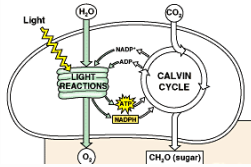


# Photosynthesis

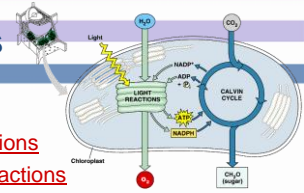
## The Light Reactions



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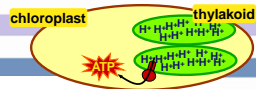
# Photosynthesis

- 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<sub>2</sub> & synthesize C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>

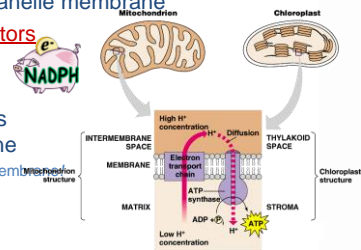


**NADPH**  
It's *not* the Dark Reactions!

# Light reactions



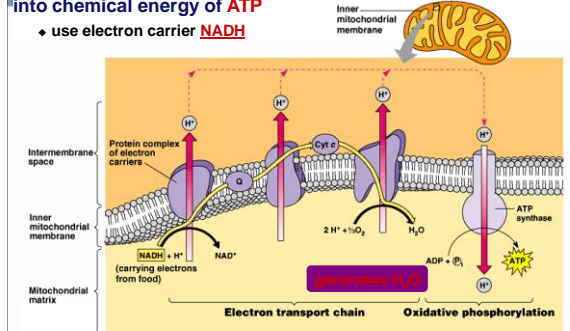
- Electron Transport Chain
  - like in cellular respiration
  - proteins in organelle membrane
  - electron acceptors
    - NADPH
  - proton (H<sup>+</sup>) gradient across inner membrane
    - find the double membrane structure
  - ATP synthase enzyme



# ETC of Respiration

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

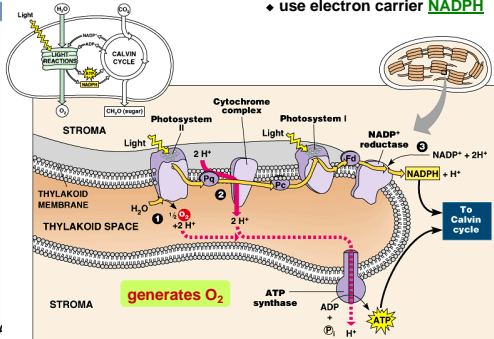
- use electron carrier **NADH**



# ETC of Photosynthesis

Chloroplasts transform light energy into chemical energy of ATP

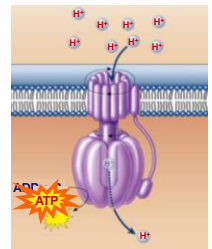
- use electron carrier **NADPH**



# ATP Synthase

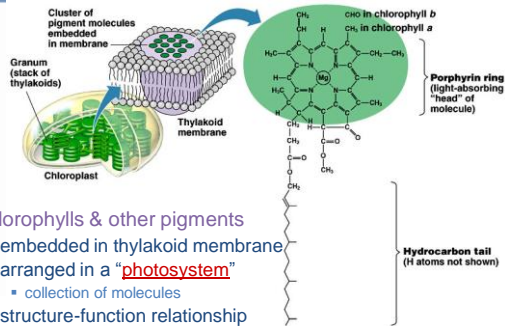
photosynthesis sunlight  
respiration breakdown of C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>

- moves the electrons
- runs the pump
- pumps the protons
- builds the gradient
- drives the flow of protons through ATP synthase
- bonds P<sub>i</sub> to ADP
- generates the ATP



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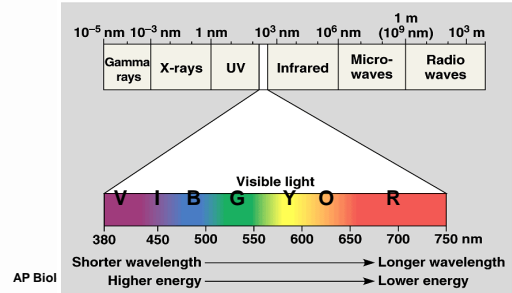
# Pigments of photosynthesis



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

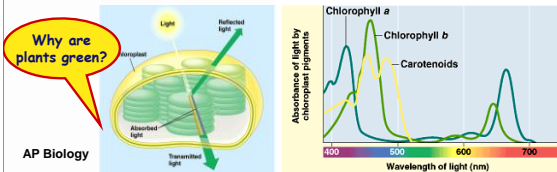
# A Look at Light

- The spectrum of color



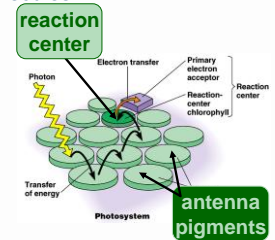
# Light: absorption spectra

- 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

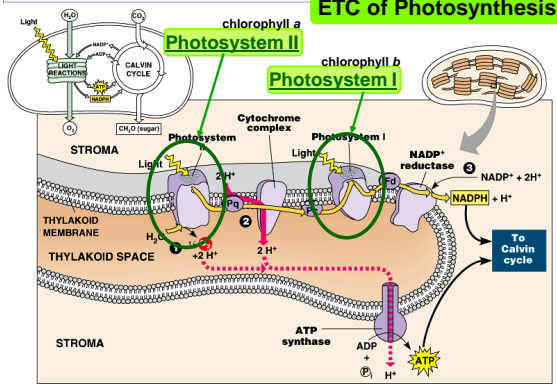


# Photosystems of photosynthesis

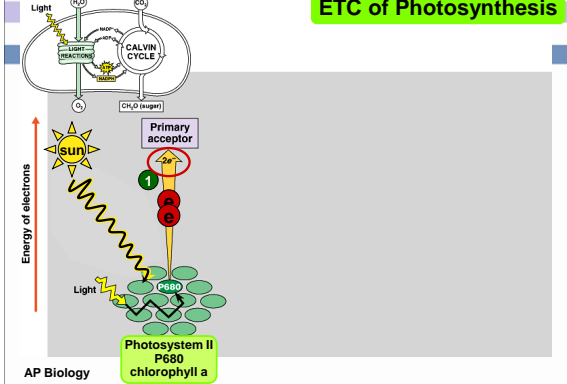
- 2 photosystems in thylakoid membrane
  - collections of chlorophyll molecules
  - act as light-gathering molecules
  - Photosystem II**
    - chlorophyll a**
      - $P_{680}$  = absorbs 680nm wavelength **red** light
  - Photosystem I**
    - chlorophyll b**
      - $P_{700}$  = absorbs 700nm wavelength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

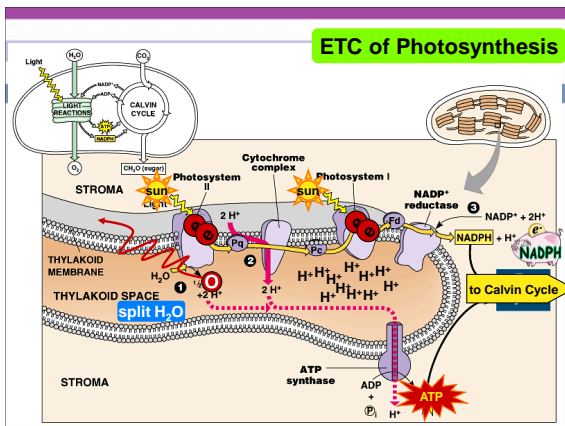
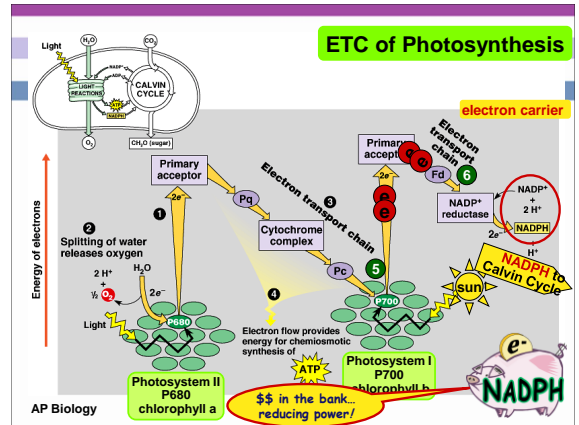
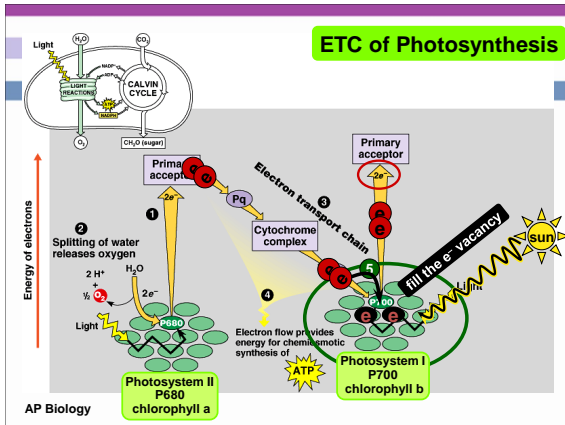
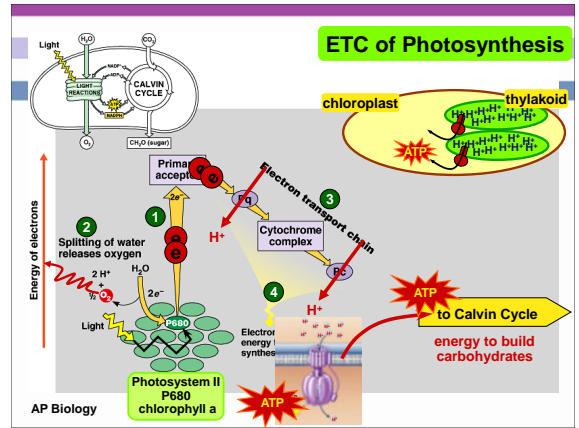
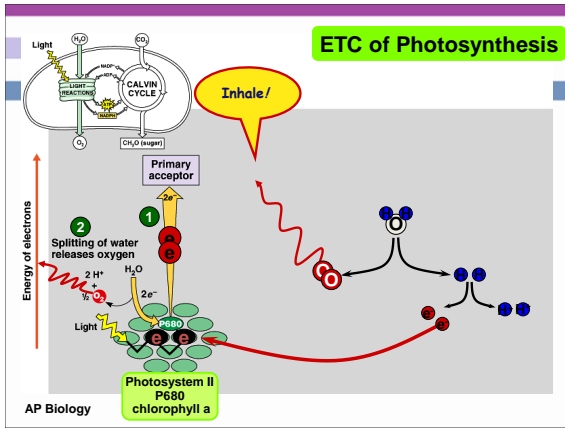


# ETC of Photosynthesis



# ETC of Photosynthesis





## ETC of Photosynthesis

- 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<sub>2</sub>O** & supplies them to chlorophyll
    - **splits H<sub>2</sub>O**
    - **O combines with another O to form O<sub>2</sub>**
    - **O<sub>2</sub> 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



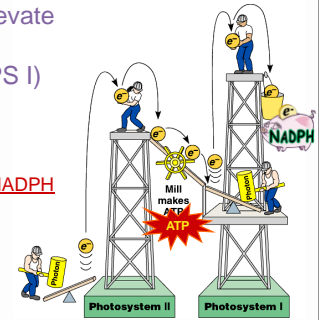
### Experiment 2



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

## Noncyclic Photophosphorylation

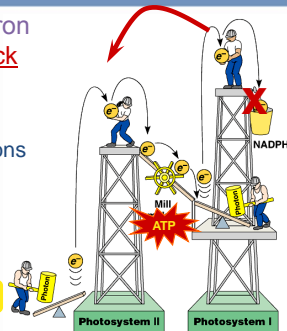
- Light reactions elevate electrons in 2 steps (PS II & PS I)
  - PS II** generates energy as ATP
  - PS I** generates reducing power as NADPH



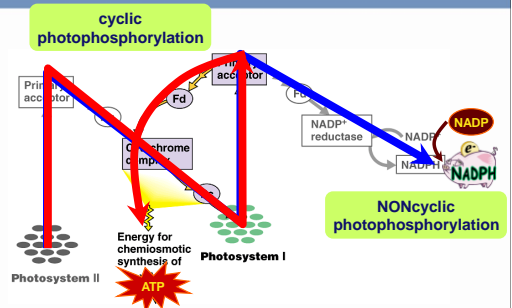
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## Cyclic photophosphorylation

- 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



## Photophosphorylation



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