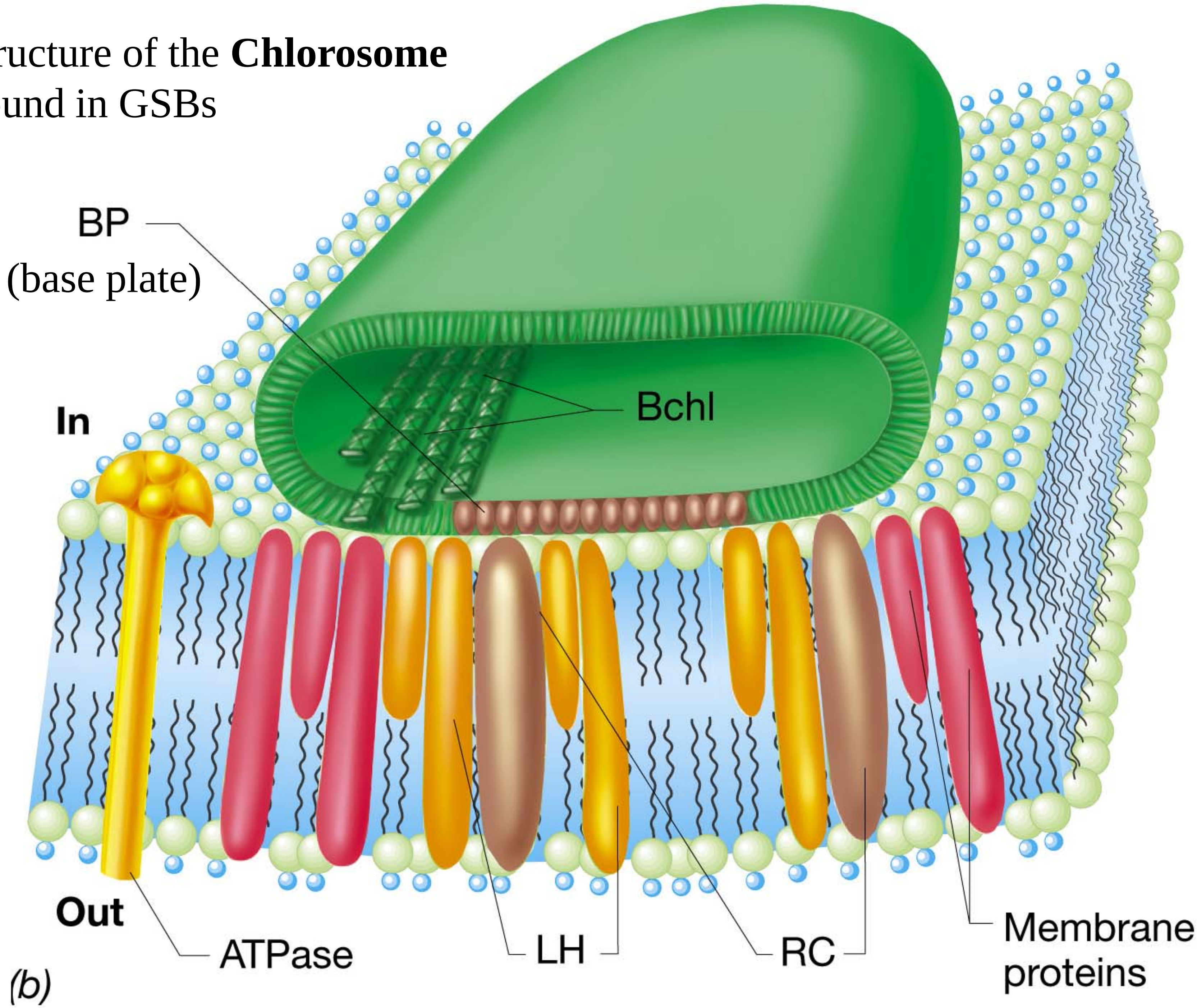
[a]Generally limited to assimilation of low molecular weight organics during autotrophic growth.

Structure and Location of the **Chlorosome**

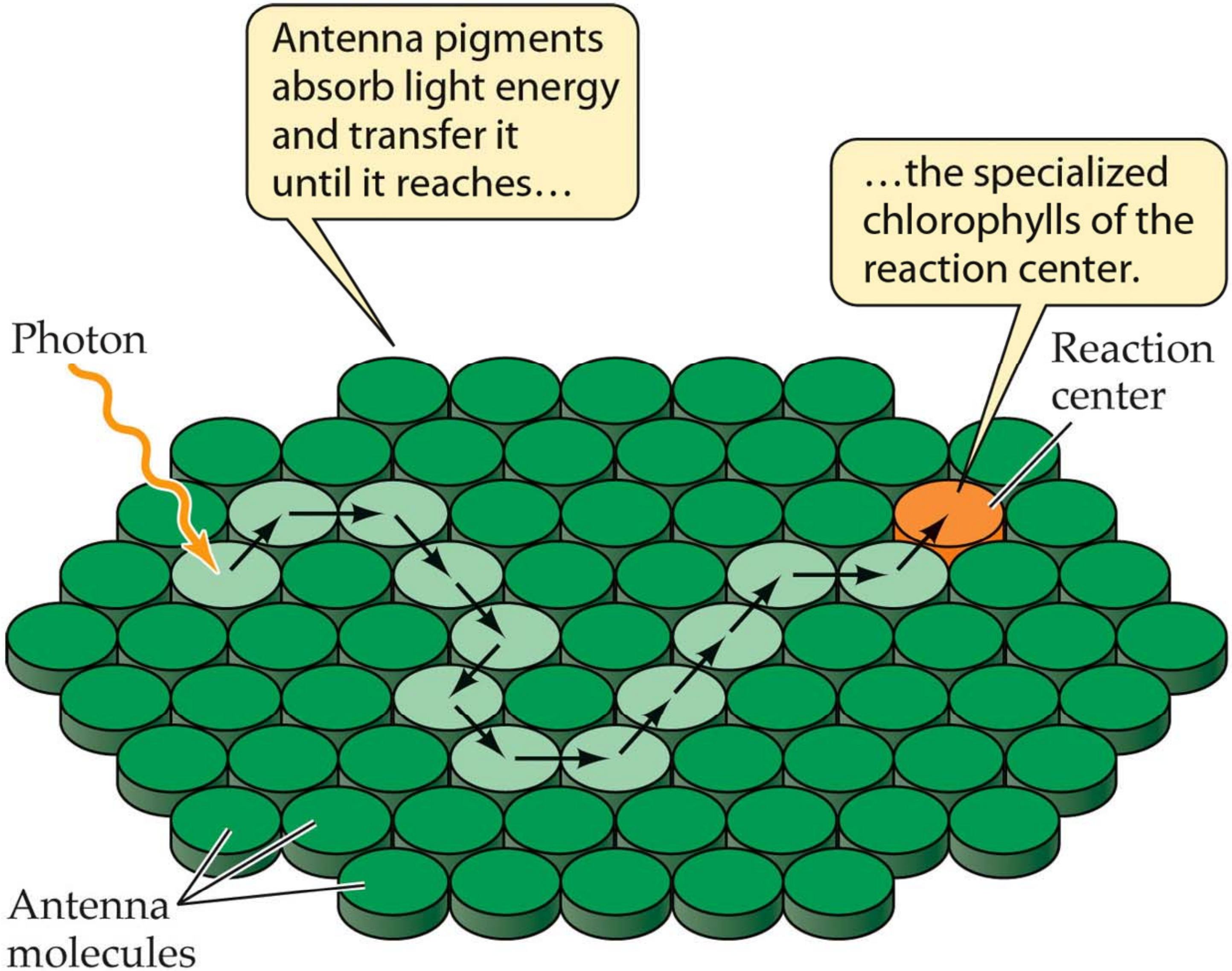


Found in GSBs

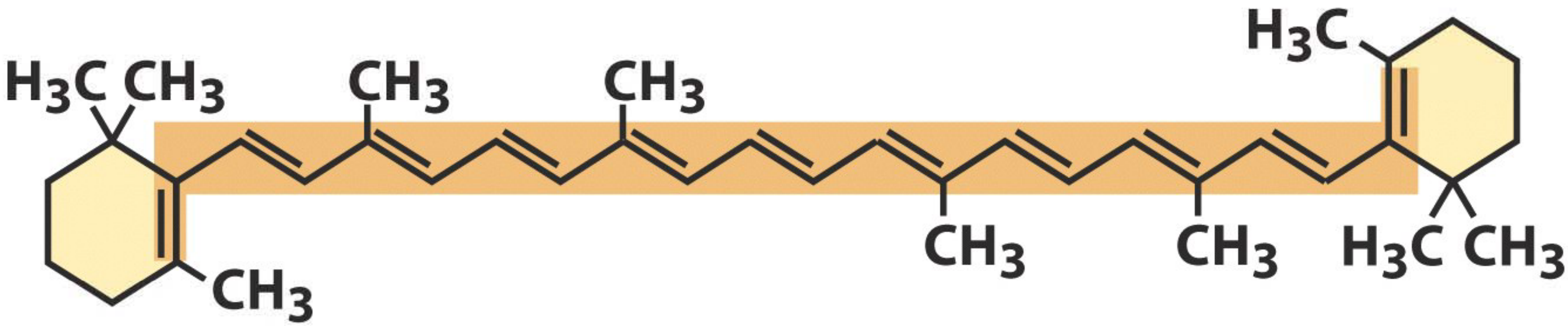
Structure of the **Chlorosome** Found in GSBs

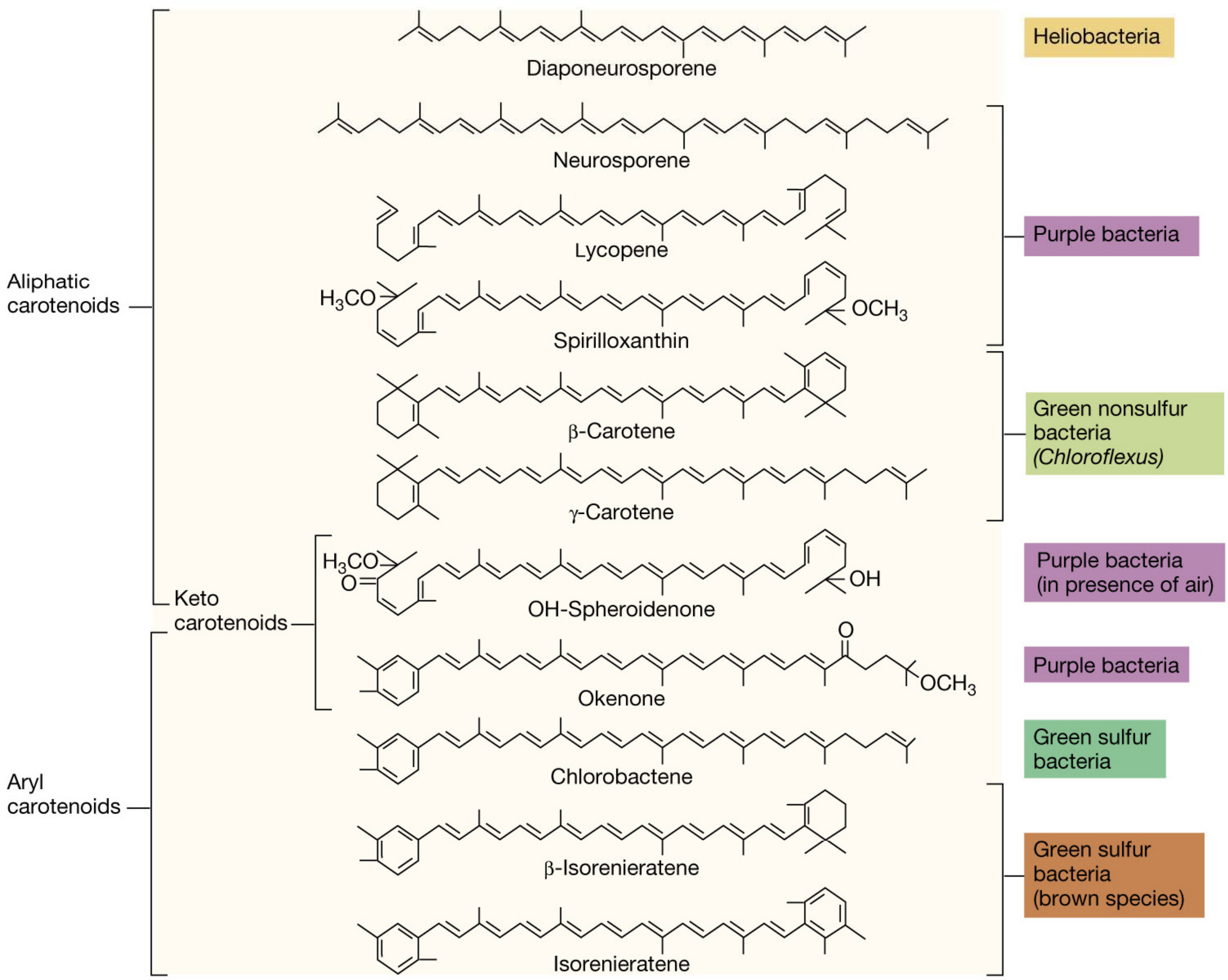


Photosynthetic unit



Beta-Carotene, a typical carotenoid



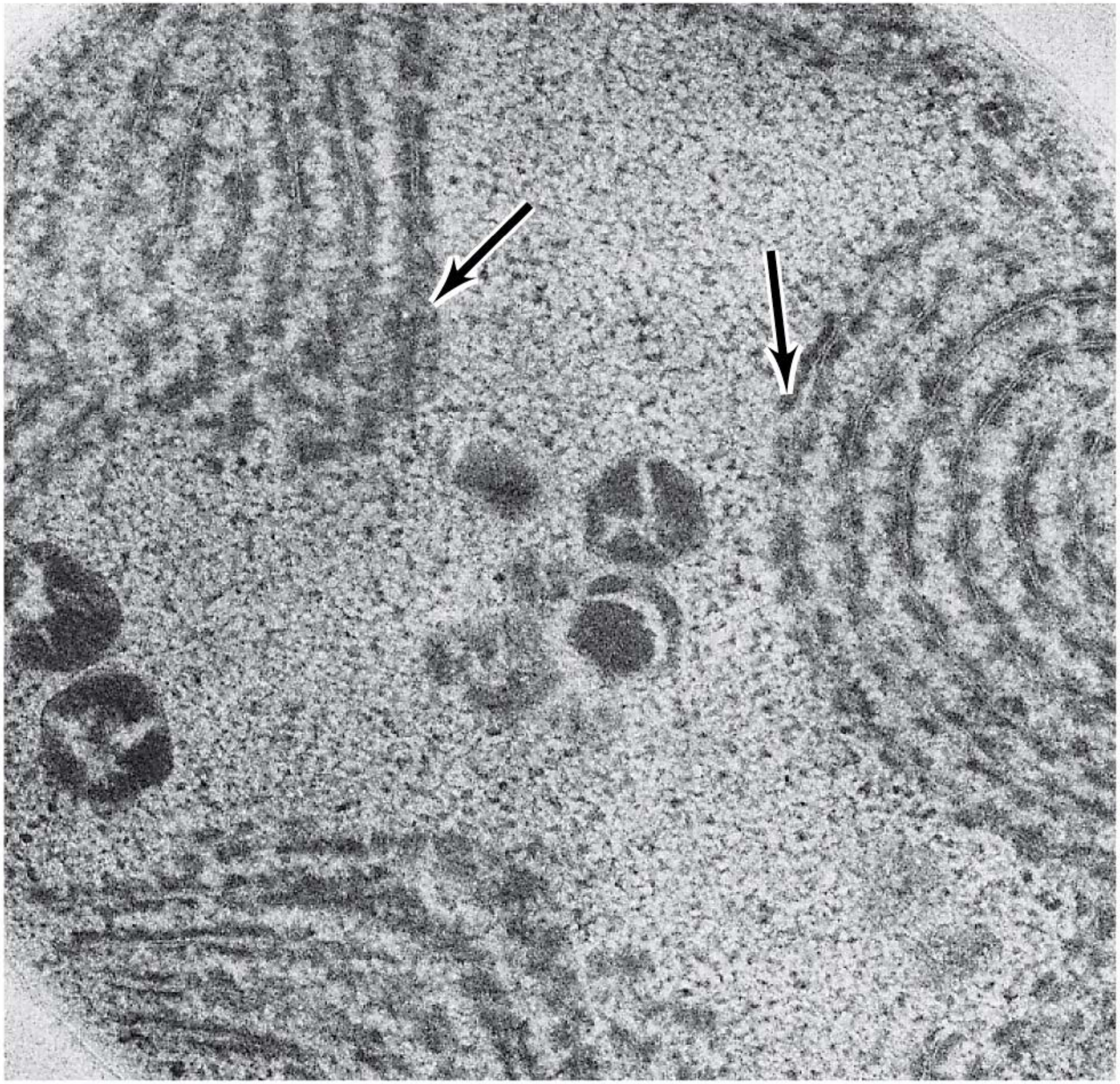


Aliphatic carotenoids
Keto carotenoids
Aryl carotenoids
Diaponeurosporene
Neurosporene
Lycopene
H3CO
OCH3
Spirilloxanthin
β-Carotene
γ-Carotene
H3CO
O
OH
OH-Spheroidenone
O
OCH3
Okenone
Chlorobactene
β-Isorenieratene
Isorenieratene
Heliobacteria
Purple bacteria
Green nonsulfur bacteria (Chloroflexus)
Purple bacteria (in presence of air)
Purple bacteria
Green sulfur bacteria
Green sulfur bacteria (brown species)

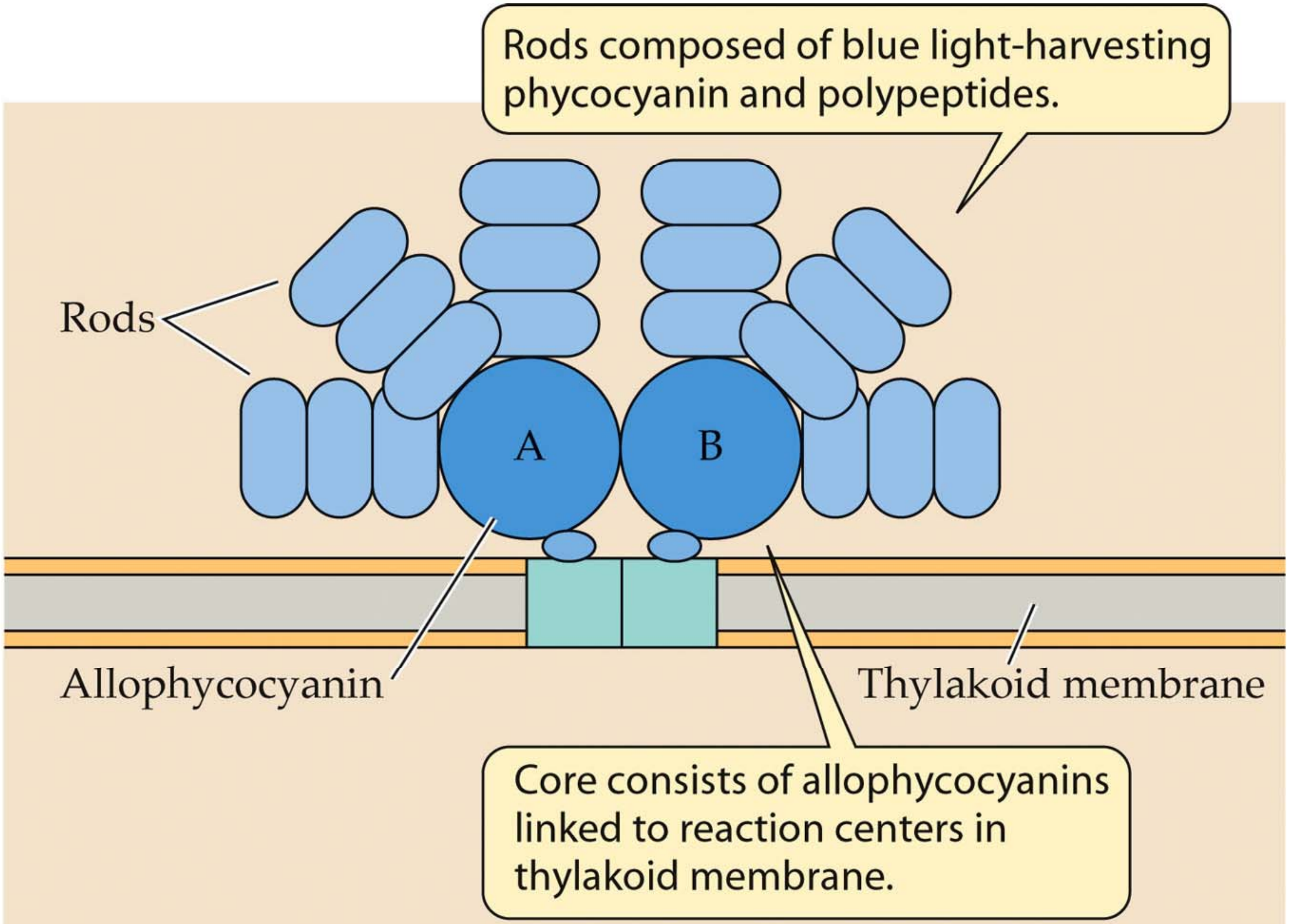
Table 9.2 **The bacteriochlorophyll present in photosynthetic bacteria and primary acceptors involved in energy conserving reactions**

	Electron Donor	Electron Acceptor
Purple nonsulfur bacteria	Bacteriochlorophyll *a* and *b*	Bacteriopheophytin *a*, Q_A, and Q_B
Green sulfur bacteria	Bacteriochlorophyll *c*, *d*, and *e*	Bacteriopheophytin *a* and FeS-protein
Cyanobacteria photosystem I	Chlorophyll *a*	Chlorophyll *a* and FeS-protein
Cyanobacteria photosystem II	Chlorophyll *a*	Pheophytin *a*, Q_A, Q_B, and plastoquinones
Heliobacteria	Bacteriochlorophyll *g*	Bacteriochlorophyll *c* and FeS-protein

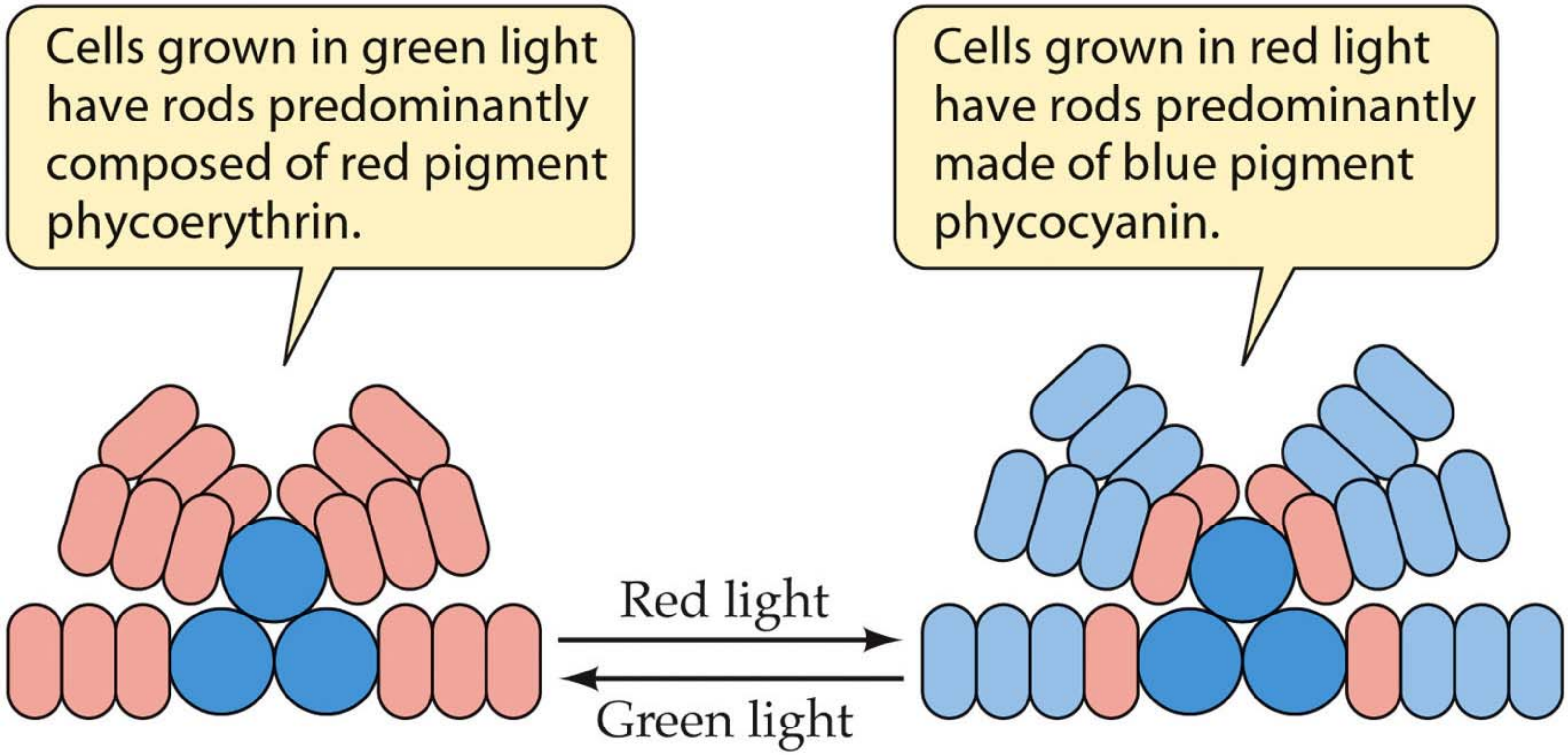
Structure and Location of **Phycobilisomes**



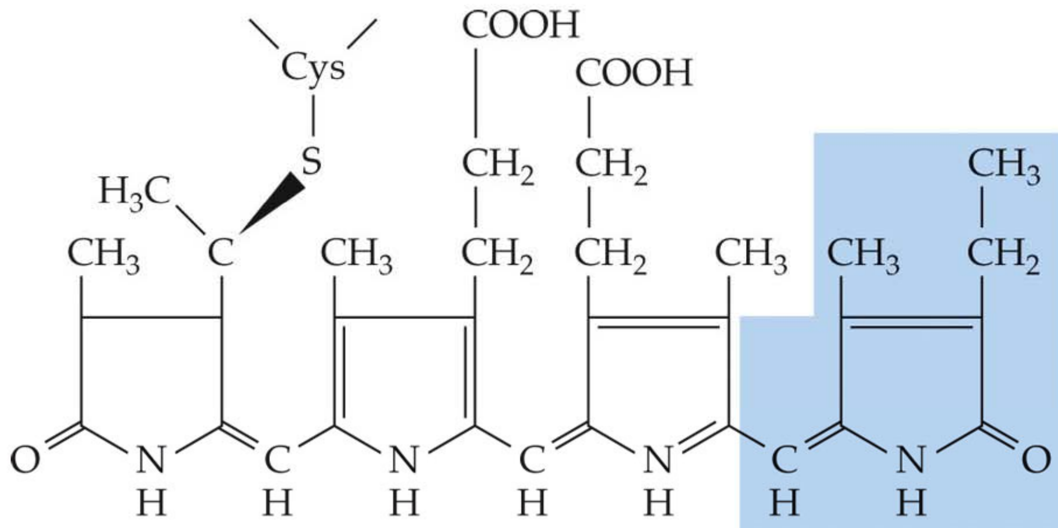
Phycobilisome of cyanobacteria



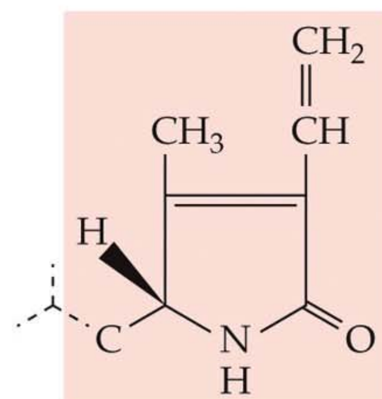
Chromatic adaptation of a phycobilisome



Chromophores of phycobilisomes

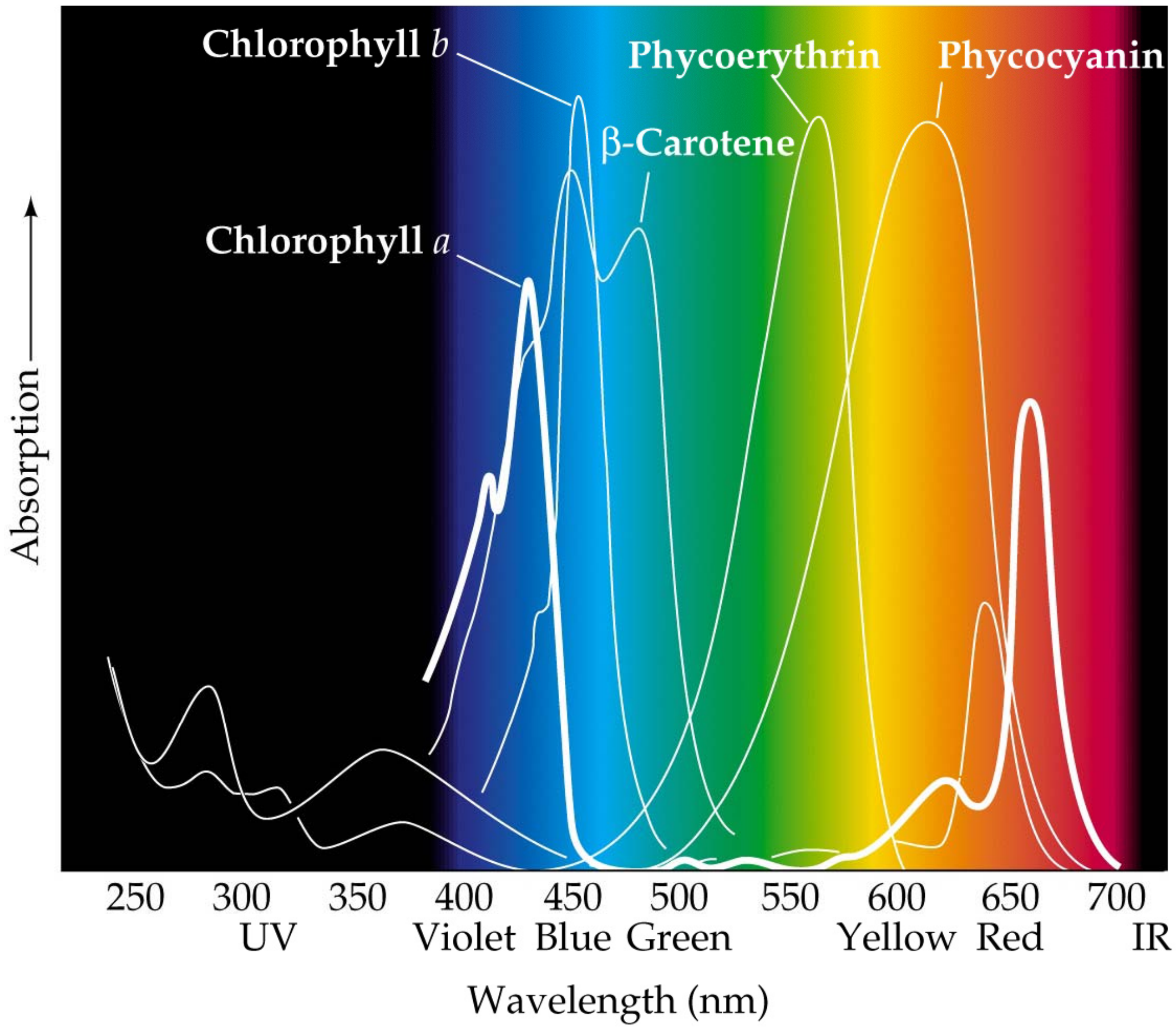


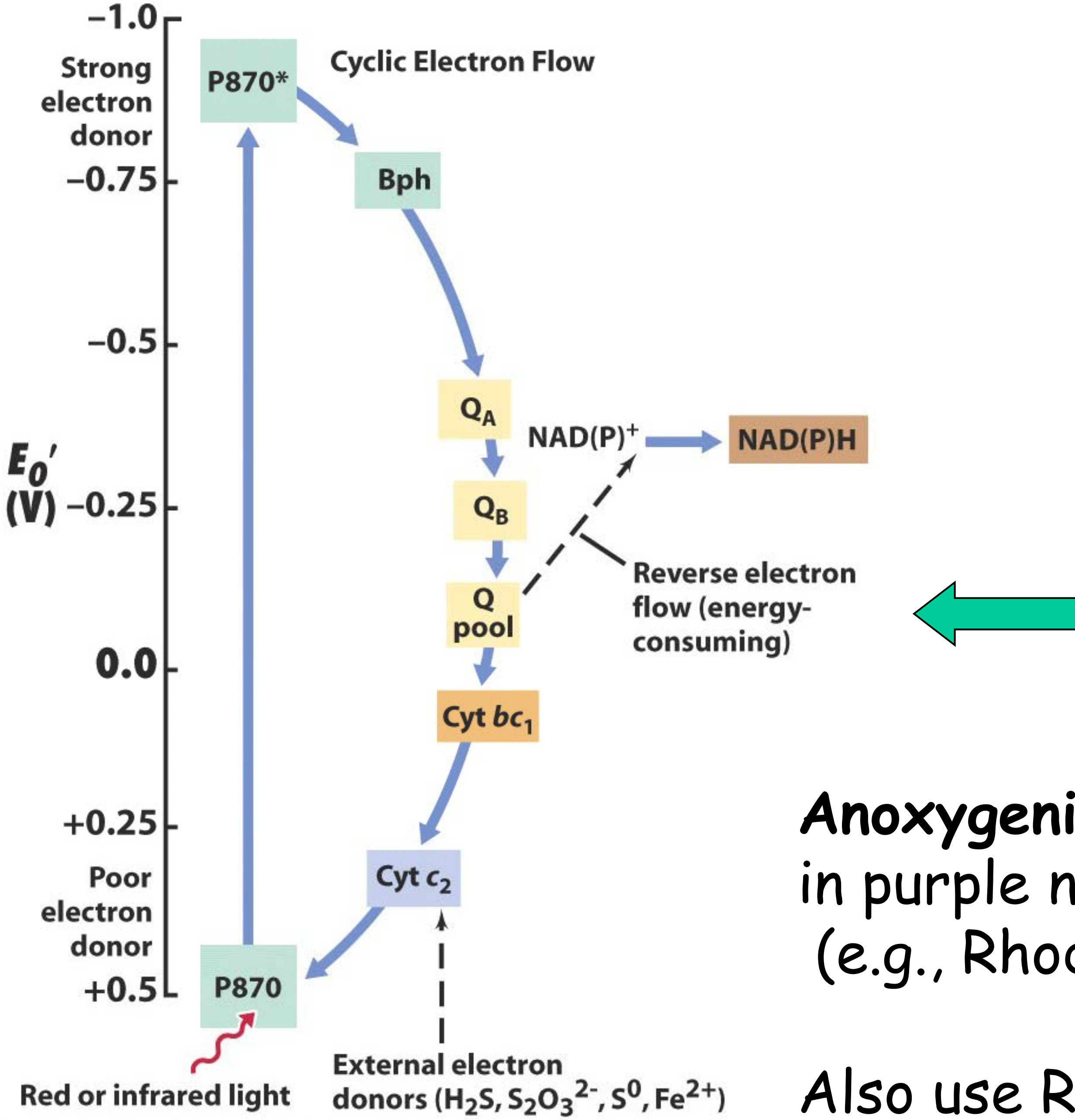
Phycocyanin (blue)



Phycoerythrin (red)

Absorption Spectra for Cyanobacteria

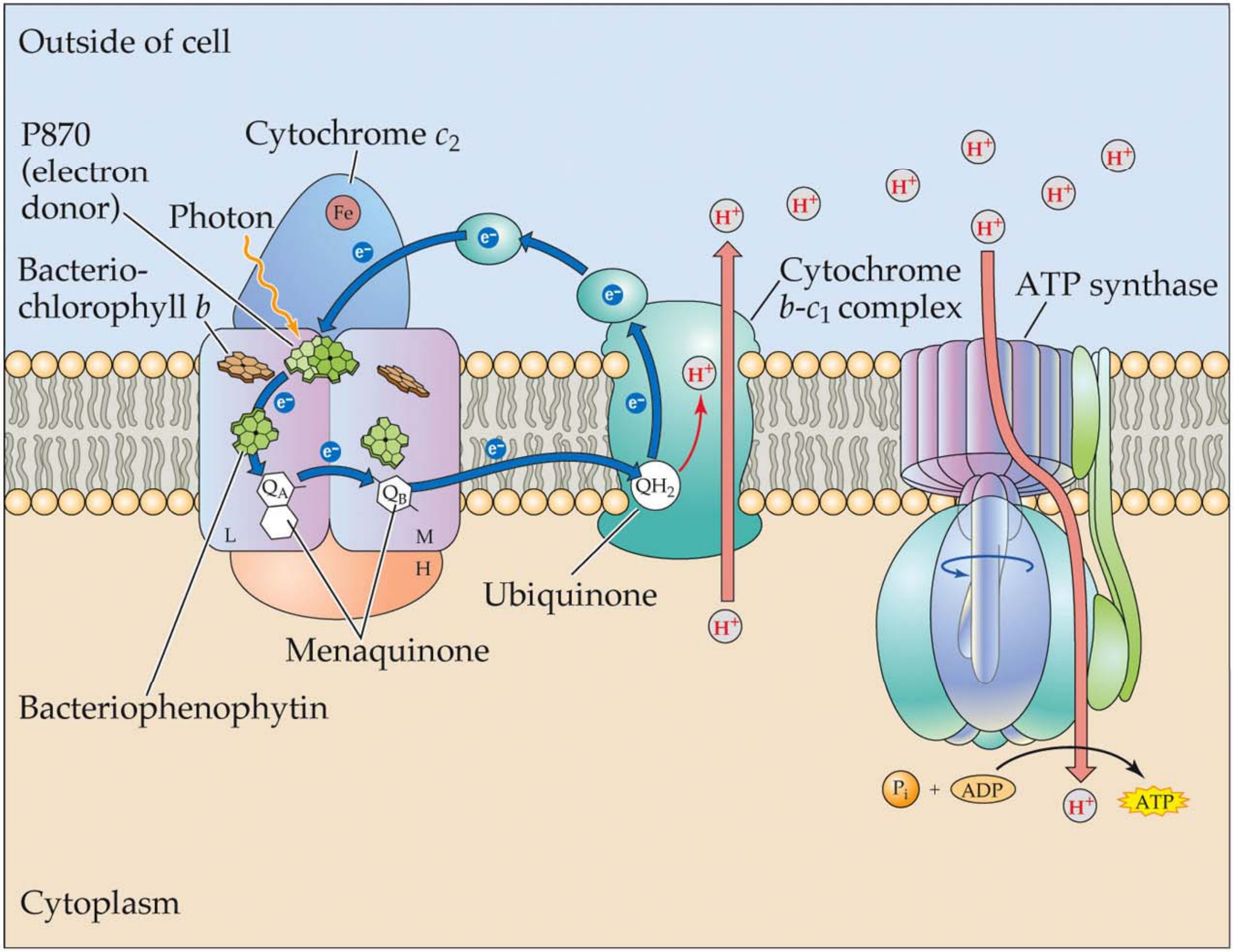




Anoxygenic photosynthesis
in purple nonsulfur bacteria
(e.g., Rhodobacter)

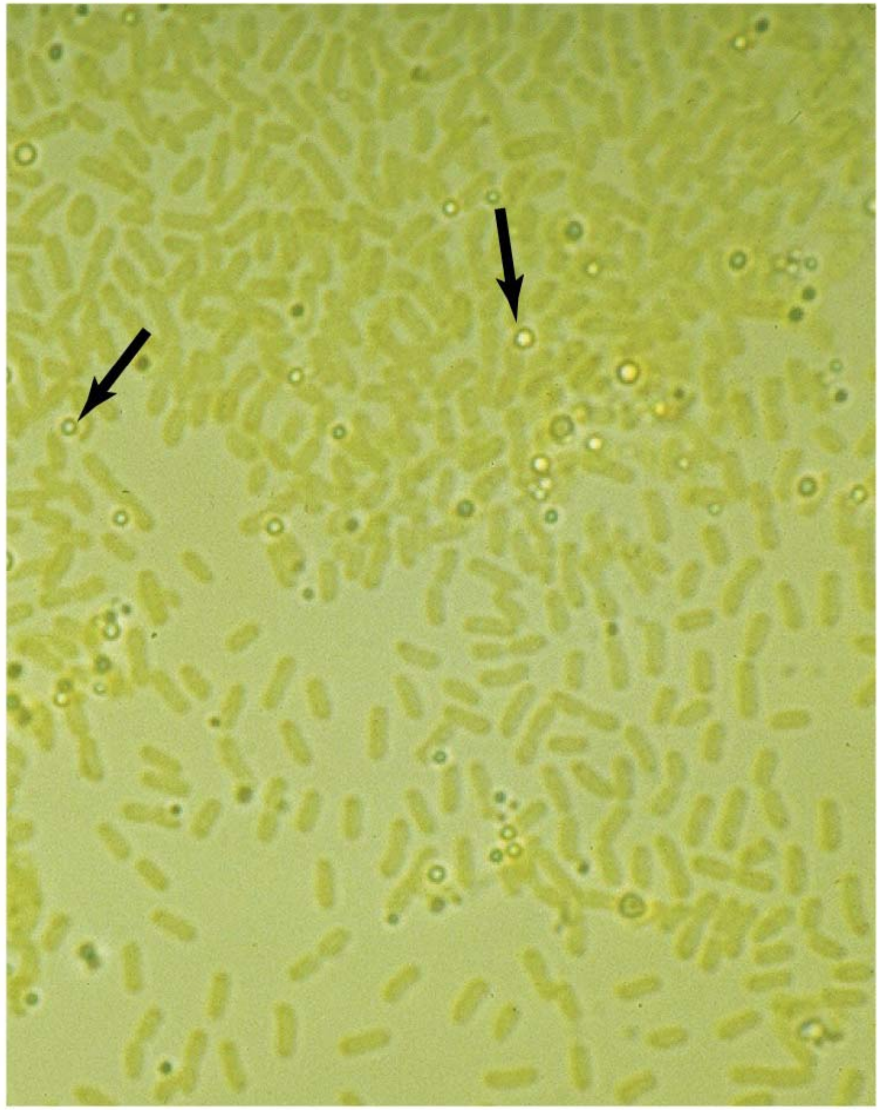
Also use REF: GNBs & PSBs

Reaction center of purple nonsulfur bacteria

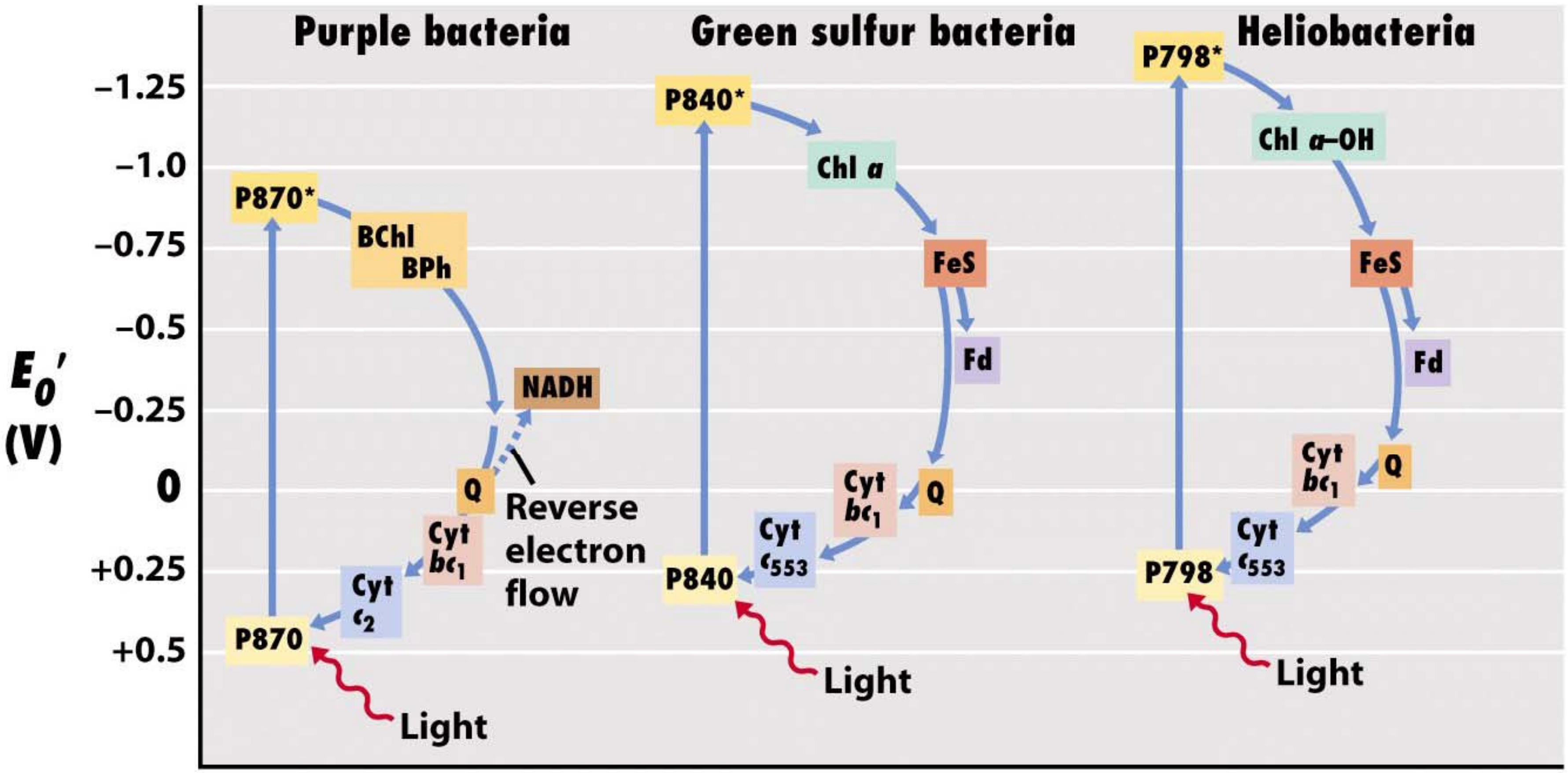


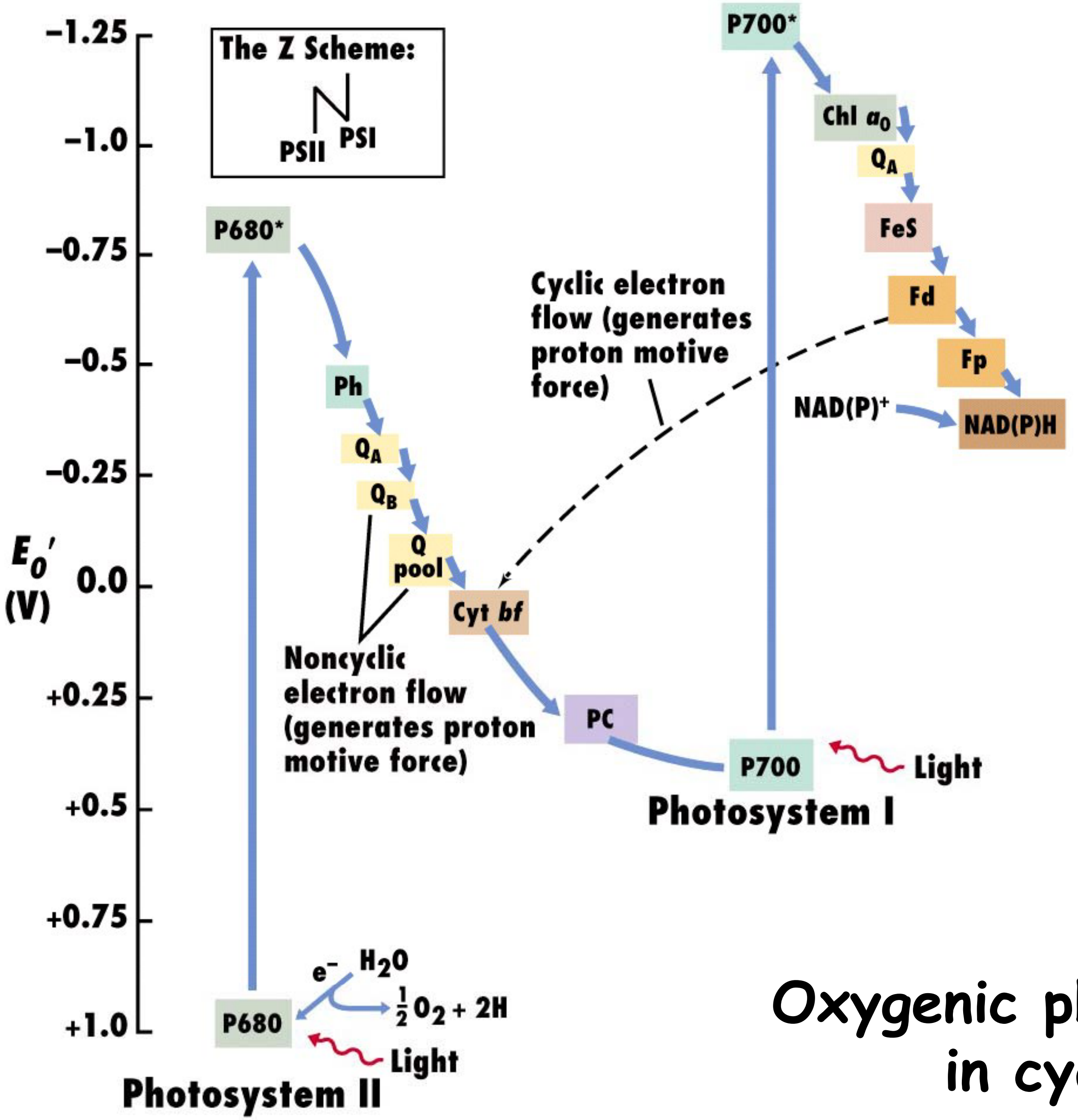
Sulfur granules in purple sulfur bacteria
e.g., Chromatium

Sulfur granules in green sulfur bacteria e.g., Chlorobium



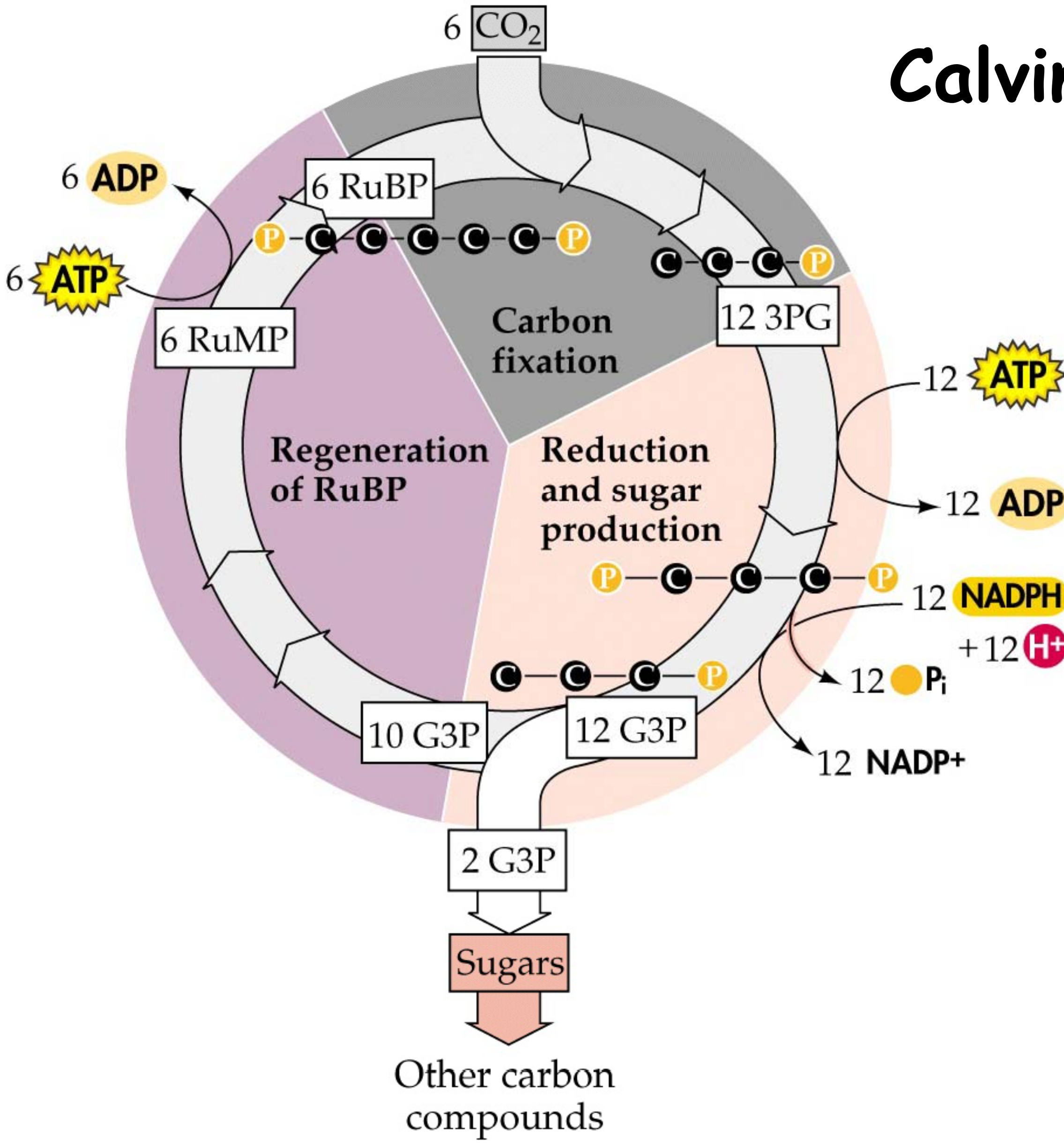
Electron flow in phototrophs

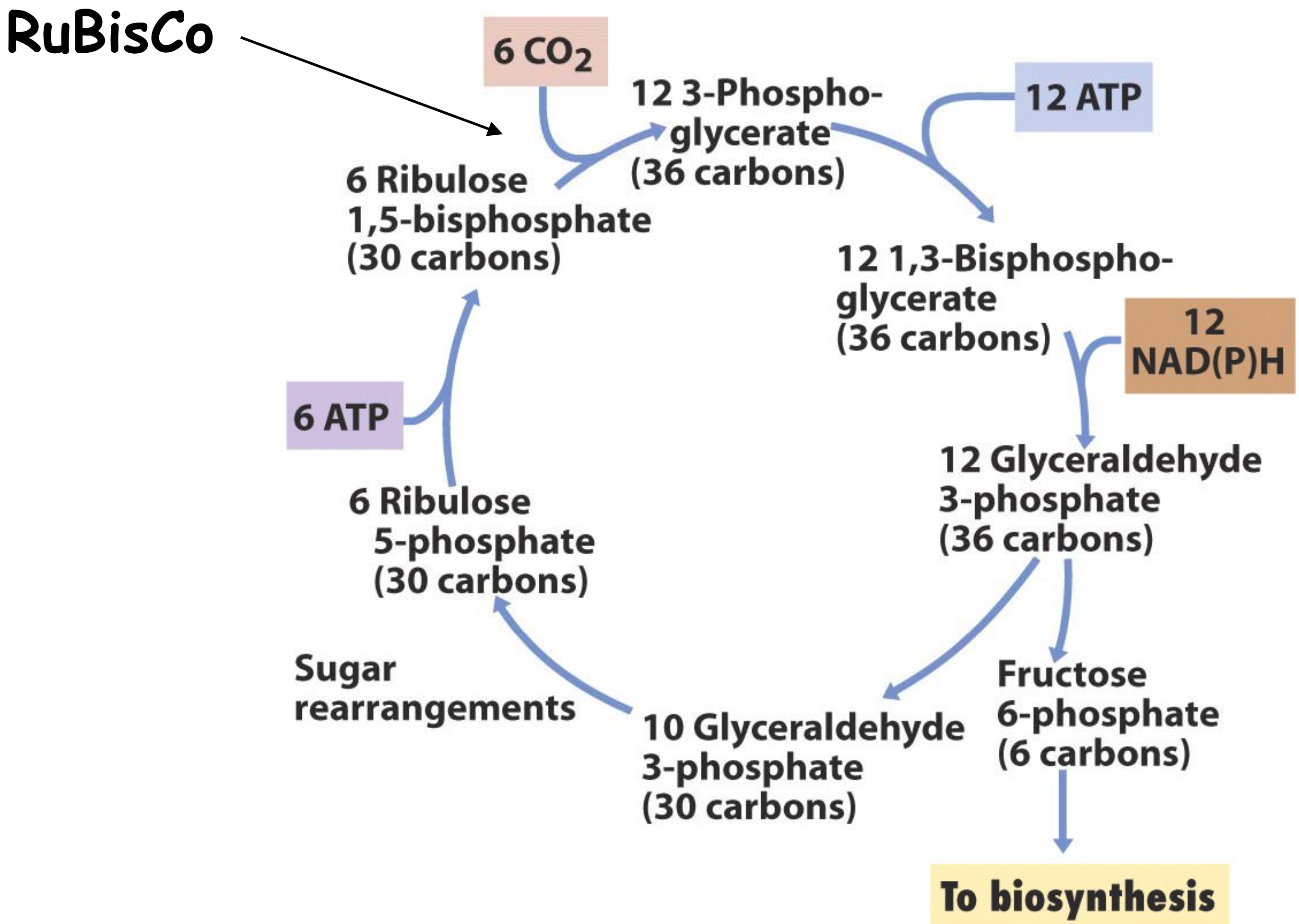




Oxygenic photosynthesis in cyanobacteria

Calvin Cycle

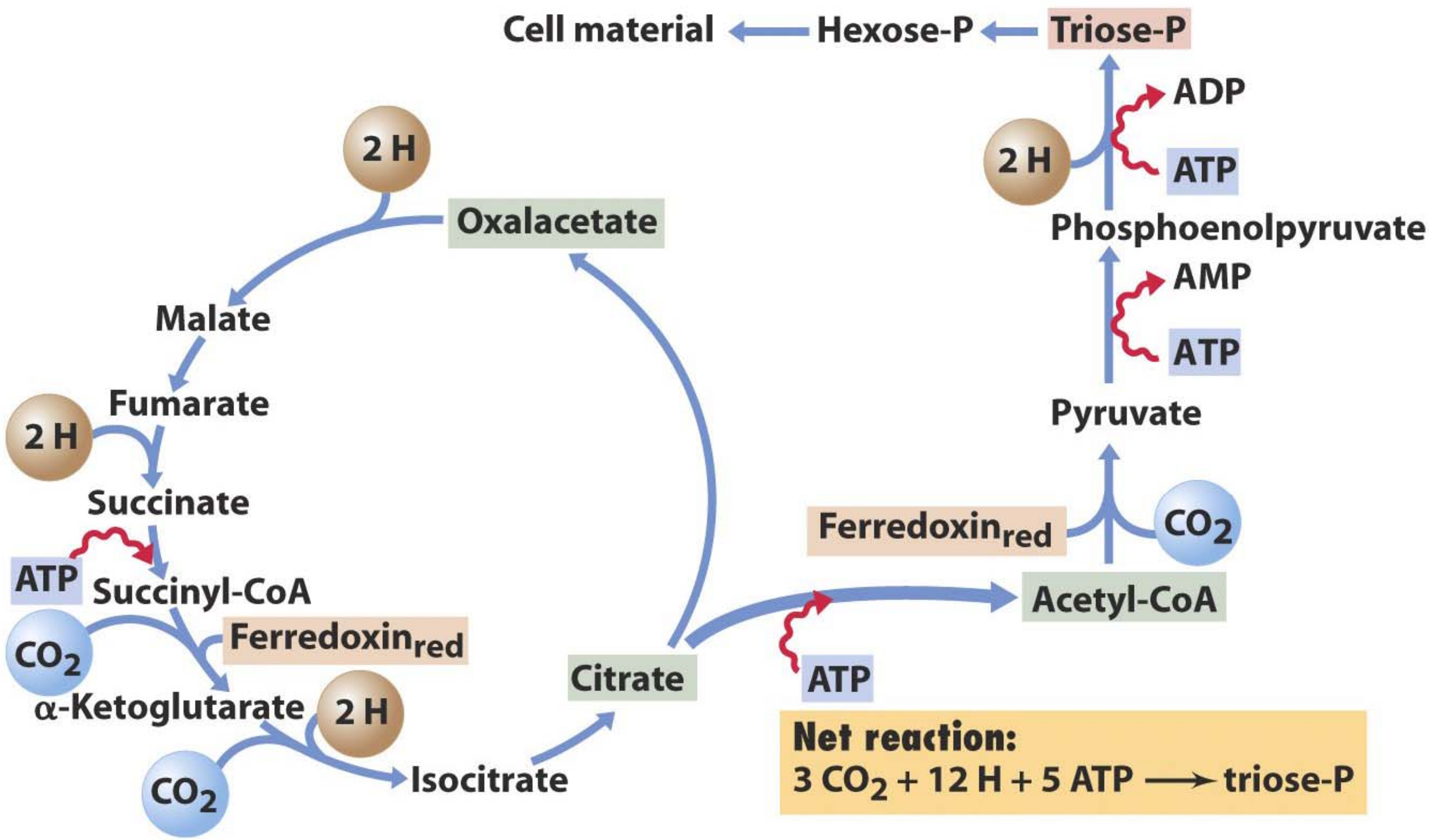




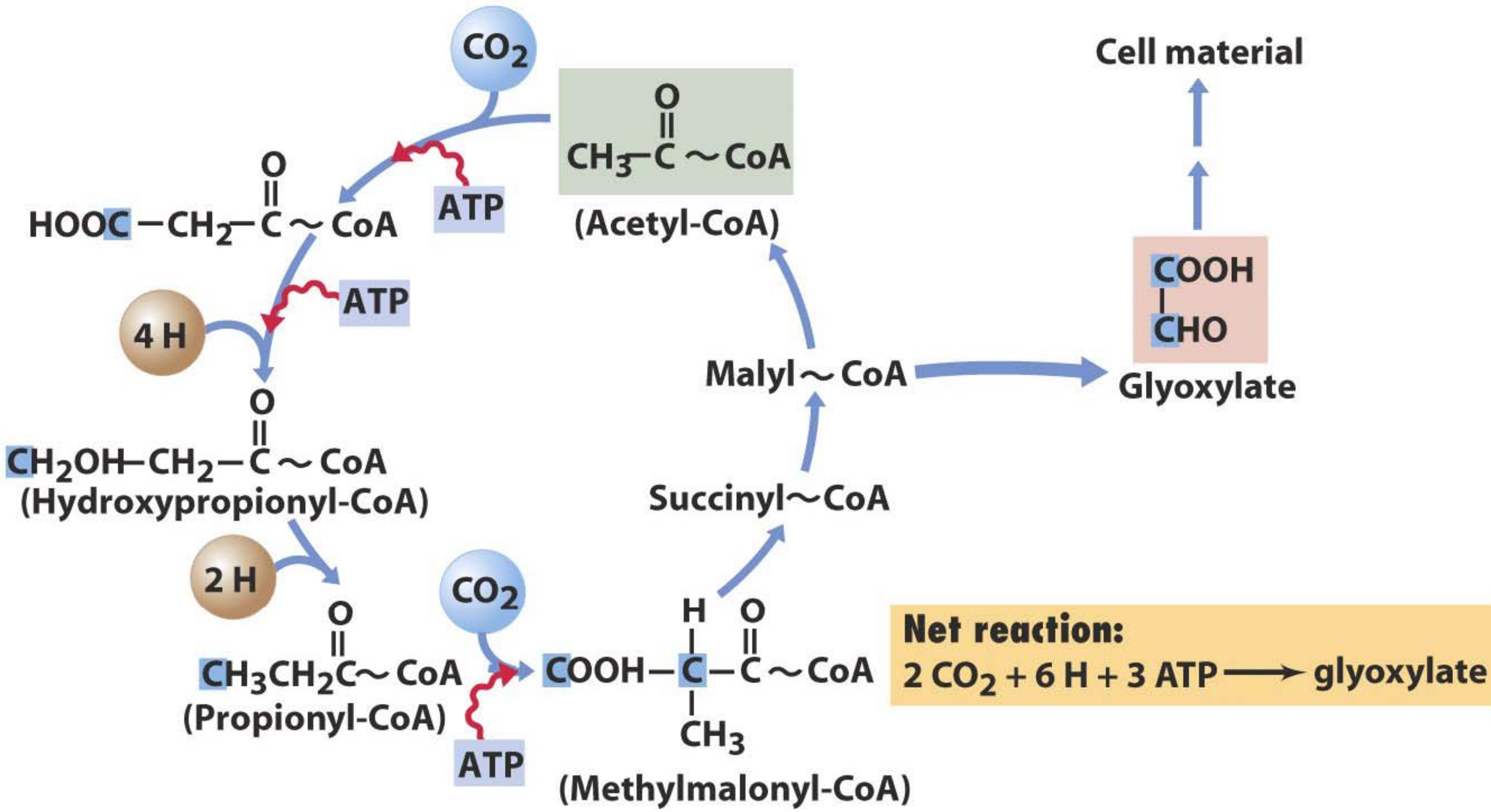
Overall stoichiometry:

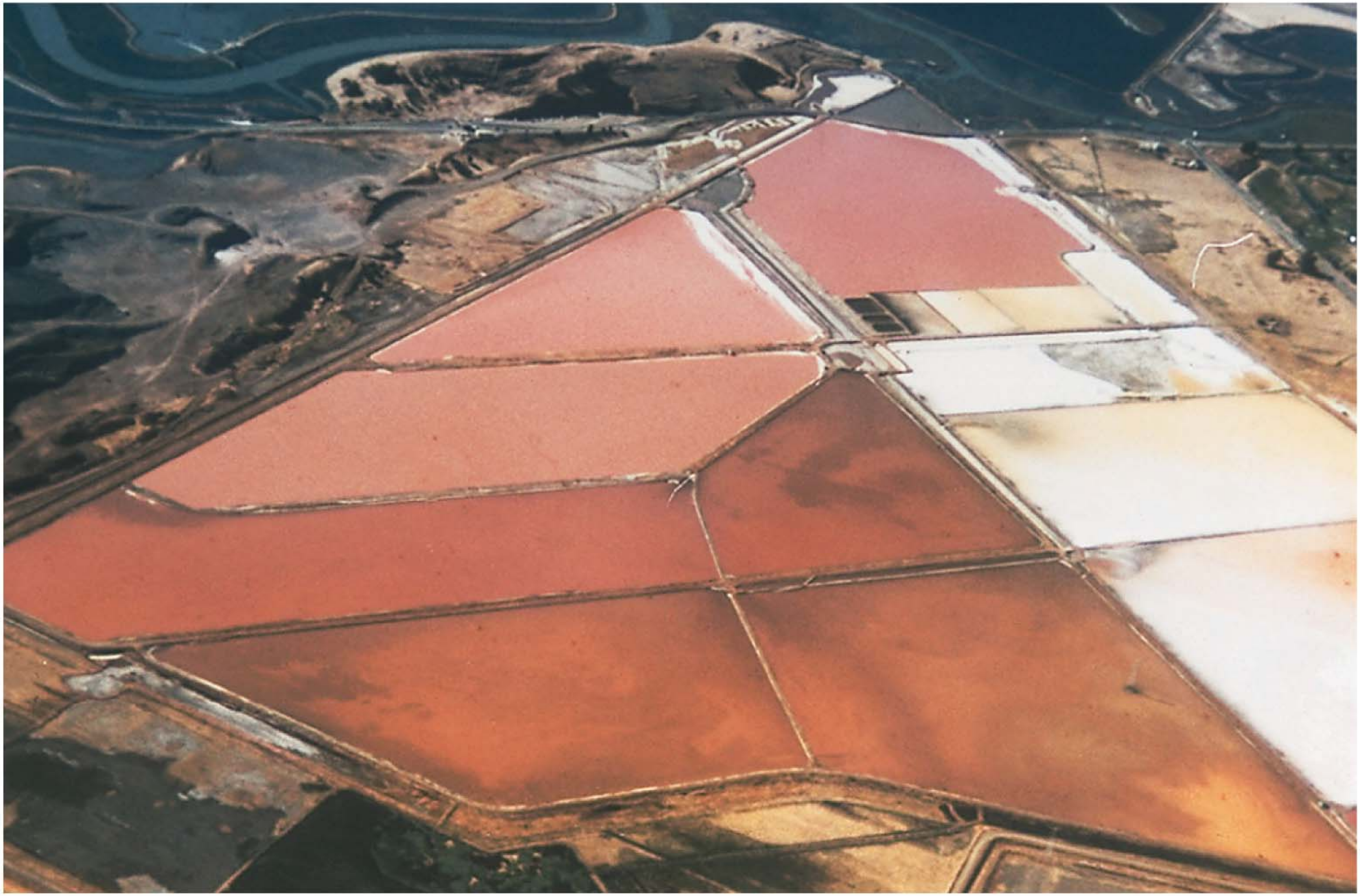
$$6\ CO_2 + 12\ NADPH + 18\ ATP \longrightarrow C_6H_{12}O_6(PO_3H_2) + 12\ NADP^+ + 18\ ADP + 17\ P_i$$

Reverse TCA in GSBs



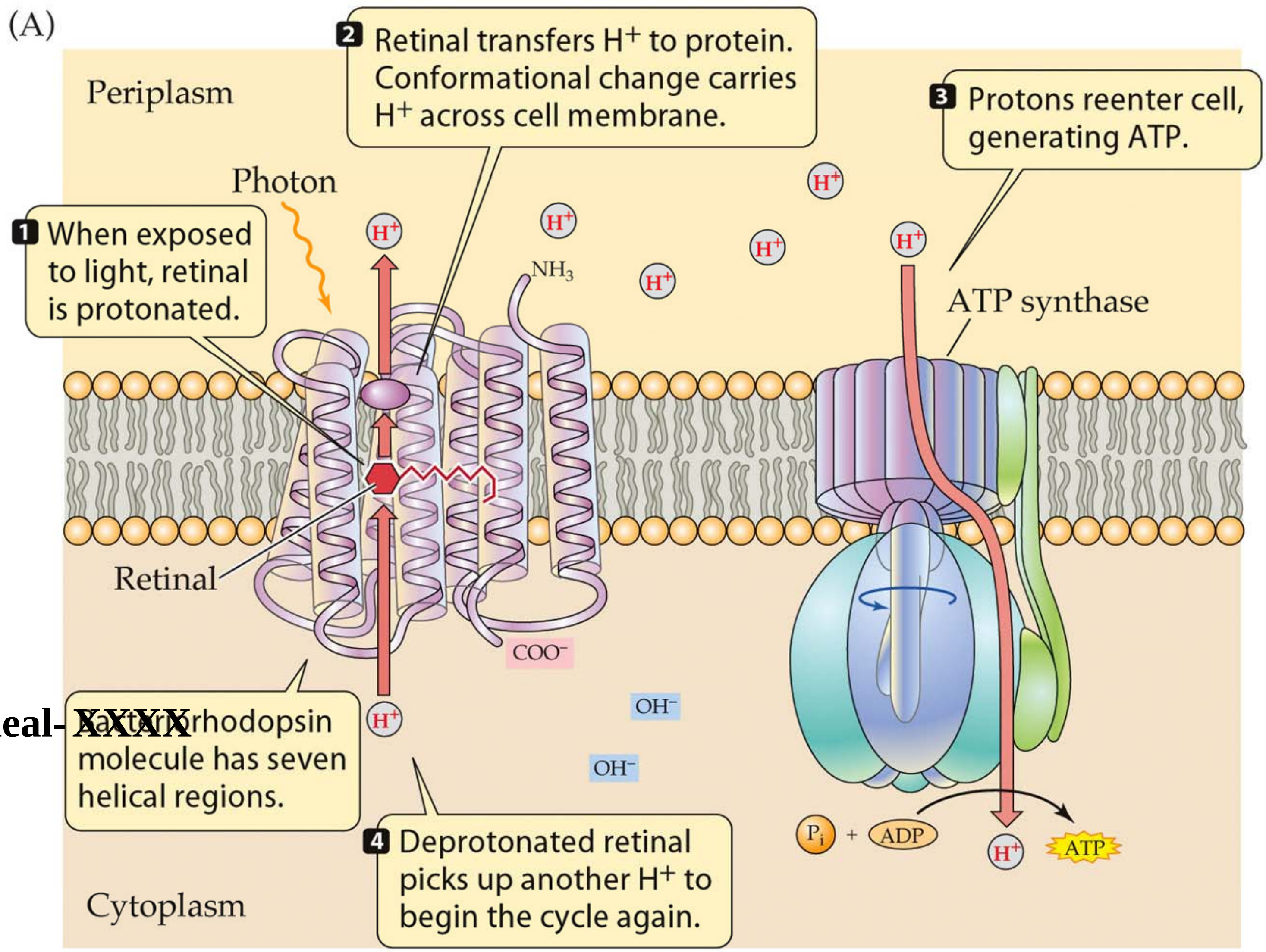
Hydroxypropionate in GNBs





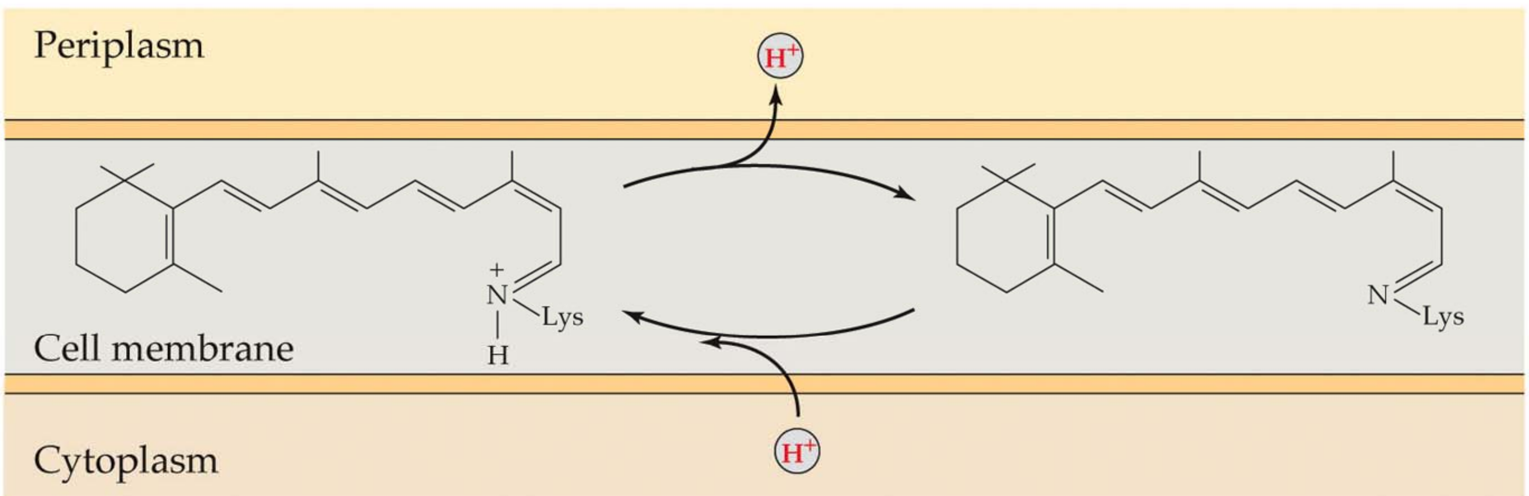
NASA

A light-driven proton pump of halophilic archaea

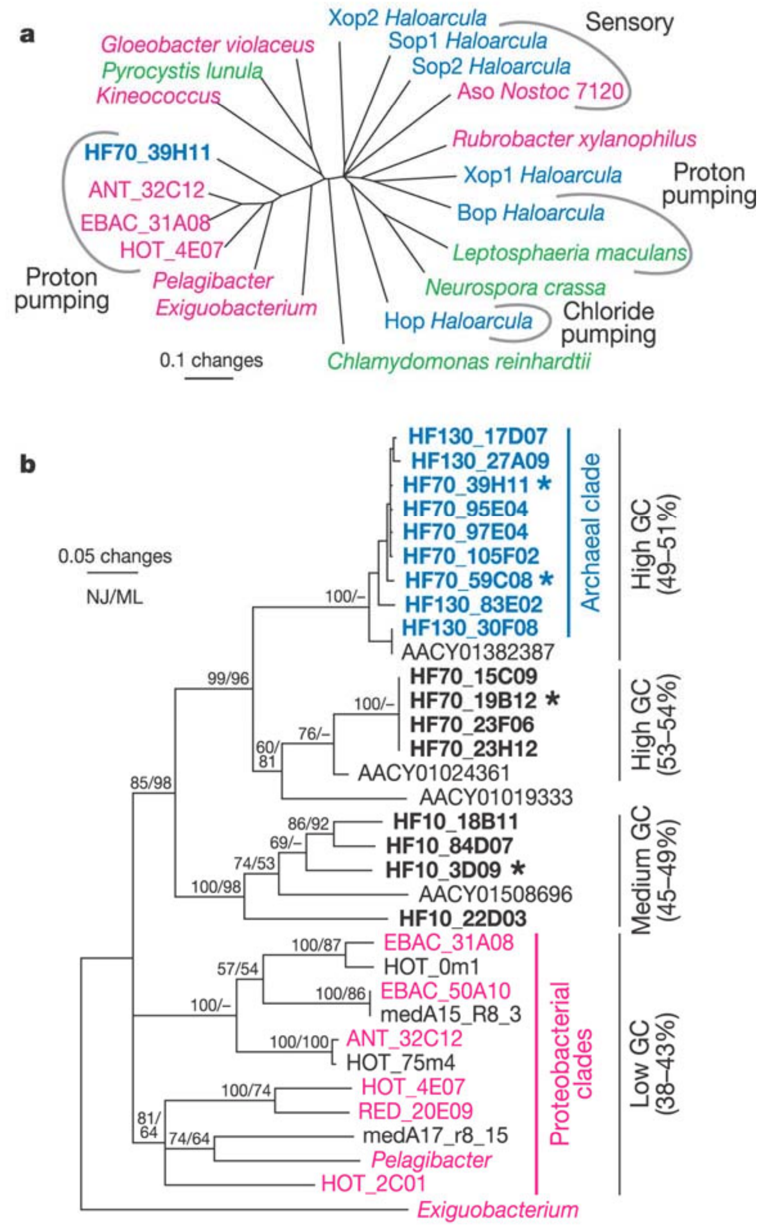


Archaeal- XXXX

Light-driven proton pump of halophilic archaea



Archaeal rhodopsin: retinal structure



Proteorhodopsin
in marine *Bacteria*
and *Archaea*