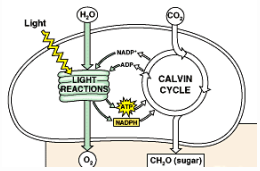
Photosynthesis
The Light Reactions



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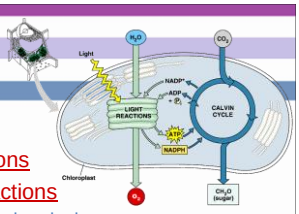
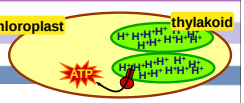
Photosynthesis

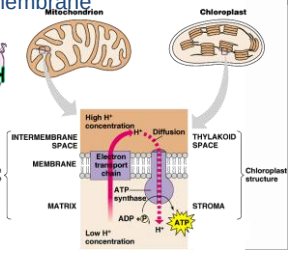


- Light reactions
  - light-dependent reactions
  - energy conversion reactions
    - convert solar energy to chemical energy
    - ATP & NADPH
- Calvin cycle
  - light-independent reactions
  - sugar building reactions
    - uses chemical energy (ATP & NADPH) to reduce CO_2 & synthesize $C_6H_{12}O_6$

Light reactions



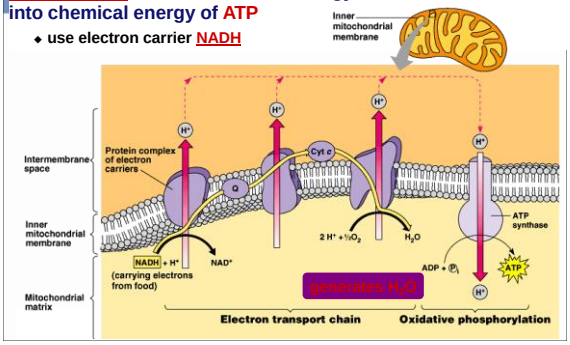
- Electron Transport Chain
  - like in cellular respiration
  - proteins in organelle membrane
  - electron acceptors
    - NADPH
  - proton (H^+) gradient across inner membrane
    - find the double membrane
  - ATP synthase enzyme



ETC of Respiration

Mitochondria transfer chemical energy from food molecules into chemical energy of ATP

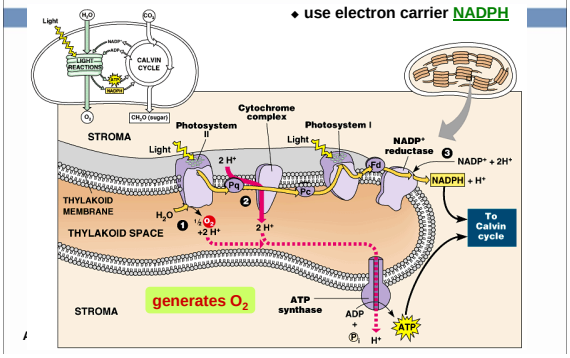
- use electron carrier NADH



ETC of Photosynthesis

Chloroplasts transform light energy into chemical energy of ATP

- use electron carrier NADPH

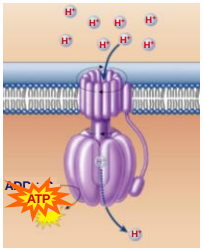


ATP Synthase

photosynthesis: **sunlight**

respiration: **breakdown of $C_6H_{12}O_6$**

- moves the electrons
- runs the pump
- pumps the protons
- builds the gradient
- drives the flow of protons through ATP synthase
- bonds P_i to ADP
- generates the ATP



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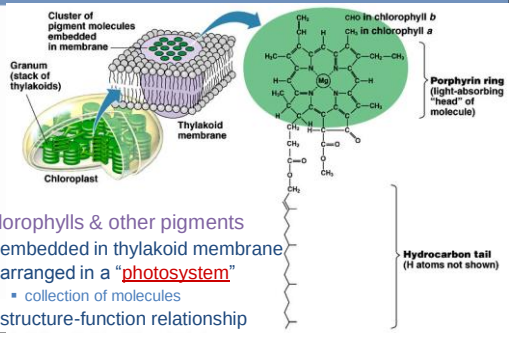
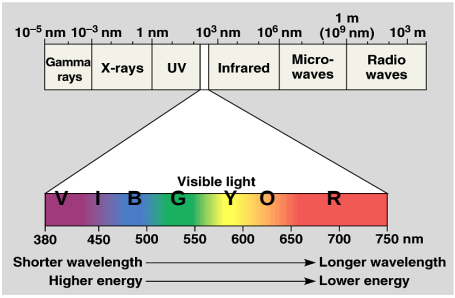
Pigments of photosynthesis



- Chlorophylls & other pigments
  - embedded in thylakoid membrane
  - arranged in a "photosystem"
    - collection of molecules
  - structure-function relationship

A Look at Light

- The spectrum of color



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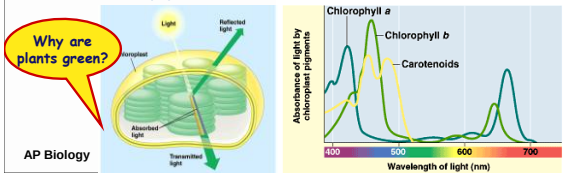
Light: absorption spectra

- Photosynthesis gets energy by absorbing wavelengths of light
  - chlorophyll *a*
    - absorbs best in red & blue wavelengths & least in green
  - accessory pigments with different structures absorb light of different wavelengths
    - chlorophyll b, carotenoids, xanthophylls



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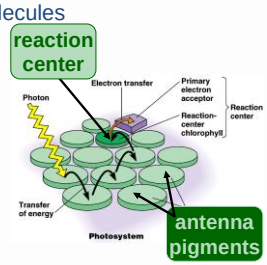
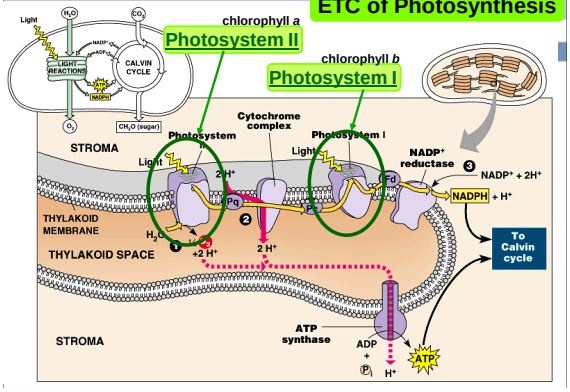
Photosystems of photosynthesis

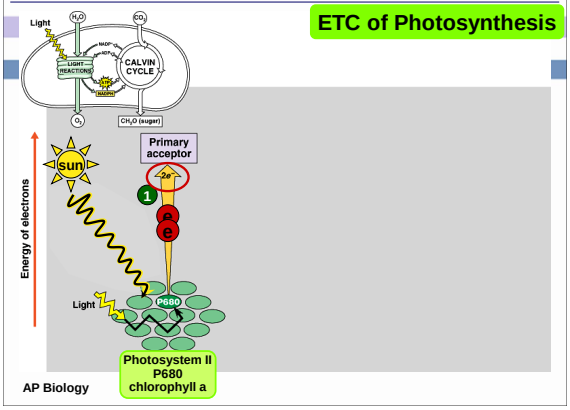
- 2 photosystems in thylakoid membrane
  - collections of chlorophyll molecules
  - act as light-gathering molecules
  - Photosystem II
    - chlorophyll *a*
    - P_{680} = absorbs 680nm wavelength red light
  - Photosystem I
    - chlorophyll *b*
    - P_{700} = absorbs 700nm wavelength red light

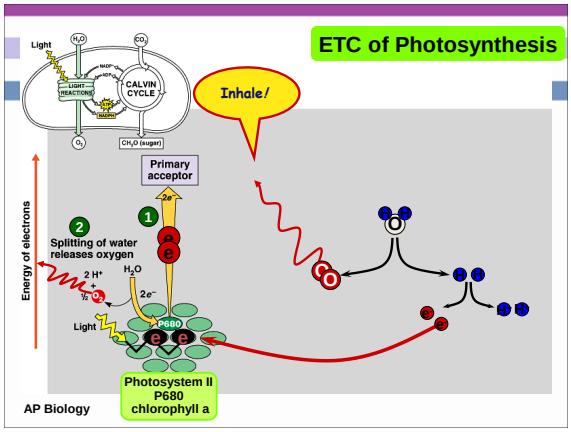


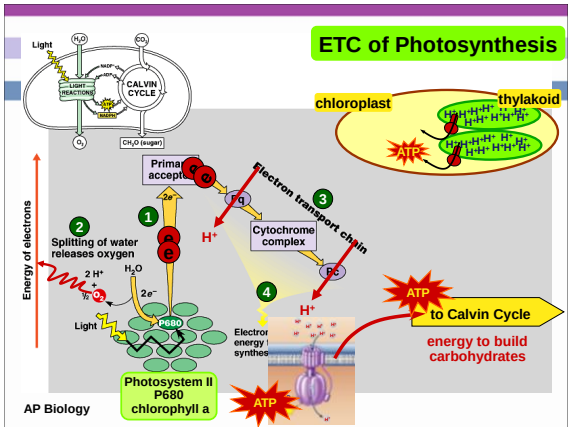
ETC of Photosynthesis

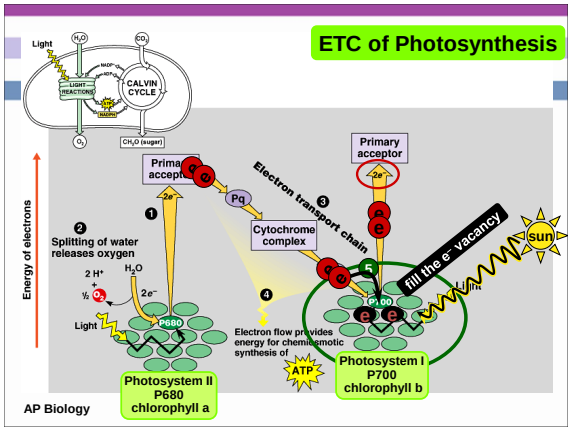


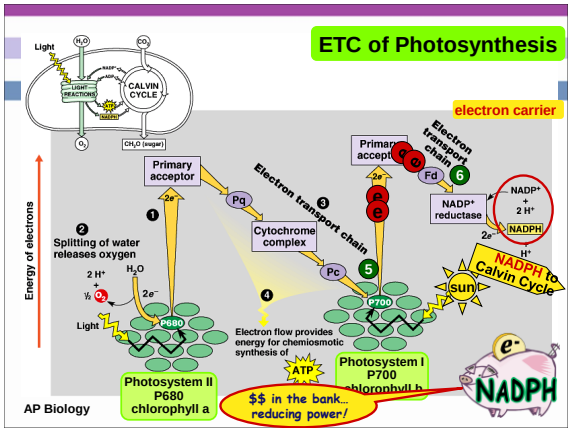
ETC of Photosynthesis

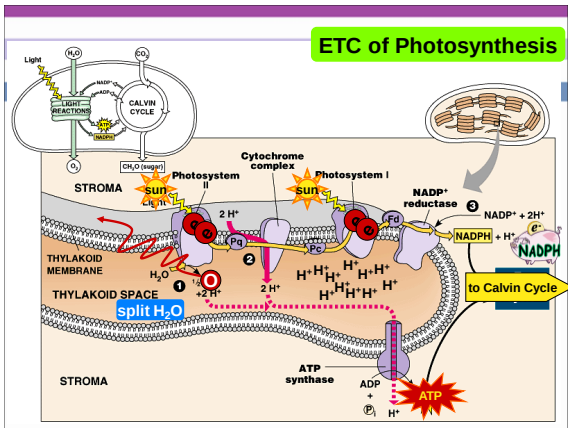



ETC of Photosynthesis
Light
CALVIN CYCLE
LIGHT REACTIONS
Inhale!
Primary acceptor
Energy of electrons
2 Splitting of water releases oxygen
Light
P680
Photosystem II
P680
chlorophyll a
AP Biology


ETC of Photosynthesis
Light
CALVIN CYCLE
chloroplast
thylakoid
ATP
Primary acceptor
Electron transport chain
Pq
3
Cytochrome complex
Pc
H+
Energy of electrons
2 Splitting of water releases oxygen
Light
P680
4
ATP
to Calvin Cycle
energy to build carbohydrates
Photosystem II
P680
chlorophyll a
AP Biology


ETC of Photosynthesis
Light
CALVIN CYCLE
Primary acceptor
Electron transport chain
Pq
3
Cytochrome complex
fill the e- vacancy
sun
Energy of electrons
2 Splitting of water releases oxygen
Light
P680
4
ATP
Photosystem I
P700
chlorophyll b
Photosystem II
P680
chlorophyll a
AP Biology





ETC of Photosynthesis

- ETC uses light energy to produce
  - ATP & NADPH
    - go to Calvin cycle
- PS II absorbs light
  - excited electron passes from chlorophyll to "primary electron acceptor"
  - need to replace electron in chlorophyll
  - enzyme extracts electrons from H_2O & supplies them to chlorophyll
    - splits H_2O
    - O combines with another O to form O_2
    - O_2 released to atmosphere
    - and we breathe easier!

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Experimental evidence

- Where did the O_2 come from?
  - radioactive tracer = O_{18}

Experiment 1

$$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

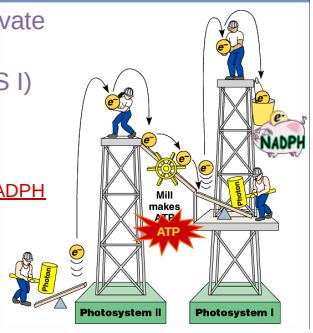
Experiment 2

$$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

Proved O_2 came from H_2O not CO_2 = plants split H_2O!

Noncyclic Photophosphorylation

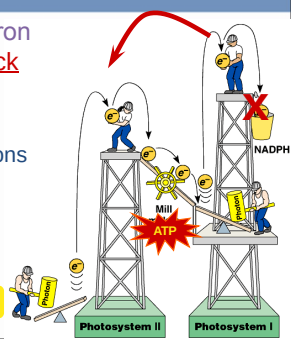
- Light reactions elevate electrons in 2 steps (PS II & PS I)
  - PS II generates energy as ATP
  - PS I generates reducing power as NADPH



Cyclic photophosphorylation

- If PS I can't pass electron to NADP…it cycles back to PS II & makes more ATP, but no NADPH
  - coordinates light reactions to Calvin cycle
  - Calvin cycle uses more ATP than NADPH

18 ATP + 12 NADPH → 1 $C_6H_{12}O_6$



Photophosphorylation