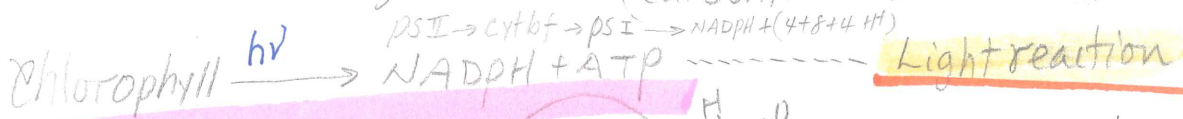
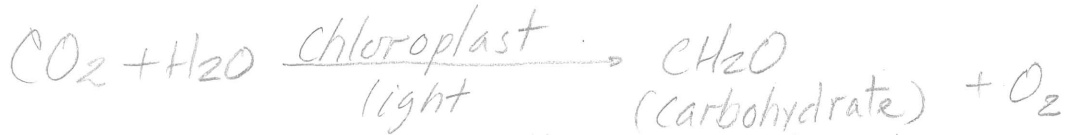
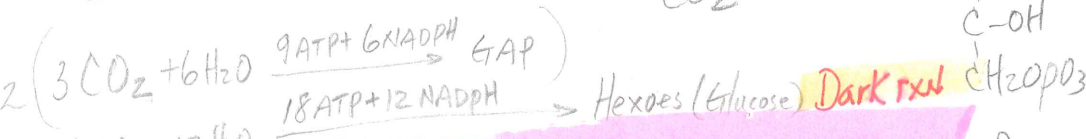


Chapter 19:
The light
reactions of
photosynthesis

Chapter 19: photosynthesis

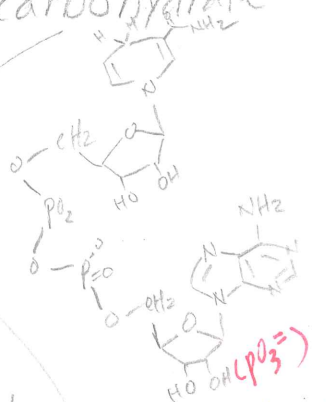


Calvin cycle
(Dark reaction)



10^{17} kcal/mole per year \rightarrow 10^{10} tons of carbohydrate
10,000,000,000 百億噸
10 Trillion

光合作用如同 oxidative phosphorylation



NADH/NADPH
Nicotinamide dinucleotide phosphate

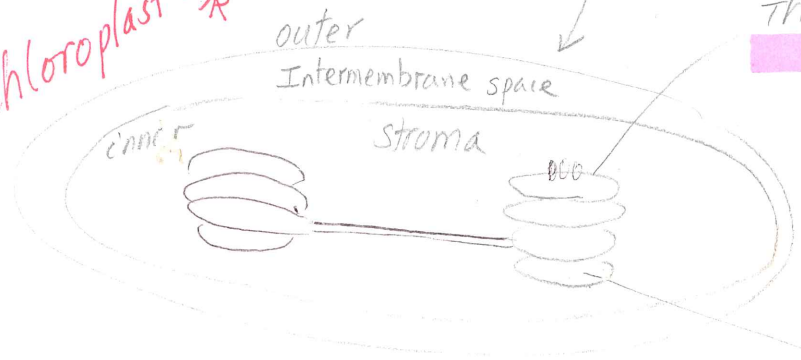
Overview

High energy electrons
proton-motive force.

Chloroplast 葉綠體

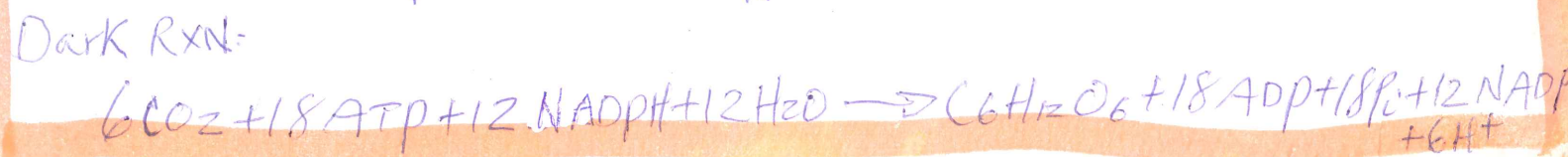
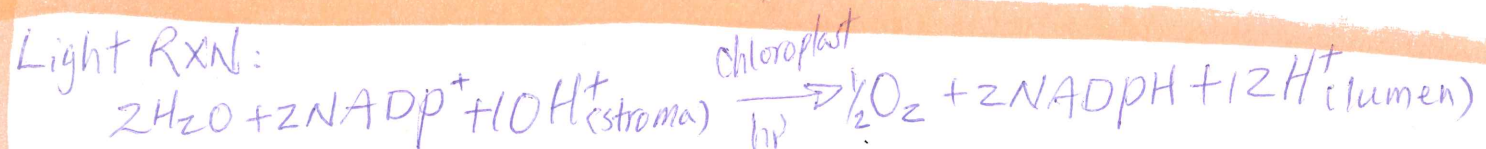
每葉綠細胞
約有100個 chloroplast

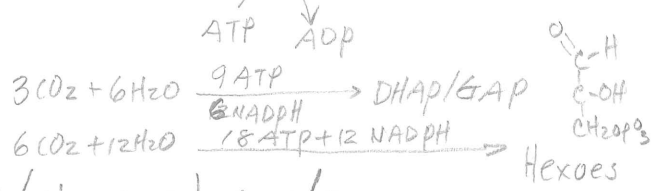
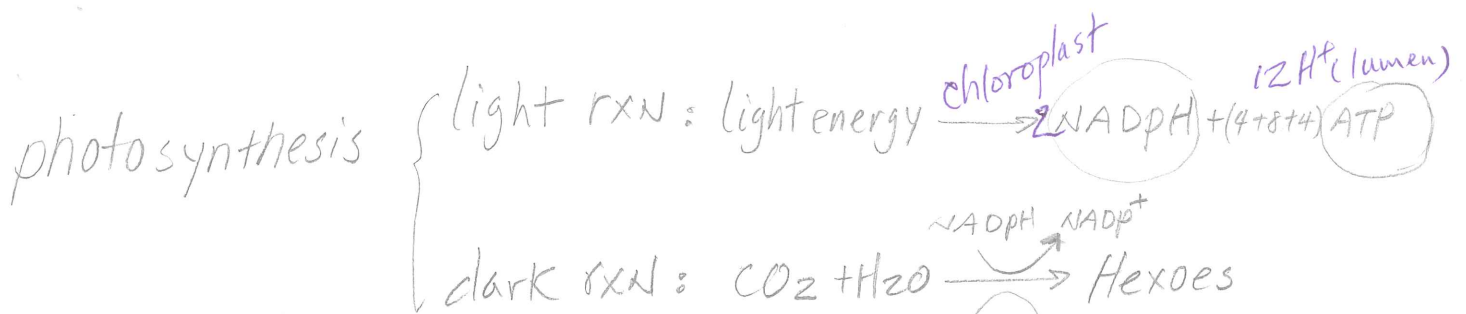
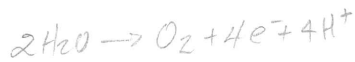
類囊體
Thylakoid membrane



Thylakoid space (Lumen)

Thylakoid 就像如 mitochondria cristae 般，是 oxidation-reduction 反應地，產生 proton-motive force 之處

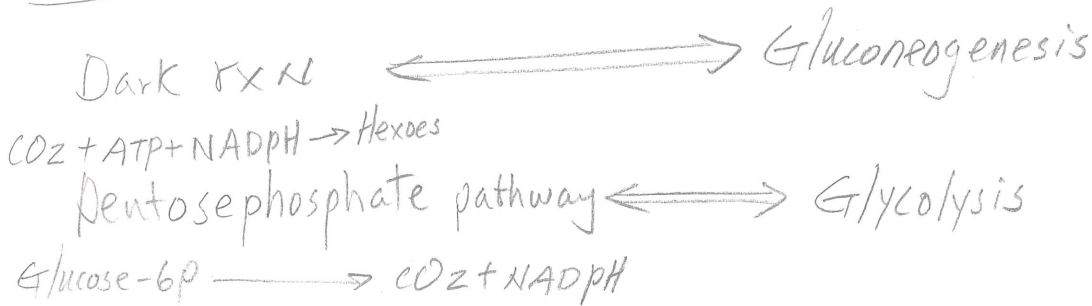




比較:

(light rxn) photosynthesis \longleftrightarrow citric Acid cycle

用 light 来 generate NADPH \longleftrightarrow generate high energy e^- (NADH, FADH₂)



Chloroplast \longleftrightarrow mitochondria

3 different membrane (outer, inner, thylakoid)

3 different space (inner membrane, stroma, thylakoid)

Bacterial rxn center 為代表 (最簡單之 system)

Rhodospseudomonas viridis

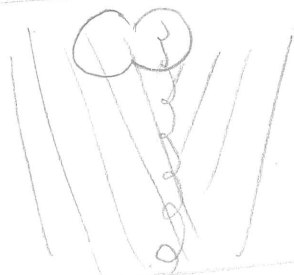
extracellular
periplasmic side

cytochrome

L-chain

M-chain

special pair: p960



cytoplasmic side
intercellular

H chain

比較

photosynthesis
light rxn

Oxidative phosphorylation

Chloroplast (thylakoid)

Mitochondria (cristae)

NADPH

NADH

ATP in stroma

ATP in Matrix

Chlorophyll

Heme

generate NADPH + ATP

Generate NADH/FADH₂ and H⁺ gradient

From: 2H₂O → O₂ + 4e⁻

NADH → NAD⁺ + e⁻

H⁺ pump into
thylakoid lumen
generate ATP in stroma

H⁺ pump into
IMS
generate ATP in ~~lumen~~ Matrix

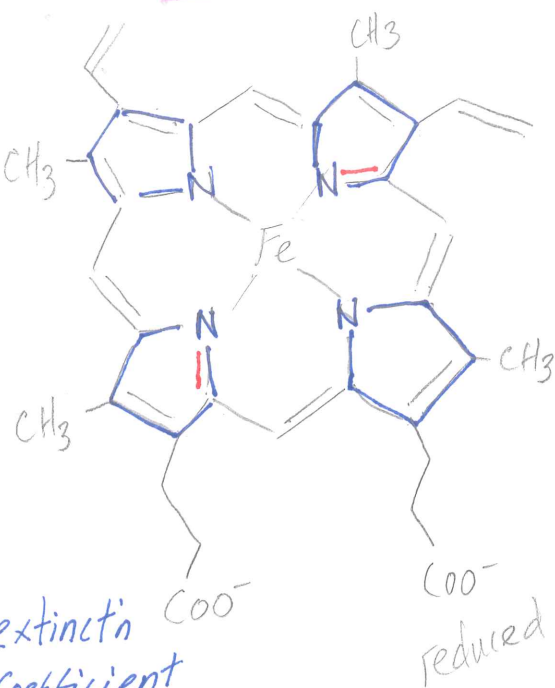
NADP⁺

NADPH

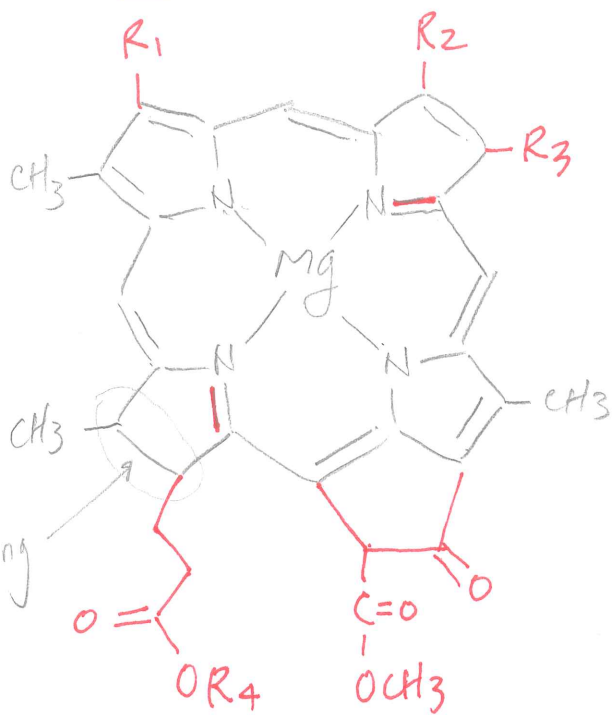
O₂

H₂O

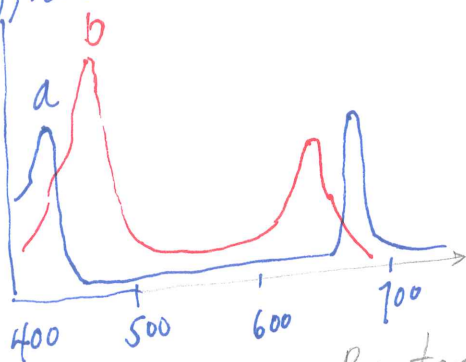
Heme



chlorophyll



extinction coefficient

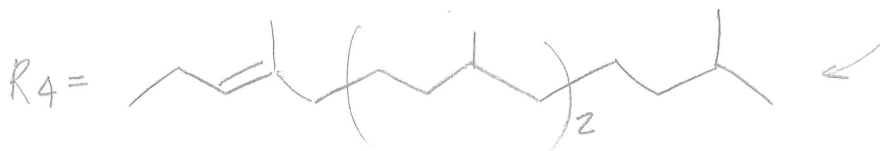


reduced pyrrole ring

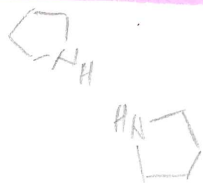
isoprene
phytyl

	R ₁	R ₂	R ₃	R ₄
Chlorophyll a	-CH=CH ₂	-CH ₃	-CH ₂ -CH ₃	p
Chlorophyll b	-CH=CH ₂	-C(=O)-H	-CH ₂ CH ₃	p
Bacteriochlorophyll a	-C(=O)-CH ₃	-CH ₃	-CH ₂ CH ₃	p or t
Bacteriochlorophyll b	-C(=O)-CH ₃	-CH ₃	=C-CH ₃	p

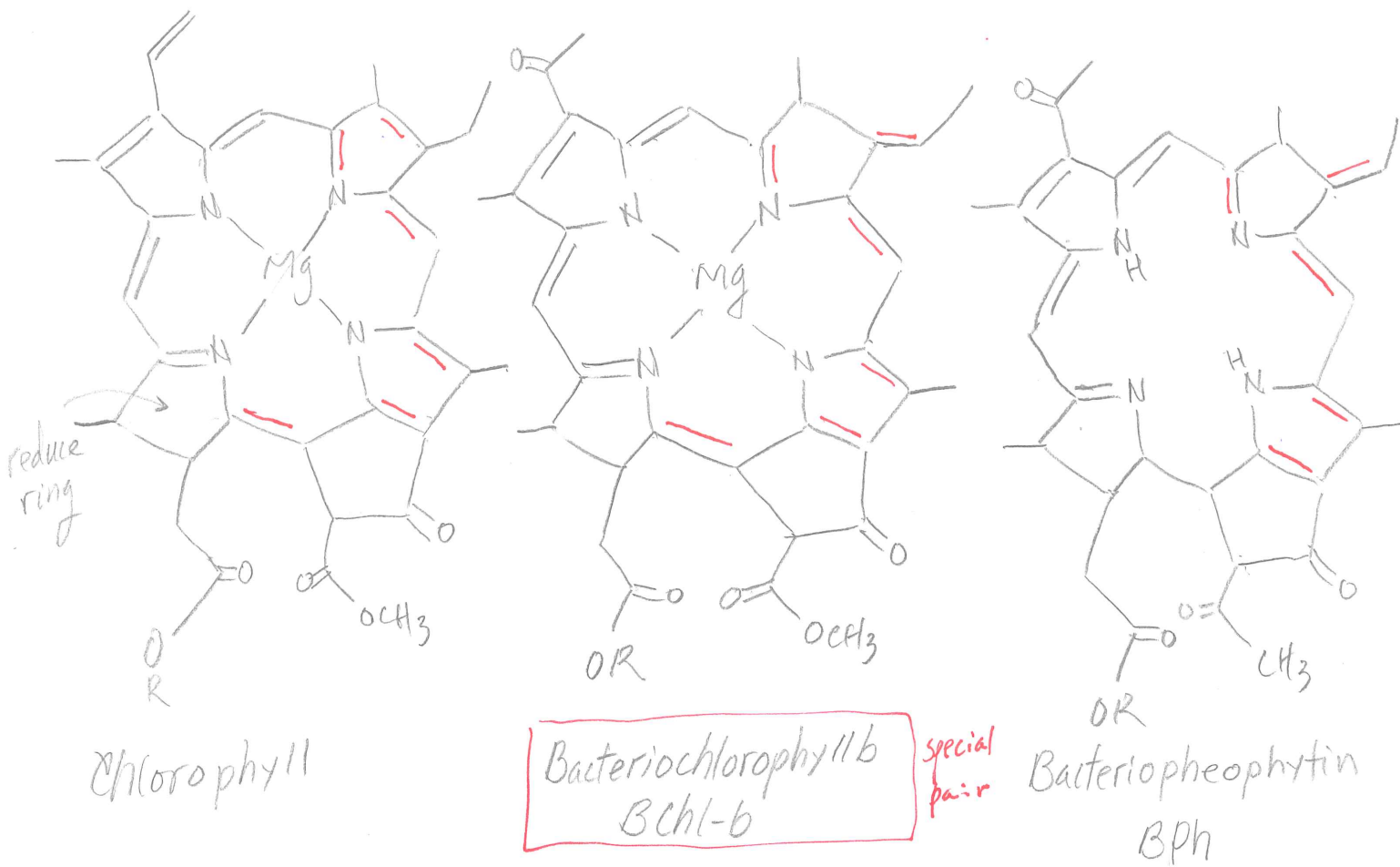
no Mg⁺⁺



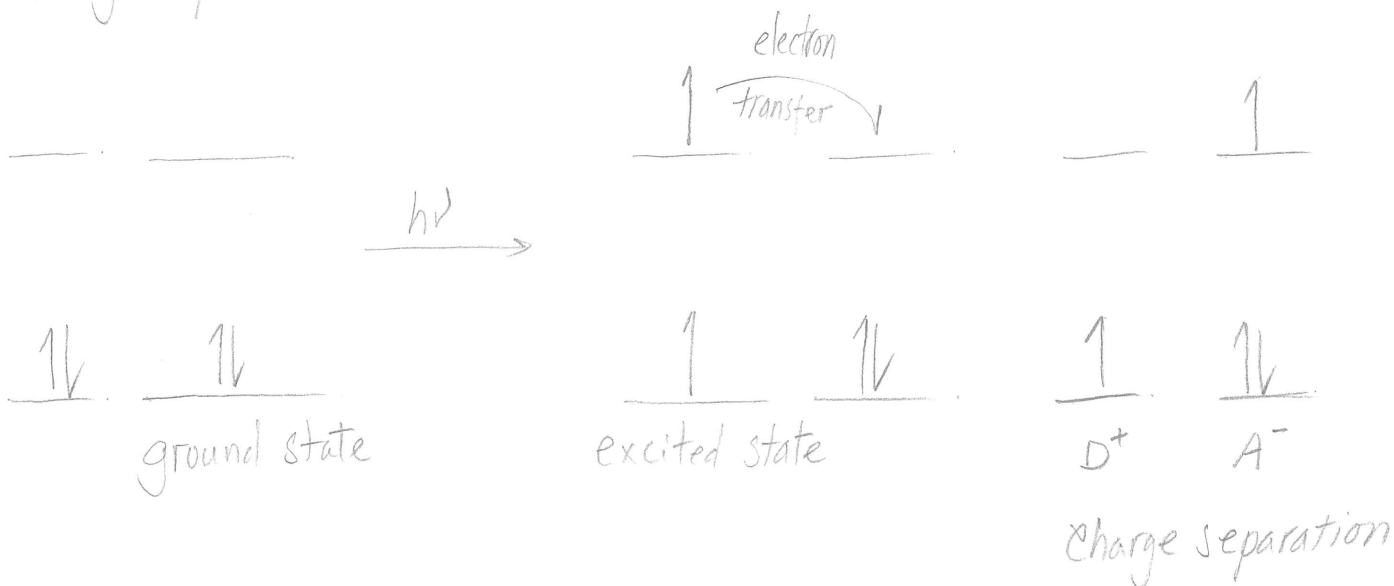
Bacteriopheophytin (Bph)

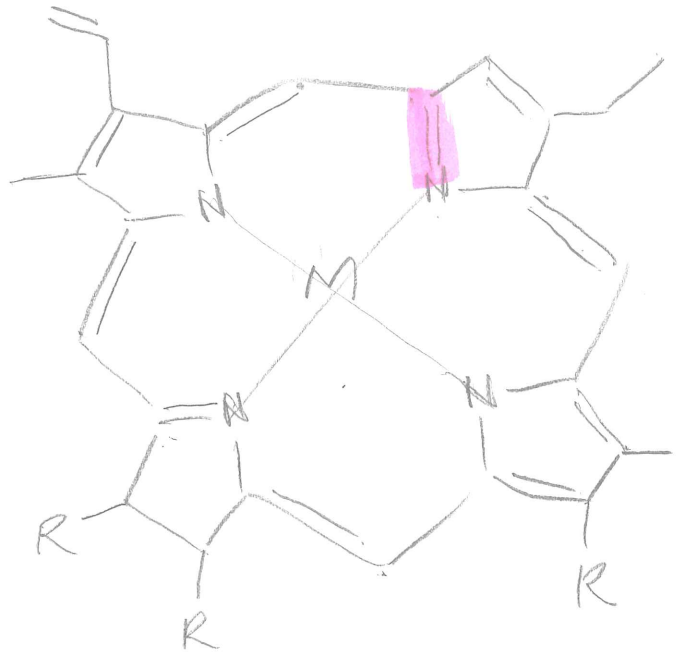
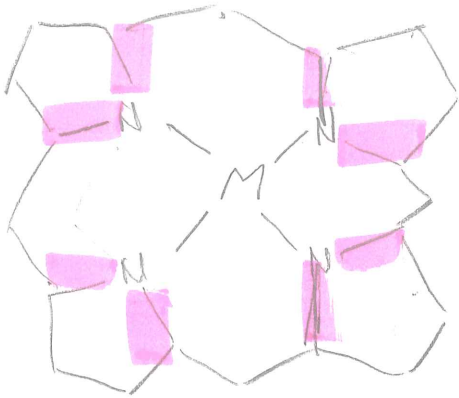


Light absorption by chlorophyll induces electron transfer



Charge Separation

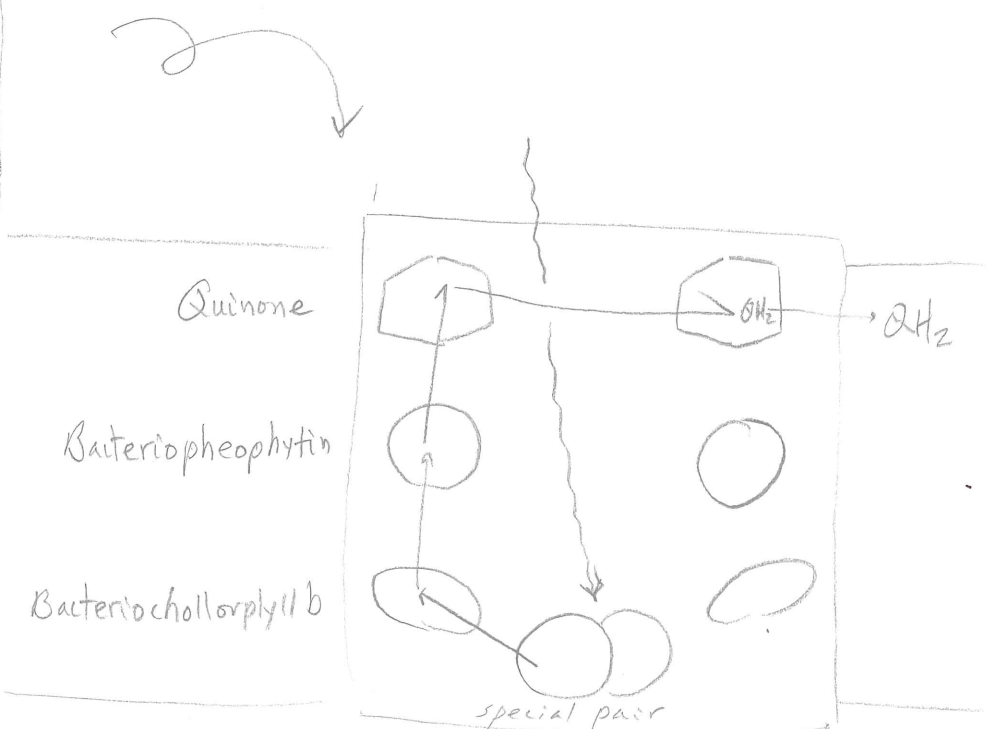
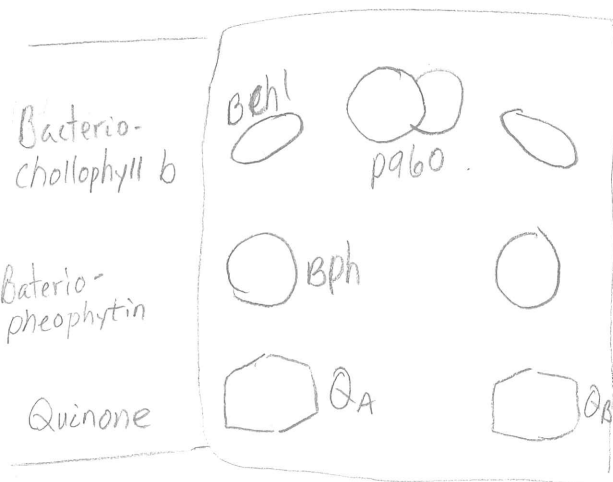




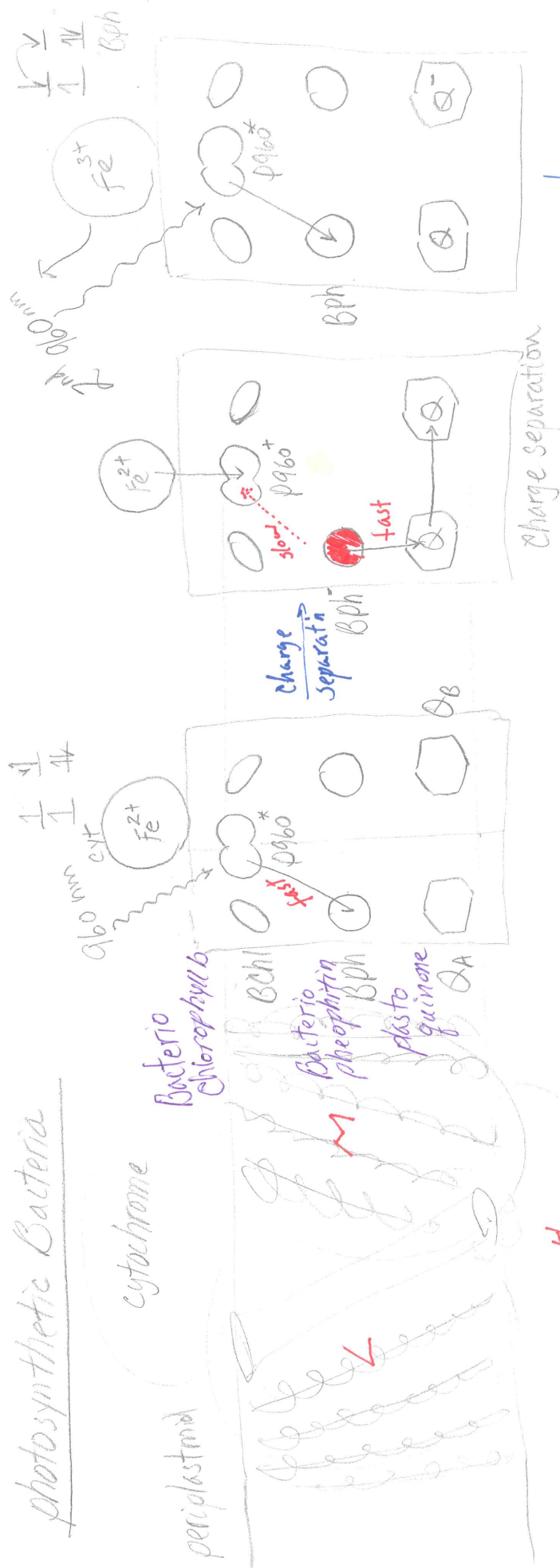
Chlorophyll

photosynthetic bacterial (Simplest model, *Rhodospseudomonas viridis*)
 reaction center

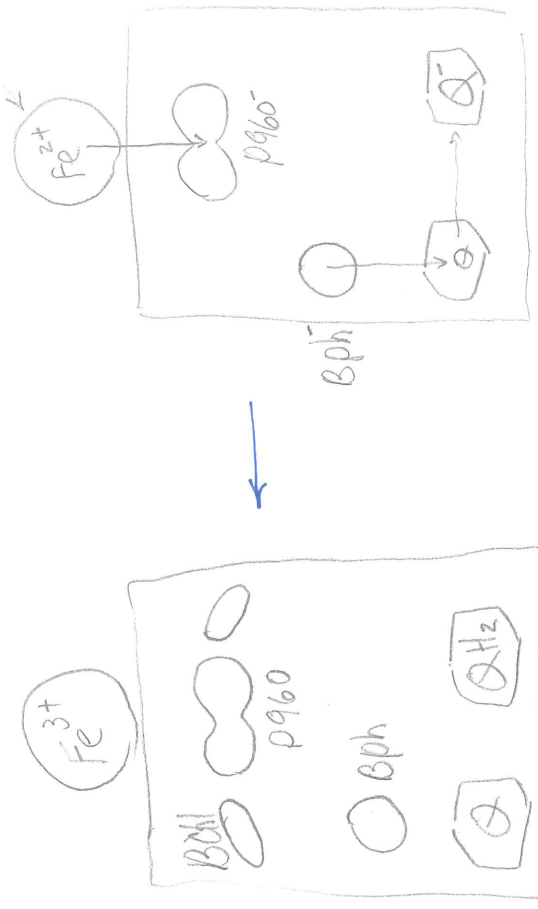
↓
 4 polypeptides = L
 M
 H
 Cytochrome c
 reaction center

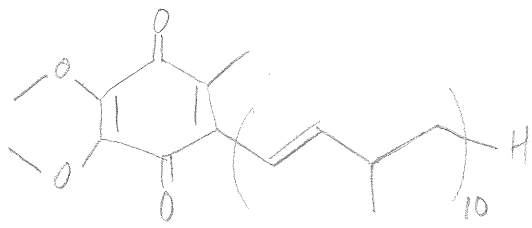


photosynthetic Bacteria

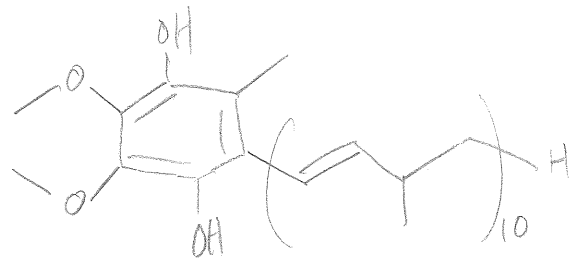


cytoplasmid



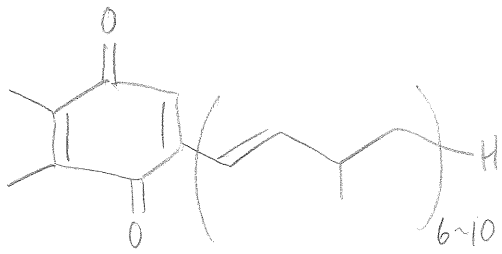


ubiquinone
Q

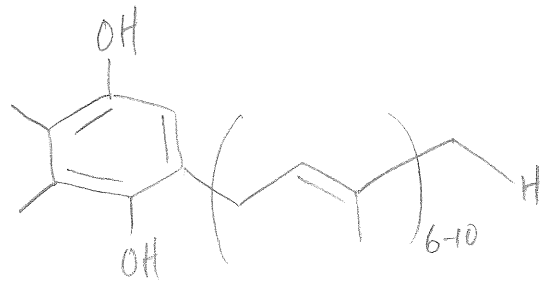


Ubiquinol
QH₂

Mitochondria
Inner membrane



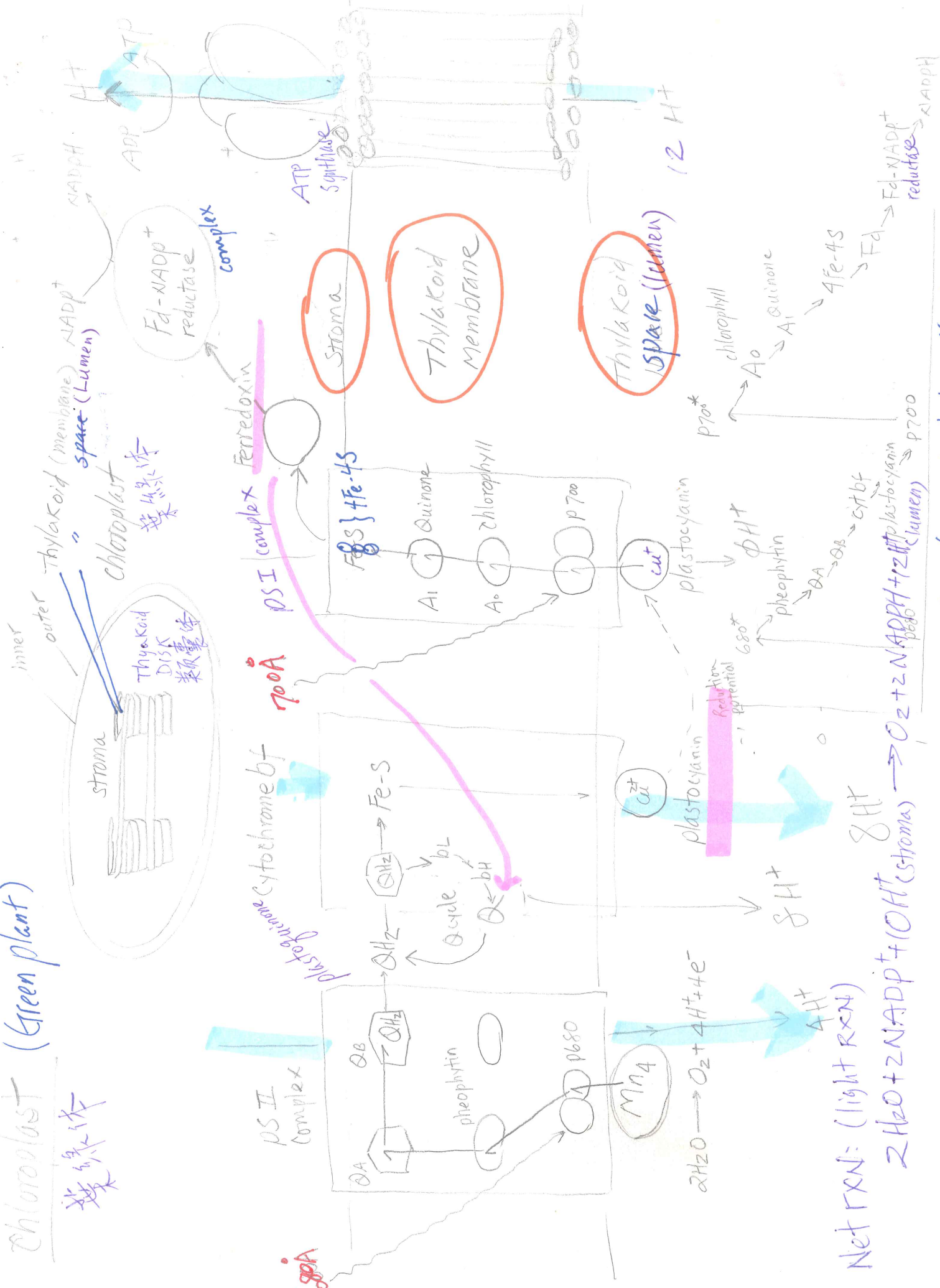
plastoquinone
Q



plastoquinol
QH₂

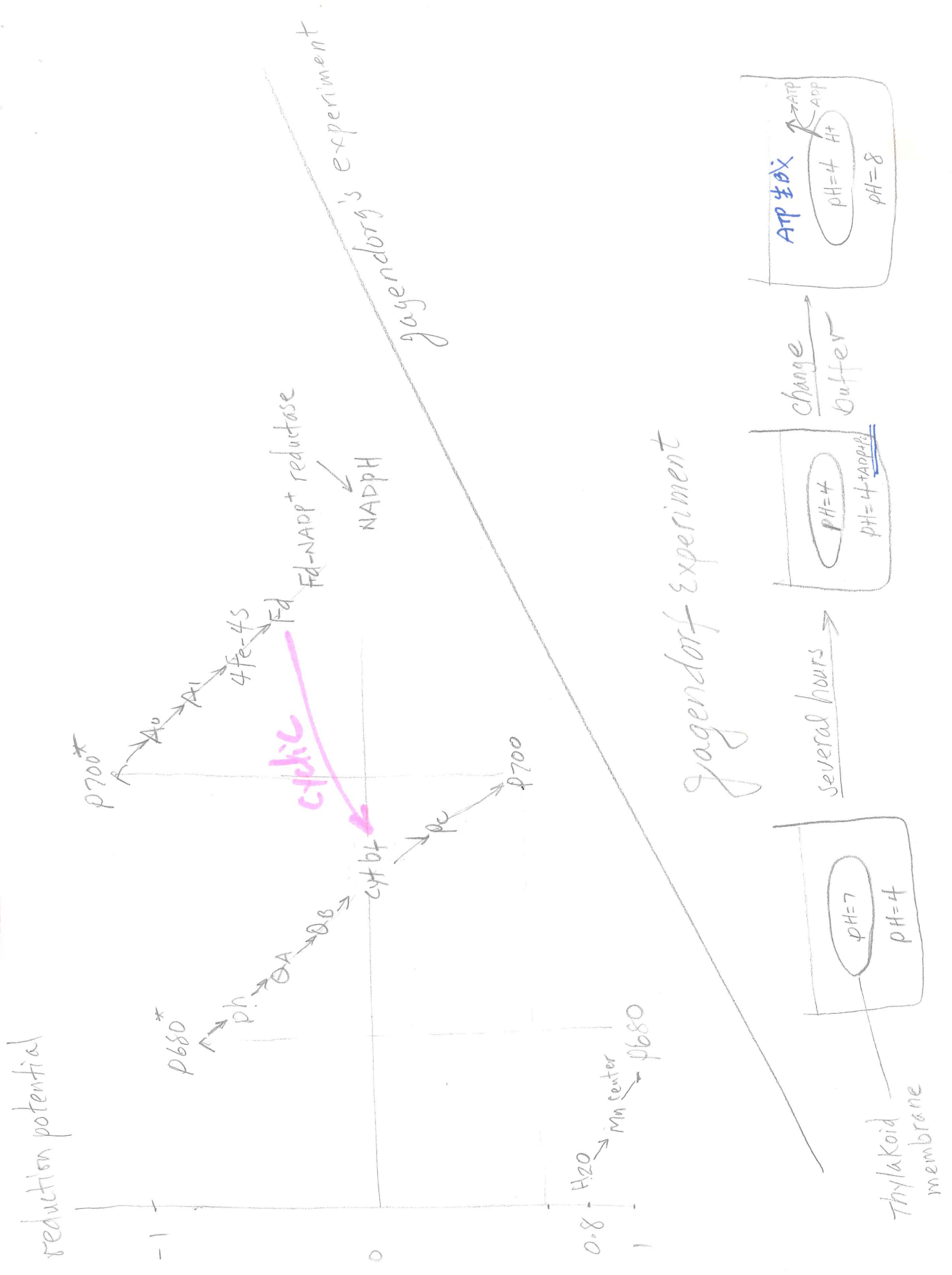
Chloroplast
Thylakoid
membrane

Chloroplast (Green plant)

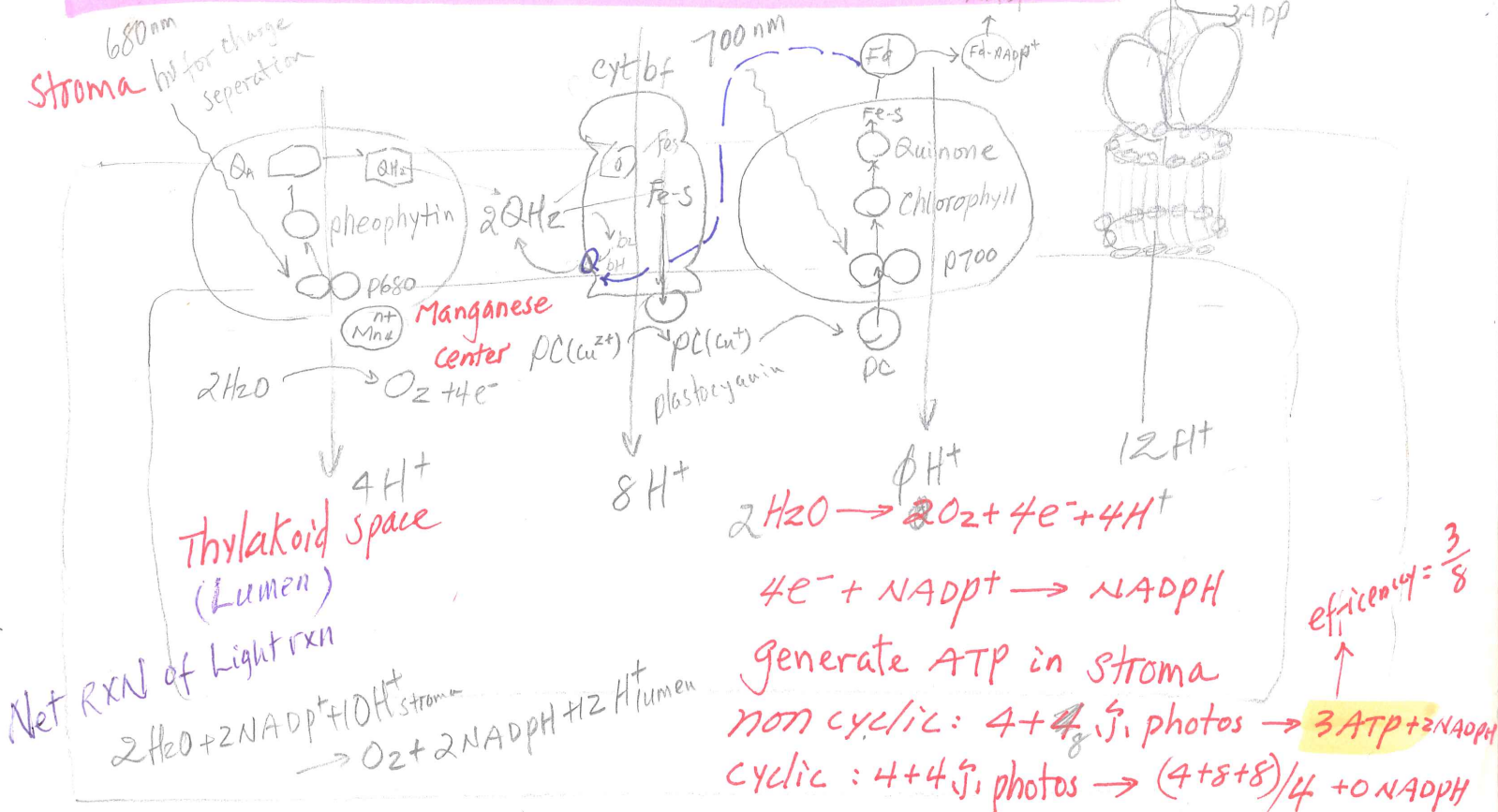


Z-scheme of photosynthesis

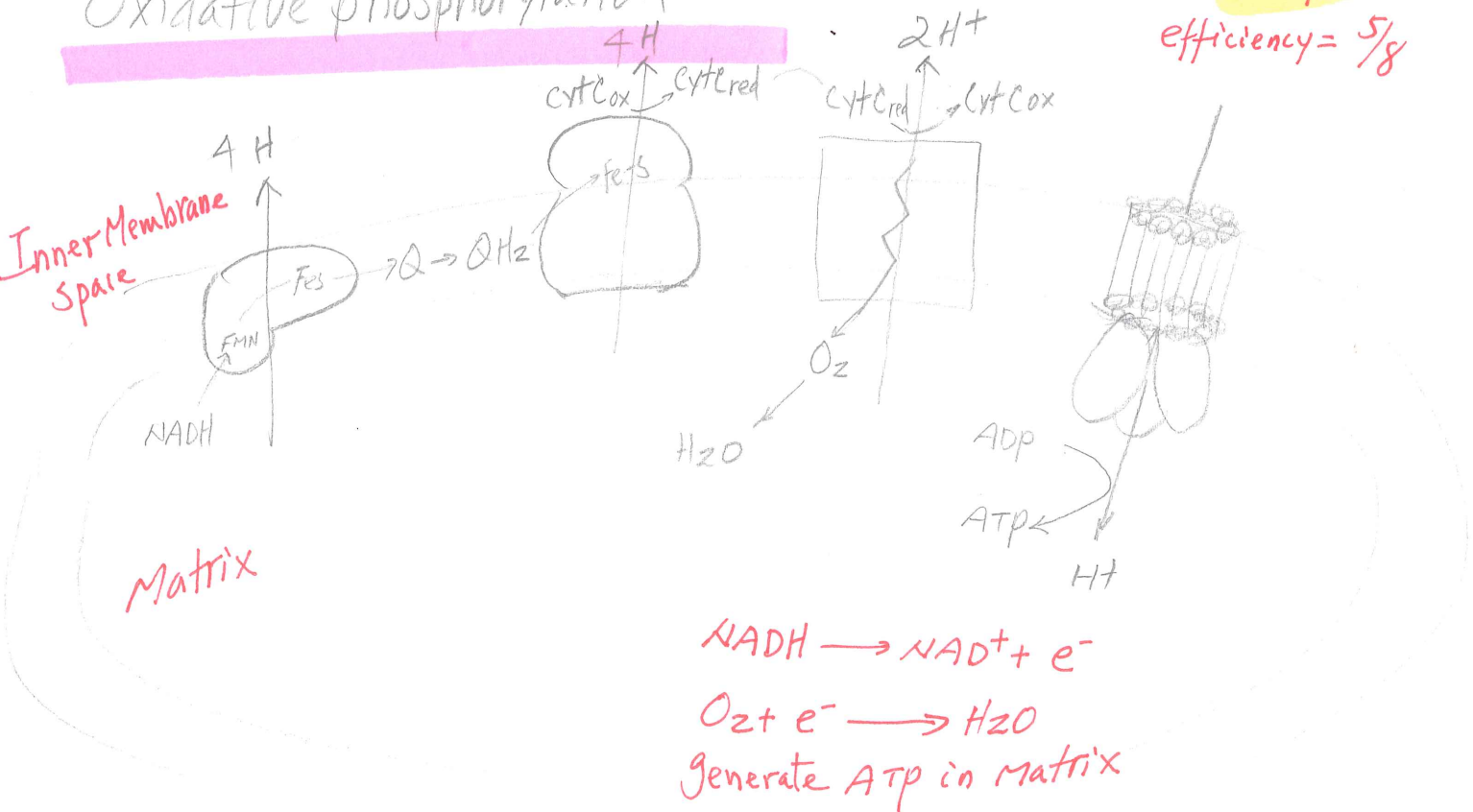
Z scheme of photosynthesis



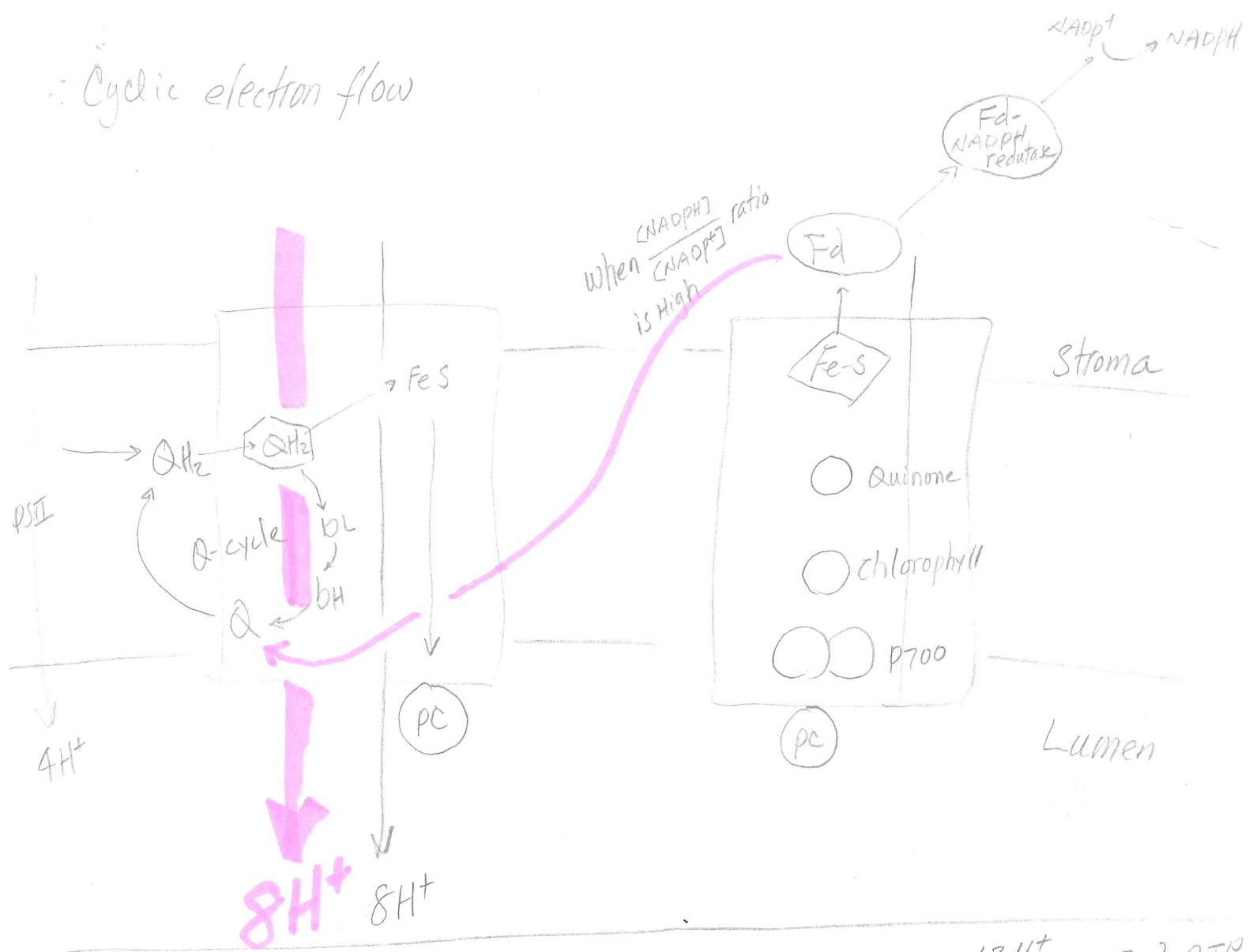
Thylakoid photosynthesis (Light reaction) in chloroplast



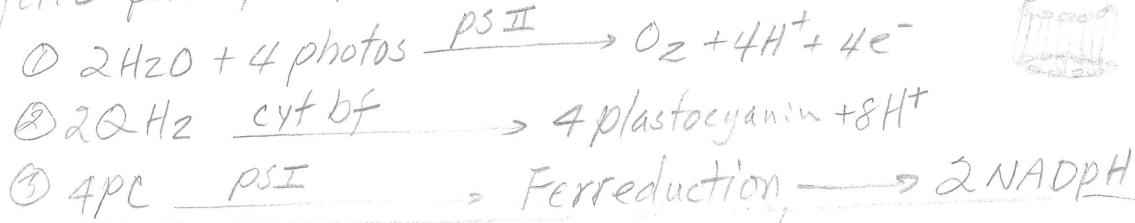
Oxidative phosphorylation



Cyclic electron flow



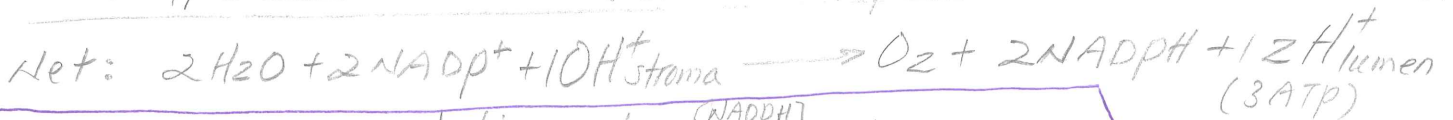
Noncyclic photophosphorylation:



$$12\text{H}^+_{\text{lumen}} = 3 \text{ ATP}$$



$$12 \text{ subunit } f_0 = 3 \text{ ATP}$$



Cyclic photophosphorylation (when $\frac{[\text{NADPH}]}{[\text{NADP}^+]}$ is high)



→ pump another 8H^+ in lumen (= 2 ATP)

即在PSI中, 每2个 photos 生成 1个 ATP

non-cyclic photophosphorylation

8个 photos 生成 3 ATP

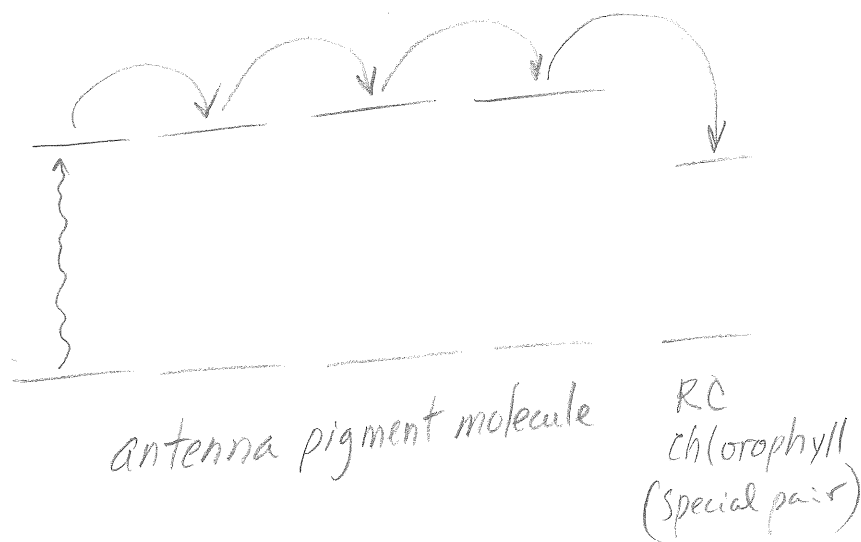
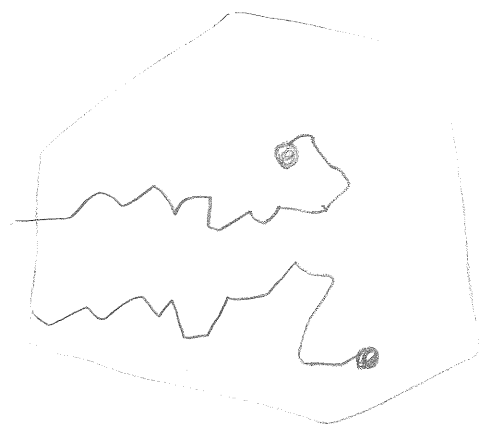
$12\text{H}^+_{\text{lumen}} = 3 \text{ ATP}$

cyclic photophosphorylation

8个 photos 生成 5 ATP

$20\text{H}^+_{\text{lumen}} = 5 \text{ ATP}$

Flow energy through a photosynthetic antenna complex

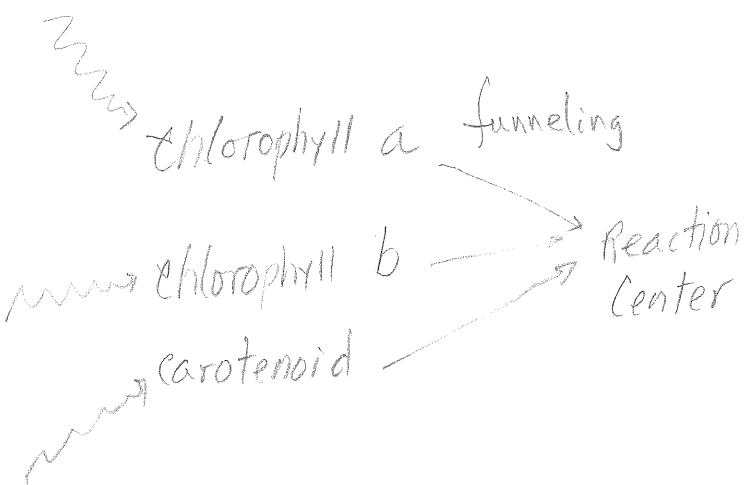


energy trapped to special pair chlorophyll (reaction center)

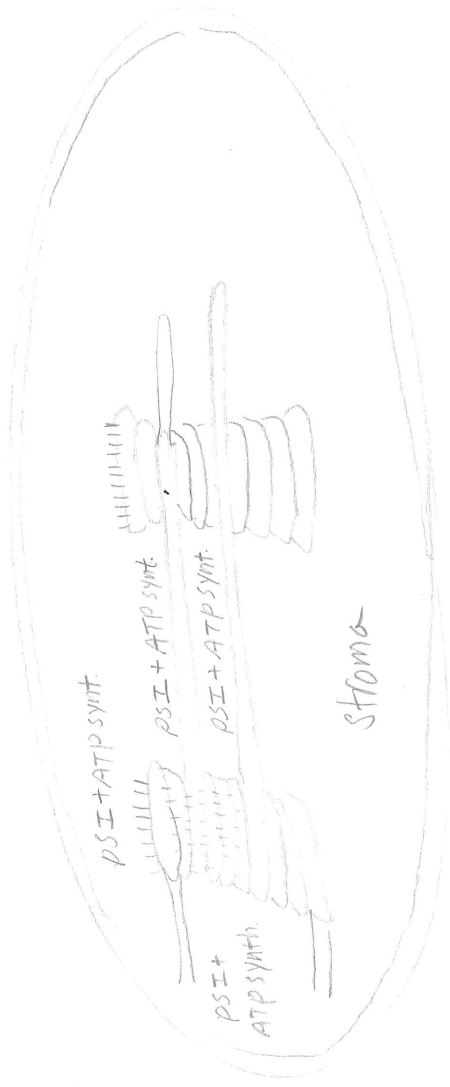
funnel, trap

light harvesting molecules = chlorophyll b + carotenoid (yellow + red)
 (green) * safe-guarding

防止日曬



Components of photosynthesis are highly organized



1. ^要PSI (located in unstacked region (stroma)): access to NADP^+

2. ATP synthase: large cF₁ globule to located unstacked region: Access to ADP

3. PSII: located in stacked region; tight quarters, small H_2O (e^- donor)

4. cytochrome b₆: located in both stacked and unstacked regions