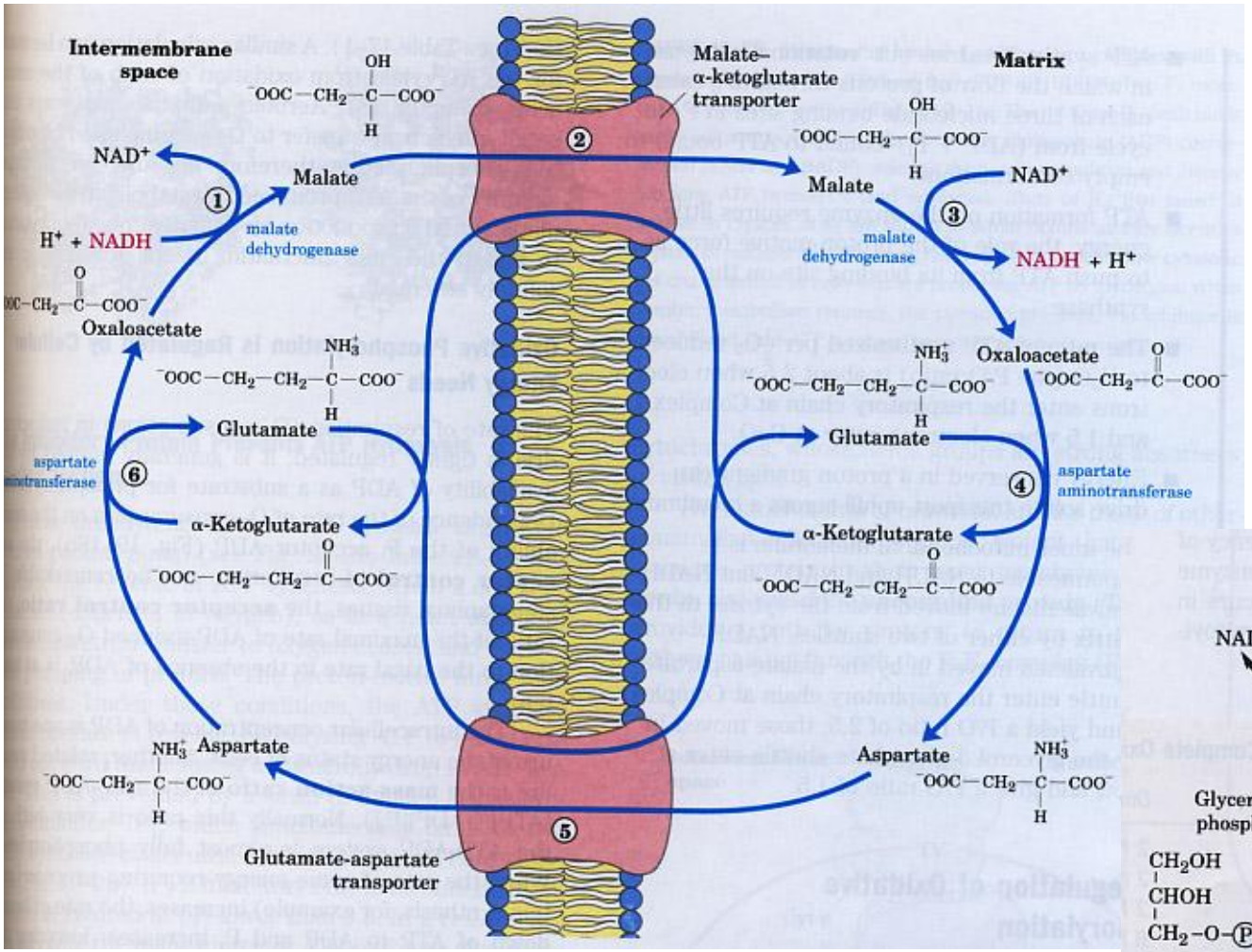
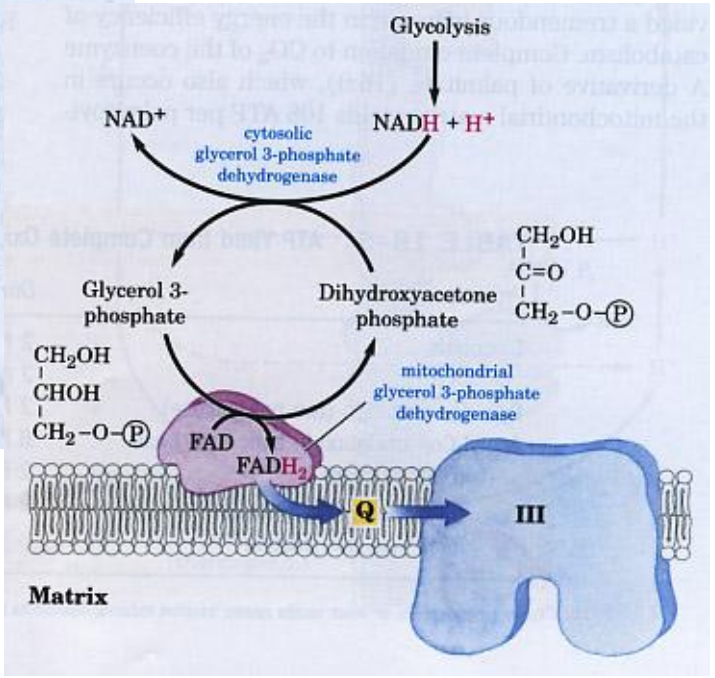
The transport of the cytosolic NADH into the mitochondria





Source of energy

Phototroph: **an organism that obtains energy from sunlight for the synthesis of organic compounds (they convert the solar energy to chemical one**)

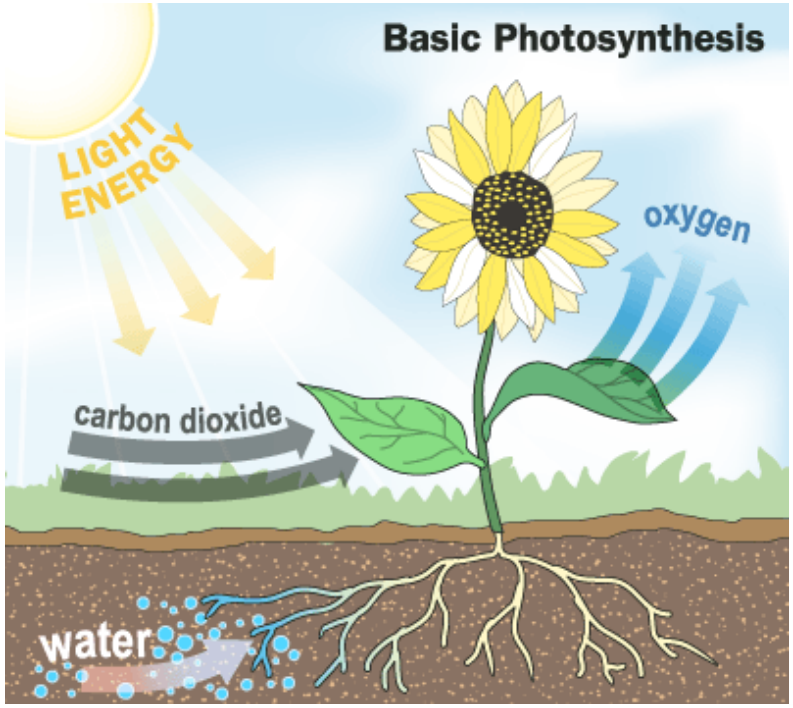
Chemotroph: an organism that cannot harvest and convert the solar energy, instead of it take up organic compounds and oxydize them to gain energy.

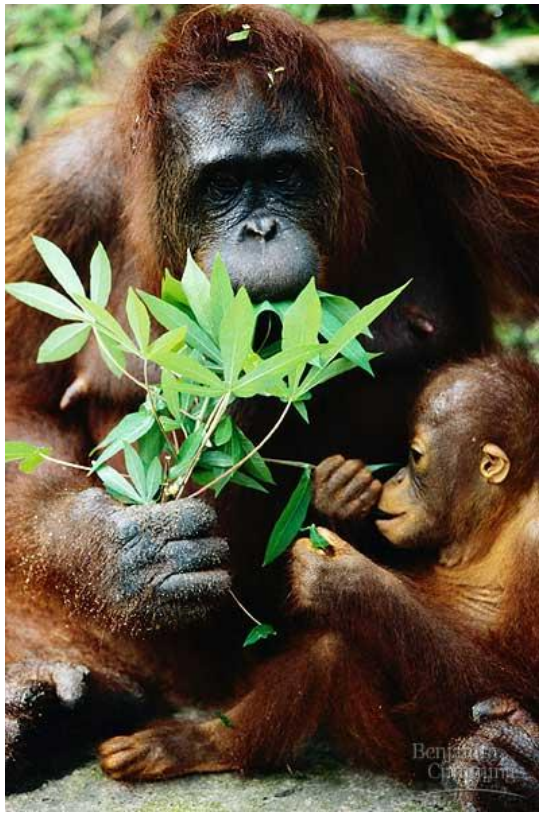
Source of carbon

Autotroph: **An organism capable of synthesizing its own foo from inorganic substances, using light or chemical energy. Green plants, algae, and certain bacteria are autotrophs.**

Heterotroph: **An organism that cannot synthesize its own food and is dependent on complex organic substances for nutrition.**

Solar energy → Photosynthesis → Chemical energy → Contraction / Transport / Biosynthesis





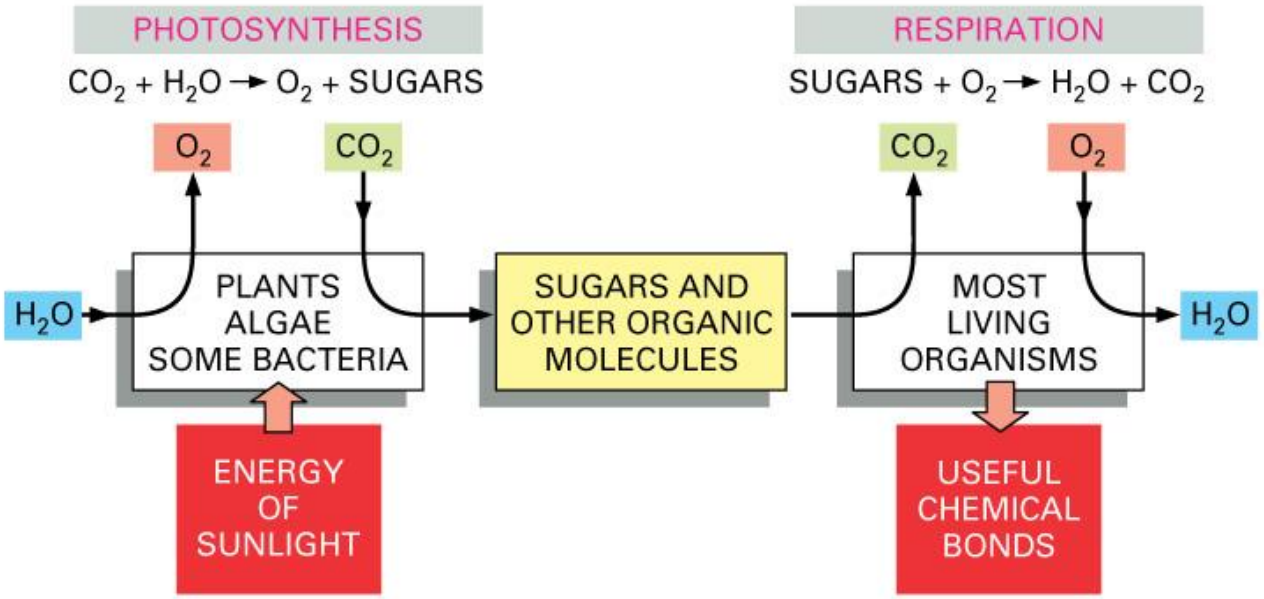
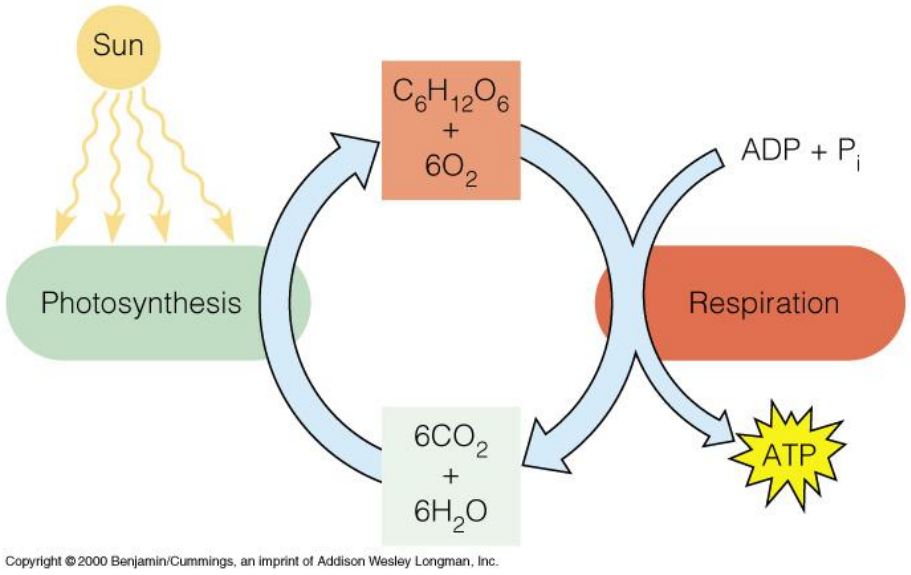
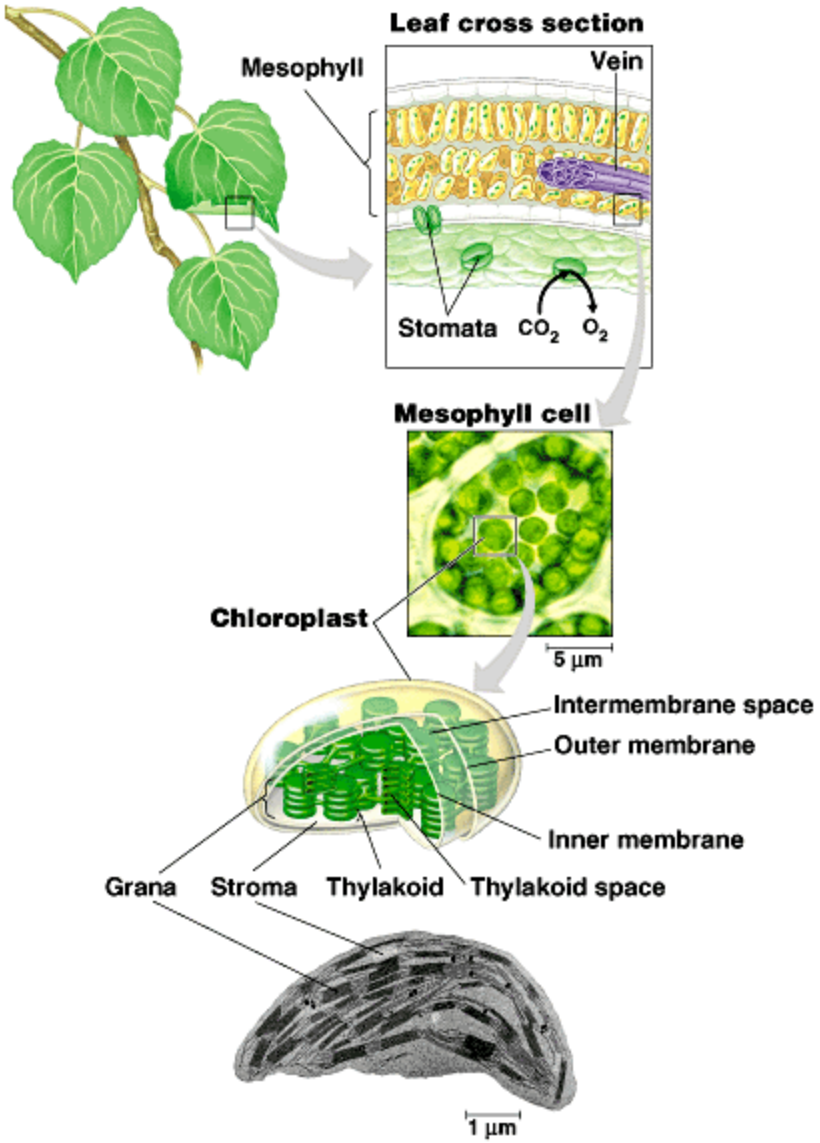


Figure 3-10 Essential Cell Biology, 2/e. (© 2004 Garland Science)

The recycling of carbon in the biosphere



The location of photosynthesis: chloroplast

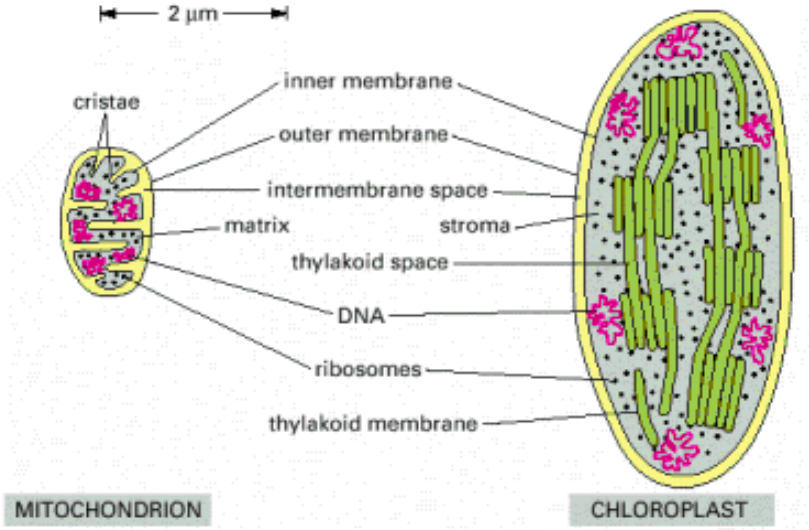


The cell organelle of plants algae

It belongs to the family of plastids

- small circular genome

- double membrane

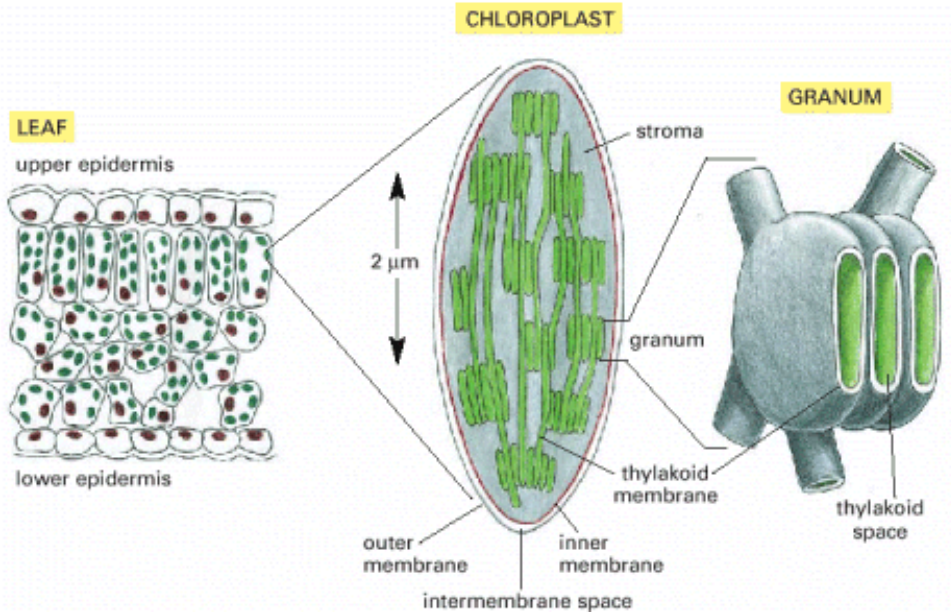


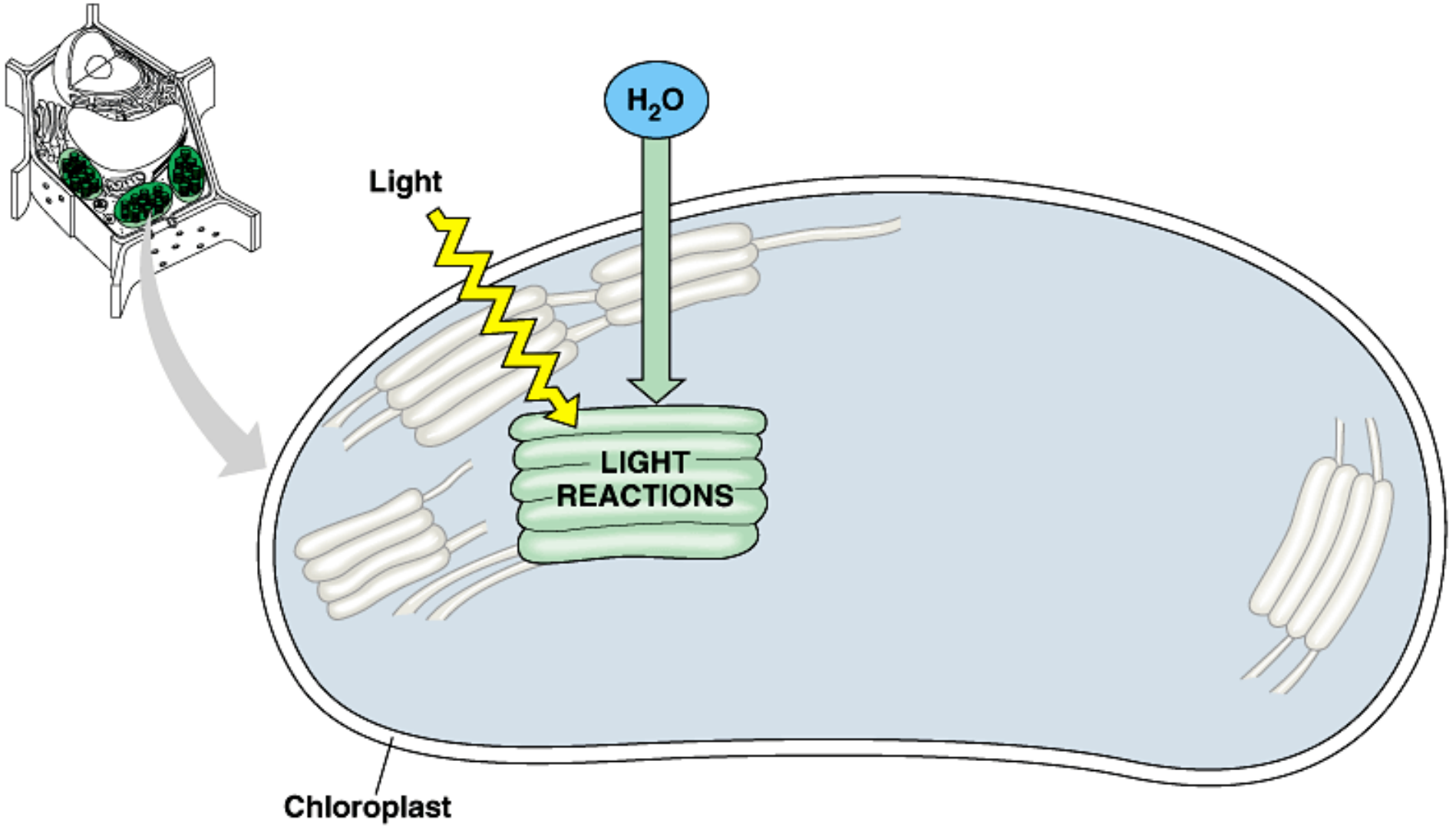
Shared features with the mitochondrion

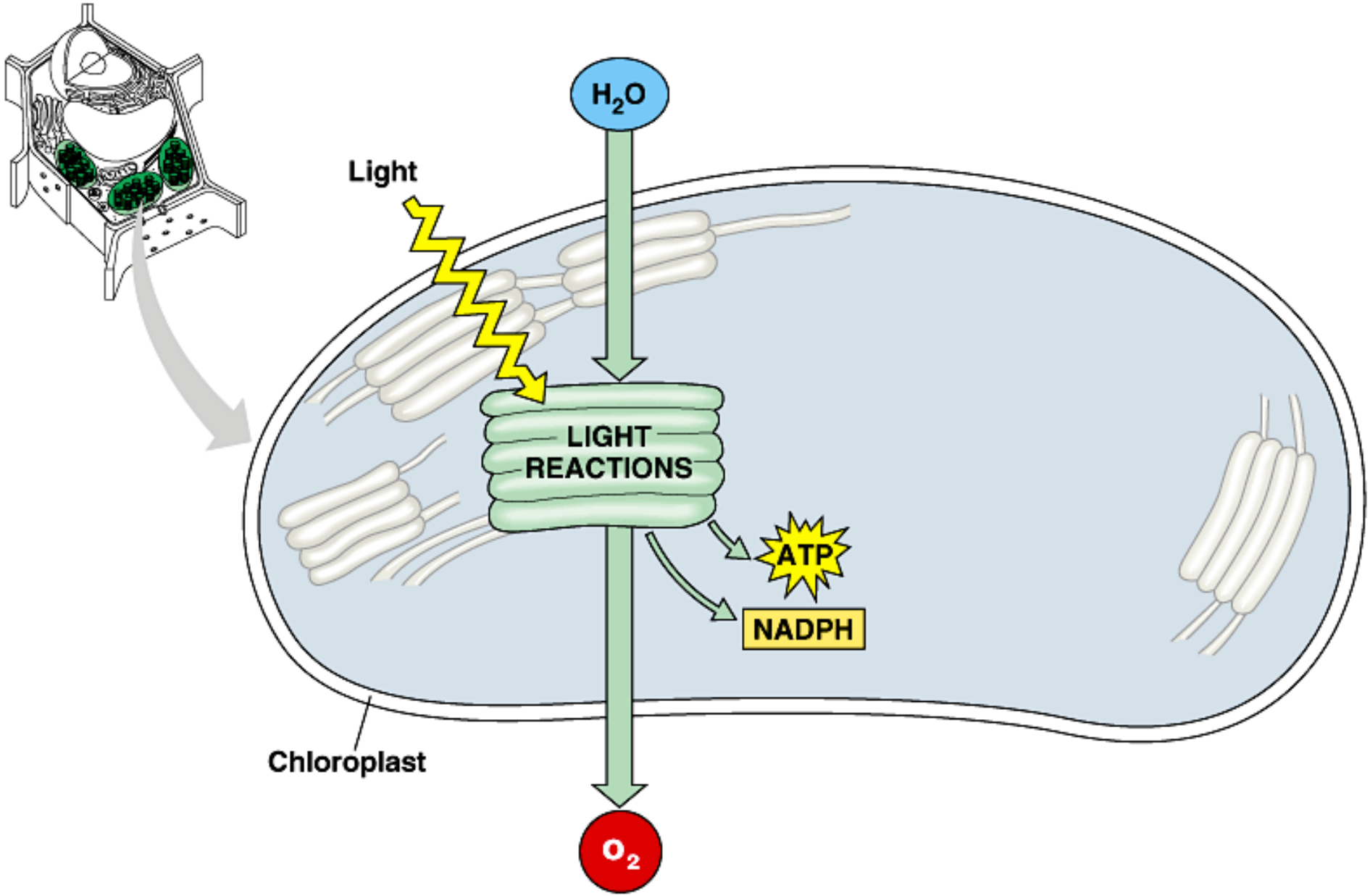
1. Permeable outer membrane
2. Non-permeable inner membrane with transport proteins
3. Intermembrane space between the two membranes
4. They have their own genome

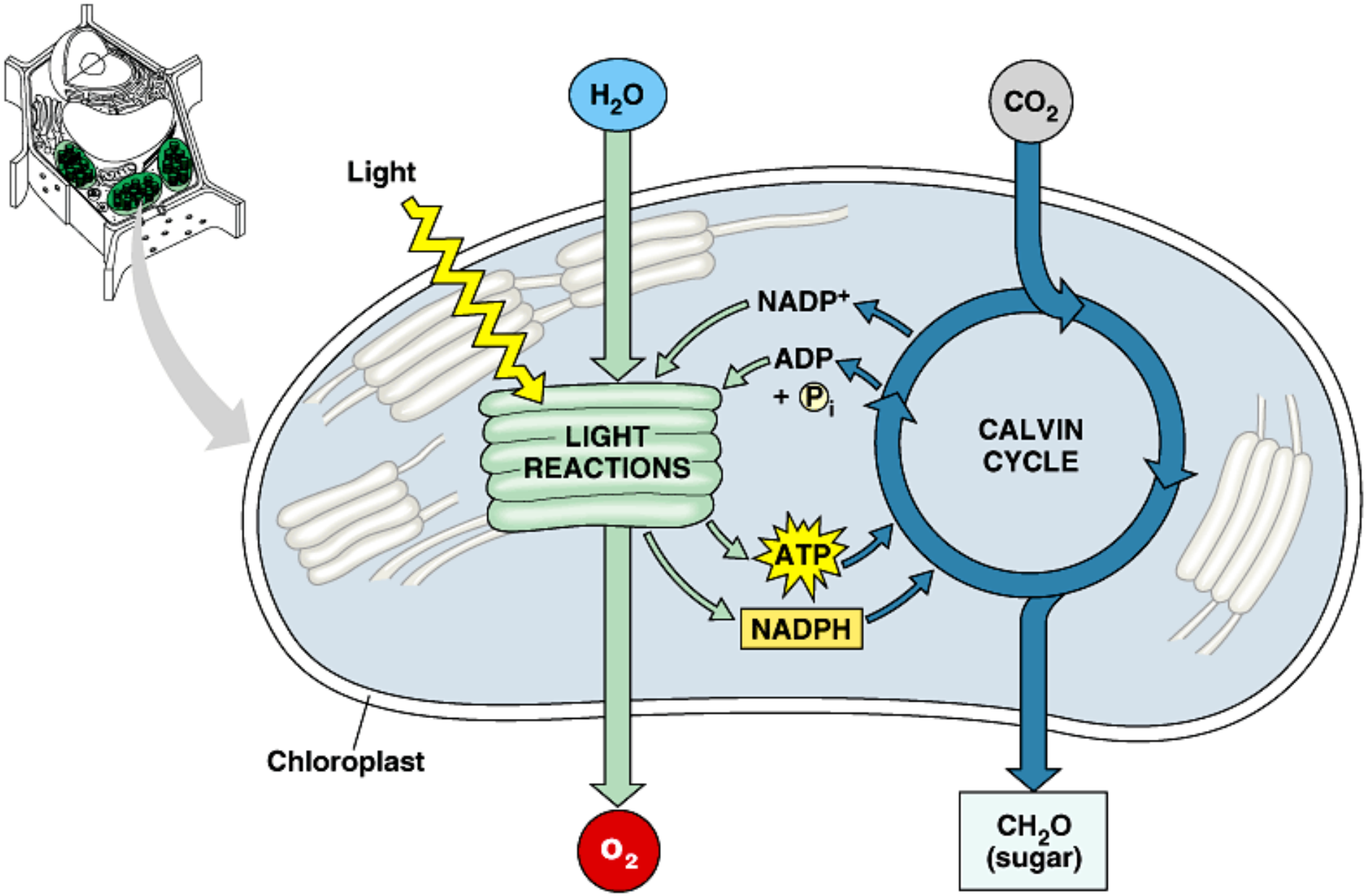
Differences:

1. There are no cristaes in the inner chloroplastic membrane
2. There is no electron transport chain in the inner chloroplastic membrane
3. There is a third membrane structure (thylakoid)
4. The electron transport chain and the light harvesting system can be found in the thylakoid membrane

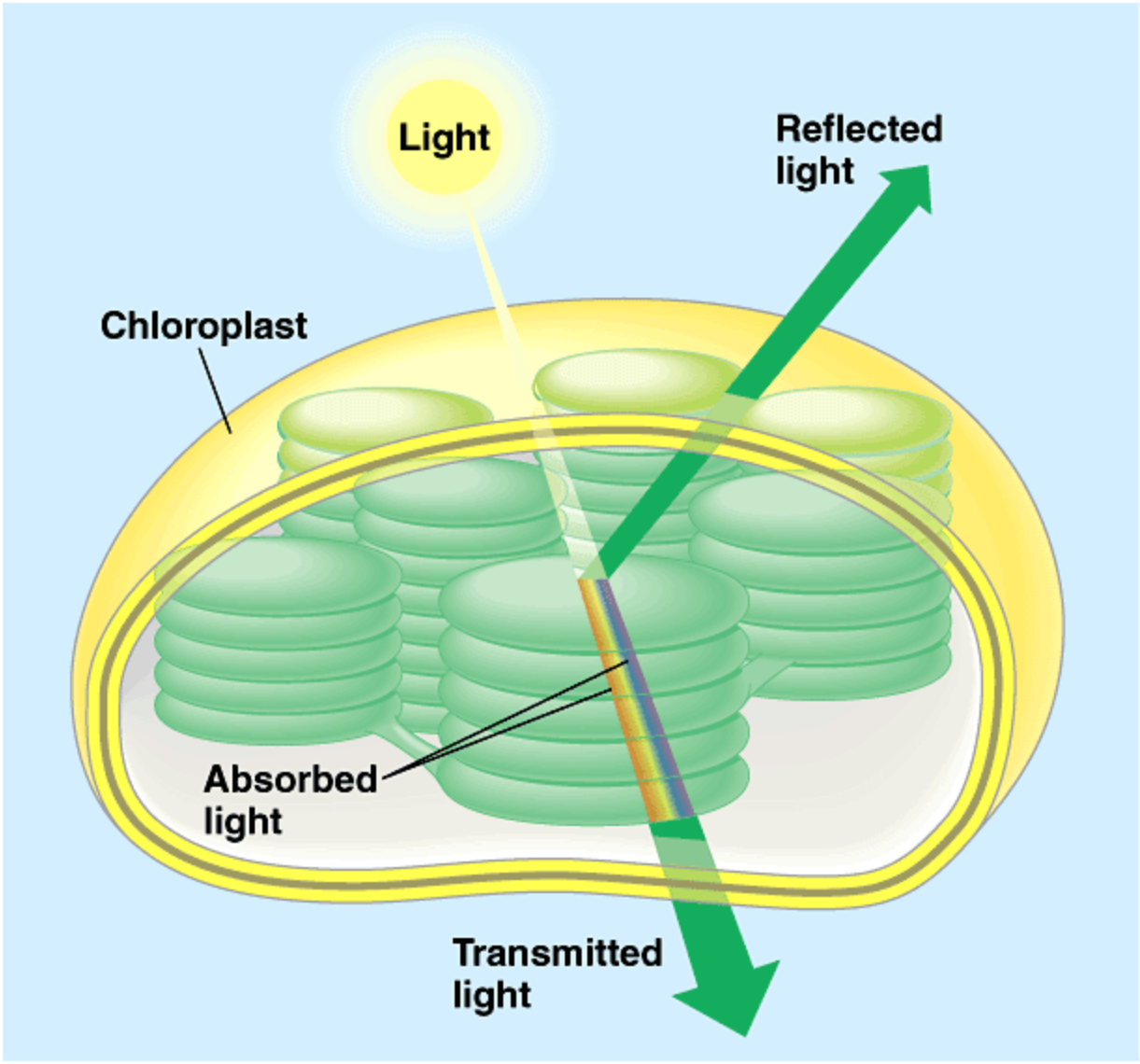






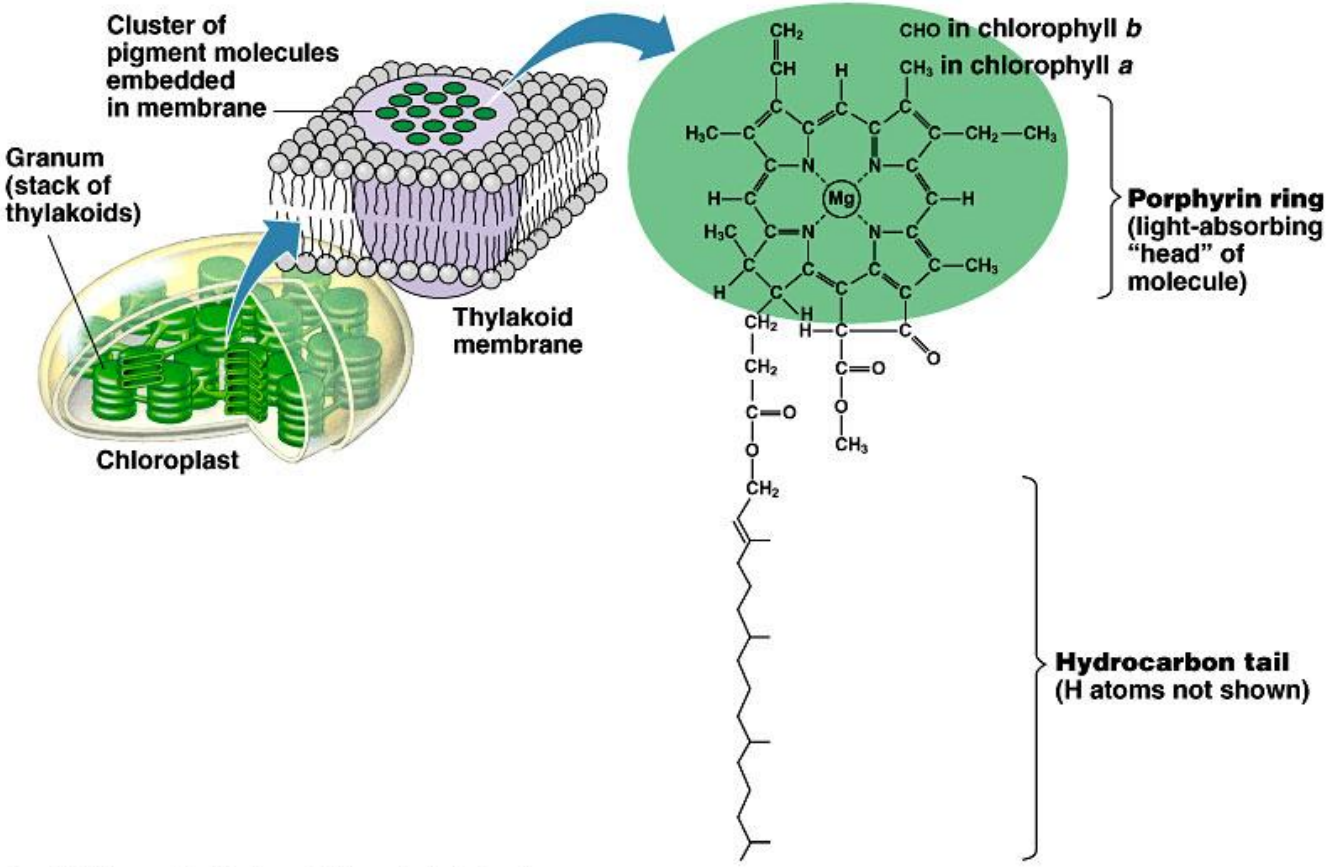


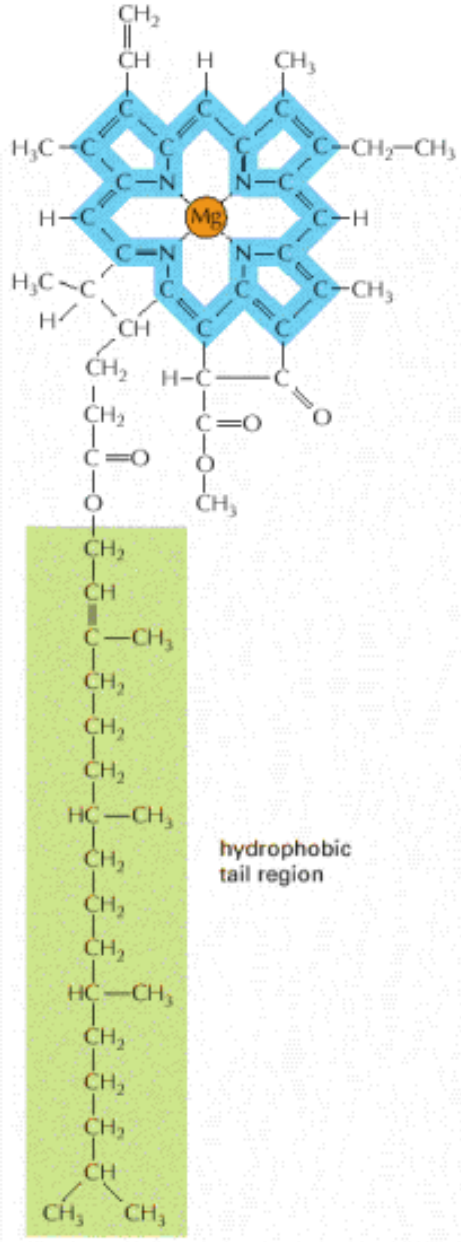
The light reaction: the conversion of the energy of sunlight to chemical energy



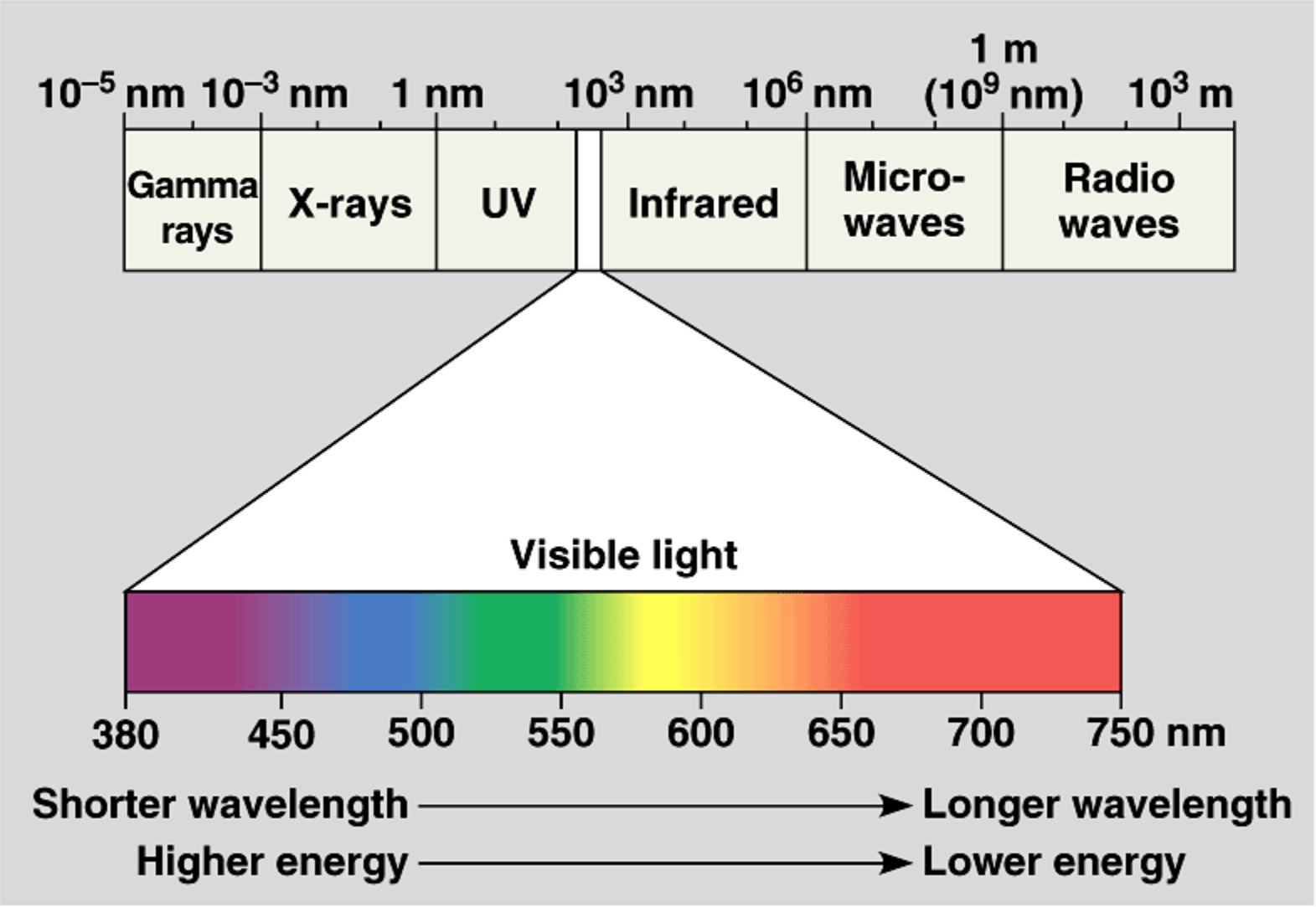
The structure of chlorophyll, the base of light harvesting

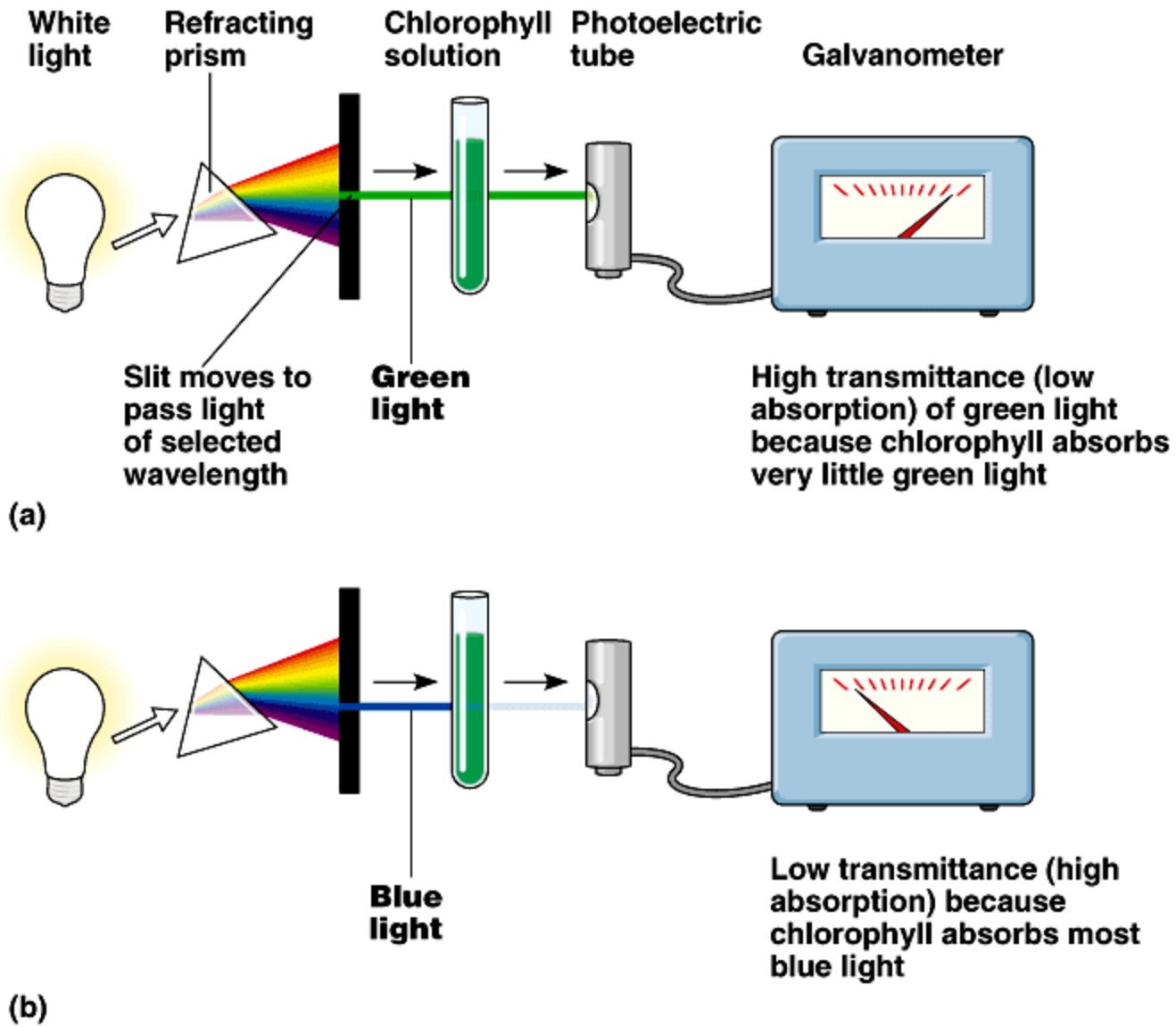
Conjugated double bond system

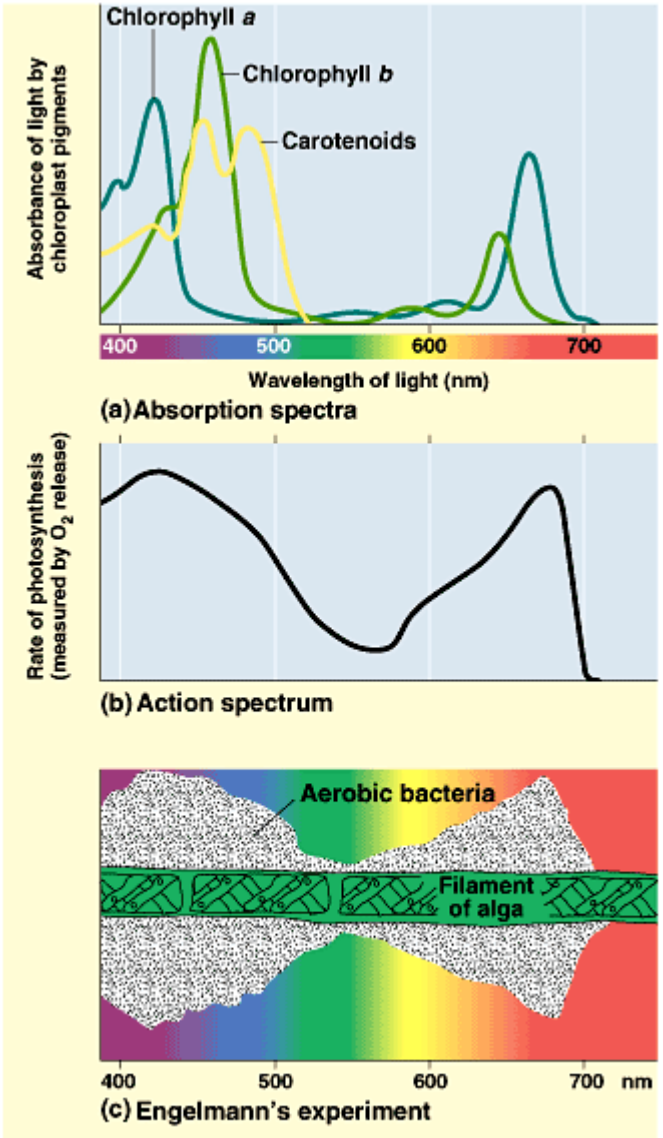


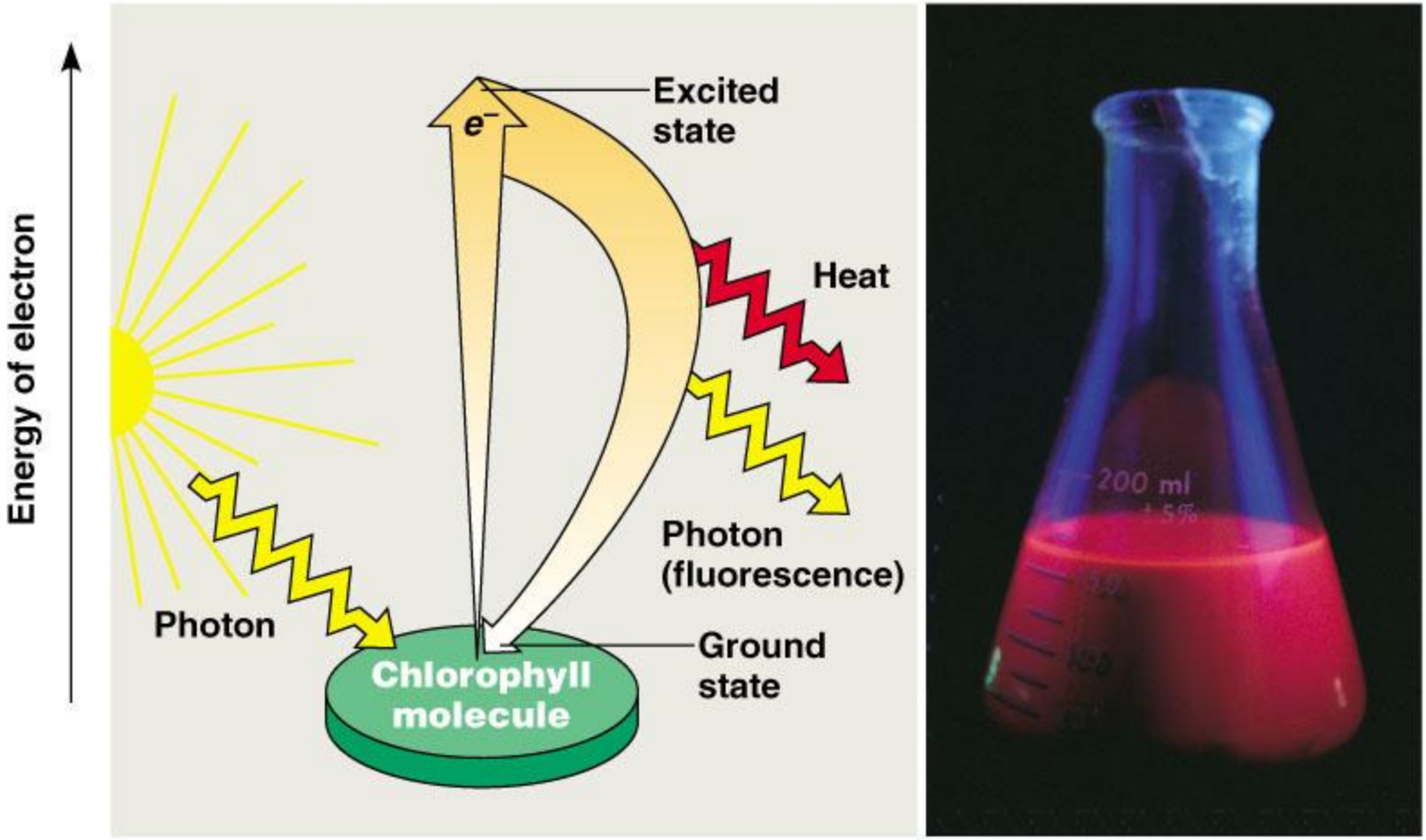


The spectra of the visiible light



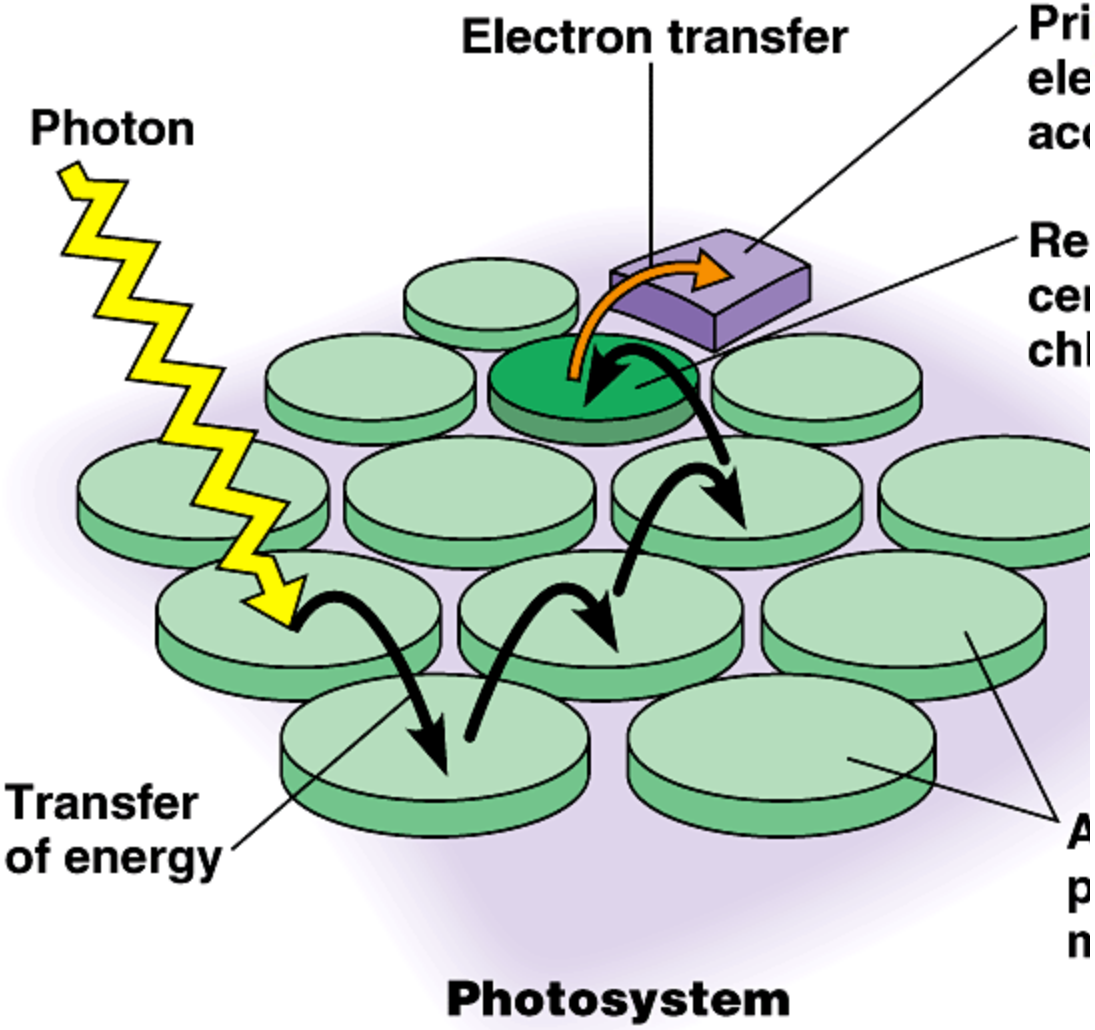


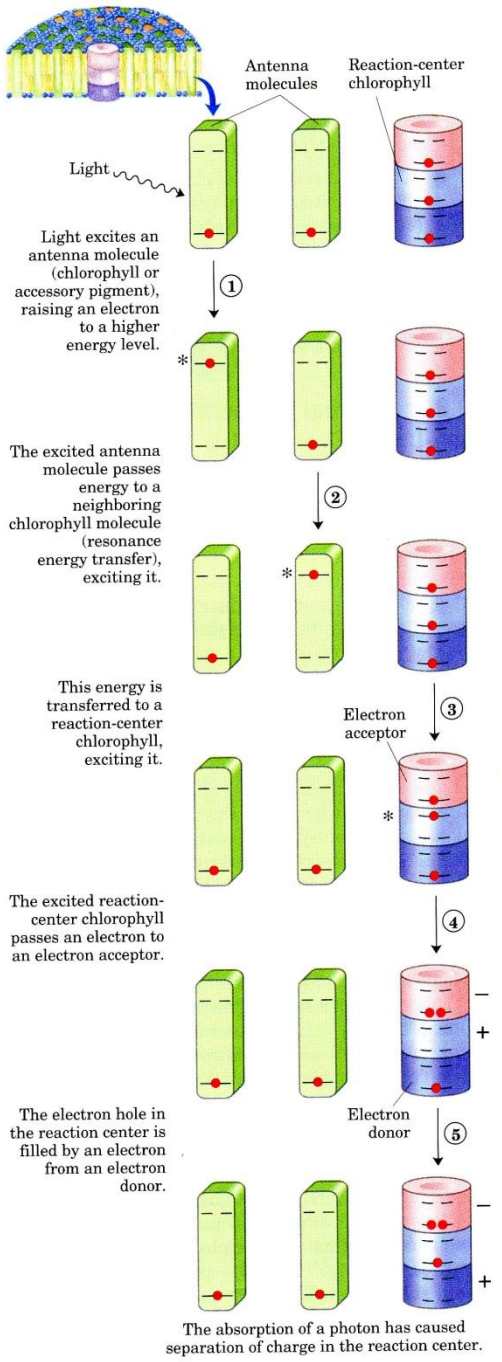




(a) Excitation of isolated chlorophyll molecule

(b) Fluorescence

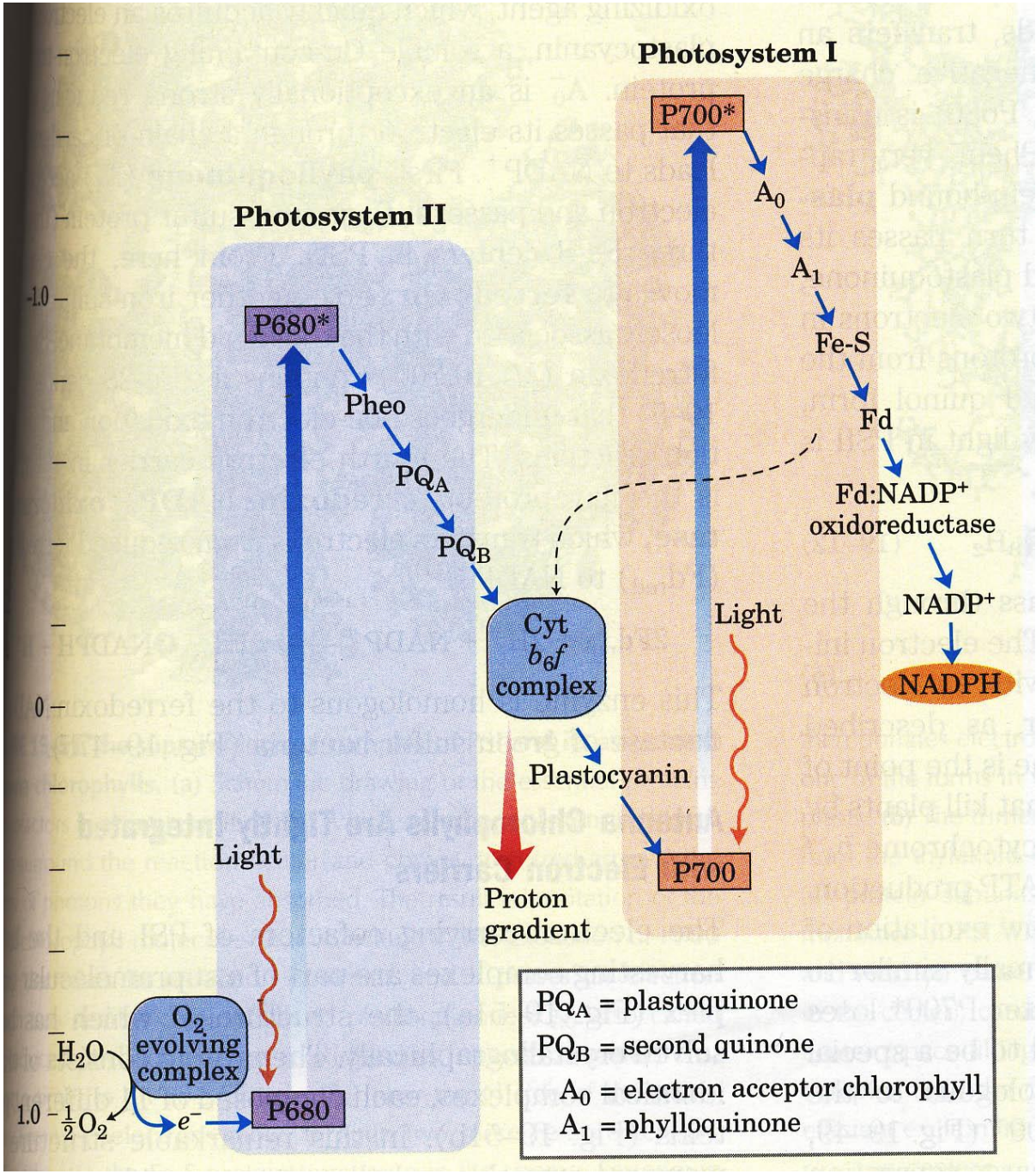


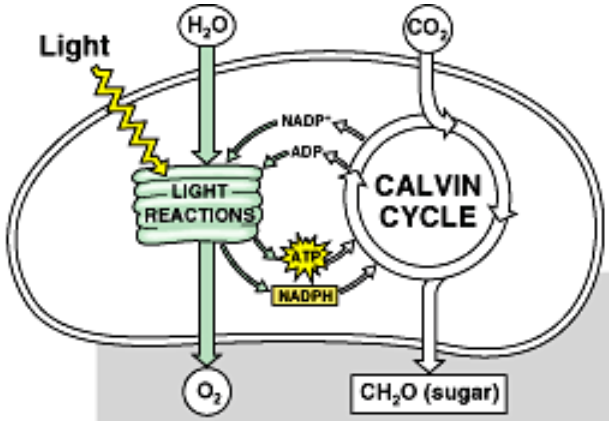


Other moleculas than chlorophylls can behave as

e.g.: carotineoids

Z-scheme

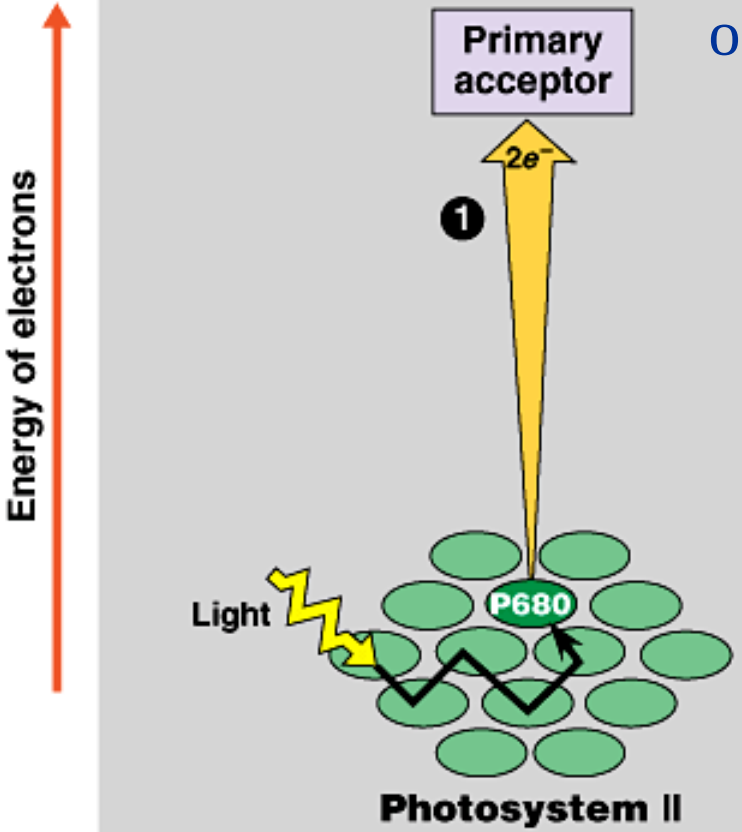

Photosystem I
P700*
A_0
A_1
Fe-S
Fd
Fd:NADP+ oxidoreductase
NADP+
NADPH
Photosystem II
P680*
Pheo
PQ_A
PQ_B
Cyt b_6f complex
Light
Plastocyanin
P700
Light
Proton gradient
O_2 evolving complex
H_2O
$\frac{1}{2}O_2$
e^-
P680
-1.0
0
1.0
PQ_A = plastoquinone
PQ_B = second quinone
A_0 = electron acceptor chlorophyll
A_1 = phylloquinone

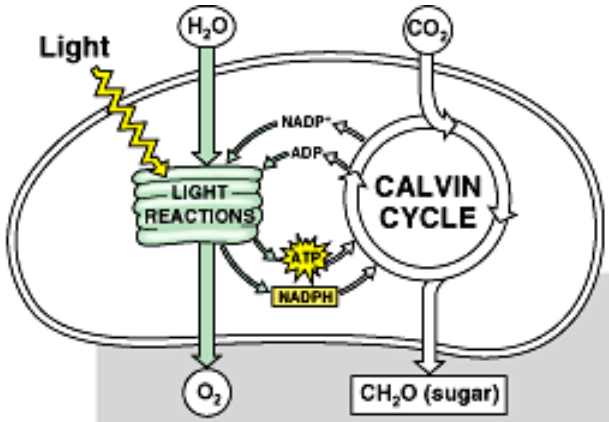


Bacteria: single photosystem

Higher plants: two complimentary photosystems (with own reaction centre and antennamolecules)

Photosystem II: approx. Equal ammount of chlorofphyll a and b

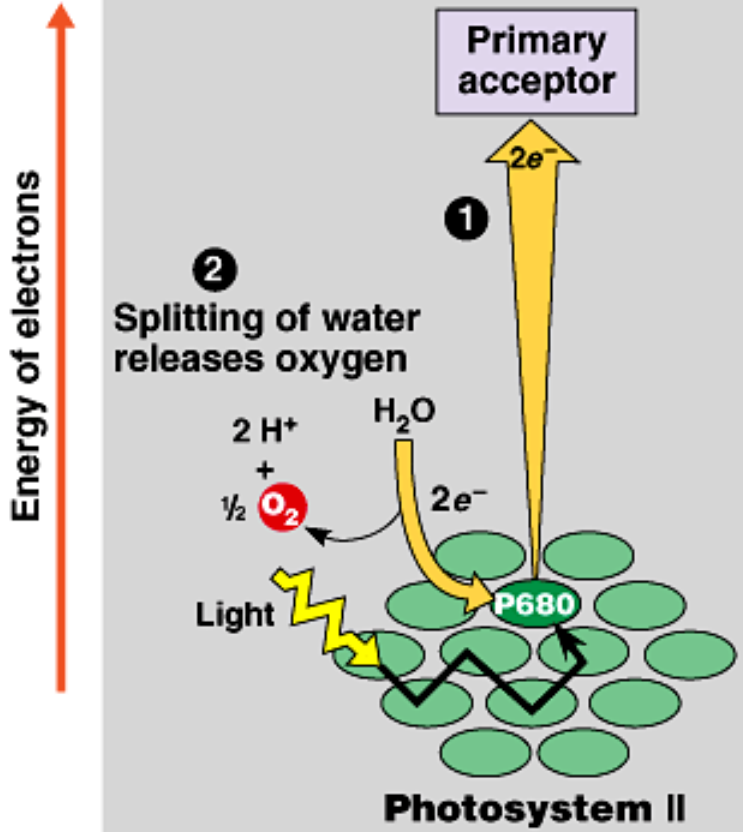


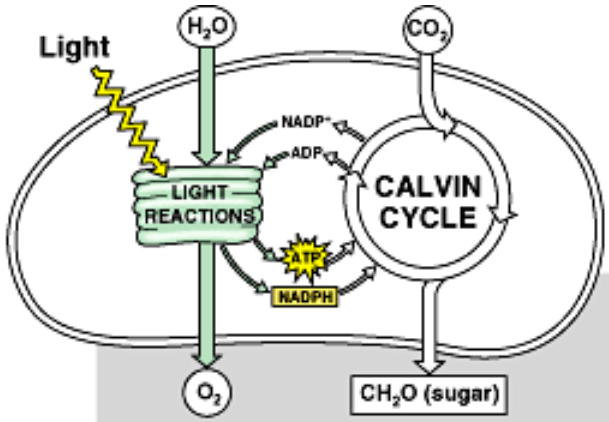


The released electrons from the reaction centre of photosystem II are refilled by the cleavage of water

Generation of O_2

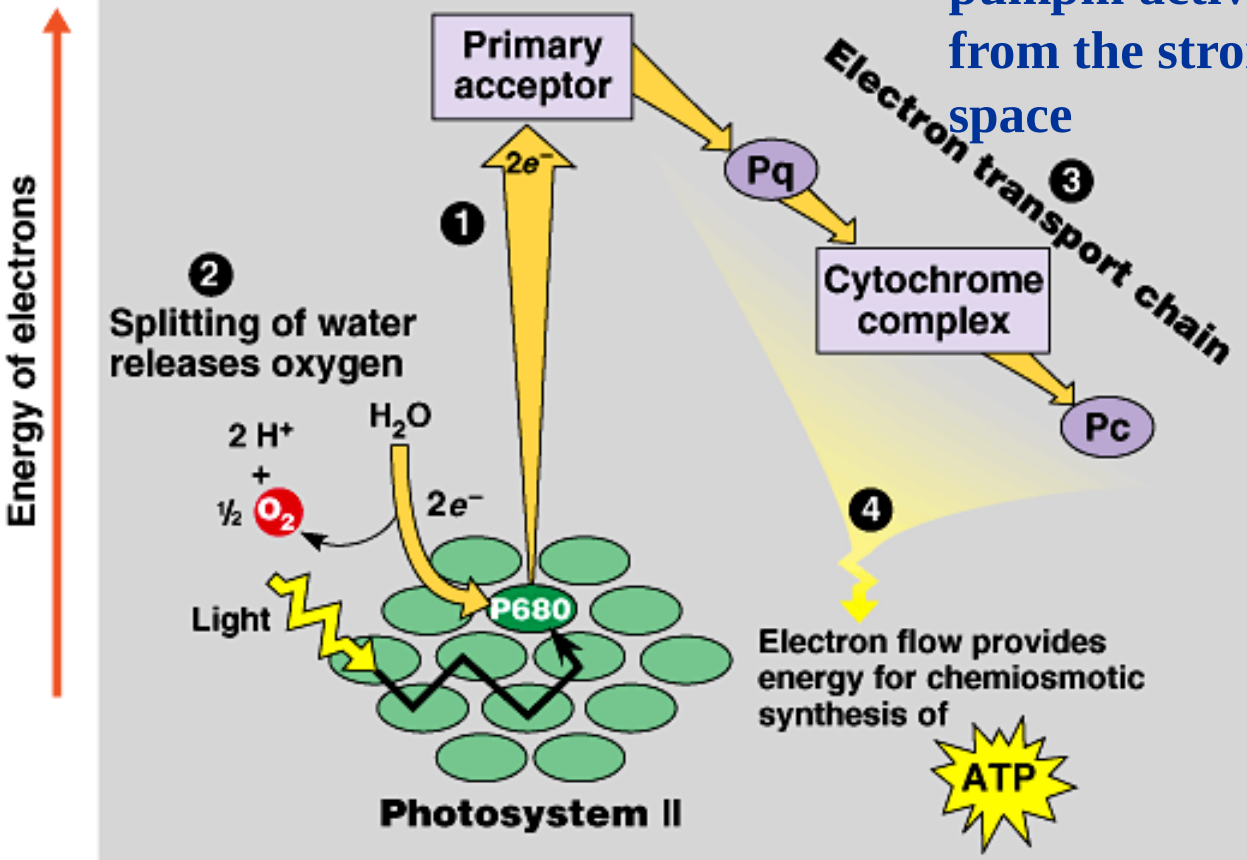
The energy of 4 photons is required to the cleavage of 1 water molecule





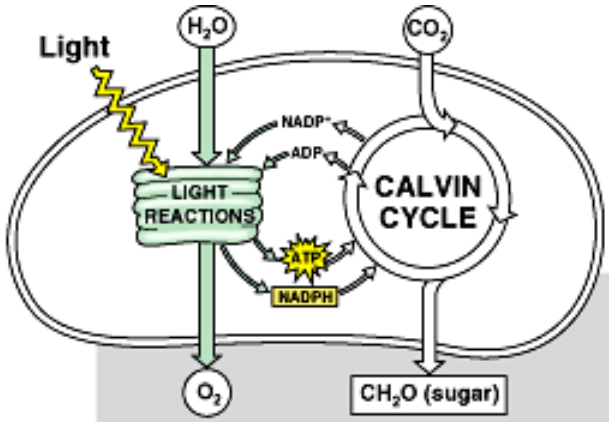
The electrons from the reaction centre of photosystem II are transferred by plastoquinone to the cytochrome b_6f complex, which mediates their transfer to plastocyanin.

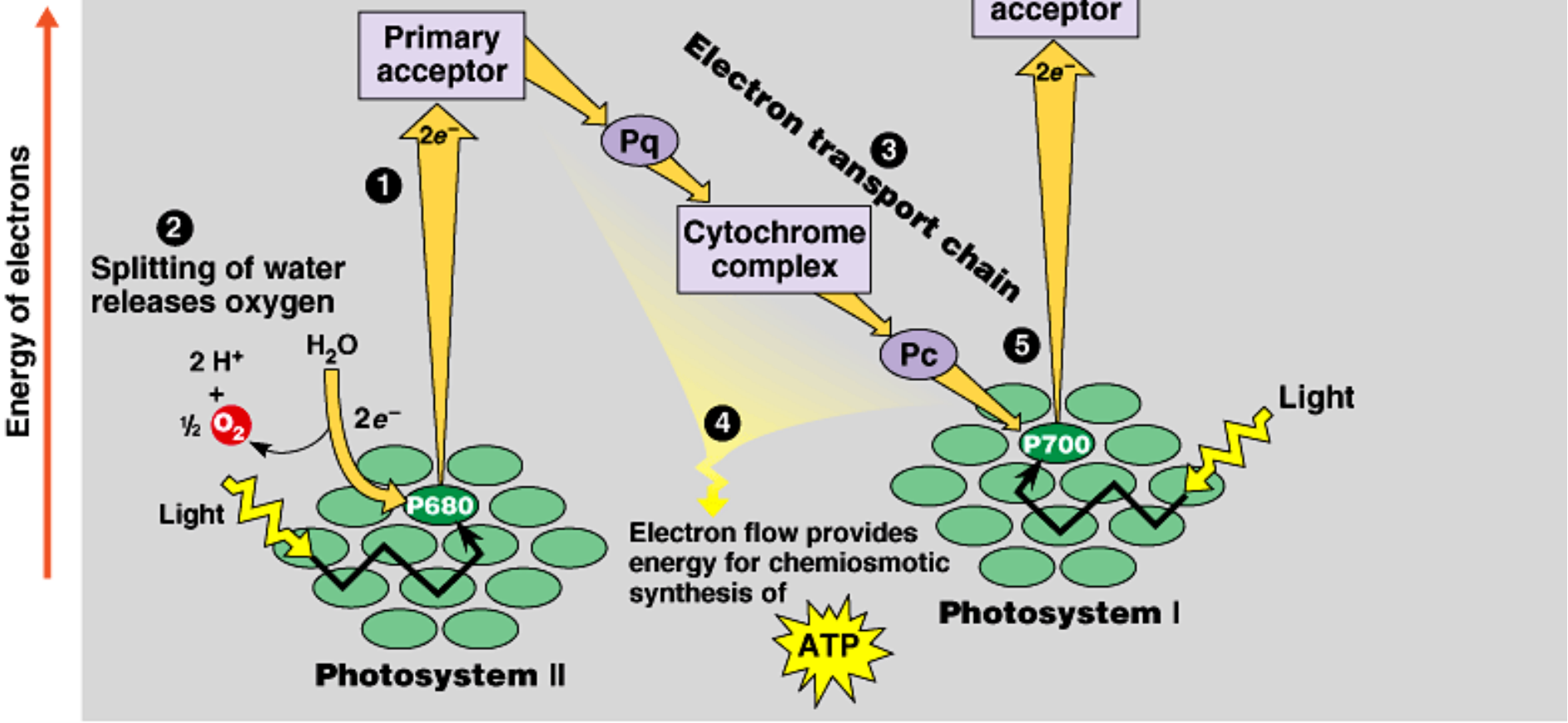
The cytochrome complex has proton pumpm activity: it pumps protons from the stroma into the thylakoid space



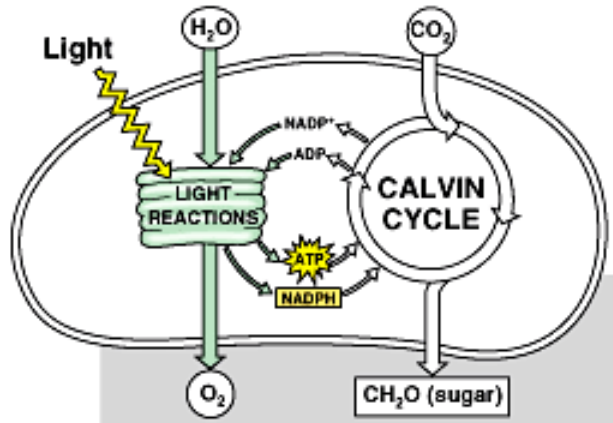
Photosystem I: higher chlrophyll a ratio

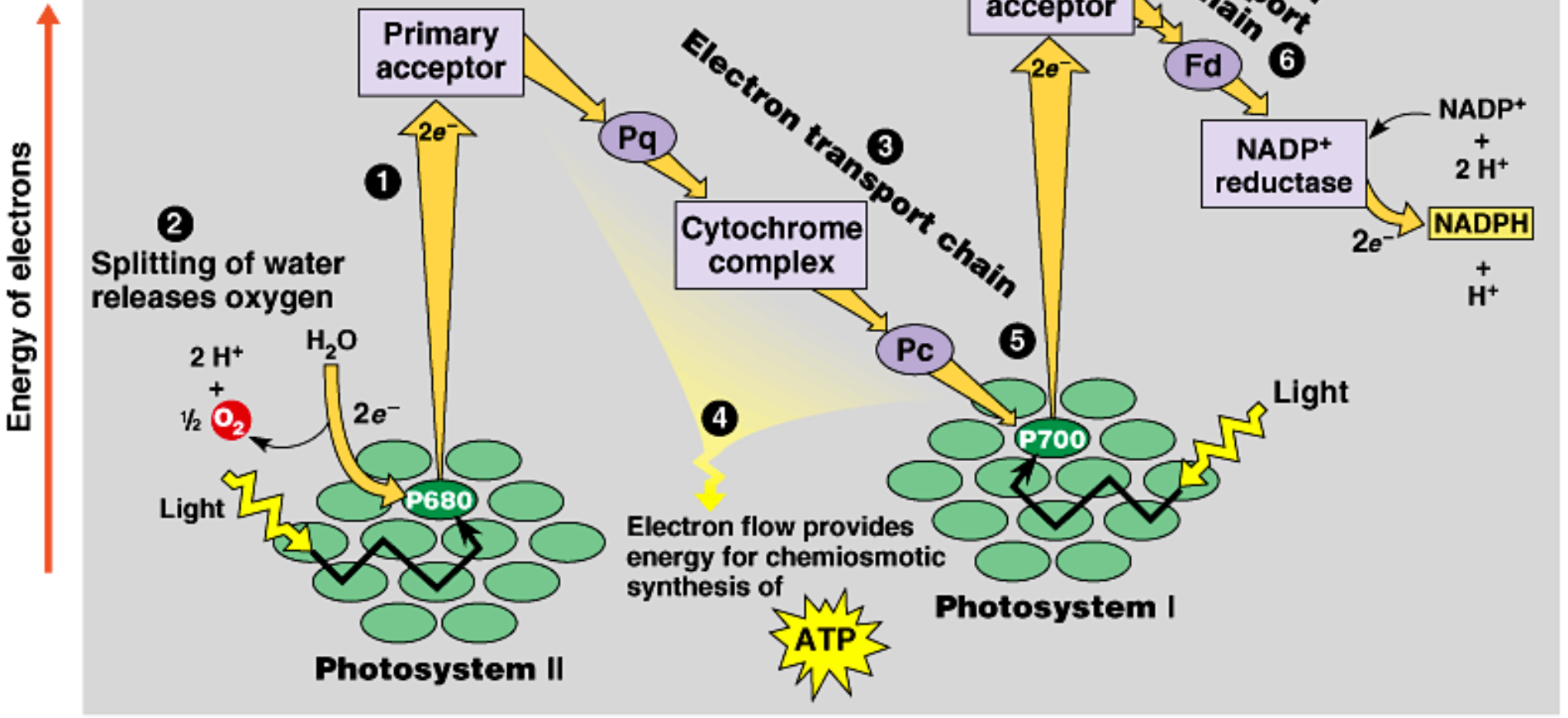
The electron hole generated by the excitation of photosystem I is refilled by the electrons comming from photosystem II via plastocyanin



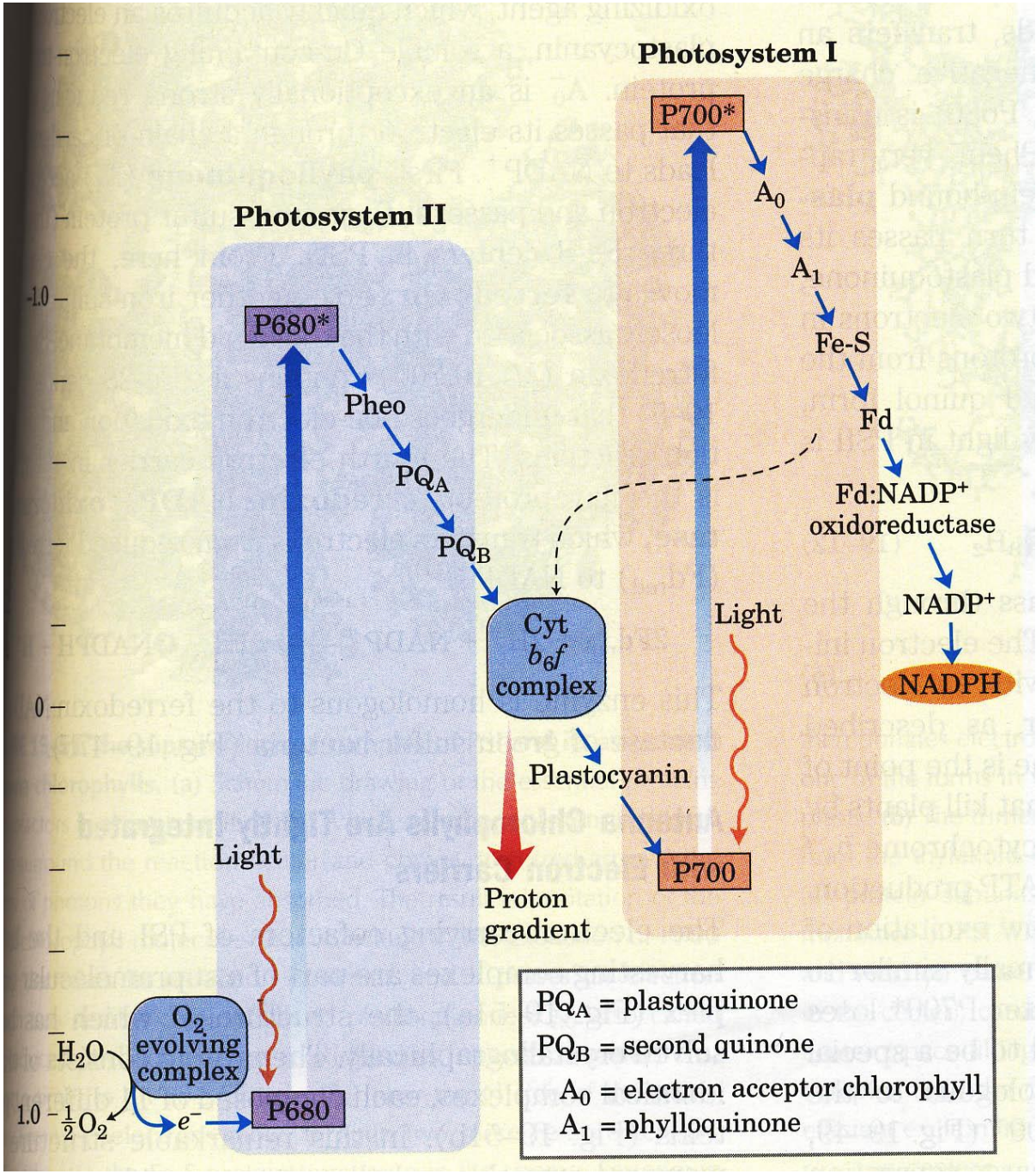


The electrons from the reaction centre of photosystem I are transferred to $NADP^+$ via ferredoxin

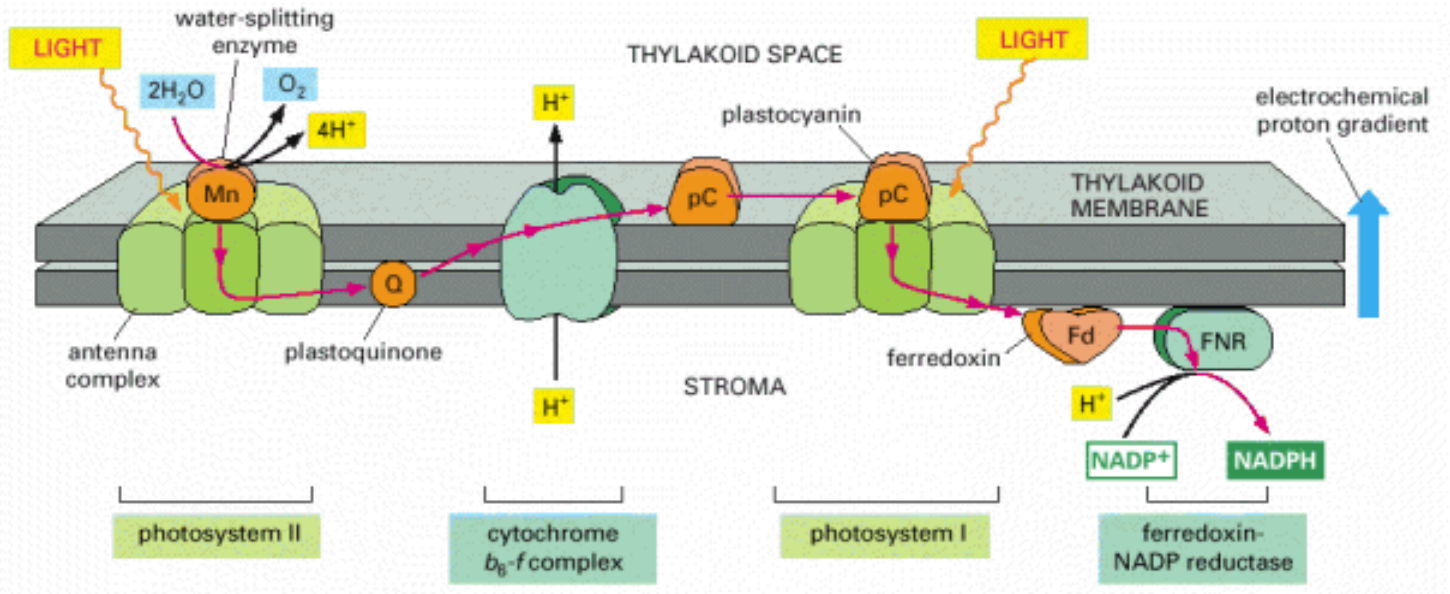




Z-scheme


Photosystem I
P700*
A_0
A_1
Fe-S
Fd
Fd:NADP+ oxidoreductase
NADP+
NADPH
Photosystem II
P680*
Pheo
PQ_A
PQ_B
Cyt b_6f complex
Light
Plastocyanin
P700
Light
Proton gradient
O_2 evolving complex
H_2O
$\frac{1}{2}O_2$
e^-
P680
-1.0
0
1.0
PQ_A = plastoquinone
PQ_B = second quinone
A_0 = electron acceptor chlorophyll
A_1 = phylloquinone

pH=5



pH=8

The transfer of 1 electron through cytochrome b_6f complexen results in the transport of 4 protons into the thylakoid space.

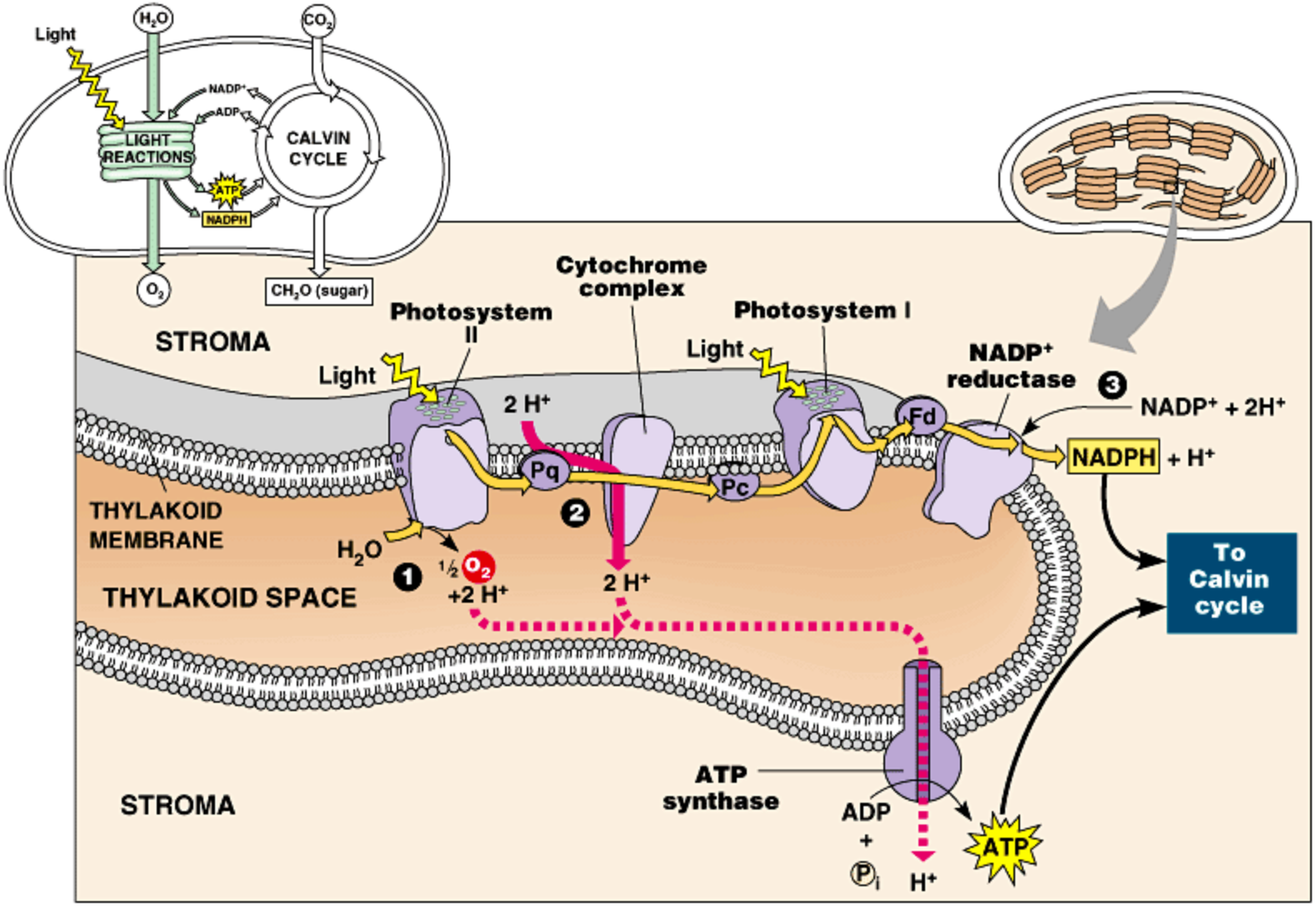
1000 times difference in protonconcentration

ATP syntesis

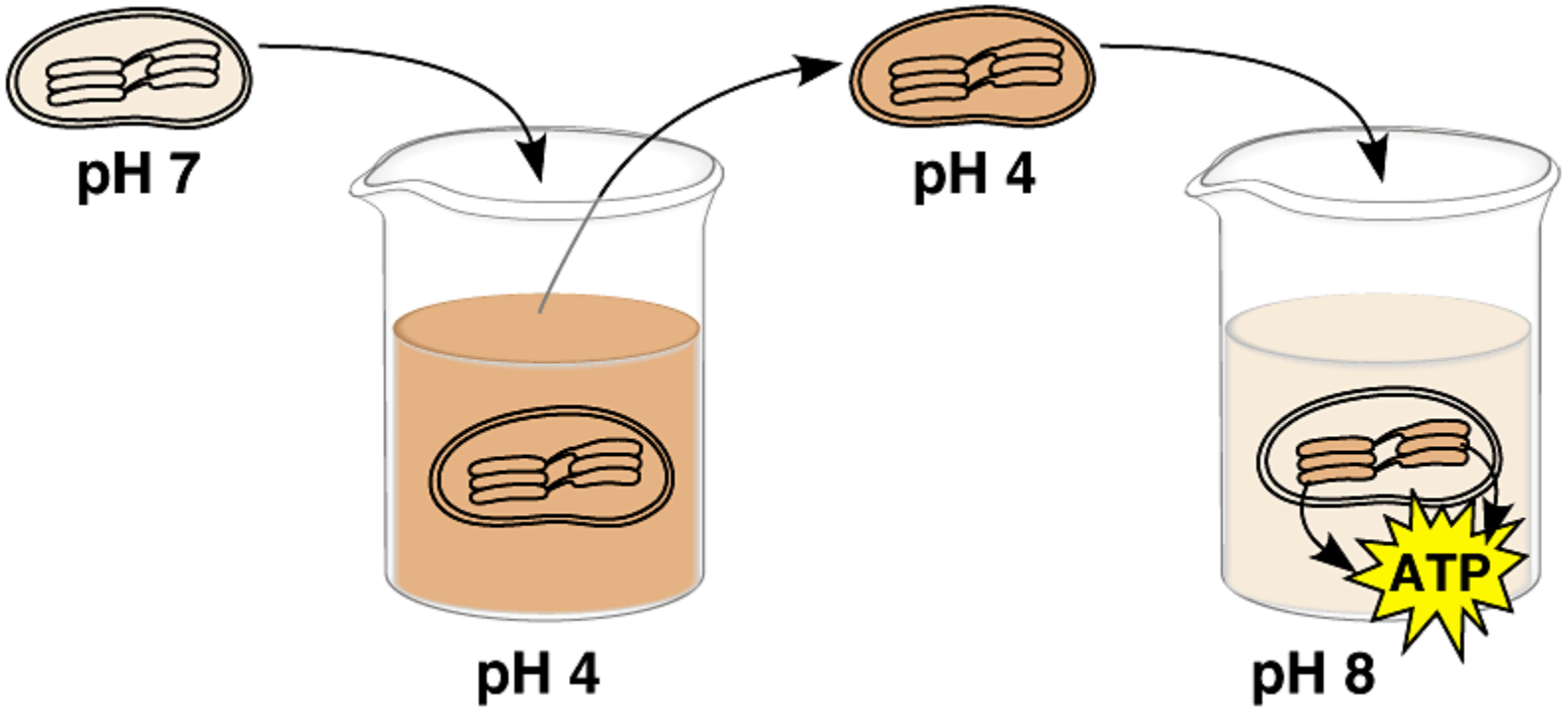
The generation of ATP in the chloroplast

Similar to the generation of ATP in the mitochondria

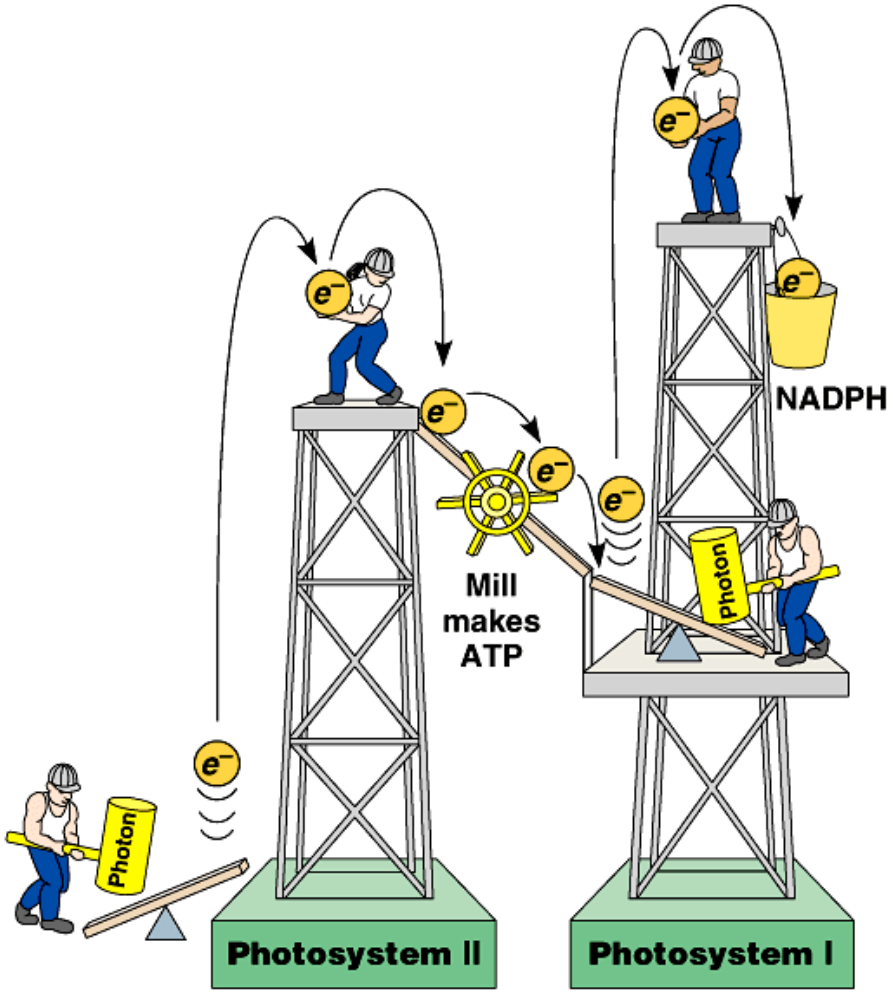
1. **Protonimpermeable membrane, with protein complexes**
2. **The electron transport and the phosphorilation can be uncoupled by uncoupling agents**
3. **The ATP-synthetase of thylakoid sacks can be inhibited by the inhibitors of mitochondrial ATP-syntetase inhibitors**
4. **F_oF_1 complex is responsible for the ATP syntesis in the thylakoid membrane**



Experiments proved the role of protongradient in ATP syntesis



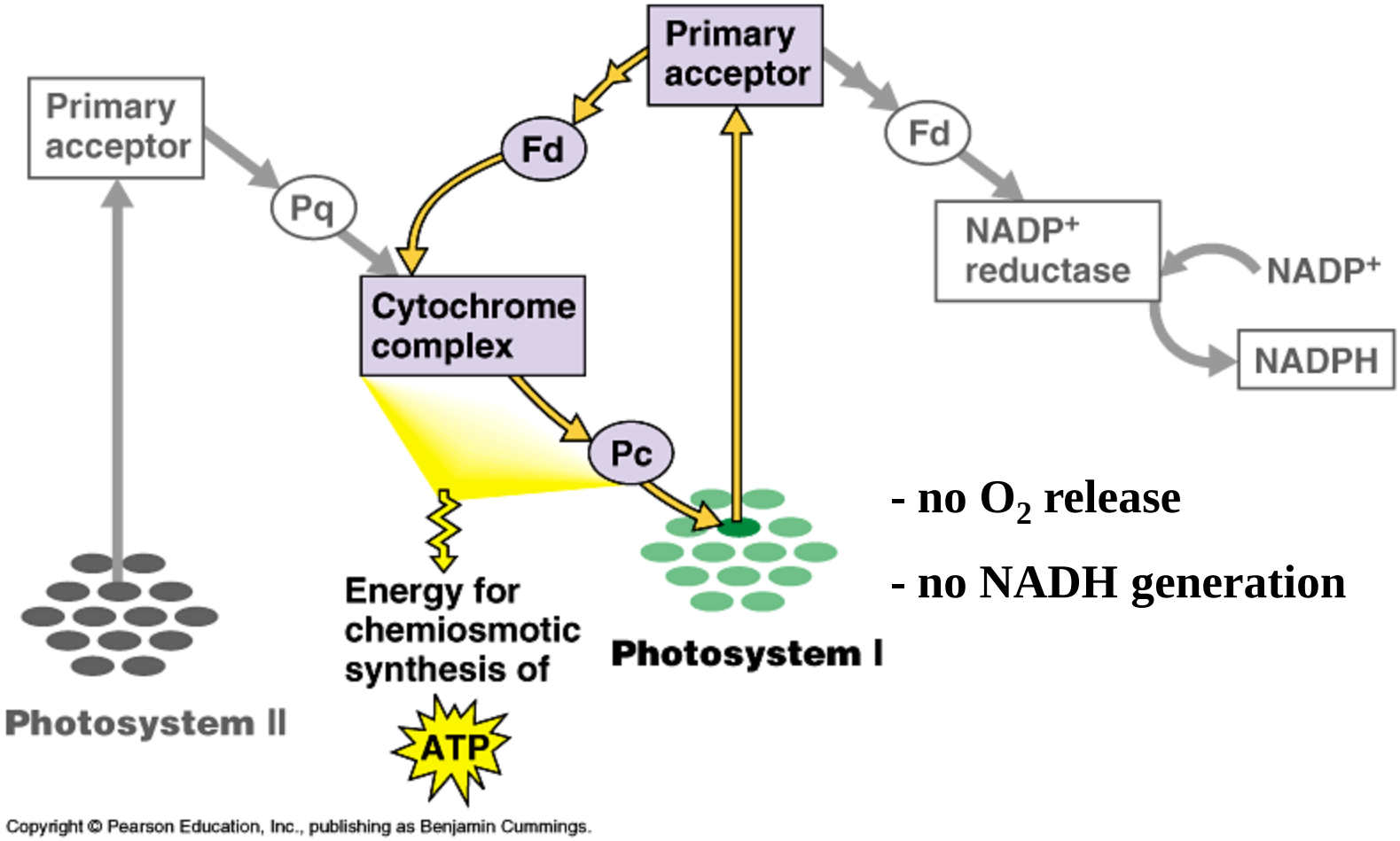
1967 André Jagendorf



Σ: 2 H_2O + 8 photons + 2 $NADP^+$ + 3 ADP + P_i

O_2 + 3 ATP +2 NADPH

The NADPH/ATP ratio is regulated

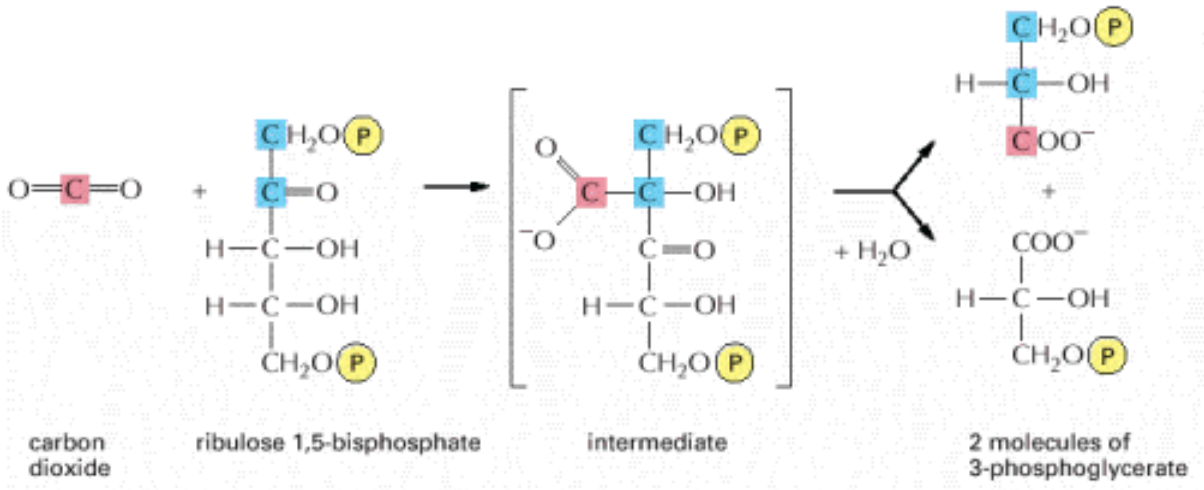


- no O_2 release

- no NADH generation

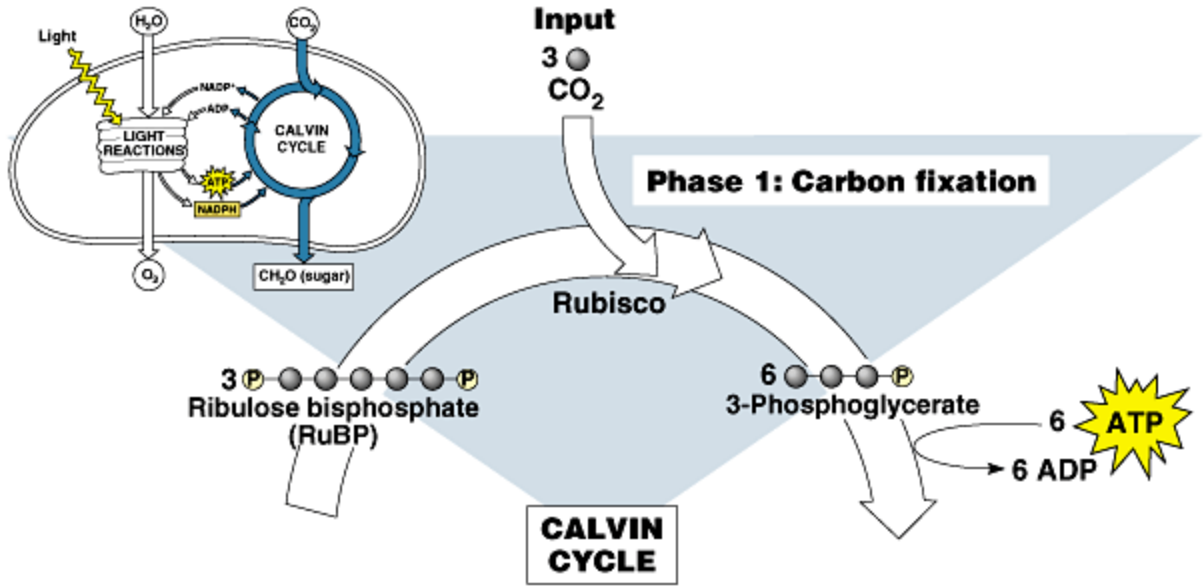
Cyclic photophosphorilation: the electrons are cycling only in photosystem I by the aid of a photon → protongradient → ATP synthesis → higher ATP/NADPH ratio

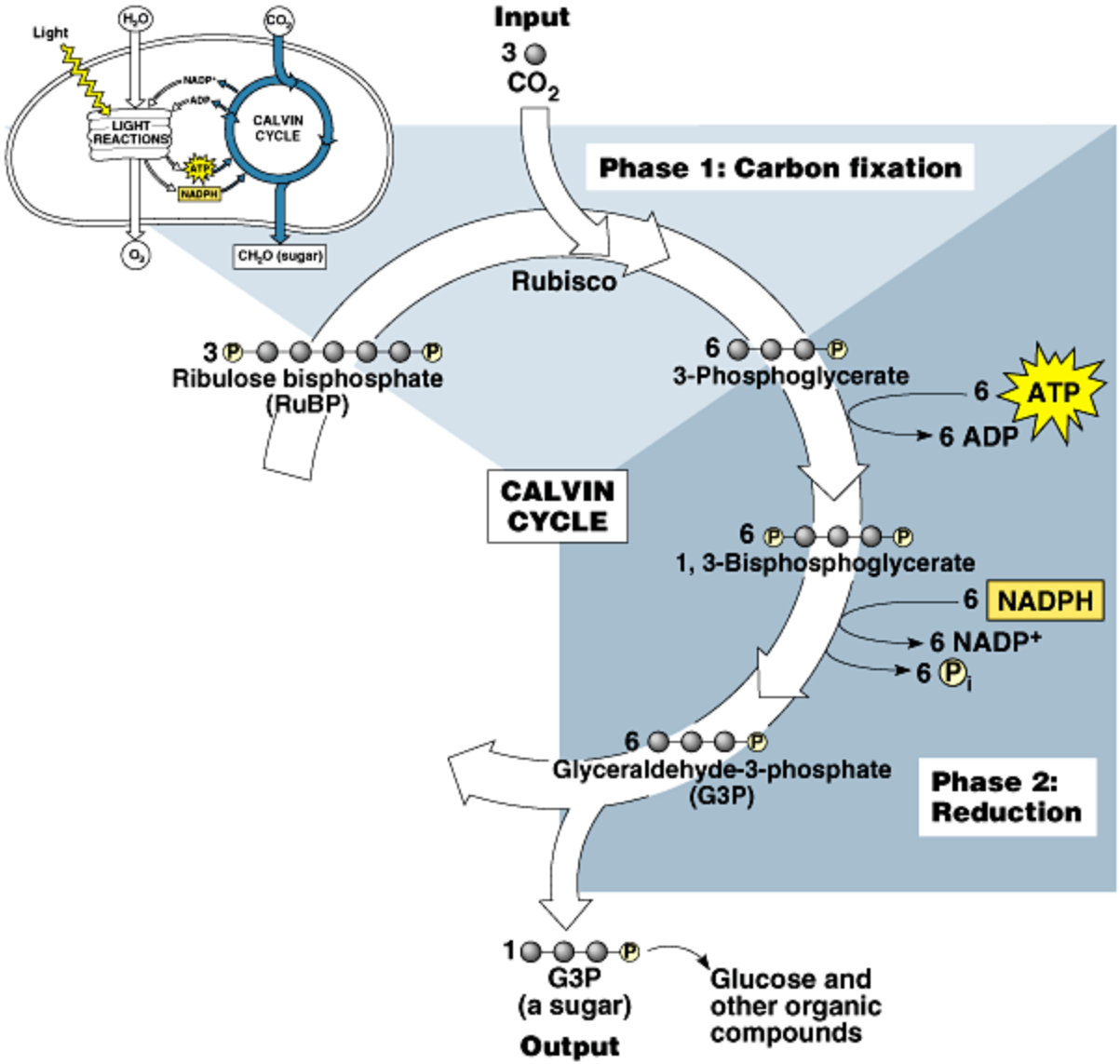
The fixation of CO_2, Calvin cycle

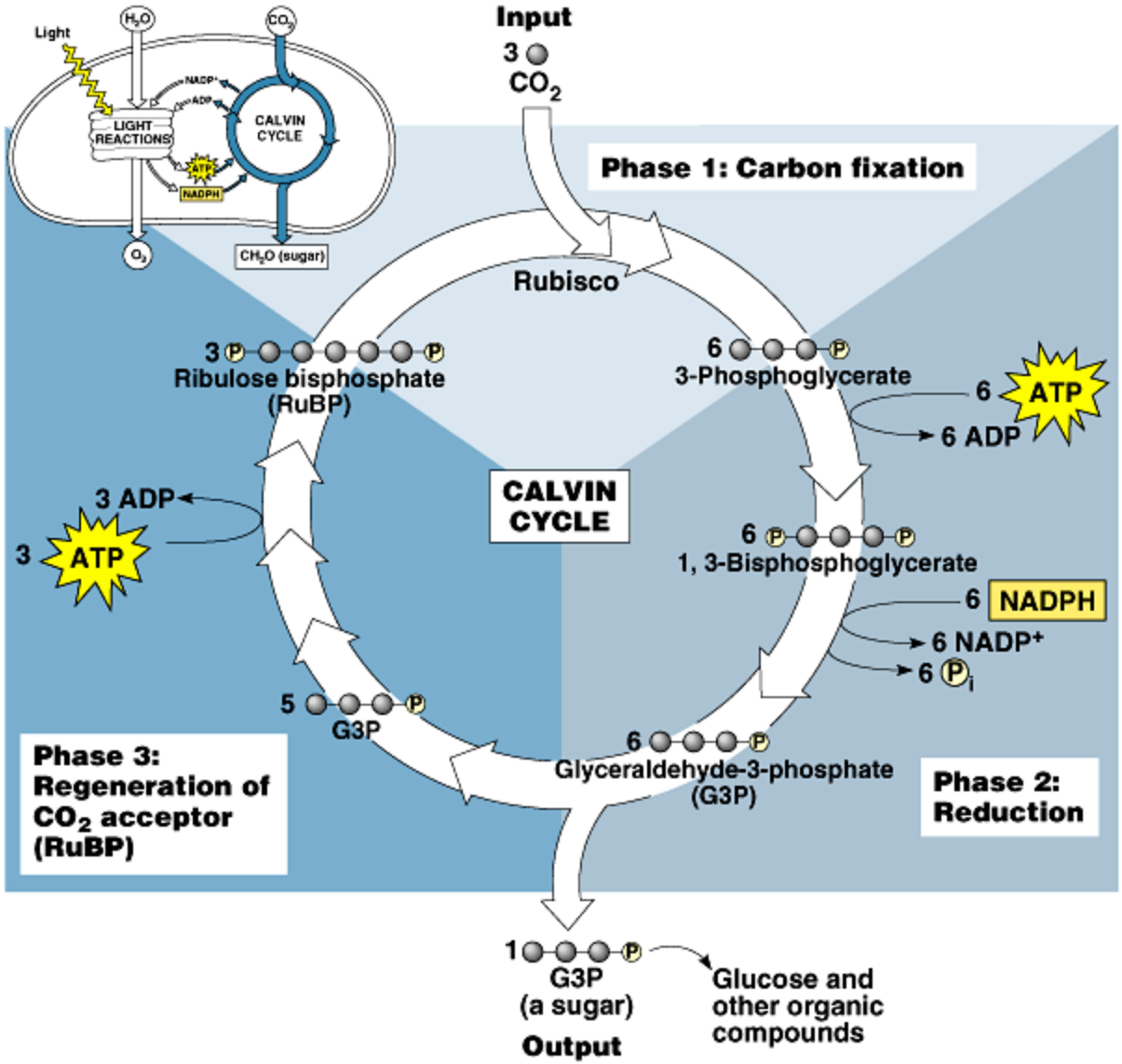


Ribulose-1,5-bisphosphate has central role in the fixation of CO_2

RUBISCO: ribulose-1,5-bisphosphate carboxylase/oxygenase

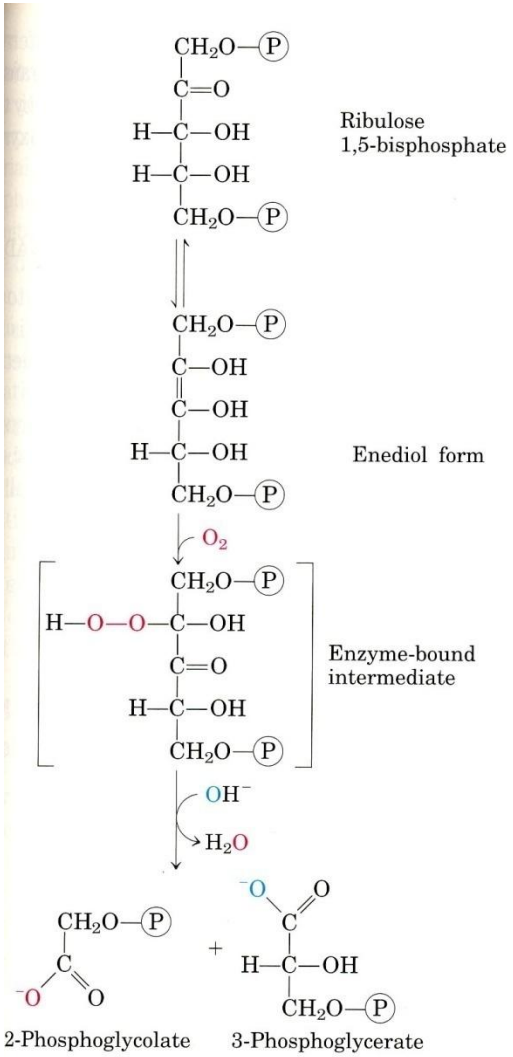






Photorespiration

The specificity of RUBISCO is limited.



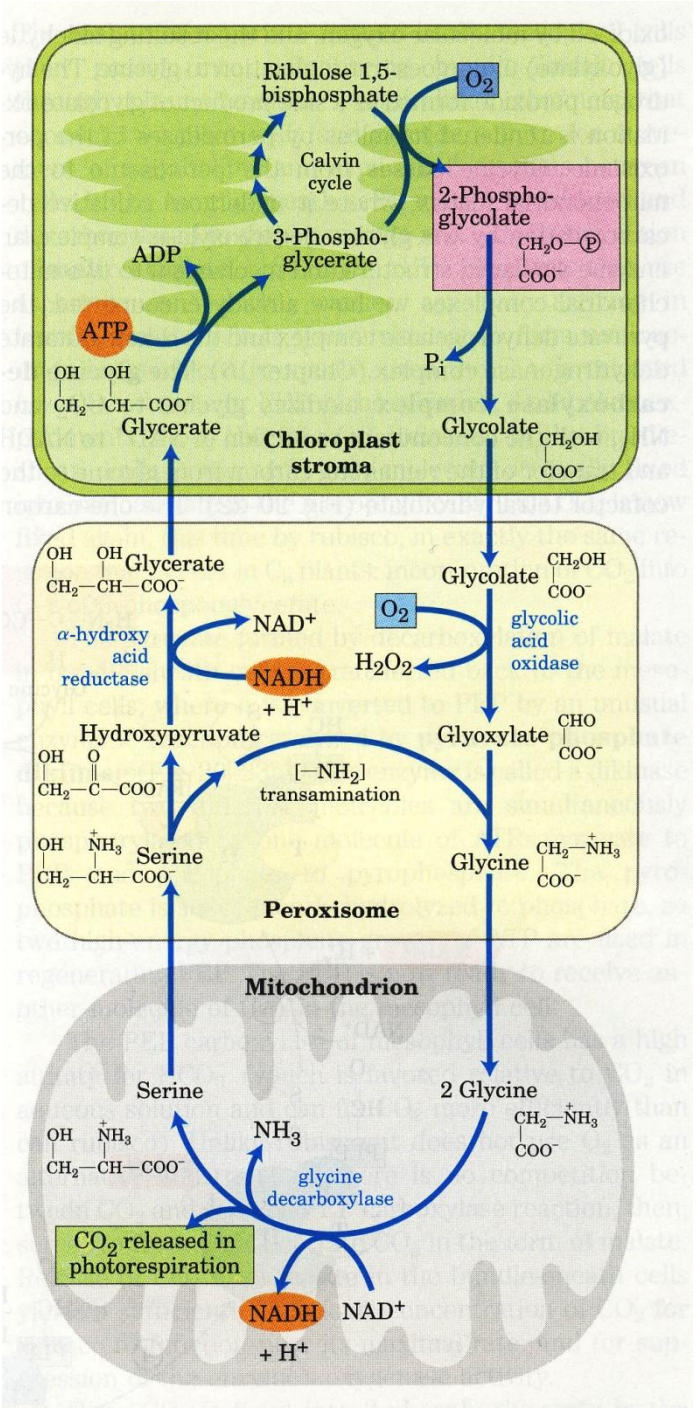
O_2: K_M = 350 μM

CO_2: K_M = 9 μM

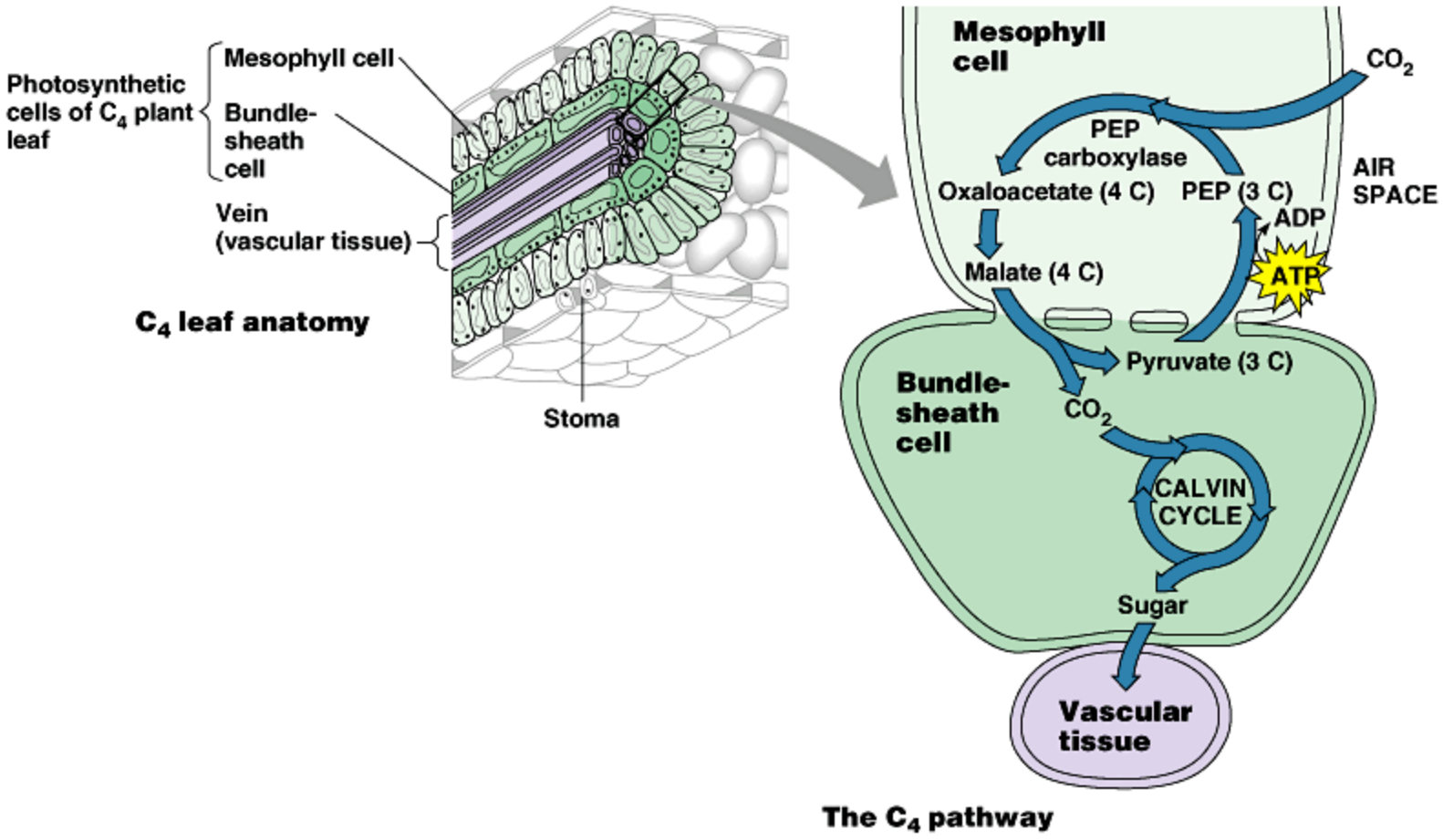
The solvation ratio of O_2/CO_2 become higher by the elevation of temperatiure

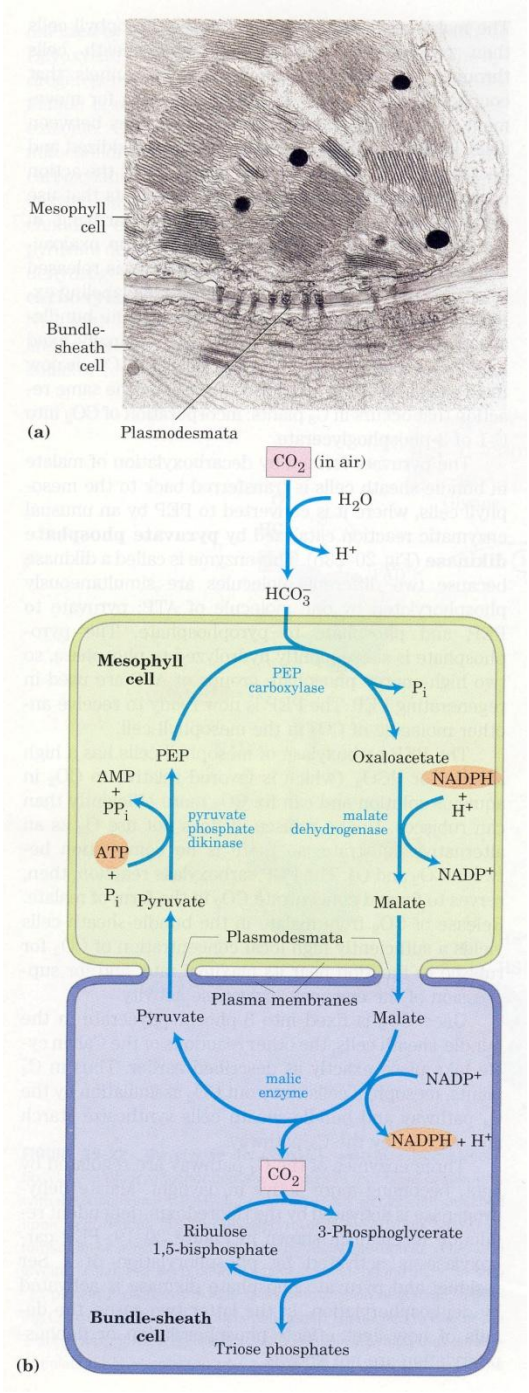
The significance of photorespiration become higher

Glycolate pathway



The plants of hot and dry climate fix the CO_2 by the C_4 pathway





The enzymes of C4 pathway are regulated by the light:

-Malate DH

-PEP carboxylase

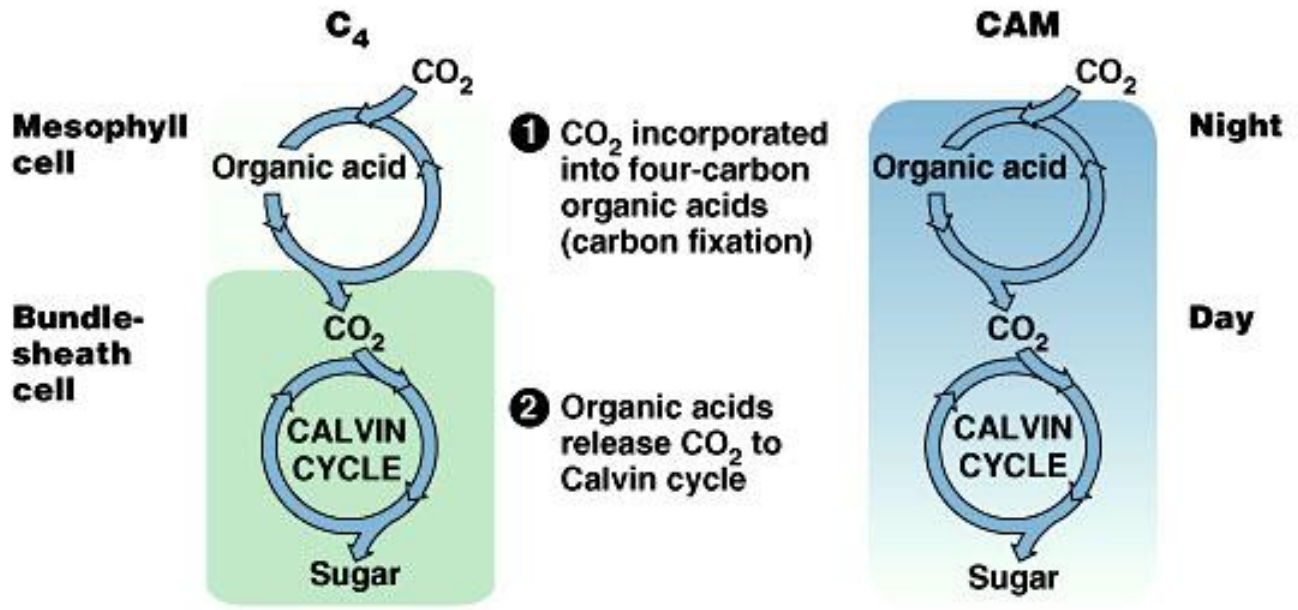
-Pyruvate-phosphate dikinase

The C4 pathway has higher energy requirement: 5 ATP vs. 3 ATP

Above 28-30 ^oC

Sugarcane

Pineapple



(a) Spatial separation of steps

(b) Temporal separation of steps