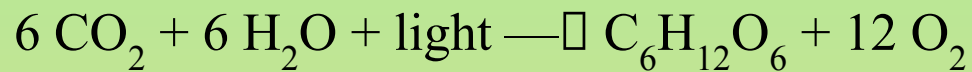
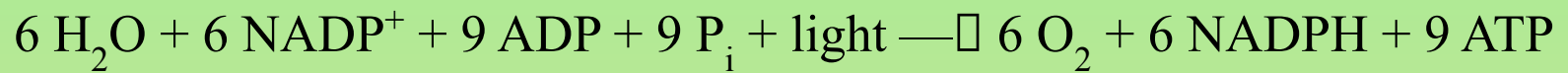
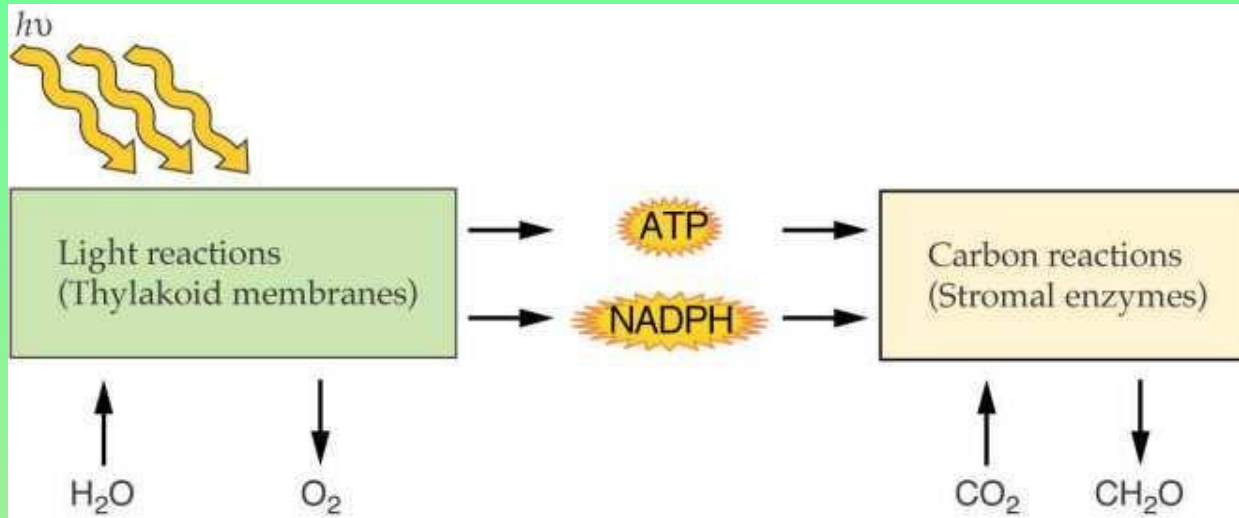
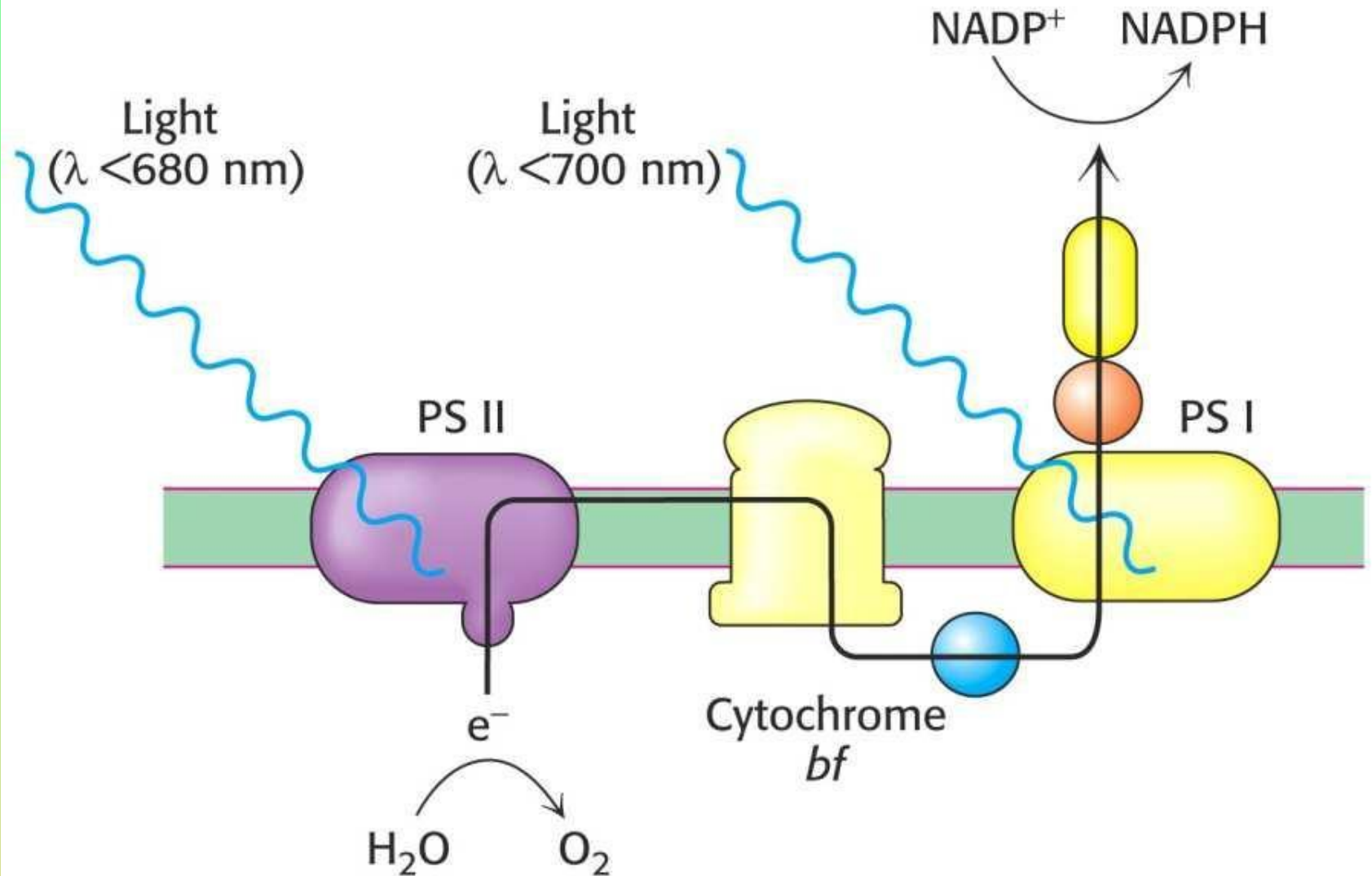


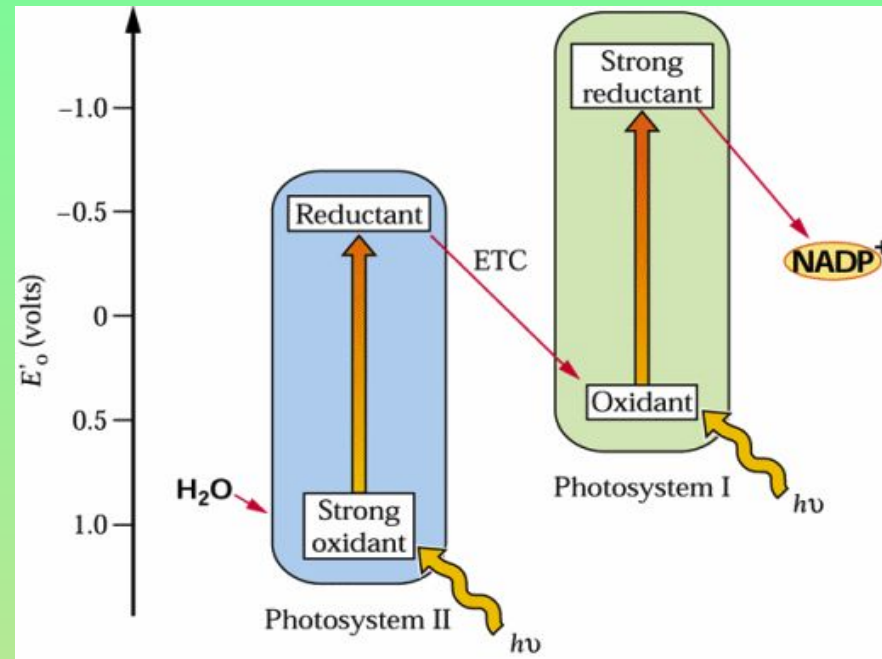
Photosynthesis



Two photosystems generate a proton gradient and NADPH in oxygenic photosynthesis



Oxidants and reductants in photosynthetic electron transfer chain



Oxidace vody
Redukce NADP^+

Energie fotonu = $h\nu = hc/\lambda$
Einstein (1905)

h = Planckova konstanta 6.626×10^{-34} joule s^{-1}

ν = kmitočet /frekvence (Hz)

λ = vlnová délka (nm)

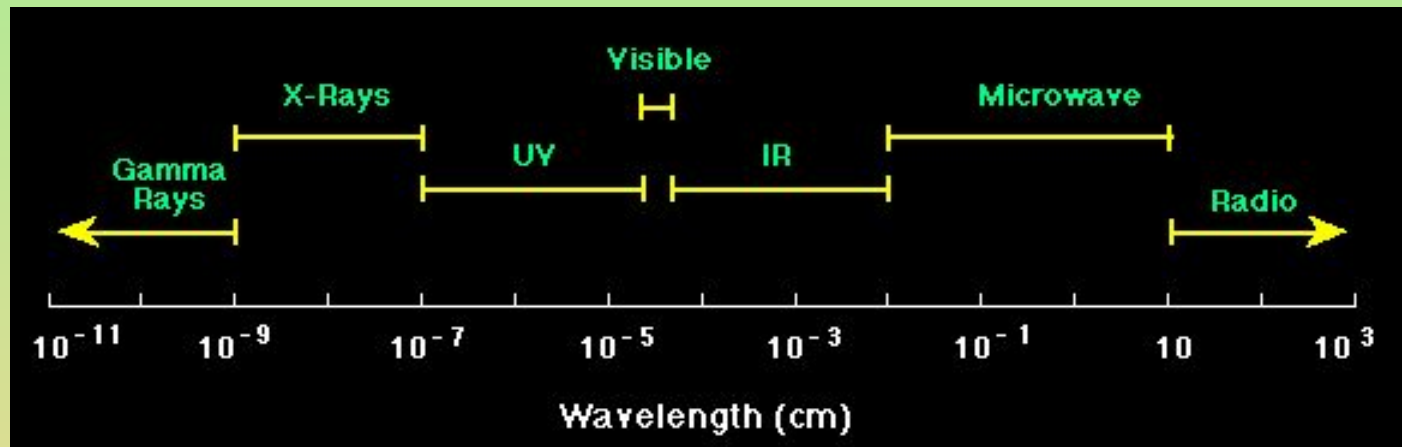
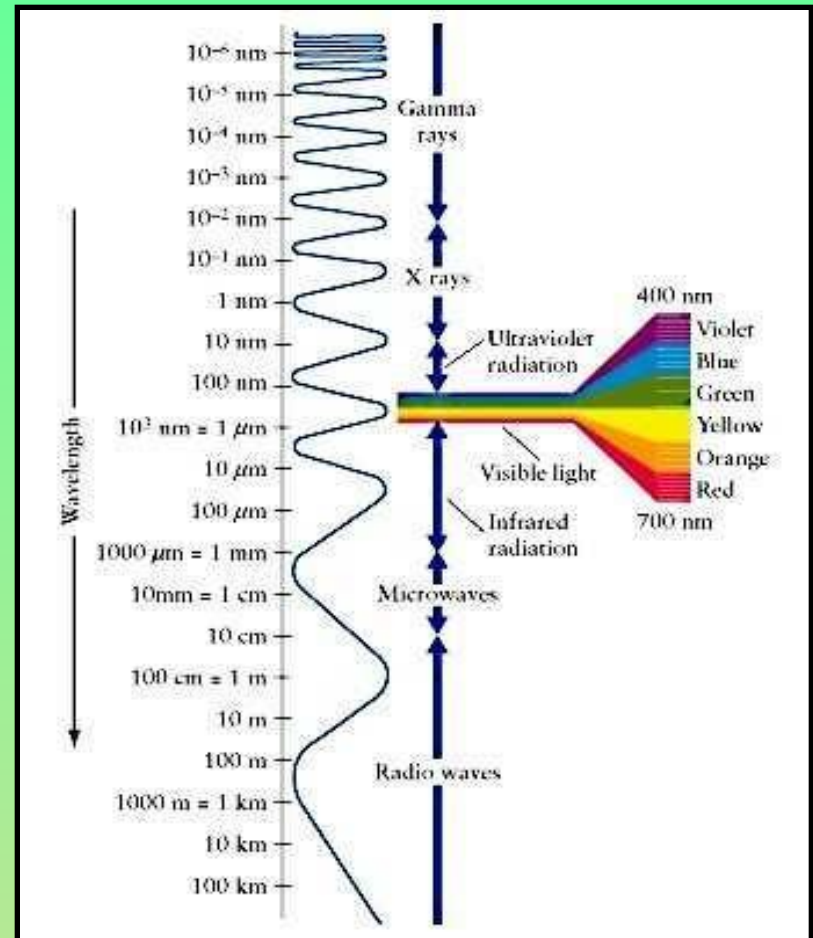
c = rychlost světla

Energie $\propto 1/\text{vlnová délka}$

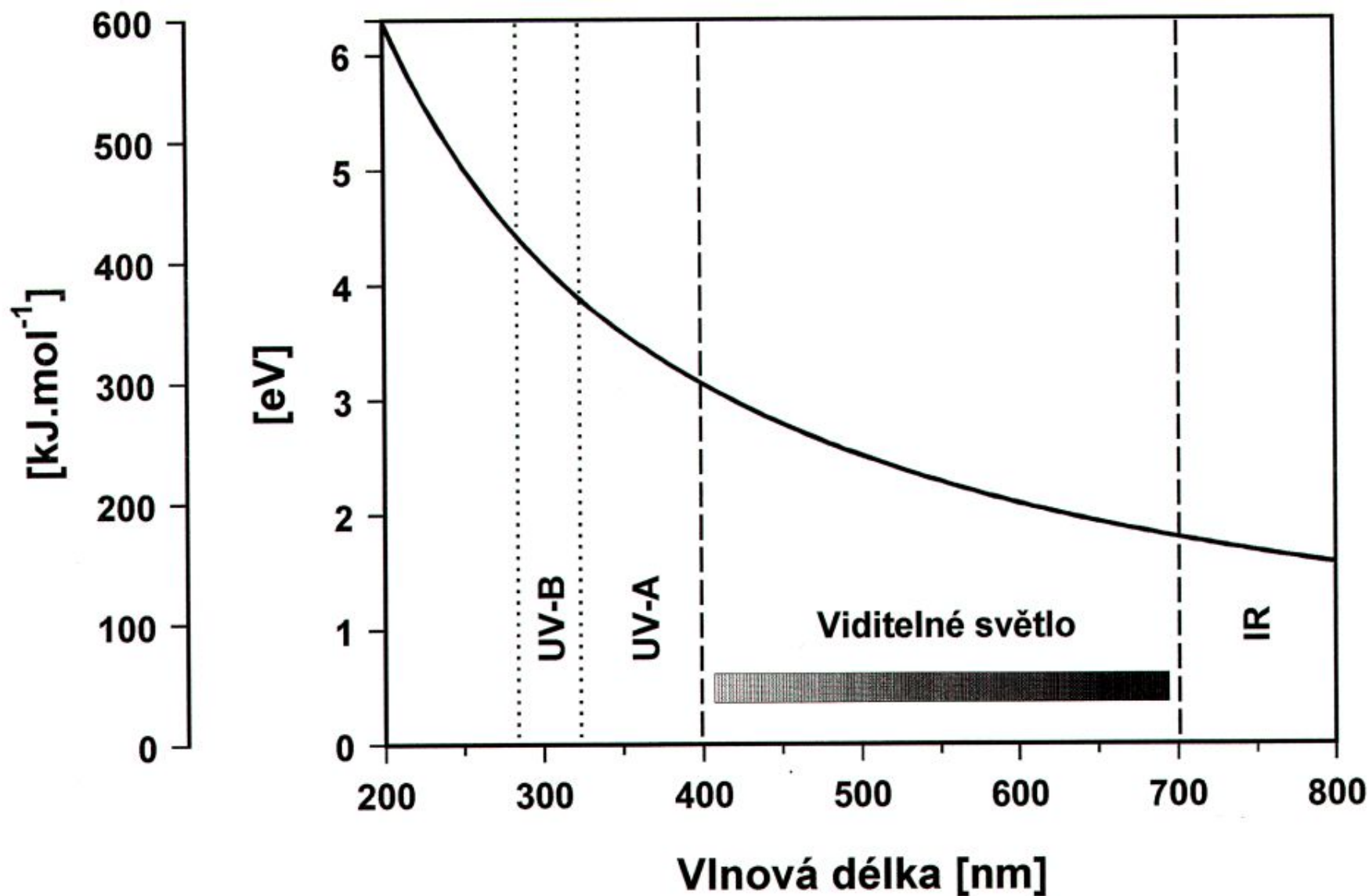
430 nm light 1 foton 3.0 eV

670 nm light 1 foton 1.7 eV

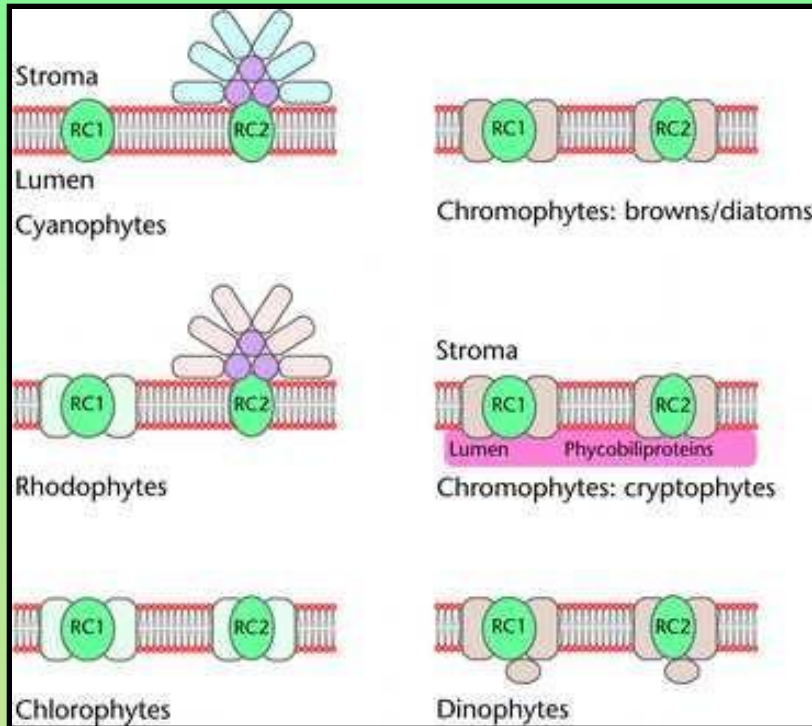
1 eV = energie potřebná k přenesení 1 e^-
rozdílem potenciálů 1V



Závislost energie záření na vlnové délce



Variabilita světloběrných antén



Rhodophyta

Chlorophyll a;
phycoerythrobilin

Chlorophyta

Chlorophylls a & b

Chromophyta

Chlorophylls a, c₁, c₂;
fucoxanthin

Haptophyta

Chlorophylls a, c₁, c₂;
fucoxanthin

Dinophyta

Chlorophylls a, c₂;
peridinin

Cryptophyta

Chlorophylls a, c₂;
phycoerythrobilin

Euglenophyta

Chlorophylls a, b

Fotosyntetické pigmenty:

- Porfyriny – (bakterio)chlorofyly, feofytiny
 - fykobiliny
- Polyisopreny – karotenoidy (karoteny, xanthofyly)

Funkce fotosyntetických pigmentů

- Zachycení a přenos fotonů
 - (B)chlorofyly a,b,c,d,e, fykobiliny, xanthofyly
- Fotochemická přeměna energie – RC
 - Chlorofyl a, Bchl a, Bchl b
- Ochrana před triplety a nadměrnou excitací
 - Karoteny, xanthofyly
- Strukturní funkce
 - Karoteny, xanthofyly

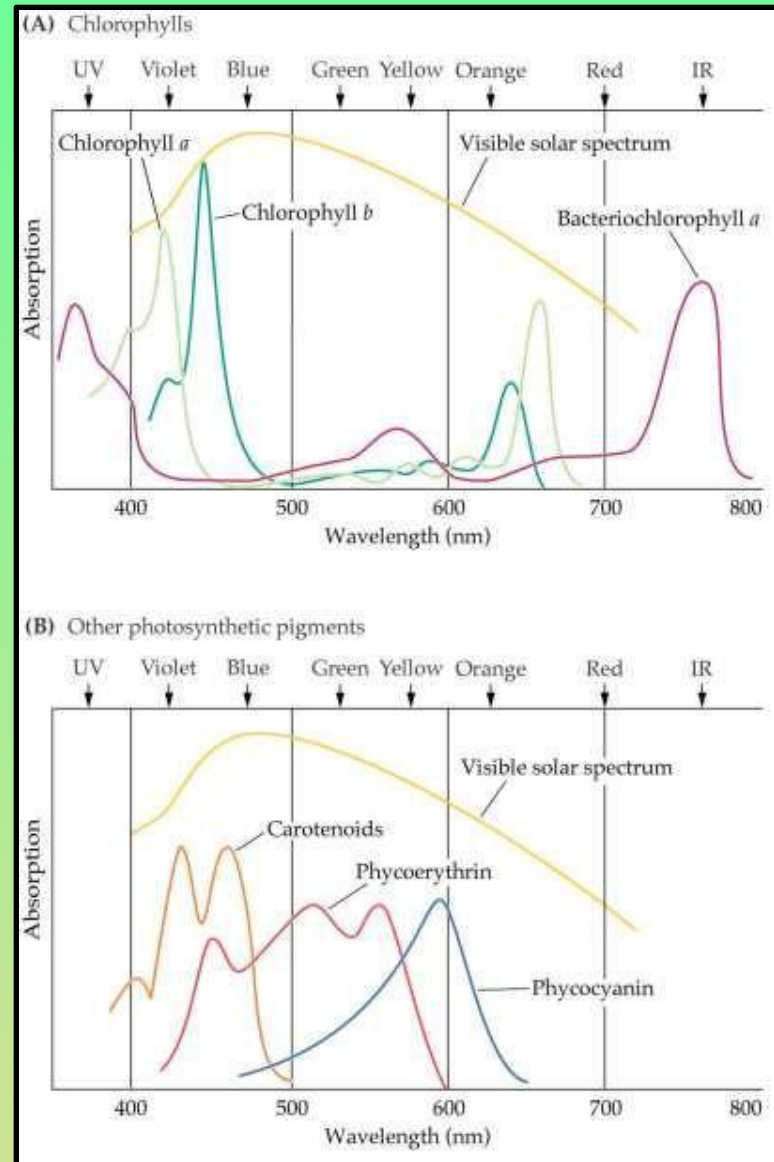
Zachycení energie

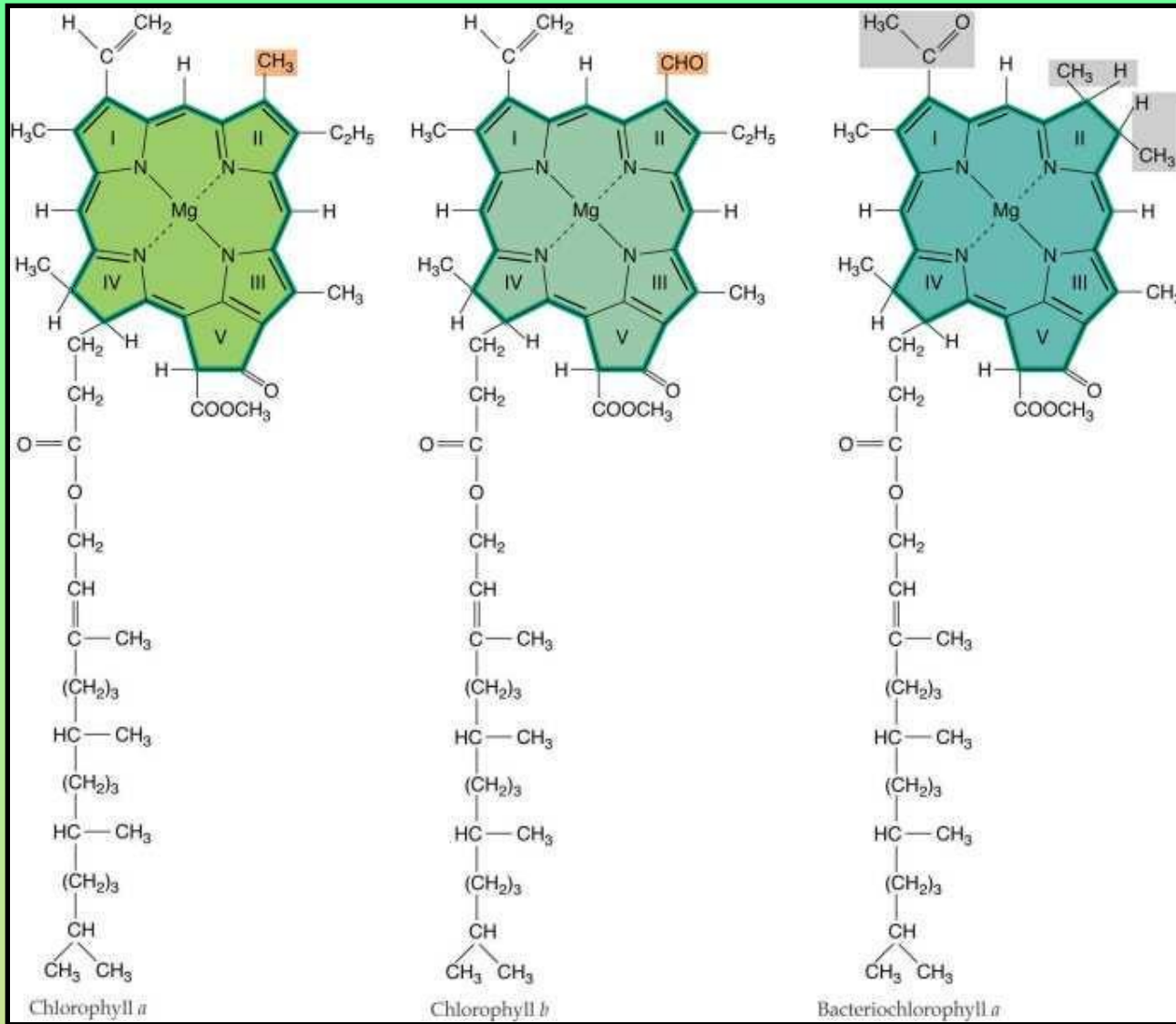


Přenos energie



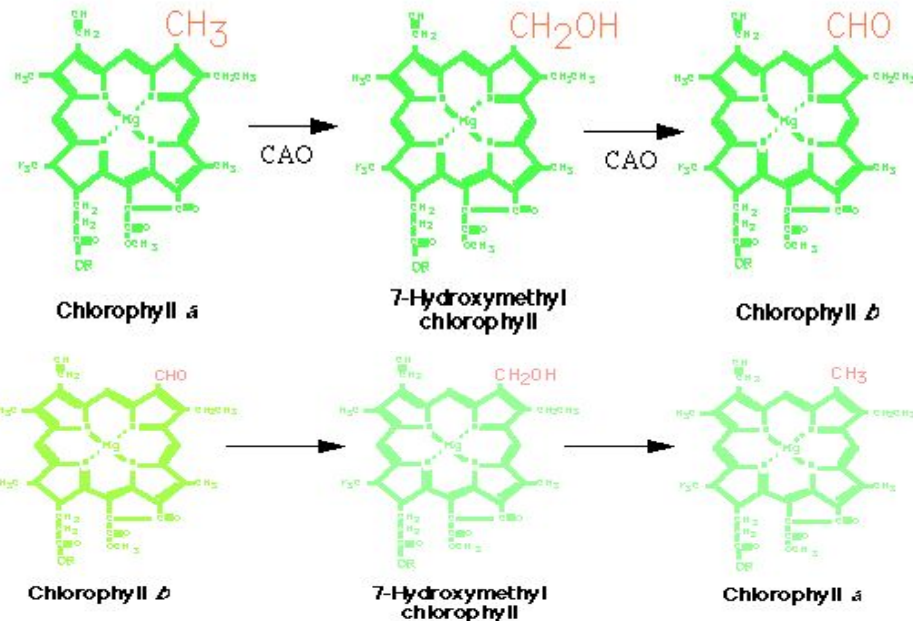
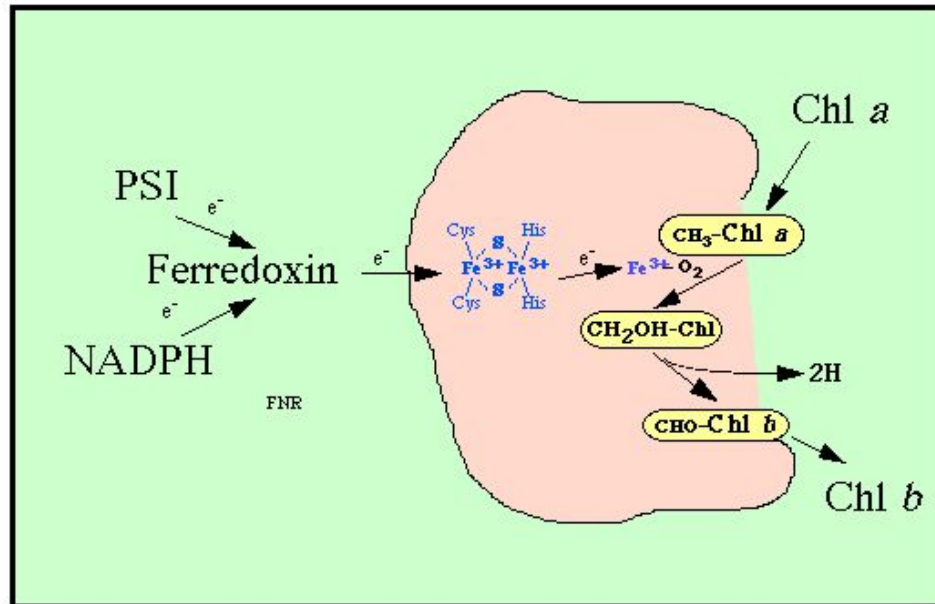
Využití energie





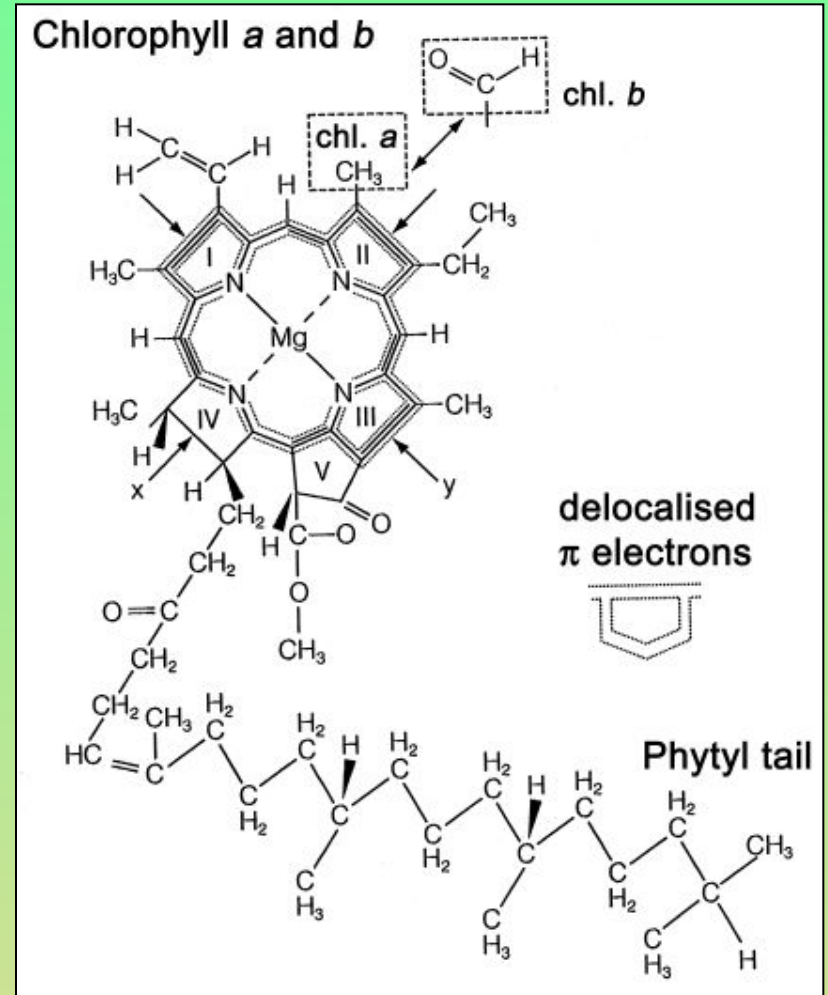
Prochlorophytes?

Chlorophyll *a* Oxygenase

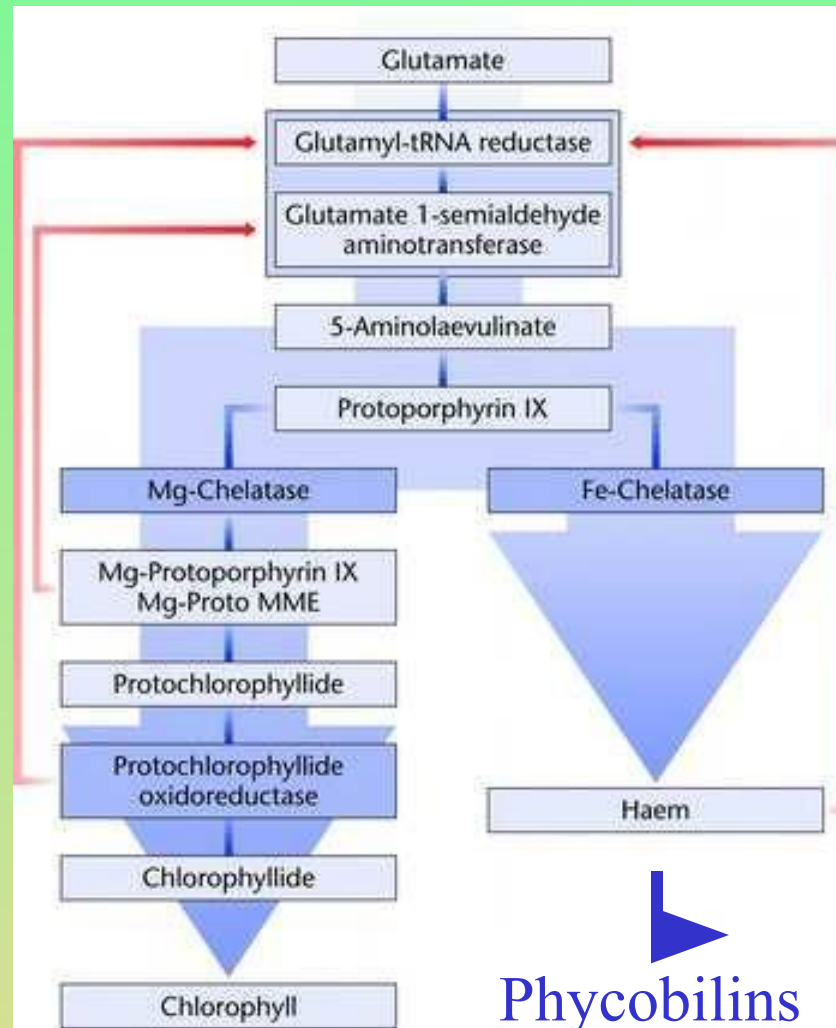


Chlorofyly

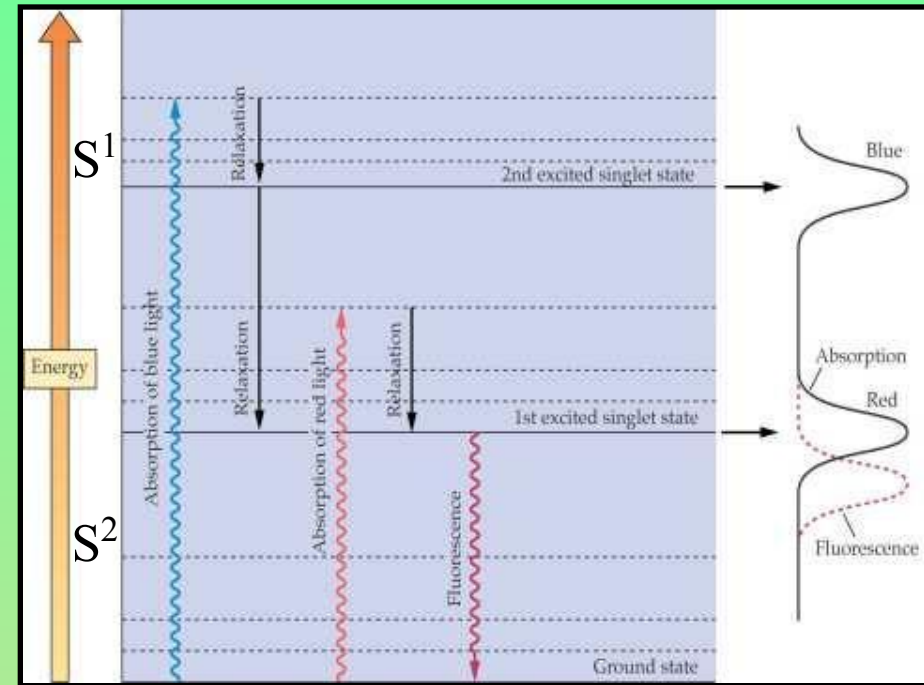
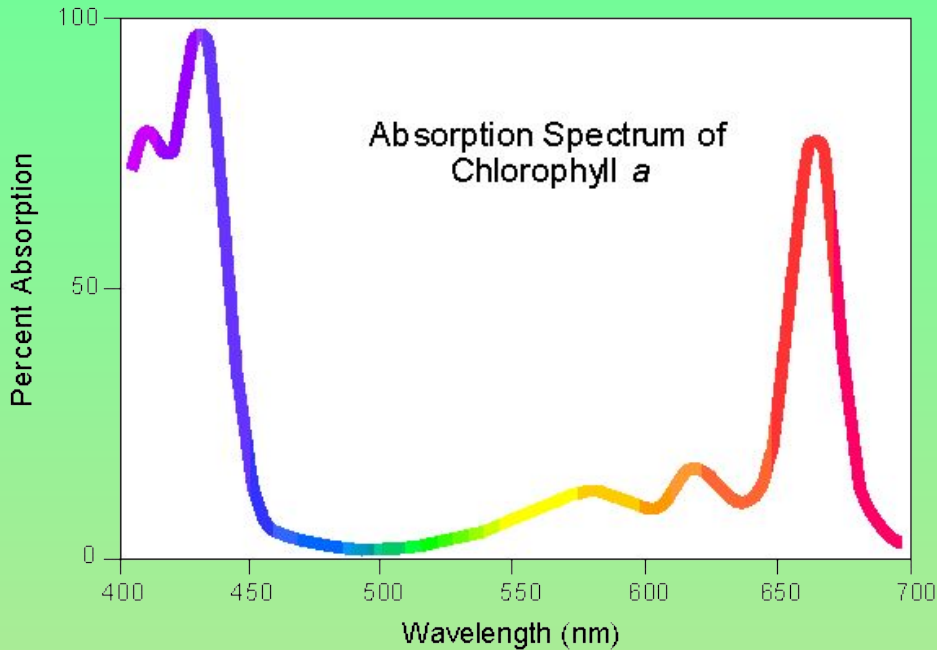
- Porfyrinová „hlava“:
tetrapyrol + Mg
- Phytolový řetězec – „ocásek“
ukotvení v membráně



Regulace syntézy tetrapyrólů



Absorbce světla



- Absorbce přesune e^- do vyššího excitovaného stavu
- Pokud je nestabilní, energie se ztratí ve formě tepla (S^1 na S^2)
- S^1 může energii rezonančně předat (RET) nebo vyzářit jako fluorescenci

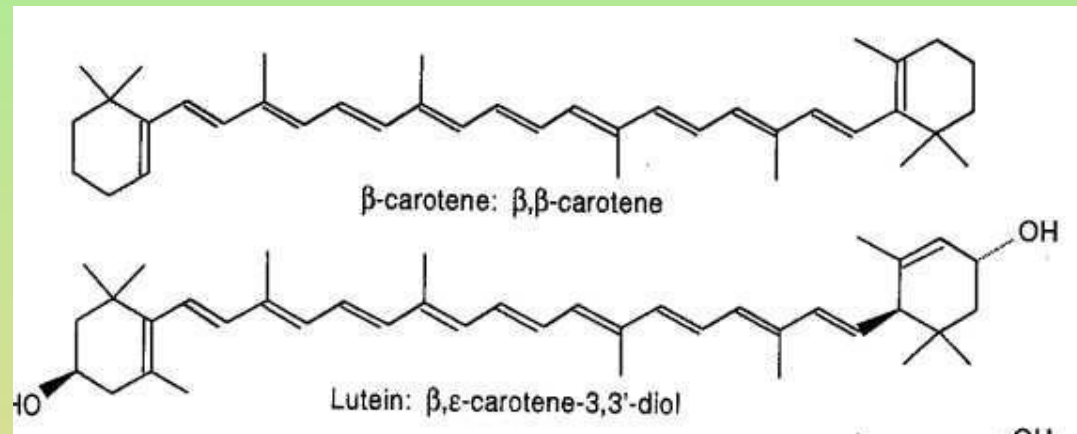
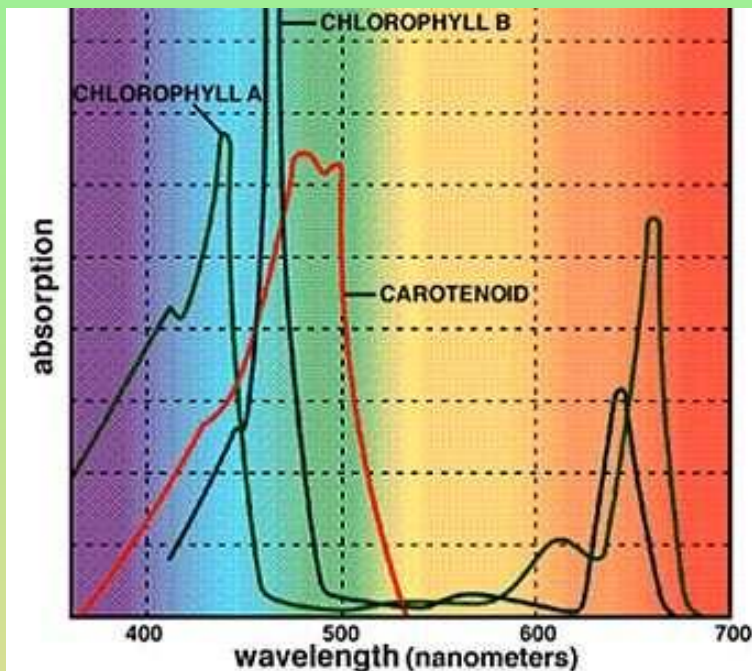
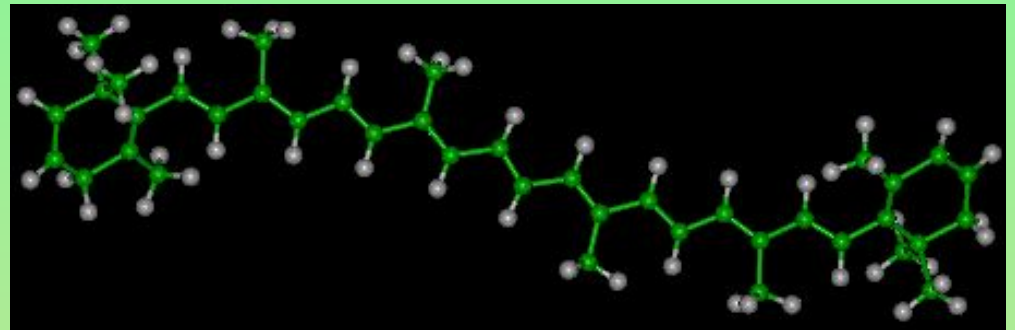
Karotenoidy

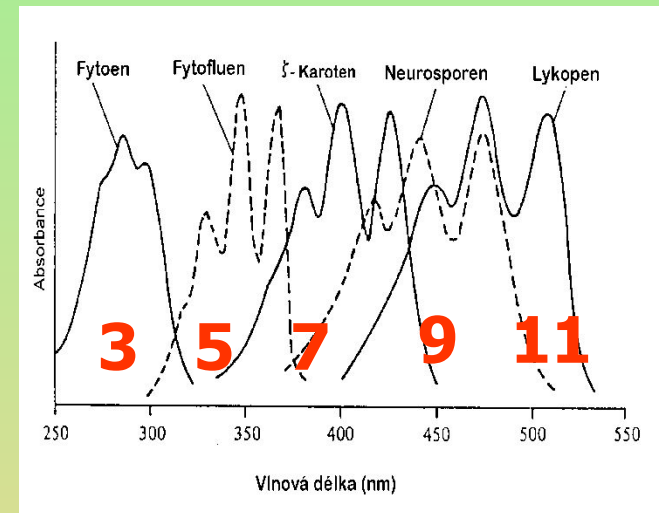
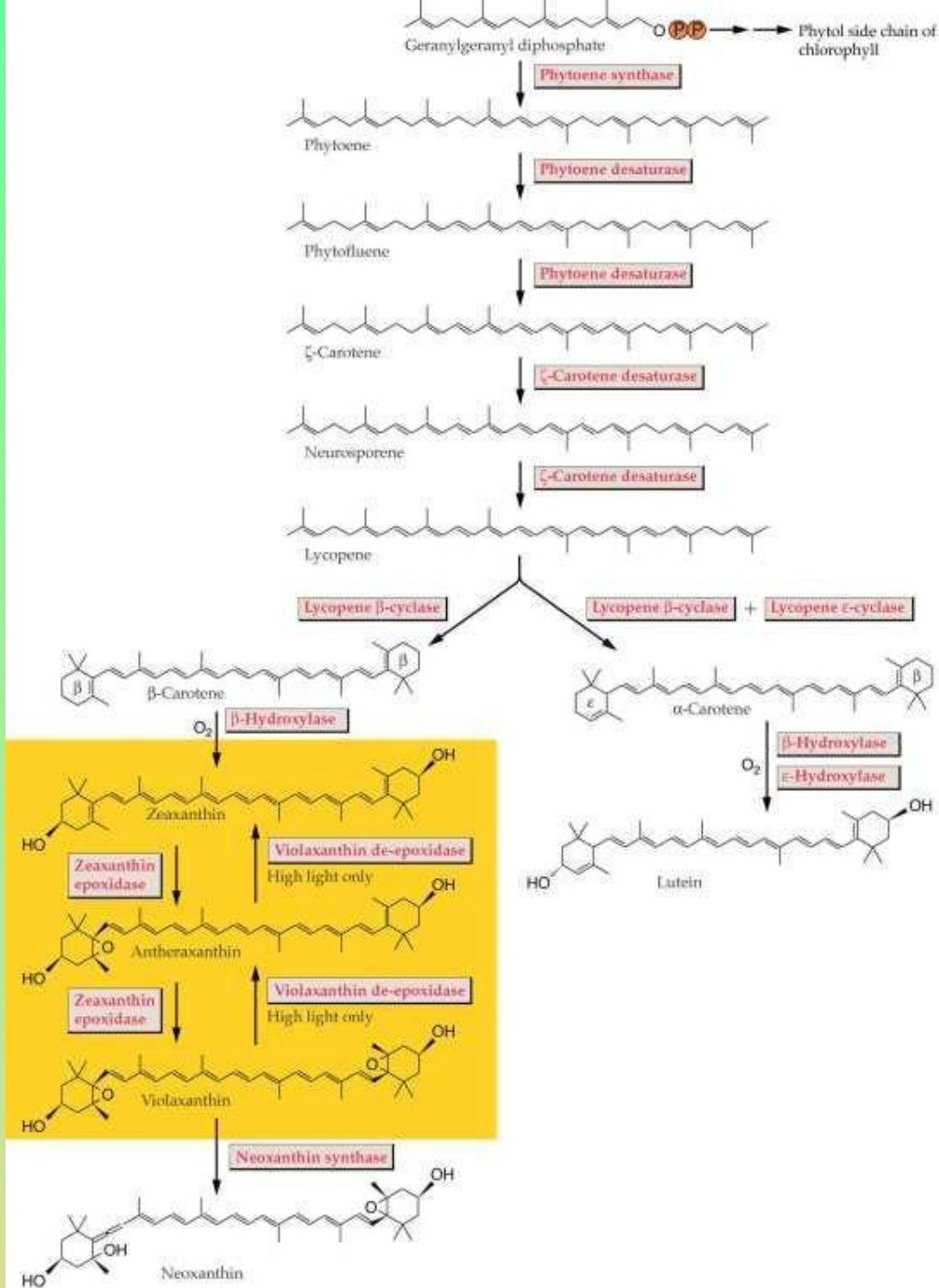
Pomocné pigmenty, strukturní funkce a disipace energie

Tetraterpeny (40 C) vytvořené z 8 isoprenových jednotek, délka 30 Å

Systém konjugovaných dvojných vazeb, symetrie, terminální alicyklické kruhy

Xanthofyly + atomy kyslíku

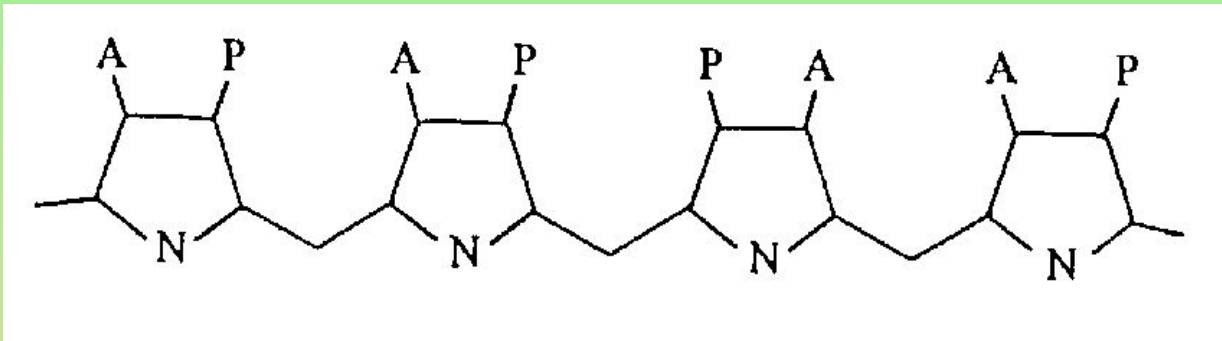




Fykobiliny

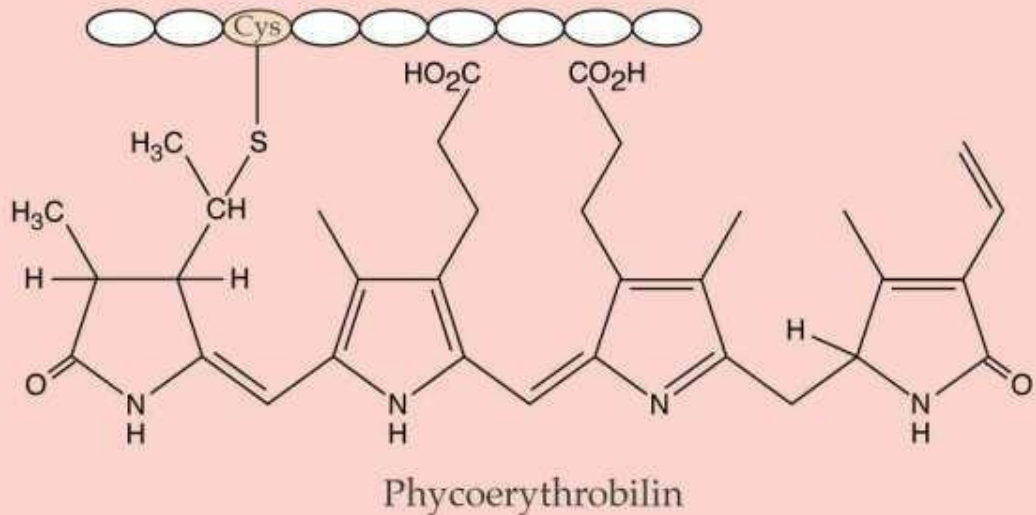
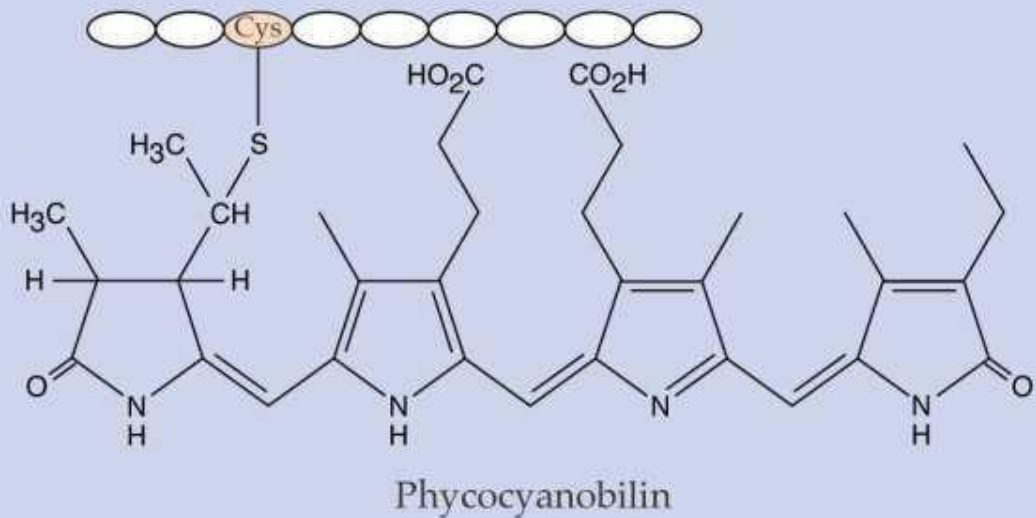
Lineární tetrapyroly, vznikají oxidačním otevřením tetrapyrolového kruhu

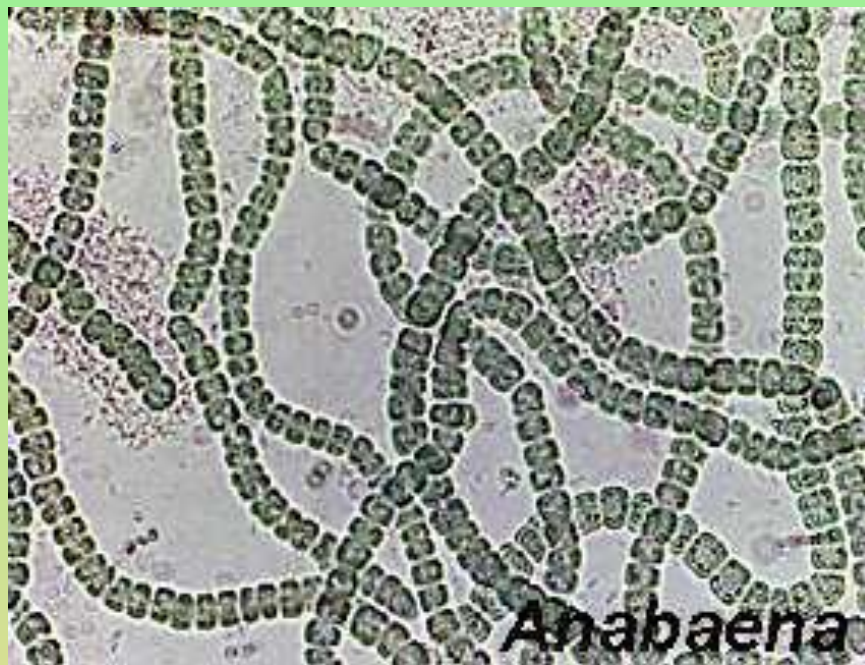
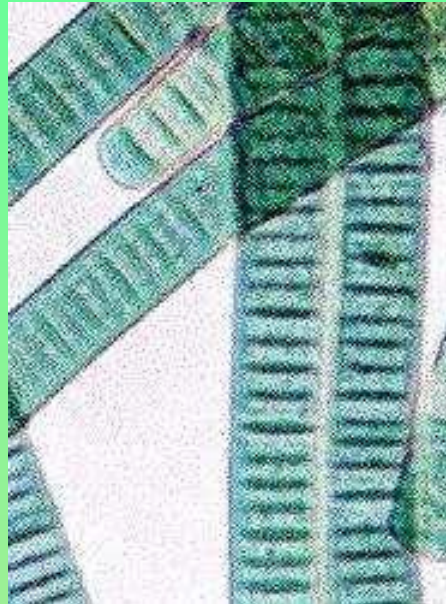
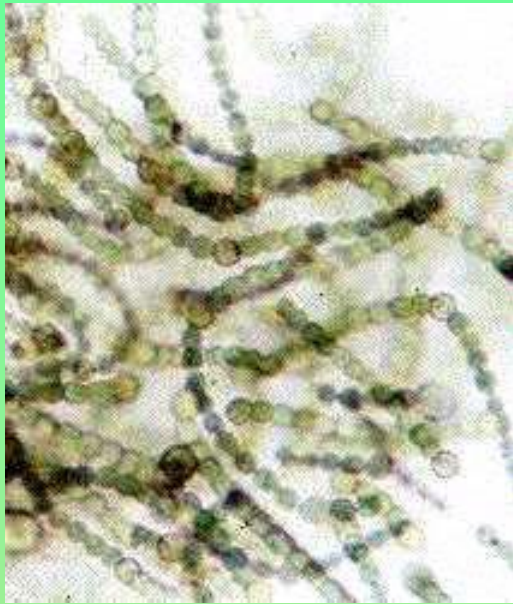
ve vodě rozpustné



Two classes of phycobilins: **phycocyanin** (left) and **phycoerythrin** (right).

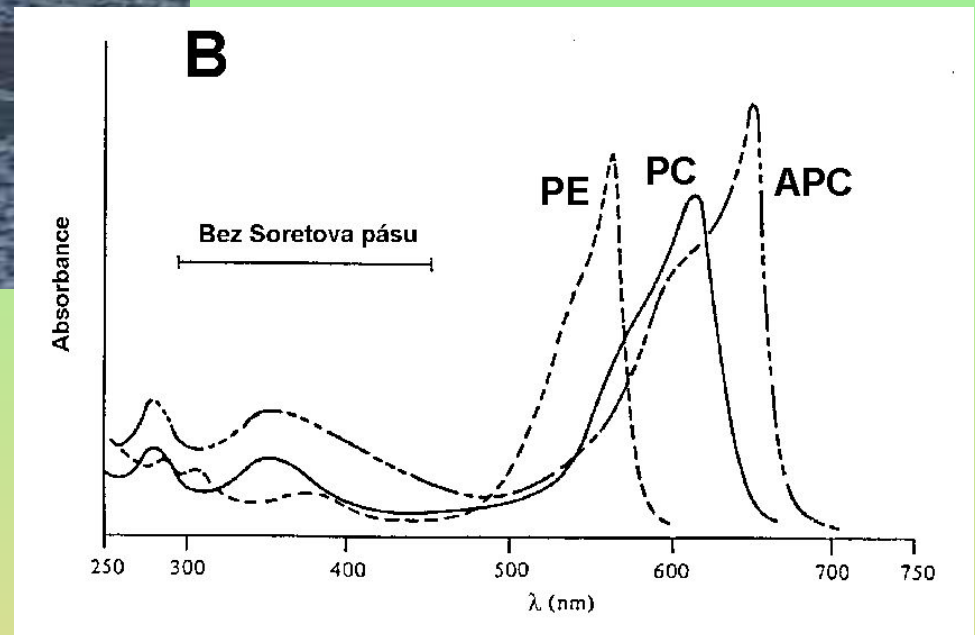
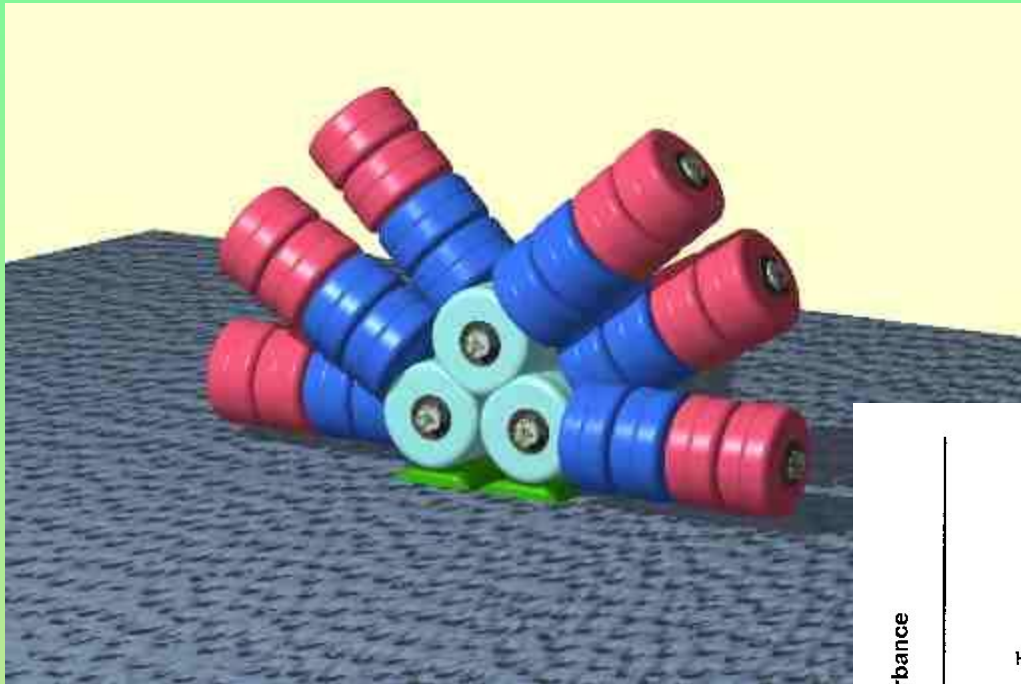
Kovalentní
thioetherová vazba
mezi cysteinem a
vinylovým
řetězcem





Anabaena

Cyanobacterial phycobilisomes



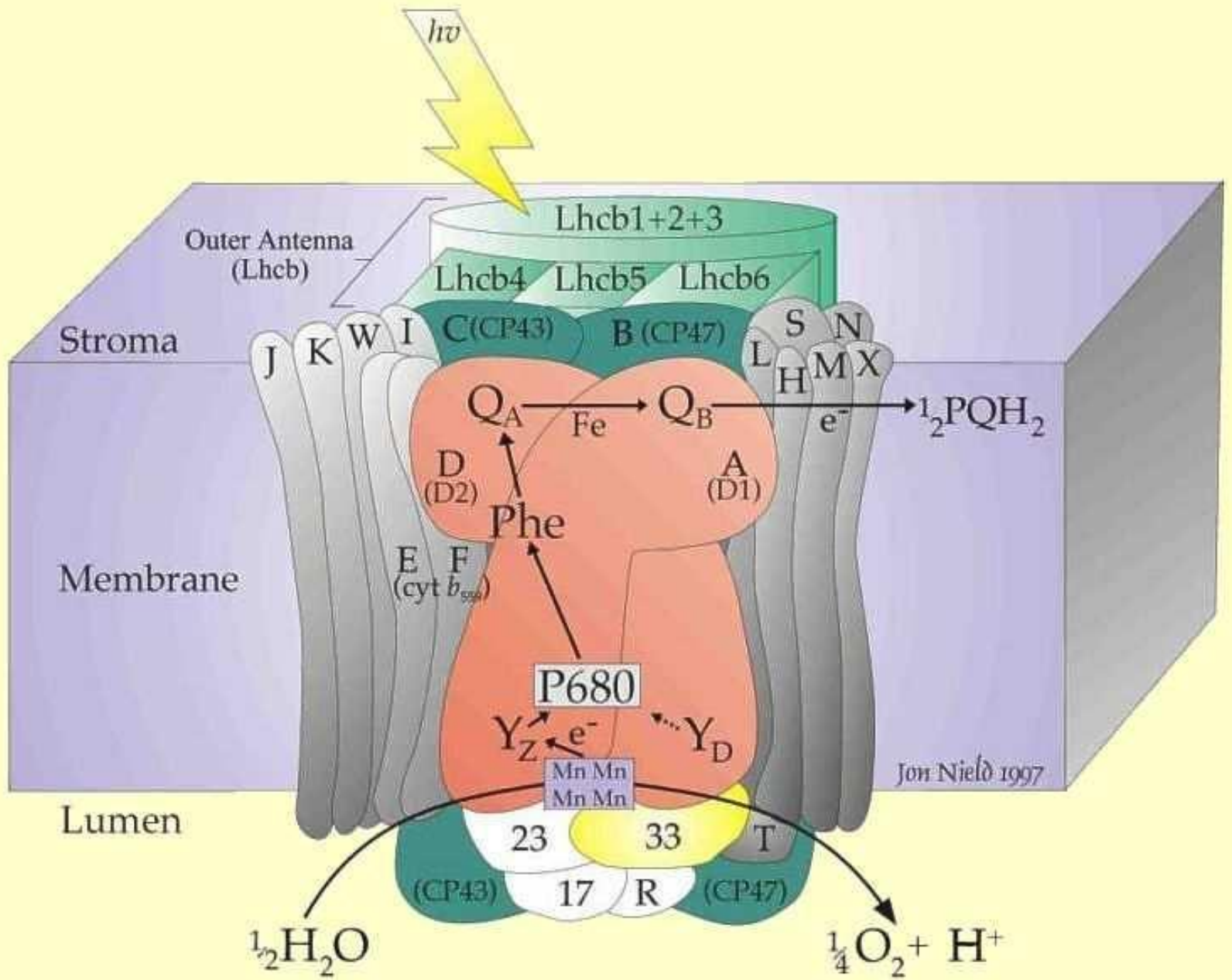
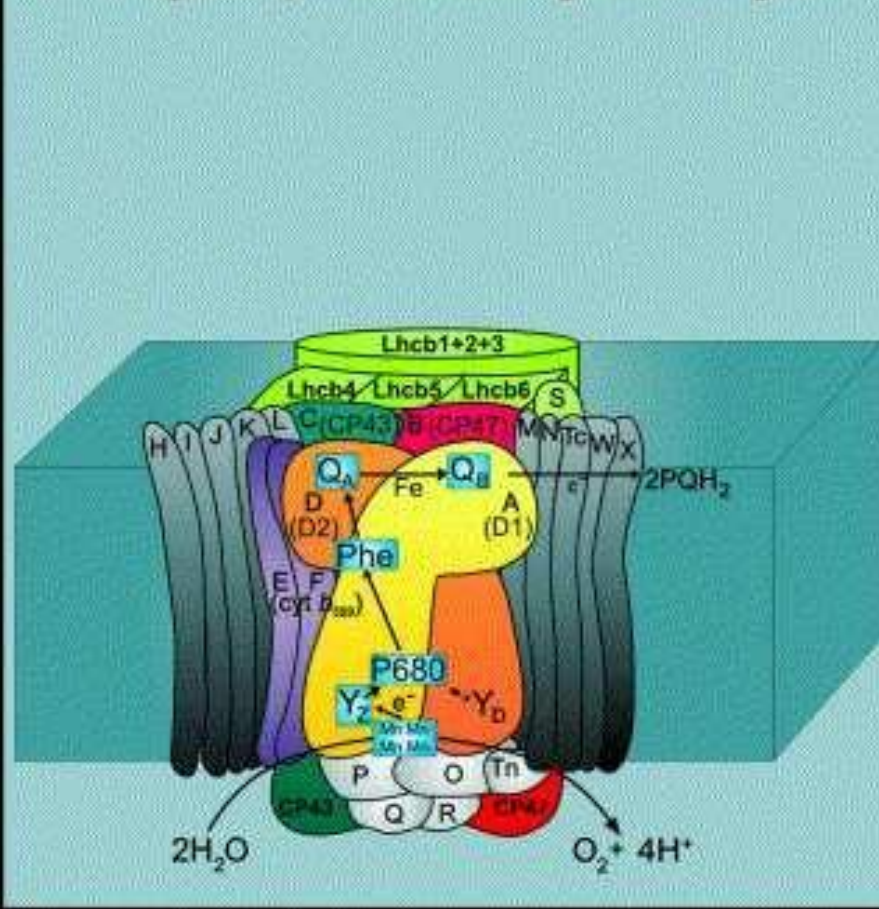


Table 6.2 Subunit structure of photosystem 2

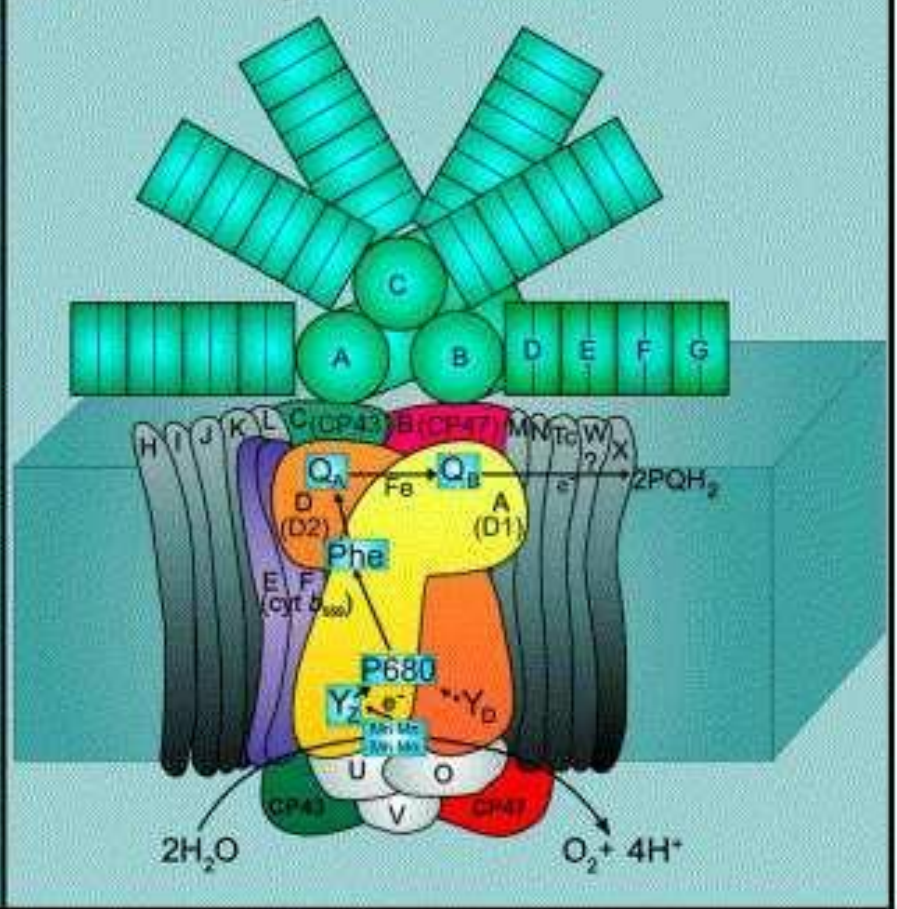
Subunit name	Gene	Gene location ^a	Mass (kDa) ^b	Cofactors	Function
PSII-A (D1)	<i>psbA</i>	C	39	chlorophyll, pheophytin, quinone, β -carotene, Fe	Core reaction center of photosystem 2
PSII-B (D2)	<i>psbD</i>	C	39	chlorophyll, pheophytin, quinone, β -carotene, Fe	Core reaction center of photosystem 2
PSII-E (cyt <i>b</i> -559 α)	<i>psbE</i>	C	9	heme	Core reaction center of photosystem 2
PSII-F (cyt <i>b</i> -559 β)	<i>psbF</i>	C	4	heme	Core reaction center of photosystem 2
PSII-I	<i>psbI</i>	C	4		Core reaction center of photosystem 2
PSII-B (CP47)	<i>psbB</i>	C	56	chlorophyll, β -carotene	Core antenna
PSII-C (CP43)	<i>psbC</i>	C	51	chlorophyll, β -carotene	Core antenna
PSII-H	<i>psbH</i>	C	8	phosphate	Photoprotection, Q_A to Q_B regulation
PSII-J	<i>psbJ</i>	C	4		Assembly of photosystem 2
PSII-K	<i>psbK</i>	C	4		?
PSII-L	<i>psbL</i>	C	4		Role in Q_A binding
PSII-M	<i>psbM</i>	C	4		?
PSII-N	<i>psbN</i>	C	5		Role in PS2 stability
PSII-T (ycf8)	<i>psbT</i>	C	3		Role in PS2 stability
PSII-W ^c	<i>PsbW</i>	N	6		?
PSII-X	<i>psbX</i>	C	4		Role in Q_A function
PSII-Y (ycf32)	<i>PsbY</i>	N	4		Mn binding?
PSII-Z (ycf9)	<i>psbZ</i>	C	9		Antenna-reaction center interaction
PSII-O (OE33)	<i>PsbO</i>	N	27		Stabilizes Mn cluster, Ca^{2+} and Cl^- binding
PSII-P (OE26) ^c	<i>PsbP</i>	N	20		Ca^{2+} and Cl^- binding
PSII-Q (OE16) ^c	<i>PsbQ</i>	N	17		Ca^{2+} and Cl^- binding
PSII-R ^c	<i>PsbR</i>	N	10		?
PSII-S (CP22)	<i>PsbS</i>	N	22	chlorophyll, carotenoids	Antenna regulation by xanthophyll cycle
PSII-U ^d	<i>psbU</i>		14		?
PSII-V (cyt <i>c</i> -550) ^d	<i>PsbV</i>		15	heme	Role in O_2 evolution
LHCII-outer ^c	<i>Lhcb1</i>	N	30	chlorophyll, carotenoids	Antenna function
LHCII-outer ^c	<i>Lhcb2</i>	N	31	chlorophyll, carotenoids	Antenna function
LHCIIa-outer ^c	<i>Lhcb3</i>	N	25	chlorophyll, carotenoids	Antenna function
LHCII-inner (CP29) ^c	<i>Lhcb4</i>	N	35	chlorophyll, carotenoids	Antenna function
LHCII-inner (CP26) ^c	<i>Lhcb5</i>	N	36	chlorophyll, carotenoids	Antenna function
LHCII-inner (CP24) ^c	<i>Lhcb6</i>	N	18	chlorophyll, carotenoids	Antenna function

Reverse genetics

A Higher plants and green algae

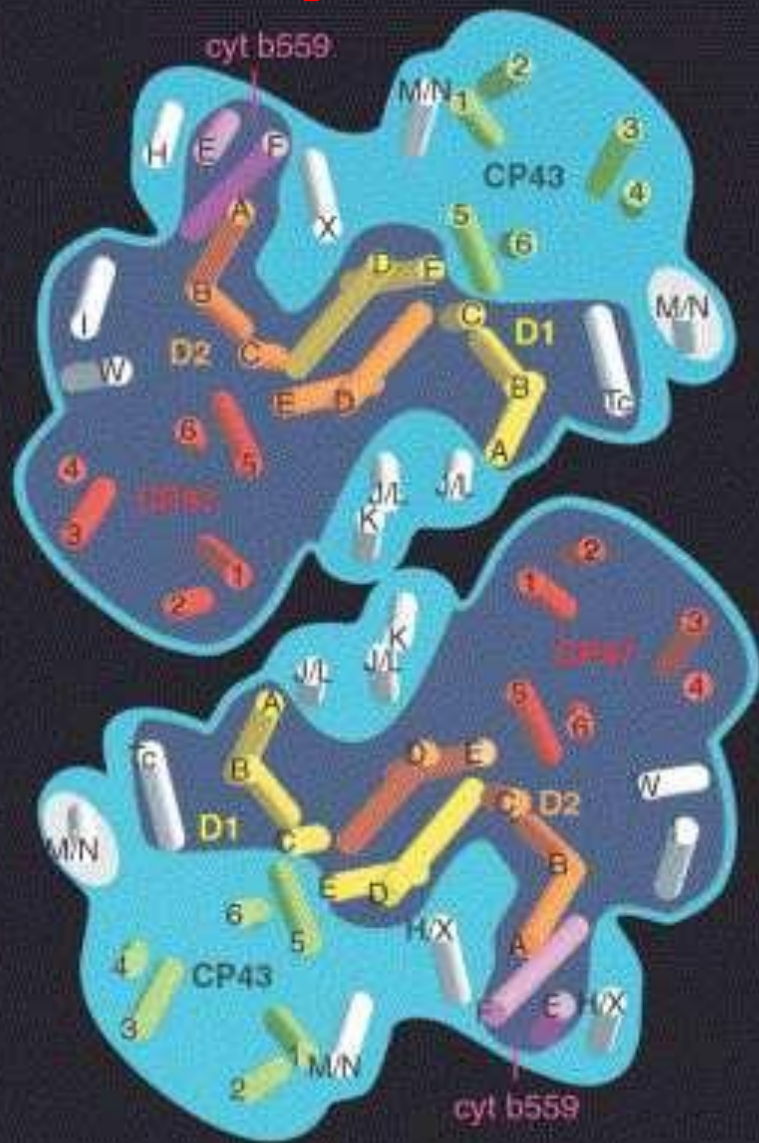


B Cyanobacteria



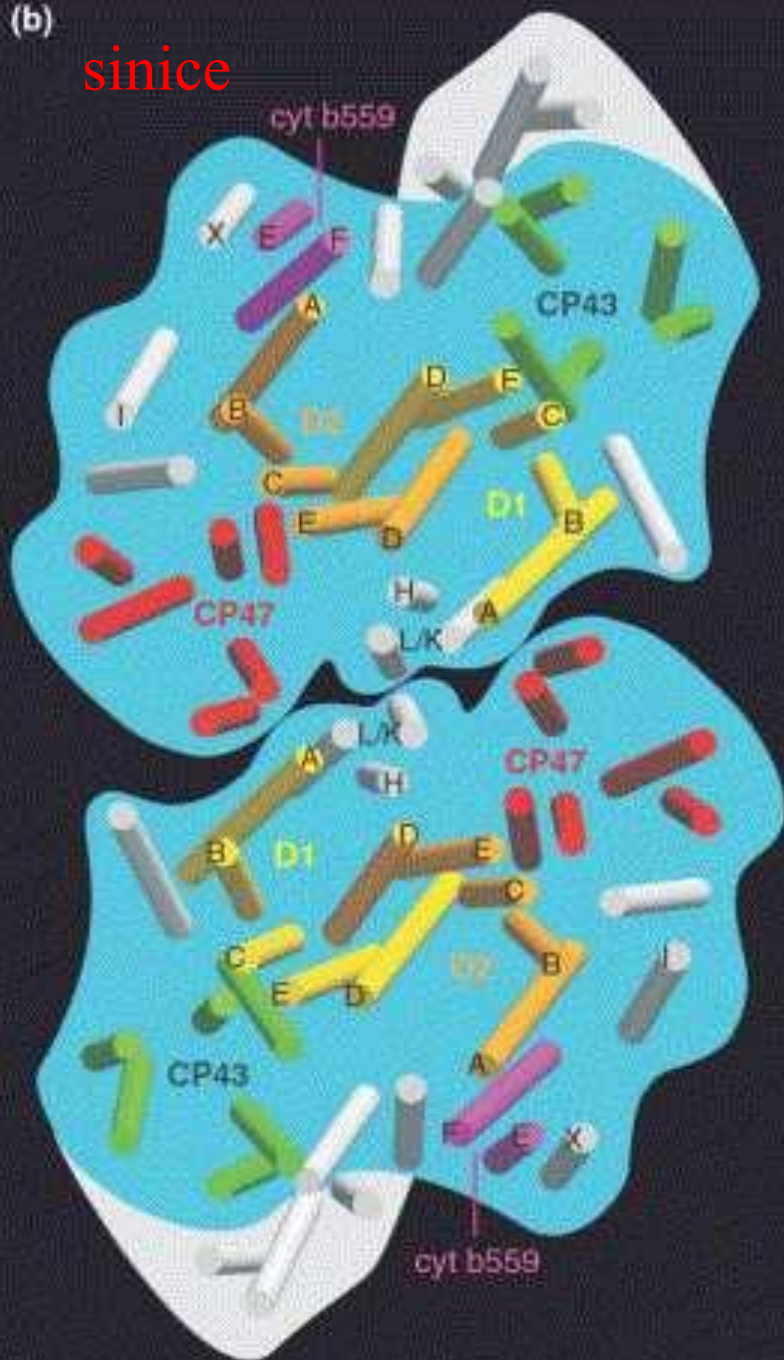
(a)

špenát

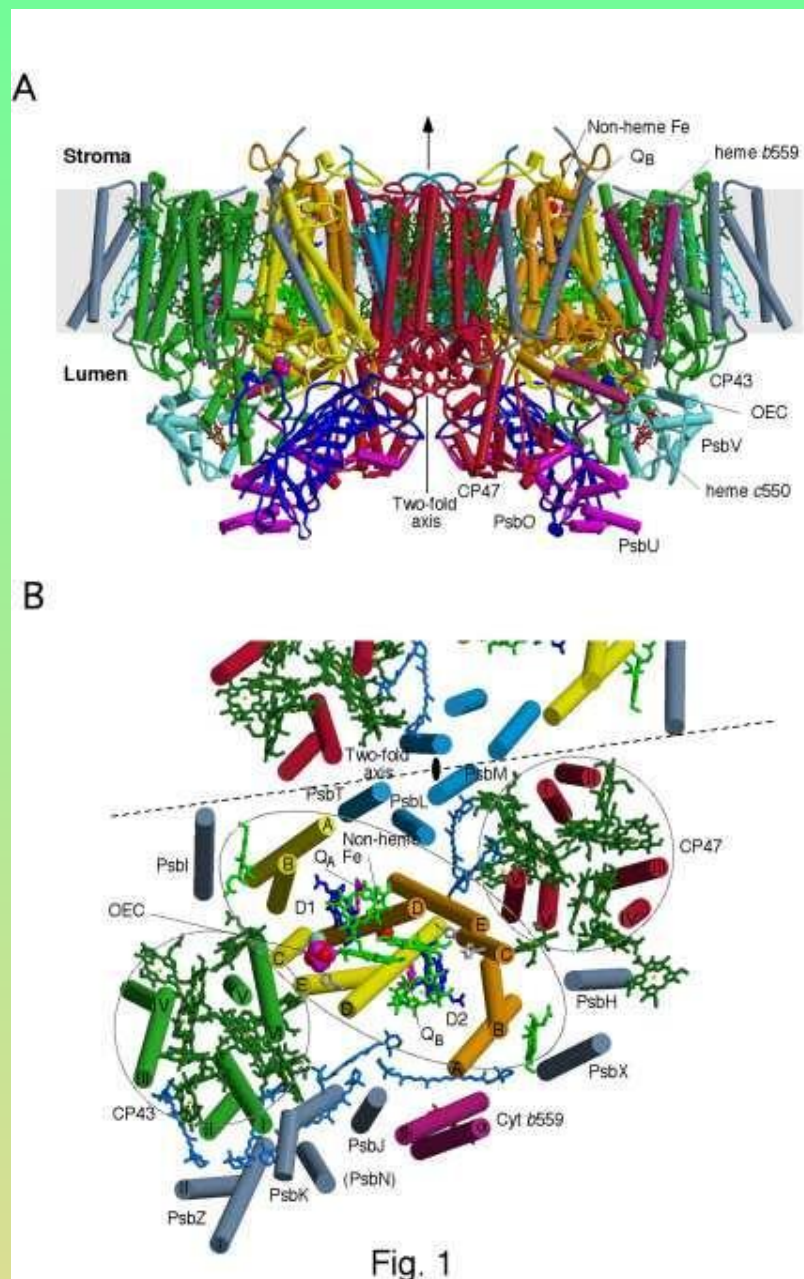


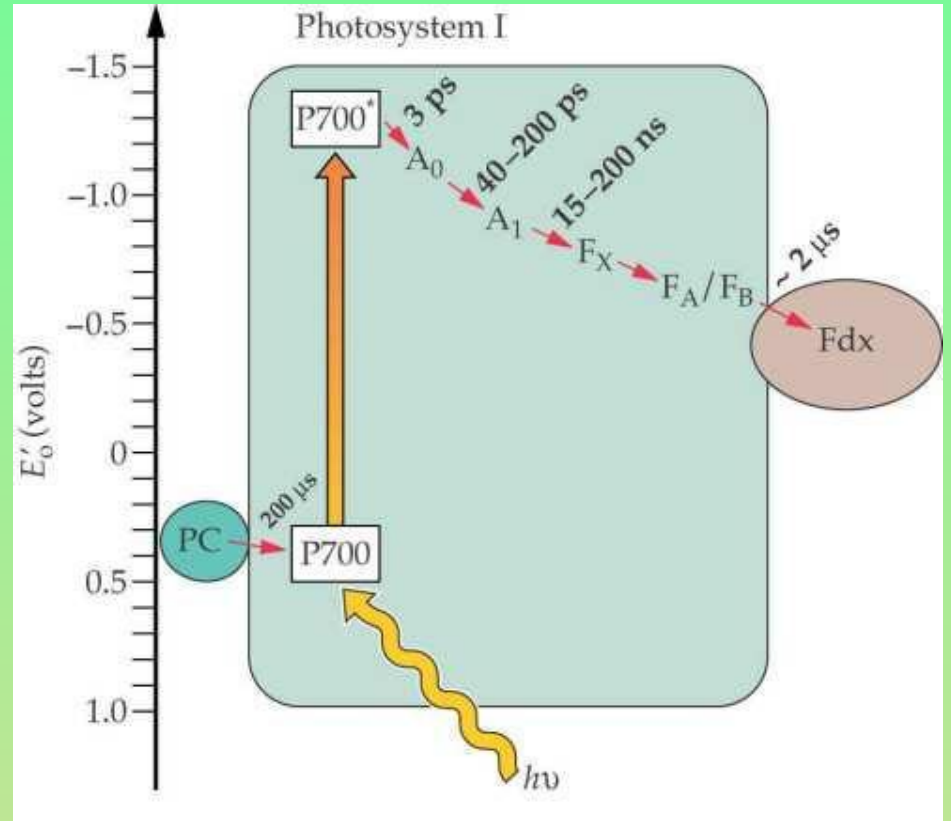
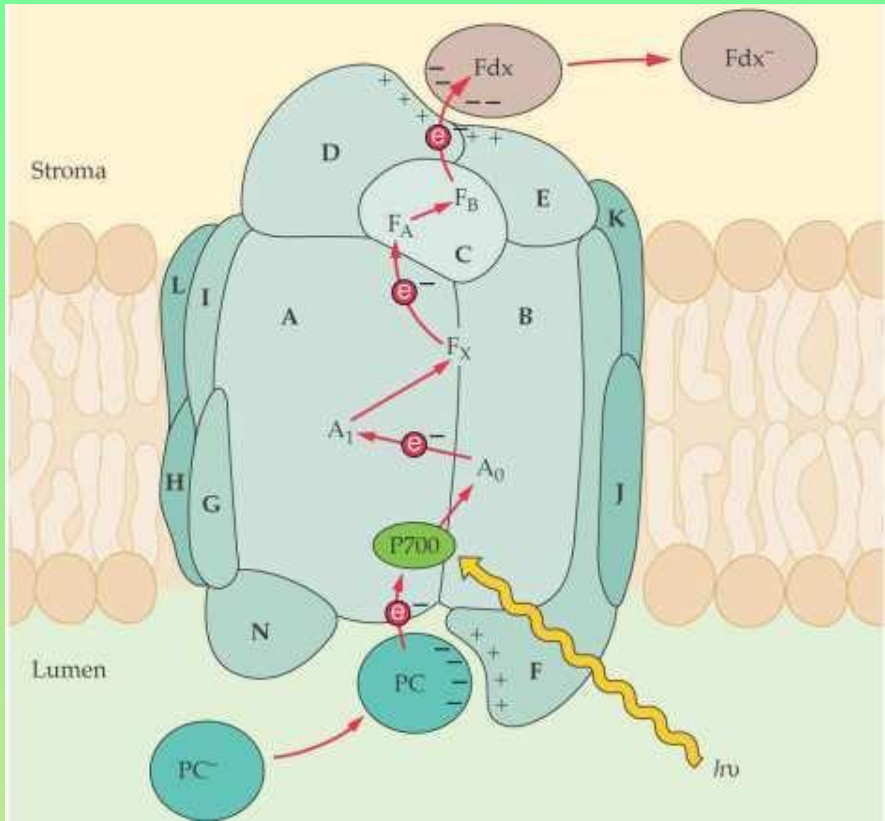
(b)

sinice

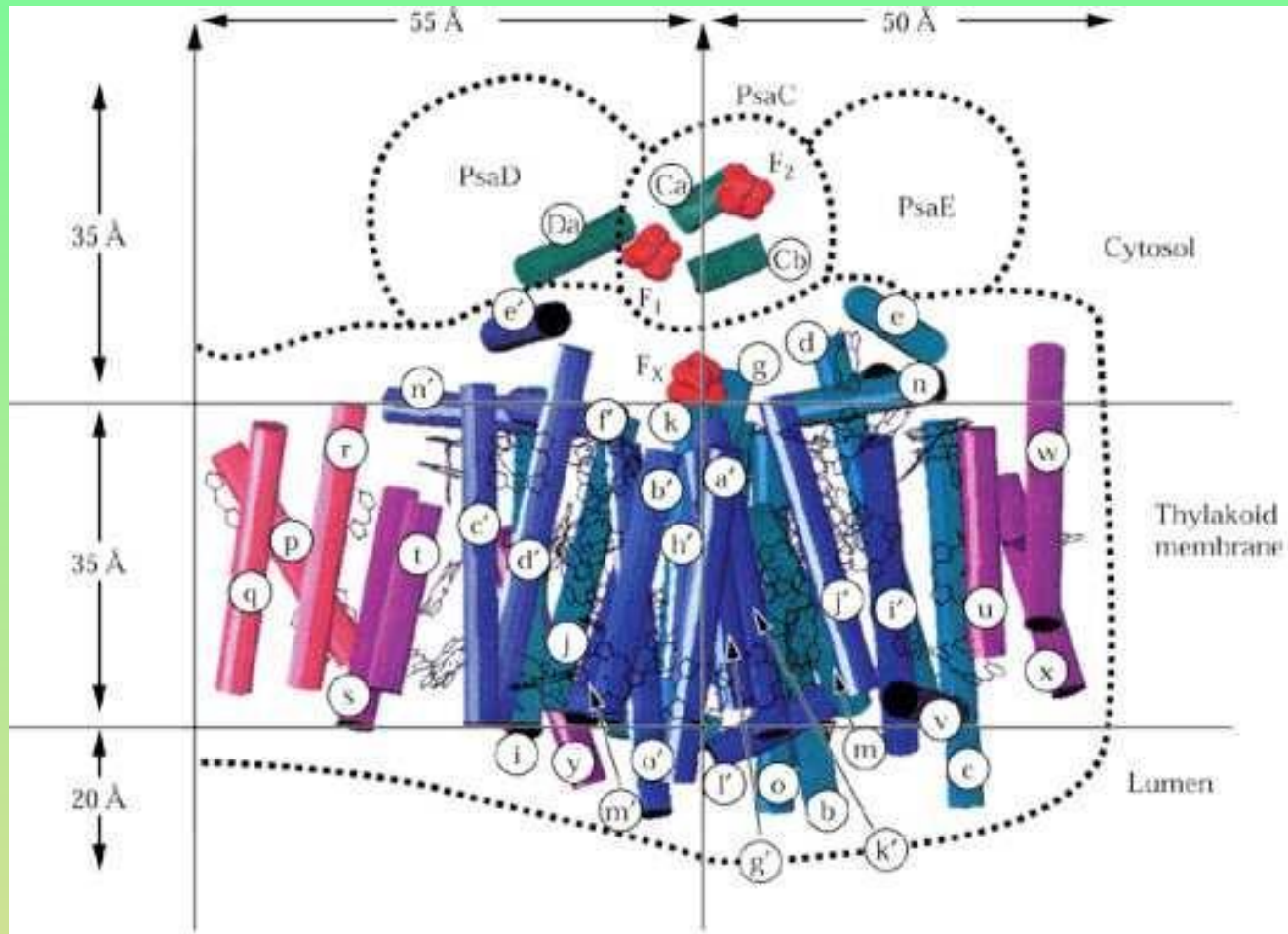


The Photosystem II complex - *Thermosynechococcus elongatus*

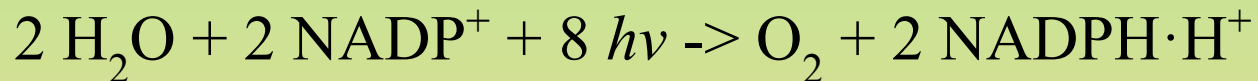
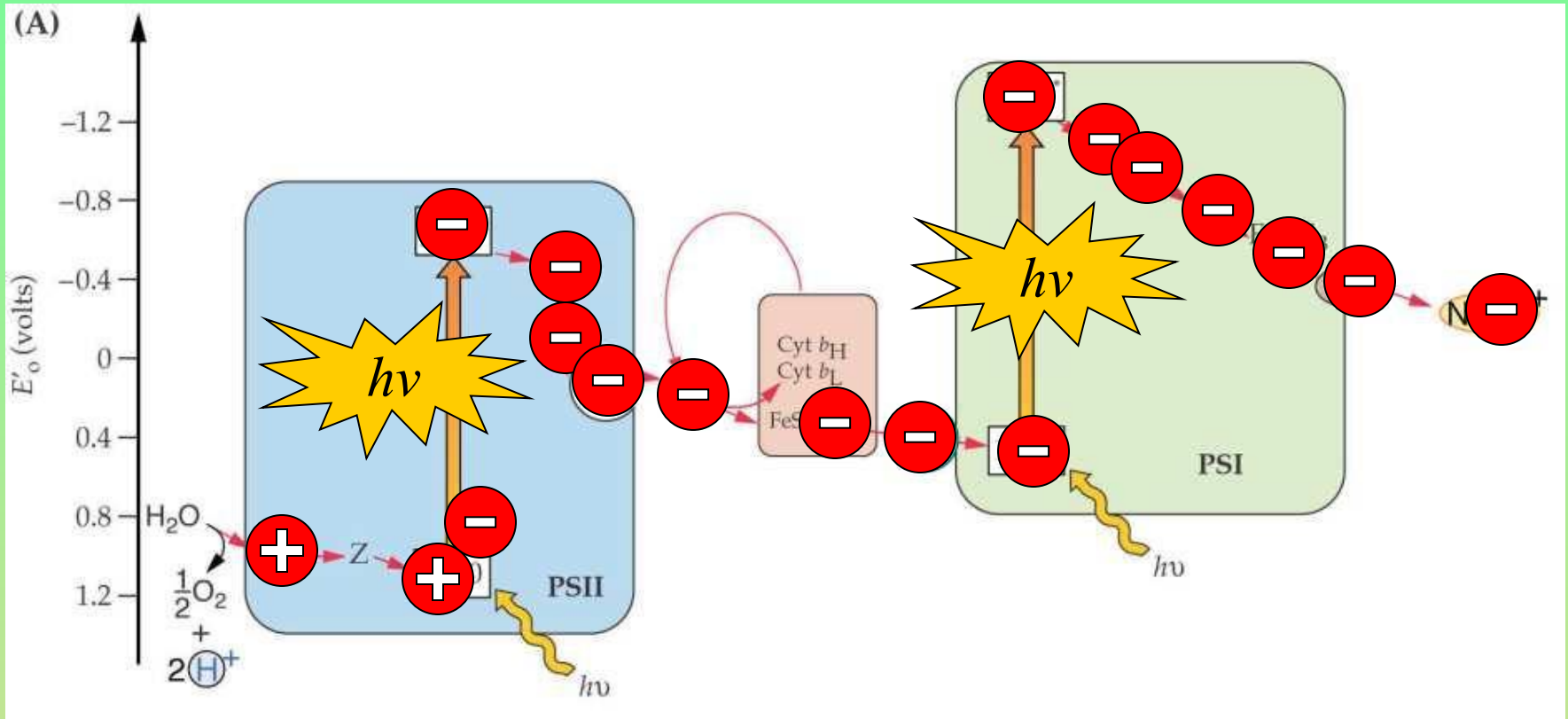




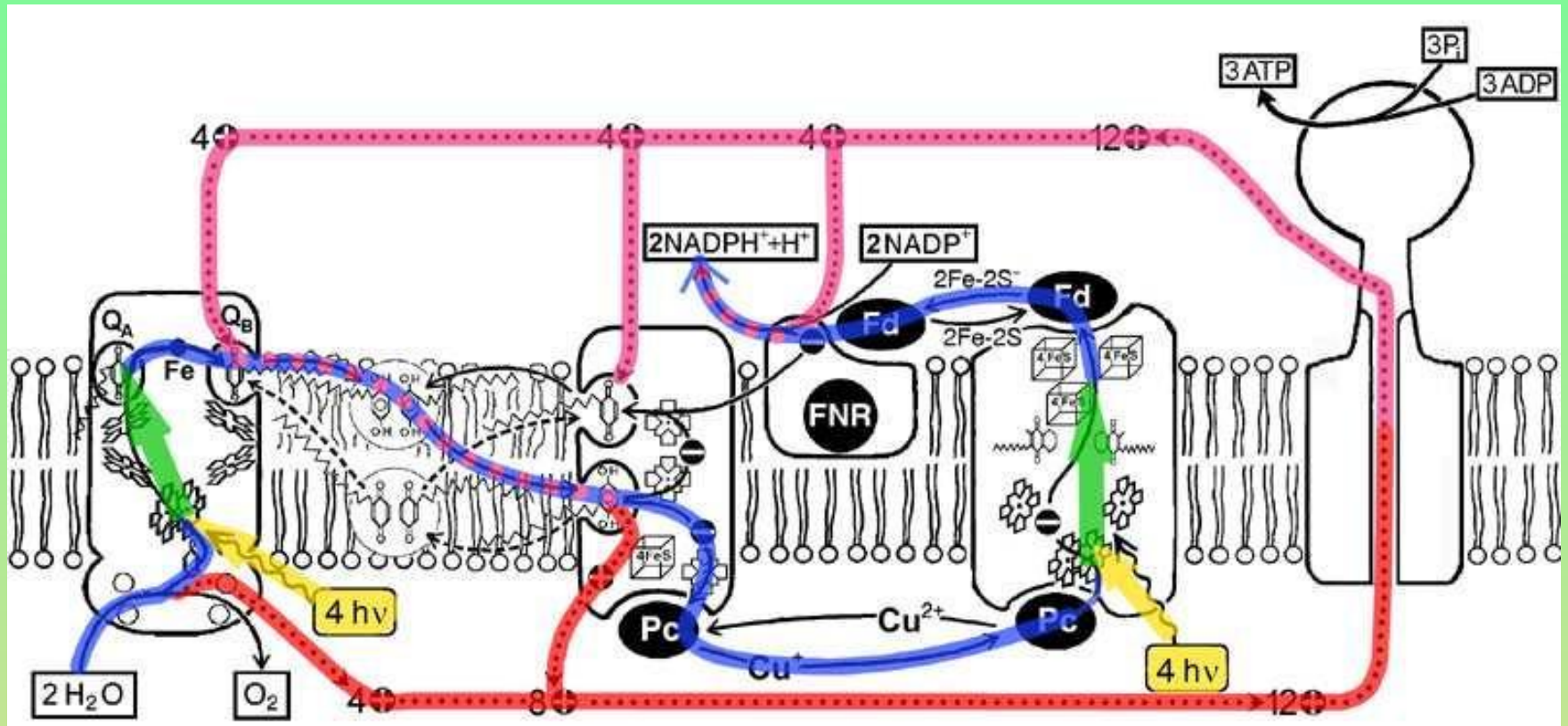
The Photosystem I complex - 2.5 A structure



Z - scheme of photosynthesis

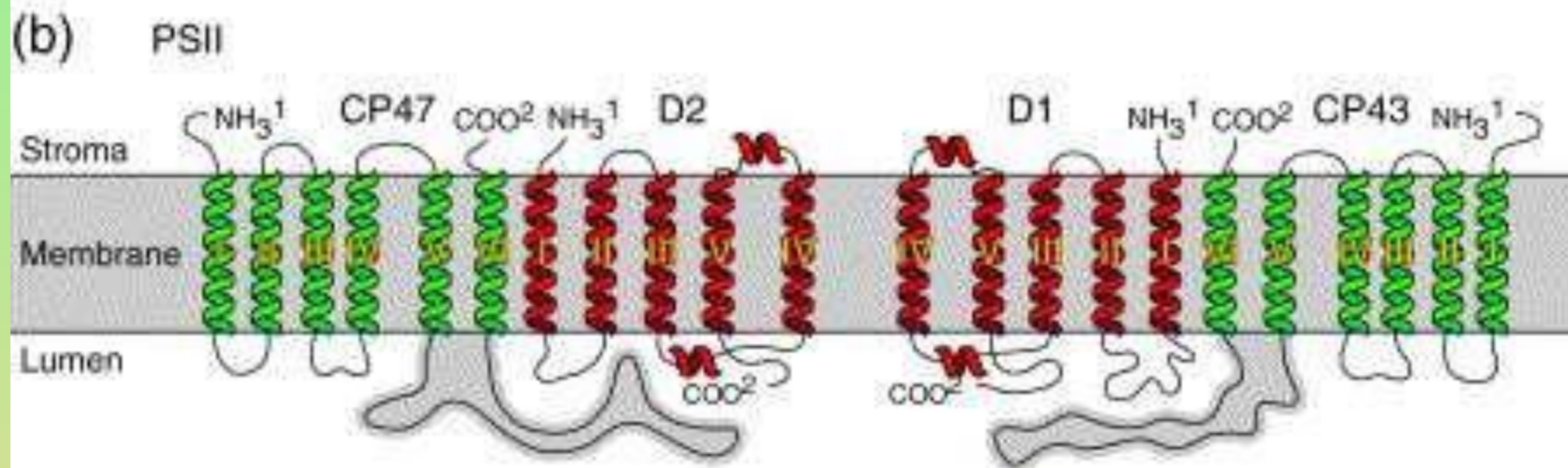
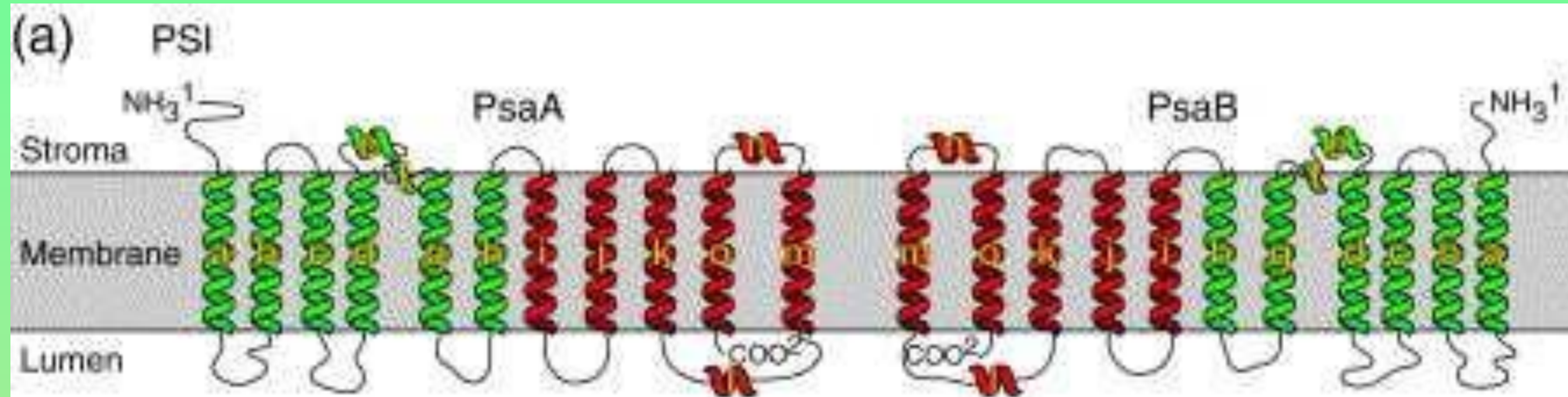


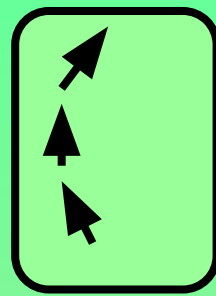
Electron transport



Chloroplast

Evolution of photosynthesis

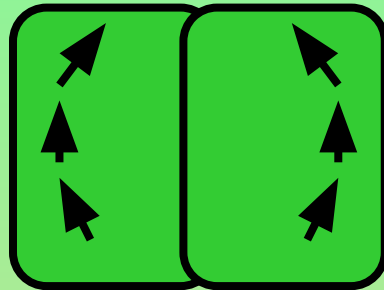




**Monomeric
Reaction
Center**



Evolutionary change



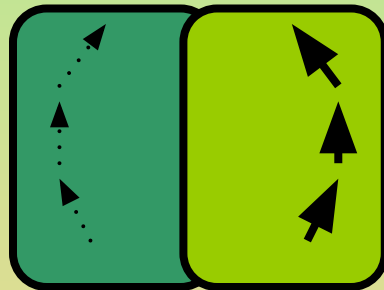
**Homodimeric
Reaction
Center**



Gene duplication



Divergence



**Heterodimeric
Reaction
Center**

Photosynthetic reaction centers are present in many phylogenetically distant organisms

?

