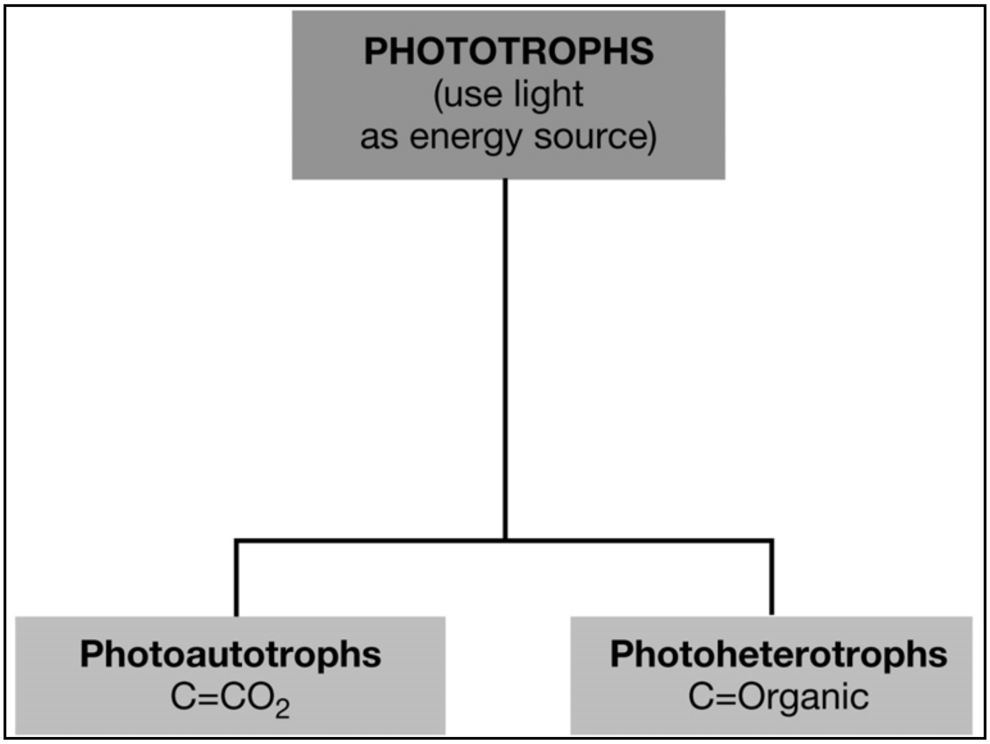
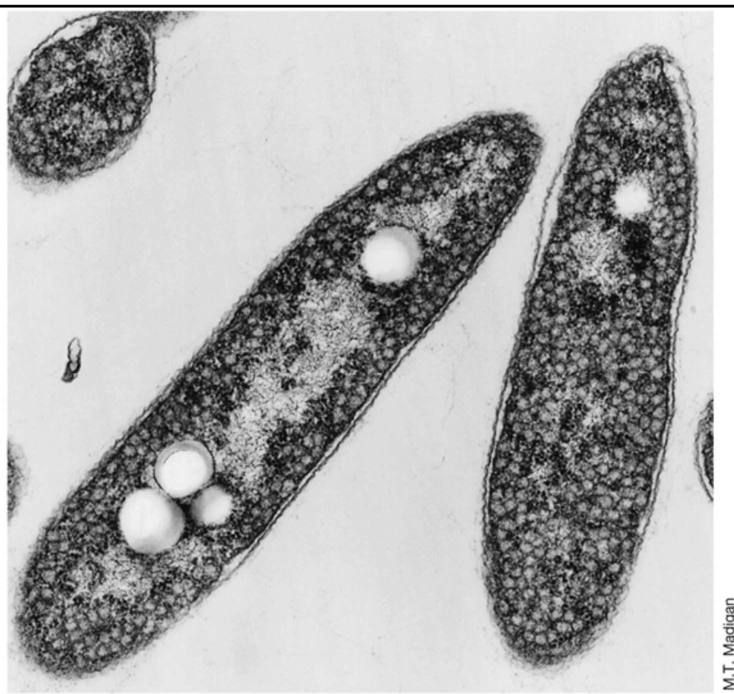
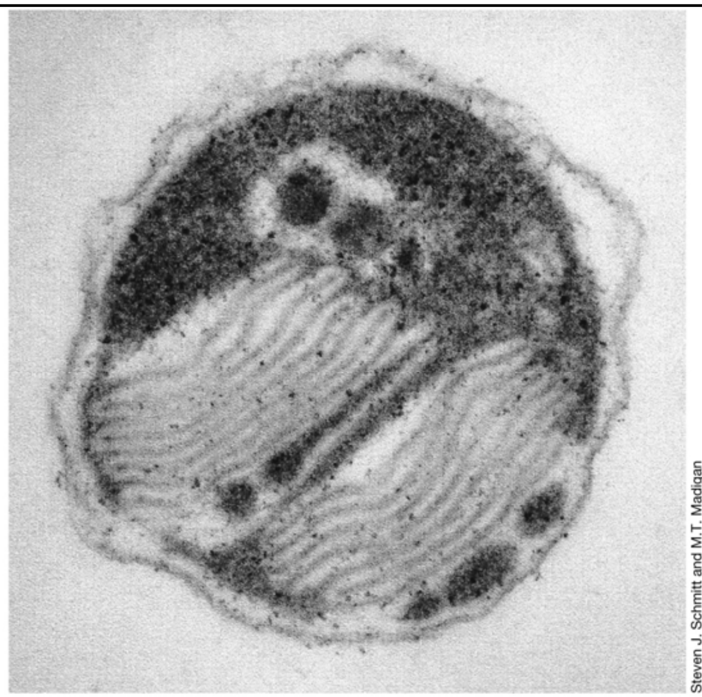
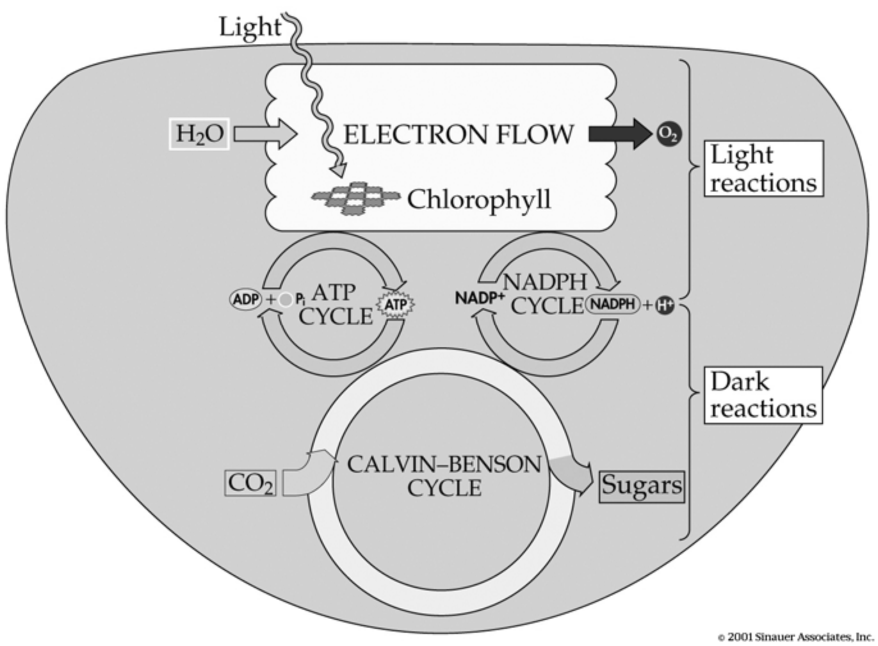

PHOTOTROPHS
(use light
as energy source)
Photoautotrophs
$C=CO_2$
Photoheterotrophs
C=Organic


M.T. Madigan

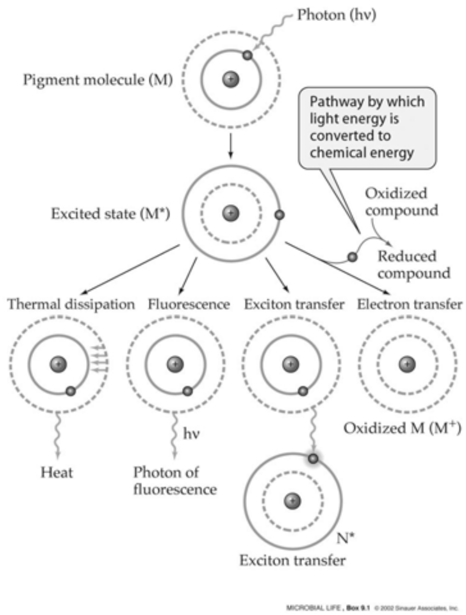
(a)

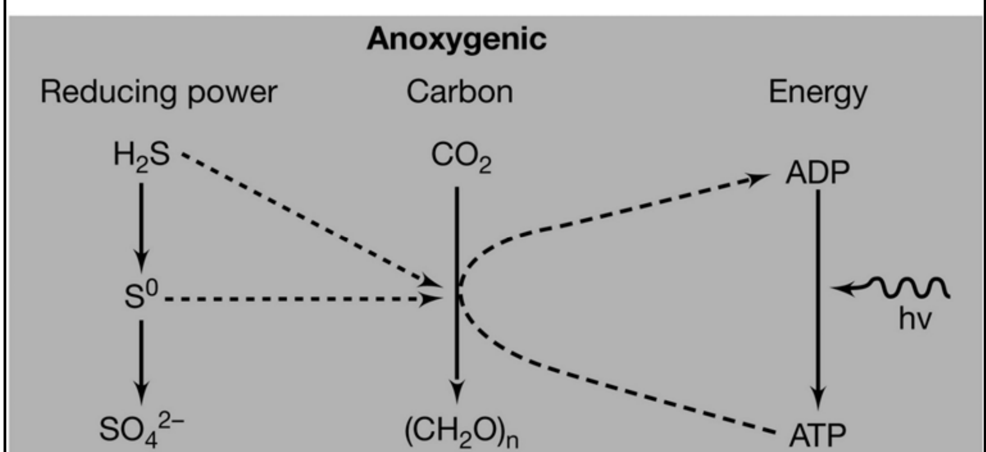

Steven J. Schmitt and M.T. Madigan

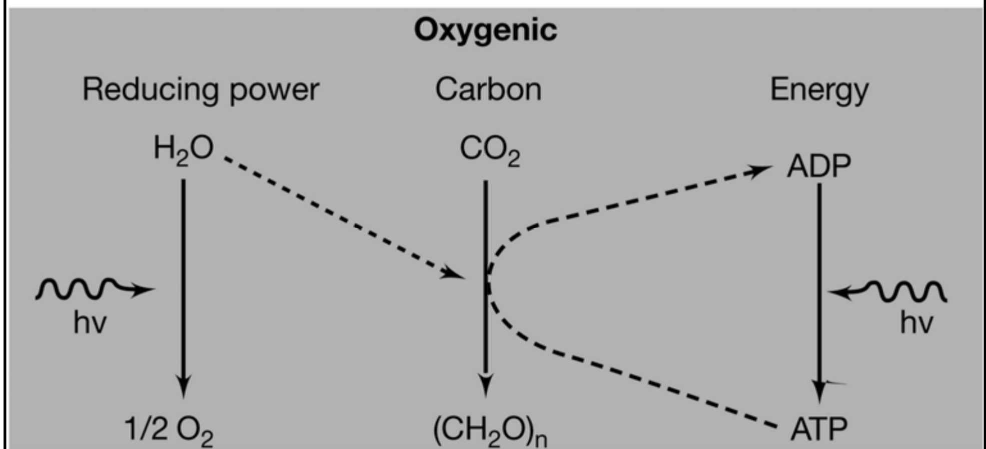
(b)


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
© 2001 Sinauer Associates, Inc.

The possible fates of an excited electron

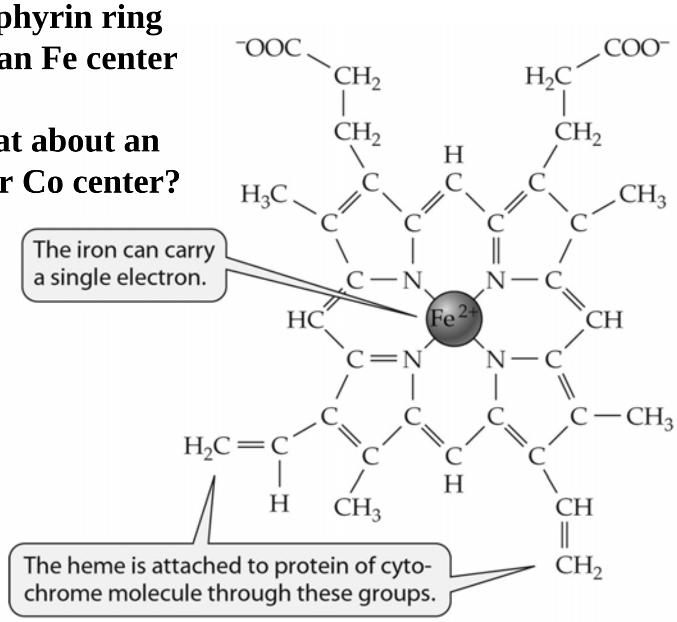


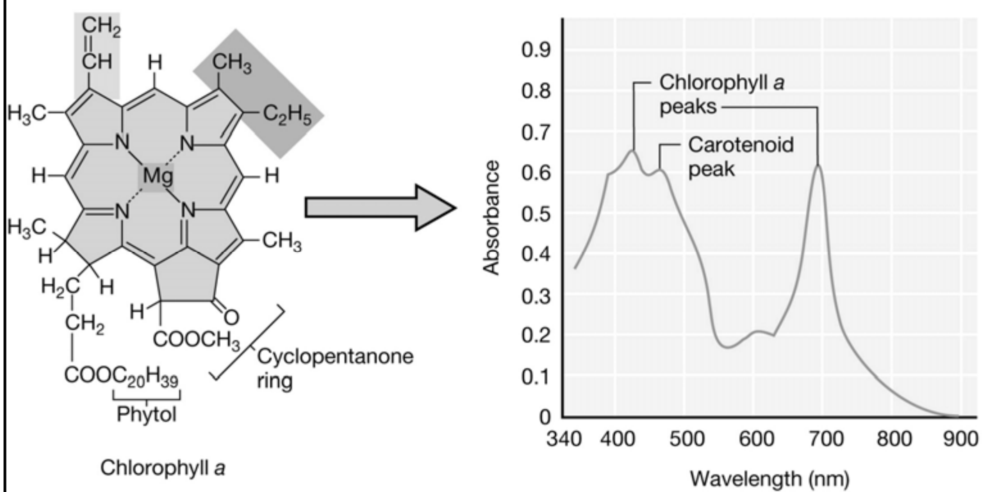


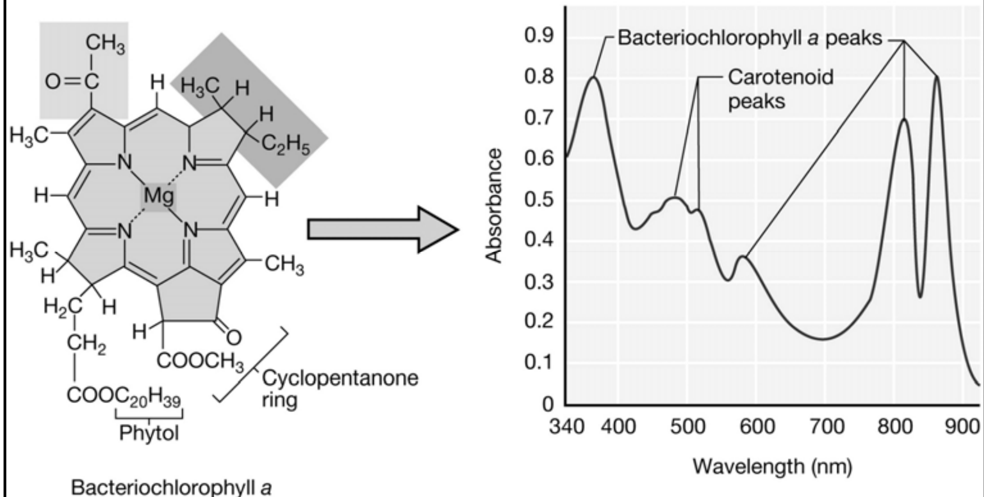


Porphyrin ring with an Fe center

What about an Mg or Co center?

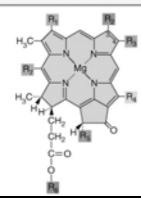



CH2
CH
H
CH3
H3C
C2H5
N
Mg
N
H
H
N
N
H3C
CH3
H
H2C
H
H
O
CH2
COOCH3
Cyclopentanone ring
COOC20H39
Phytol
Chlorophyll a
Absorbance
Chlorophyll a peaks
Carotenoid peak
Wavelength (nm)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
340
400
500
600
700
800
900


CH3
O=C
H
H3C
H
H
C2H5
H3C
N
Mg
N
H
H
N
N
H3C
CH3
H
H2C
H
H
O
CH2
COOCH3
Cyclopentanone ring
COOC20H39
Phytol
Bacteriochlorophyll a
Absorbance
Bacteriochlorophyll a peaks
Carotenoid peaks
Wavelength (nm)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
340
400
500
600
700
800
900

Pigment	R_1	R_2	R_3	R_4	R_5	R_6	R_7	Absorption maxima (nm) In vivo	Absorption maxima (nm) Extract (methanol)
Bacteriochlorophyll *a* (purple bacteria)	$-C(=O)-CH_3$	$-CH_3$[b]	$-CH_2-CH_3$	$-CH_3$	$-C(=O)-O-CH_3$	P/Gg[a]	—H	805 830–890	771
Bacteriochlorophyll *b* (purple bacteria)	$-C(=O)-CH_3$	$-CH_3$[c]	$=C(H)-CH_3$	$-CH_3$	$-C(=O)-O-CH_3$	P	—H	835–850 1020–1040	794
Bacteriochlorophyll *c* (green sulfur bacteria)	$-C(H)(OH)-CH_3$	$-CH_3$	$-C_2H_5$ $-C_3H_7$[d] $-C_4H_9$	$-C_2H_5$ $-CH_3$	—H	F	$-CH_3$	745–755	660–669
Bacteriochlorophyll c_s (green nonsulfur bacteria)	$-C(H)(OH)-CH_3$	$-CH_3$	$-C_2H_5$	$-CH_3$	—H	S	$-CH_3$	740	667
Bacteriochlorophyll *d* (green sulfur bacteria)	$-C(H)(OH)-CH_3$	$-CH_3$	$-C_2H_5$ $-C_3H_7$ $-C_4H_9$	$-C_2H_5$ $-CH_3$	—H	F	—H	705–740	654
Bacteriochlorophyll *e* (green sulfur bacteria)	$-C(H)(OH)-CH_3$	$-C(=O)-H$	$-C_2H_5$ $-C_3H_7$ $-C_4H_9$	$-C_2H_5$	—H	F	$-CH_3$	719–726	646
Bacteriochlorophyll *g* (heliobacteria)	$-C(H)=CH_2$	$-CH_3$[b]	$-C_2H_5$	$-CH_3$	$-C(=O)-O-CH_3$	F	—H	670, 788	765

[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.



Bacteriochlorophyll Structures

Chloroplast Structure

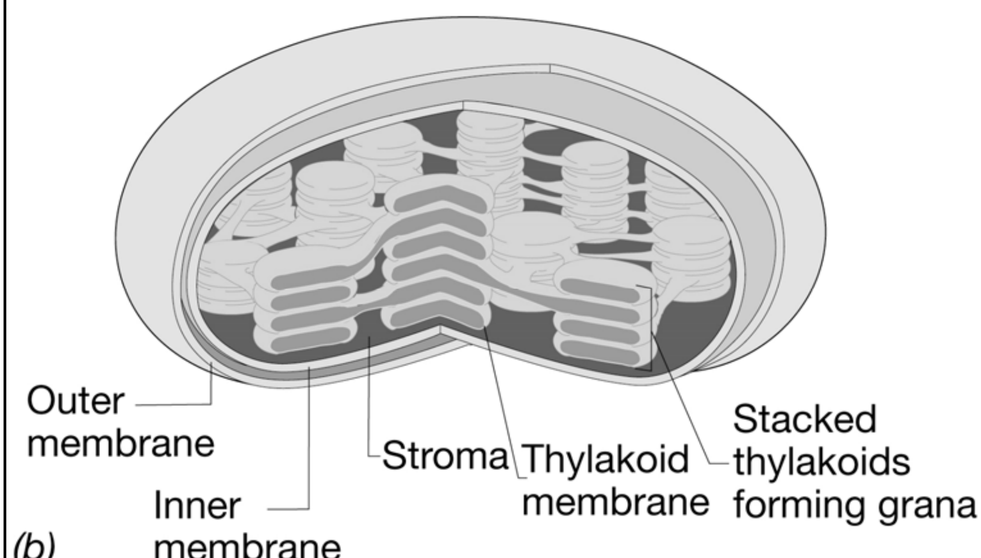
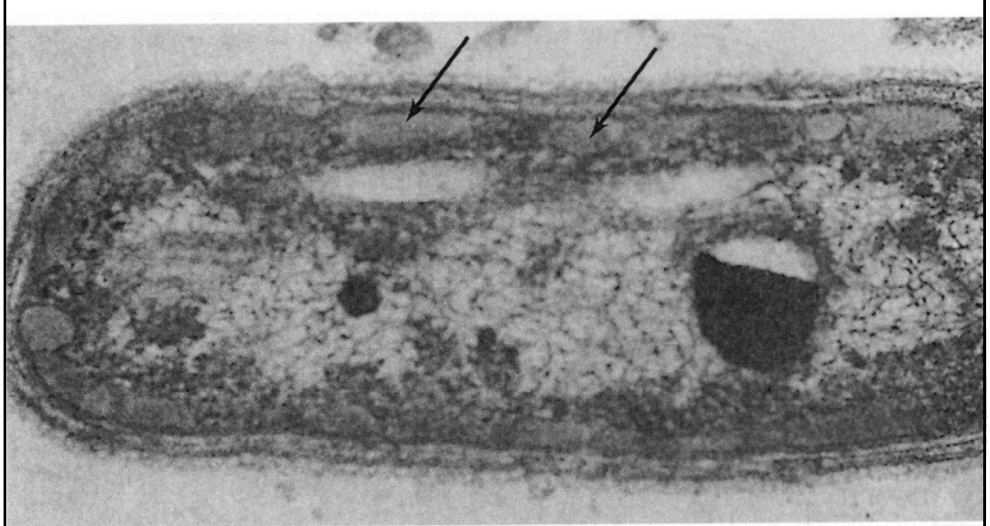


Table 9.1 Some general properties of the various photosynthetic bacteria

	Nonsulfur Purple Bacteria	Purple Sulfur Bacteria	Green Sulfur Bacteria	Cyano-bacteria	Helio-bacteria
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.

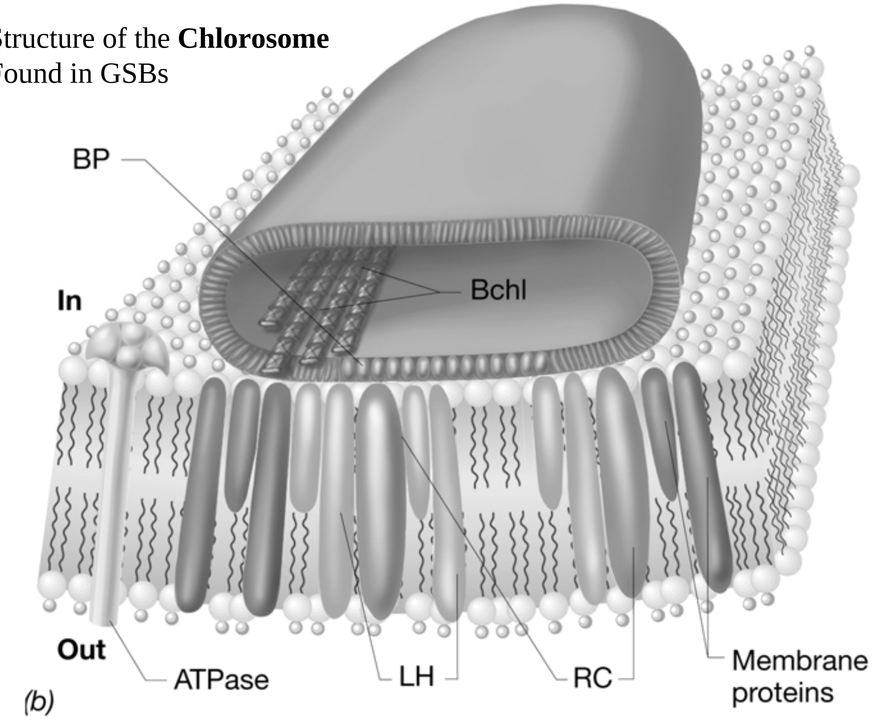
Structure and Location of the **Chlorosome**



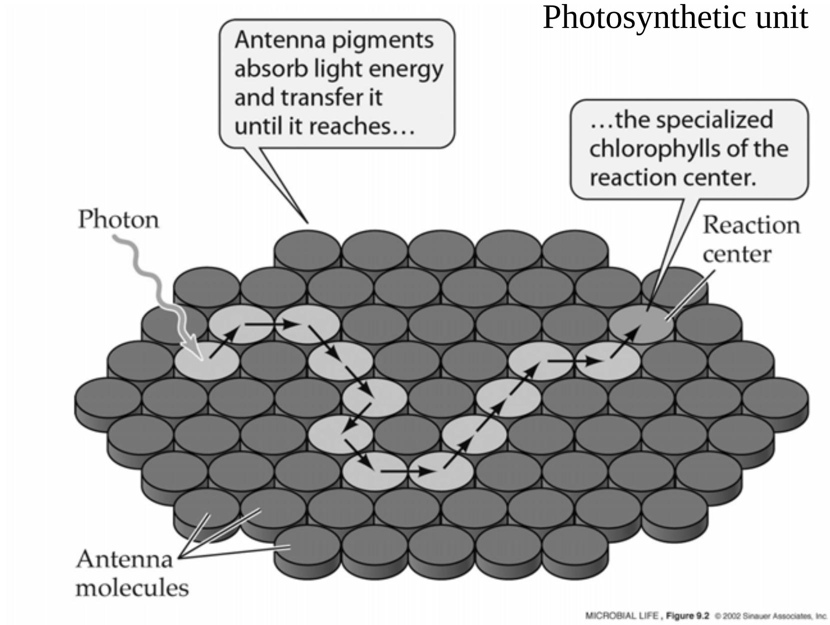
(a)

Found in GSBs

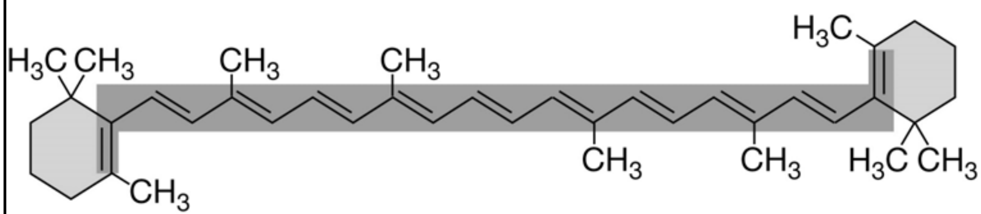
Structure of the **Chlorosome**
Found in GSBs



Photosynthetic unit



Beta-Carotene, a typical carotenoid



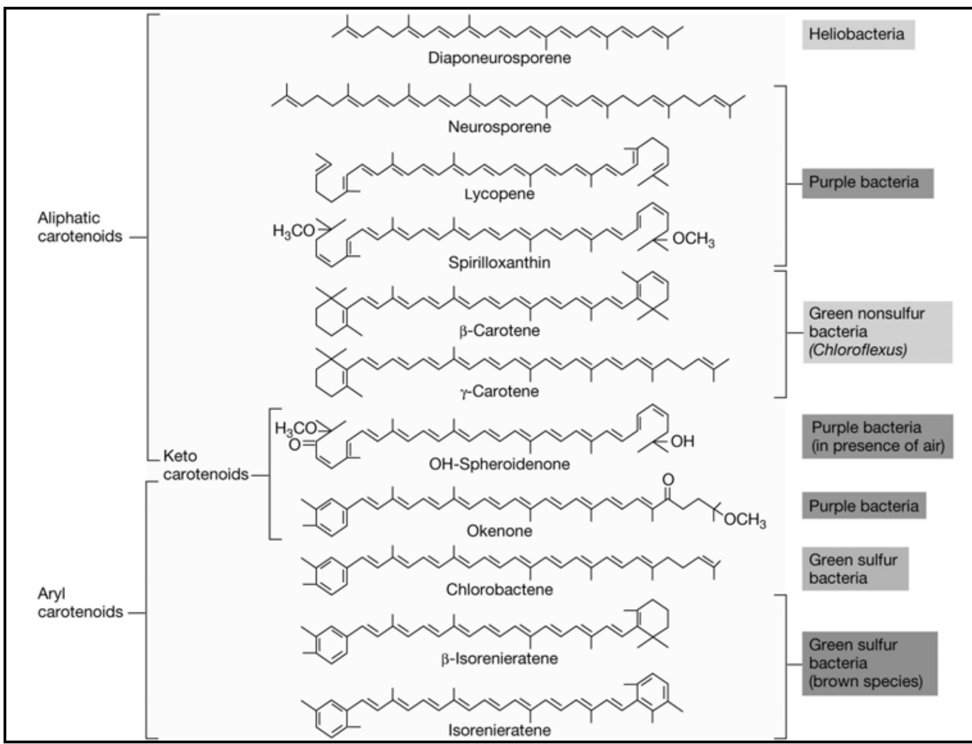
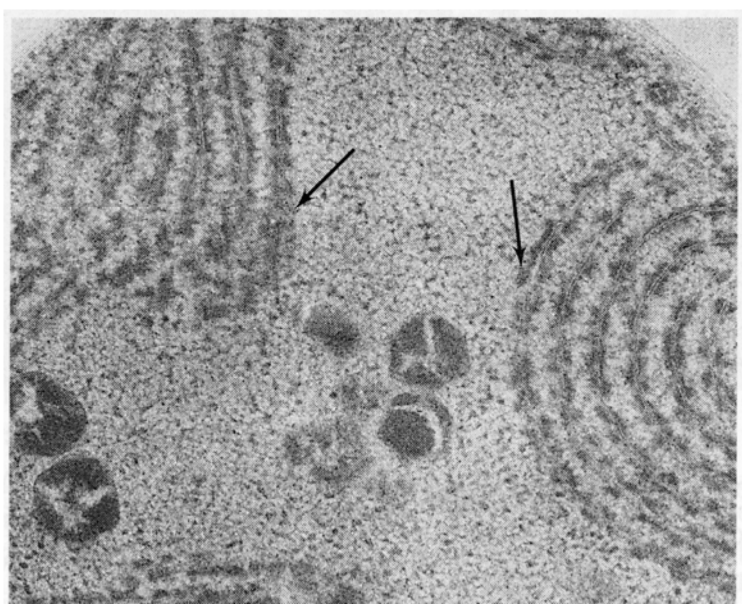


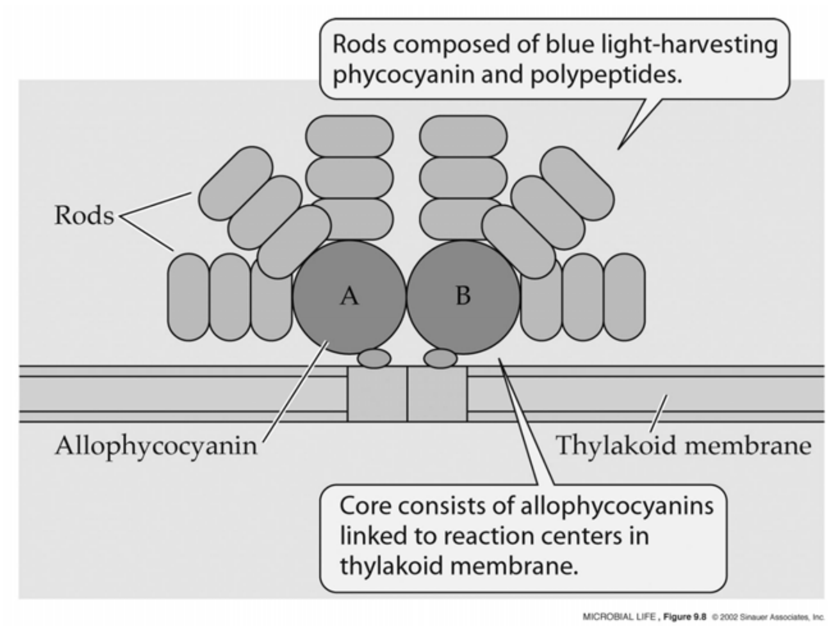
Table 9.2 The bacteriochlorophyll present in photosynthetic bacteria and primary acceptors involved in energy conserving reactions

	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

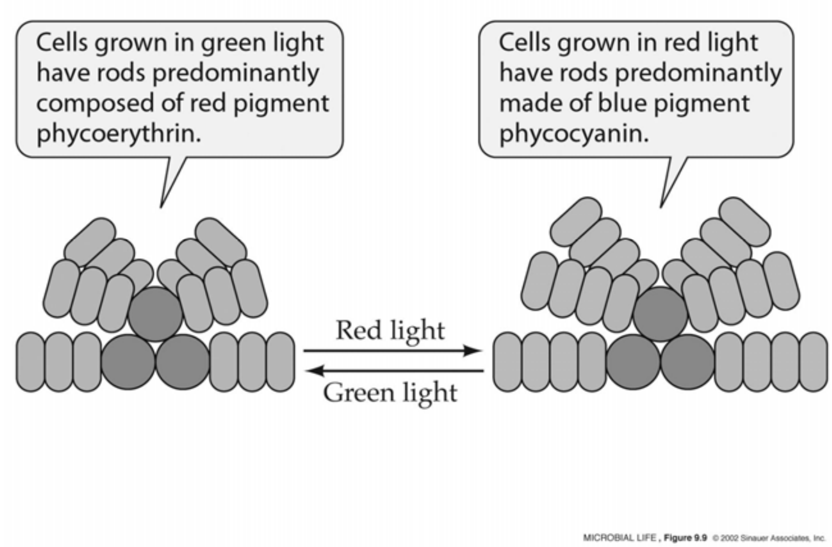
Structure and Location of **Phycobilisomes**



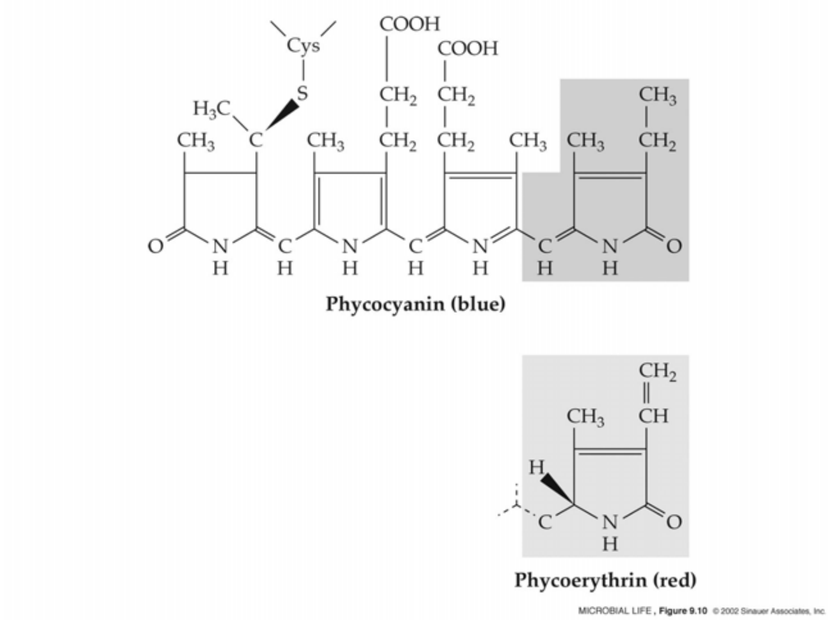
Phycobilisome of cyanobacteria



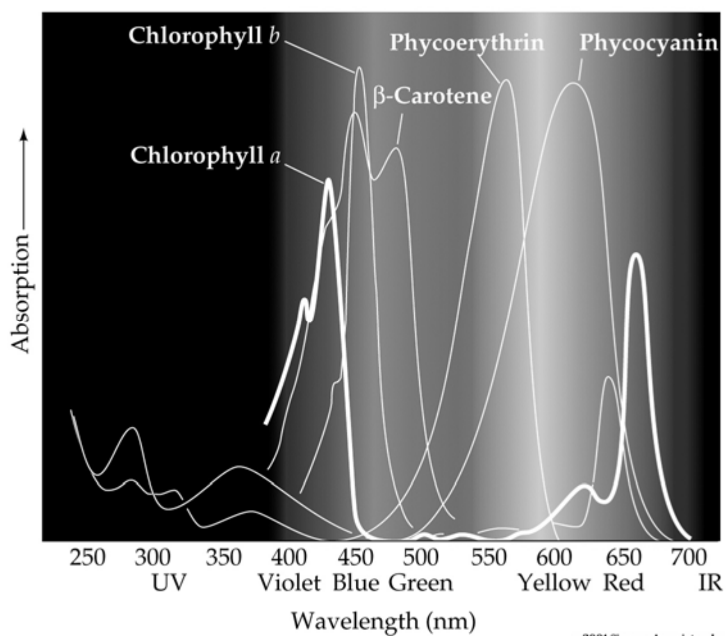
Chromatic adaptation of a phycobilisome

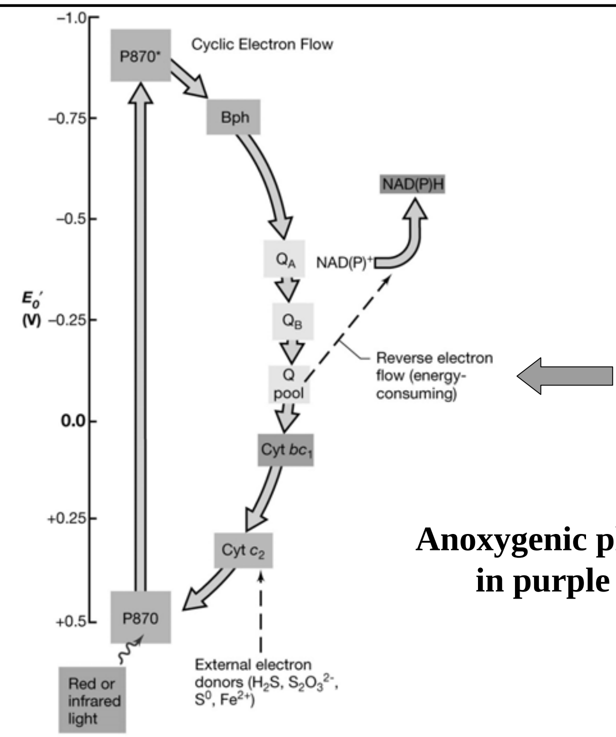


Chromophores of phycobilisomes



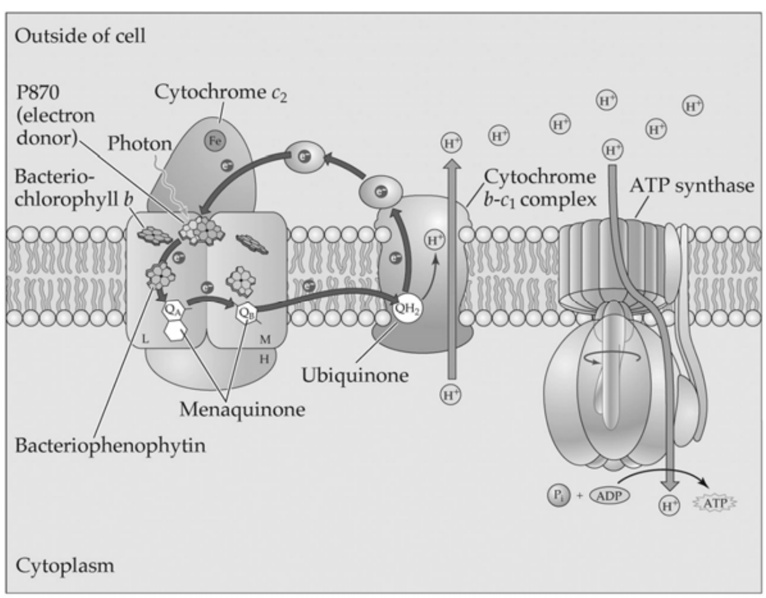
Absorption Spectra



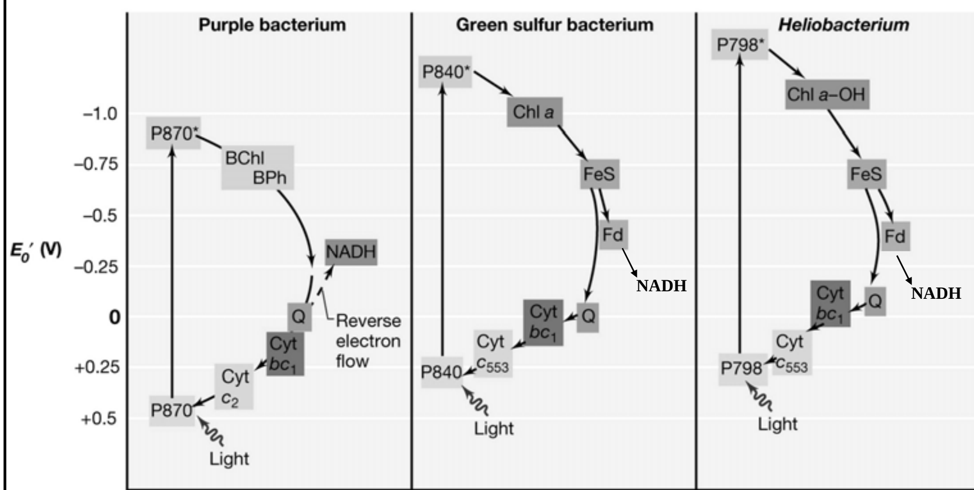


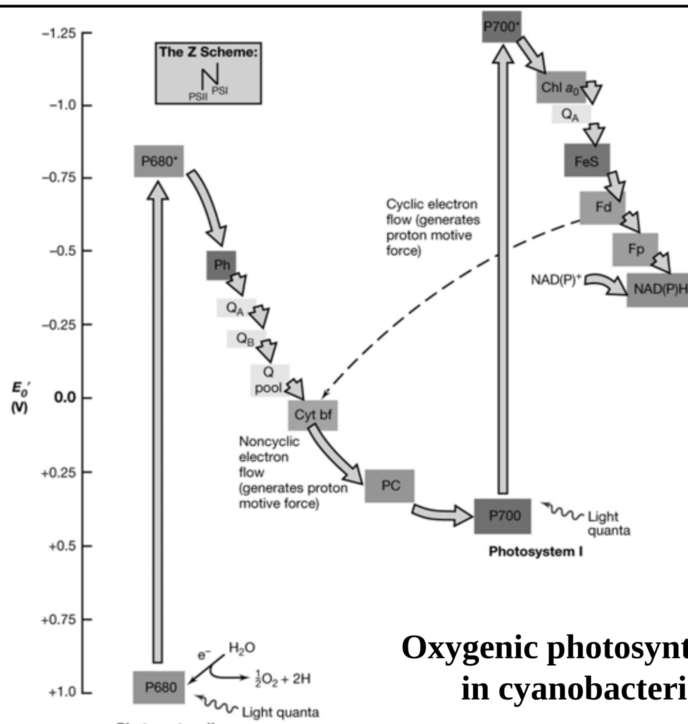
Anoxygenic photosynthesis in purple bacteria

Reaction center of purple nonsulfur bacteria



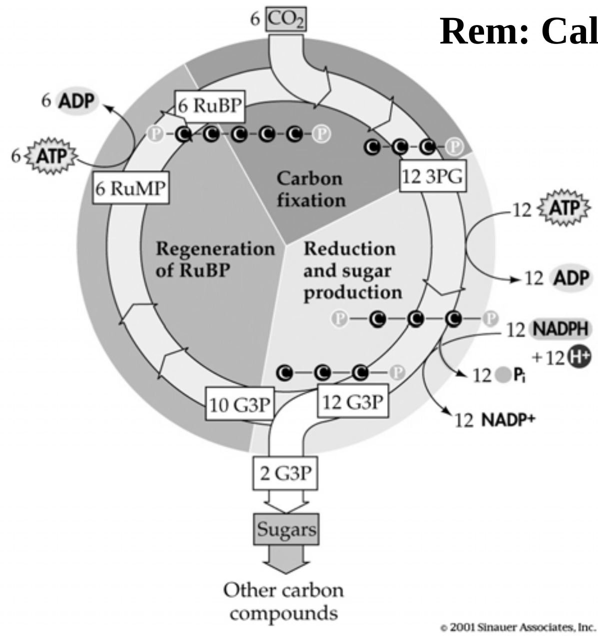
Electron flow in phototrophs

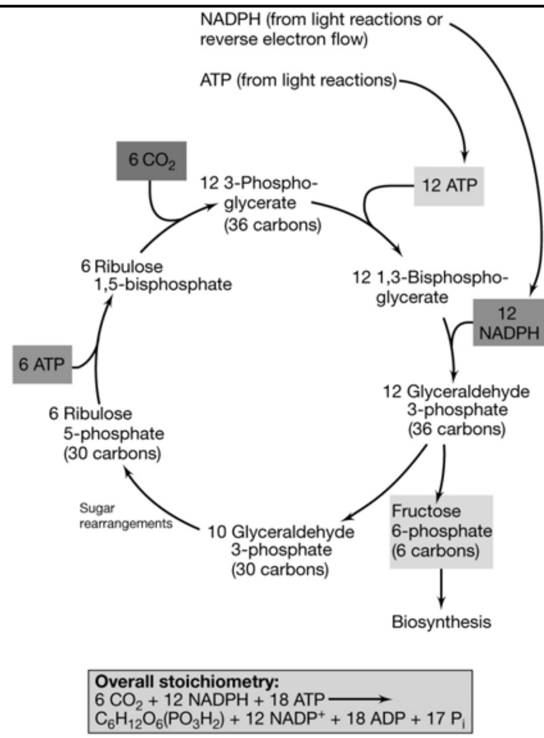




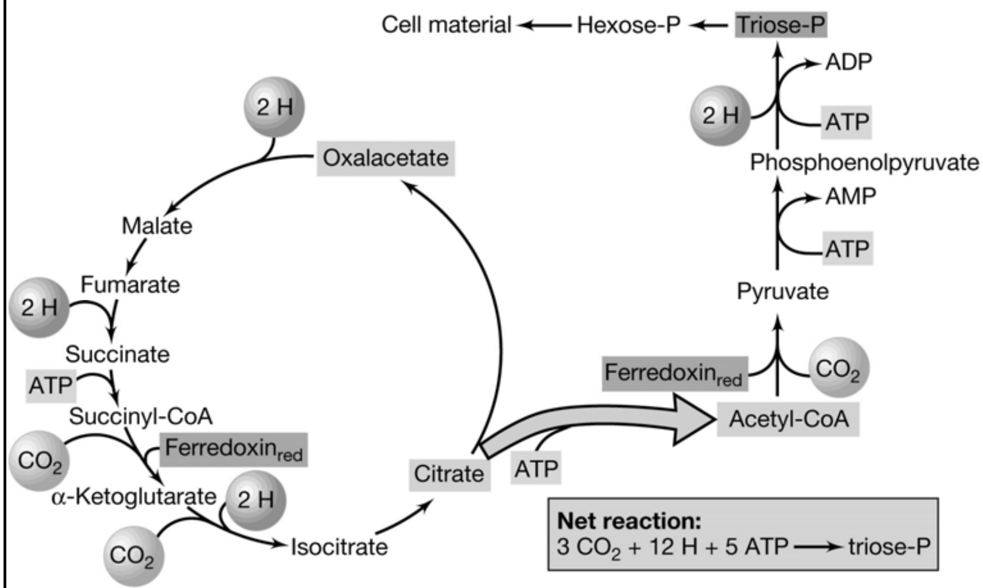
Oxygenic photosynthesis in cyanobacteria

Rem: Calvin Cycle

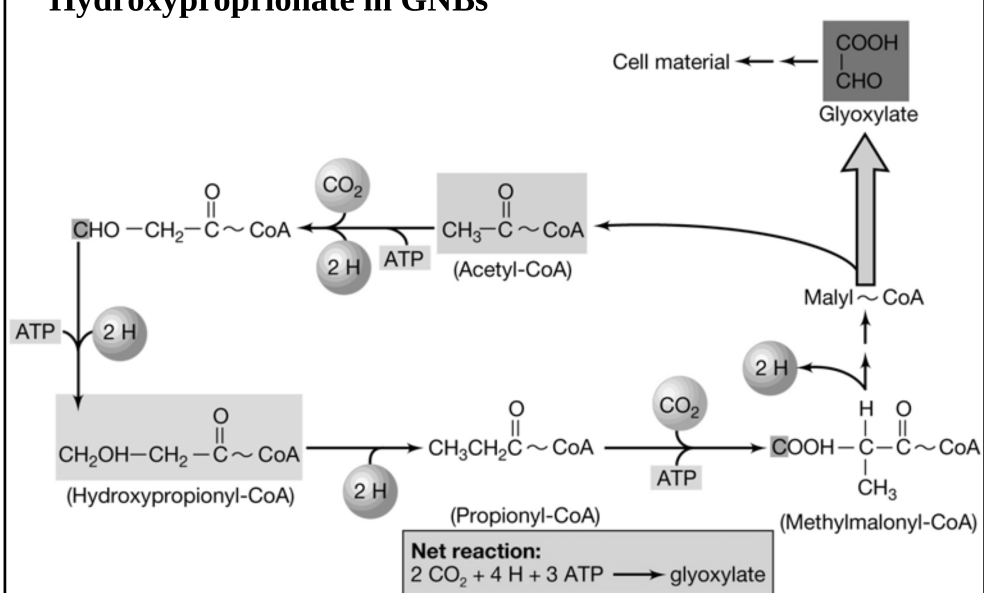




Reverse TCA in GSBs

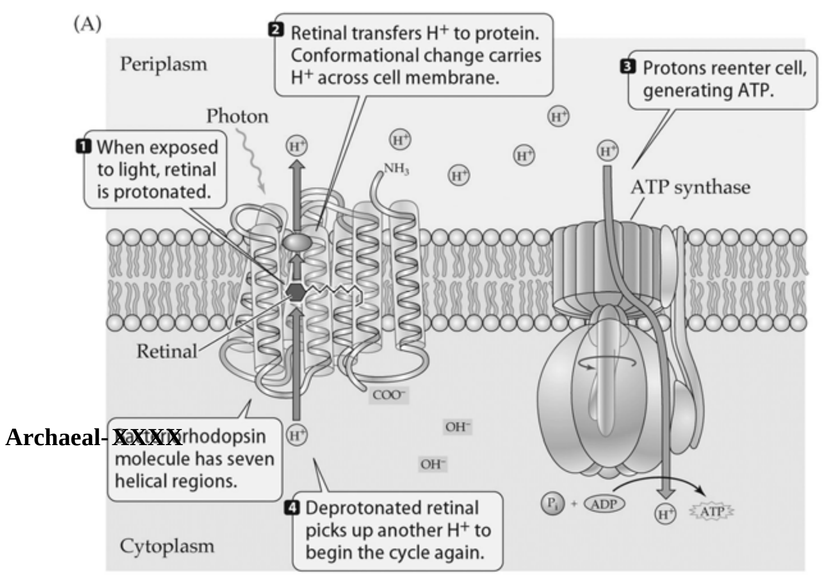


Hydroxyproprionate in GNBs

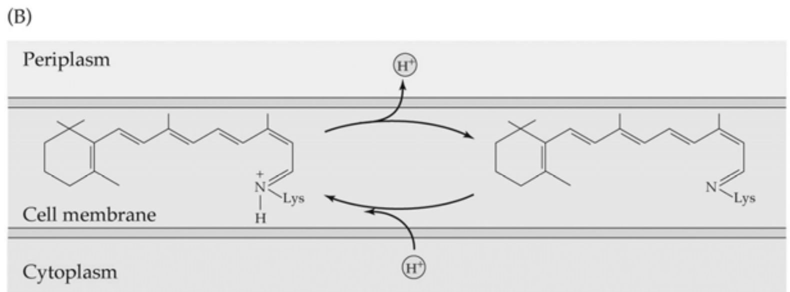


(b)

A light-driven proton pump of halophilic archaea



Light-driven proton pump of halophilic archaea



Archaeal rhodopsin: retinal structure

Banded Iron Formations ~2.5 Bya

Oxygenic or anoxygenic photosynthesis: Fe^{2+}_{sol} to Fe^{3+}_{insol}