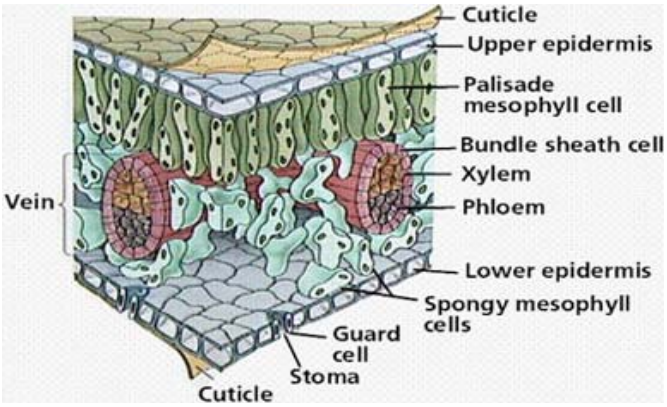
PHOTOSYNTHESIS LIGHT REACTIONS



revised 11 July 2016
BRP p 374-389, BKH pp 451-469, BKH 5th: 445-474, Campbell Reece, 7th; 181-193, Sadava: 159-169, Campbell 9th: 189-197, Campbell 10th: 185-208

Flourescence Demo (on a cart)

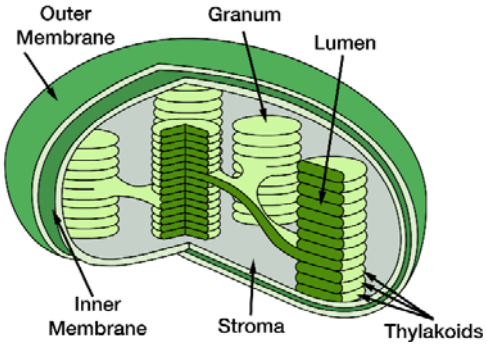
leaf model	parafilm square (2 cm x 2 cm)
1 Tbl Parsley flakes	filter funnel
mortar and pestle	Whatman #1 filter paper
>5 mL 95% EtOH, add 1 mL by 1mL	Fluorescein solution
25 mL graduated cylinder	UV light
3 16 x 150 mm test tubes	visible light
tt rack	spectroscope

Phototrophs conduct **reductive carboxylation (LEARN)**, using a variety of sources of electrons:

Overall rxn: $CO_2 + 2H_2A = [CH_2O] + 2A + H_2O$

Two functional processes:	light rxns:	**energy transduction**	LEARN: photophosphoryllation & photoreduction
LEARN:	dark reactions:	**reductive carboxylation**	carbon assimilation:

LEAF STRUCTURE	epidermis	vascular tissues:	phloem (small diameter); xylem (larger diameter)
illust: p 765	parenchyma layer	palisades	spongy
	guard cells	epidermis	



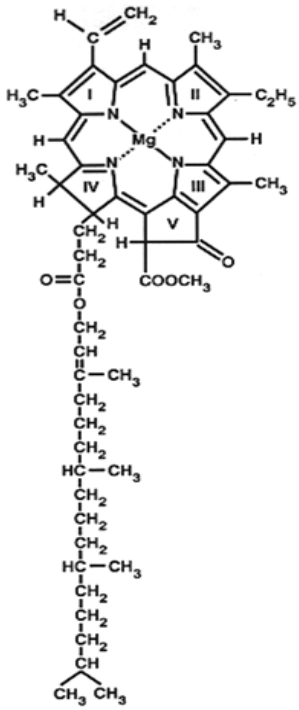
CHLOROPLASTS: chloroplast, '**energy transducer**' first seen by Leeuwenhoek
20-50 chloroplasts per cell, outer plus inner membranes. Inside is highly structured: (p. 187)
thylakoids (sack, pouch-like), flattened sacs forming **grana**
connected by membranous **stroma lamellae** (anything spread out, coverlet)

CHLOROPHYLL: (p 192) porphyrin with Mg: blue-green (420-480 nm) & red (620-680 nm) light causes an activation of an electron in Mg (porphyrin ring allows multiple levels of excited state, thus absorbs broad range of wavelengths)

ACCESSORY PIGMENTS: Collect light at other wavelengths, resonance transfer energy
carotenoids absorb in violet to green (thus look yellow-orange)
phycobilins absorb in green to orange (appear purple) [porphyrin cut open like bilirubin]

Photosynthetic unit: group of 250-300 antennae chlorophyll molecules

LIGHT: (p 195, 192)
Electromagnetic Radiation. Unit is photon. Packet of energy with traits of both a particle and a wave.
LEARN: **electromagnetic spectrum**: cosmic, Xrays, UV, VIBGYOR, infra red, microwaves, radiowaves



TRANSDUCTION: converts from radiant to chemical energy Illustrate, demonstrate with chlorophyll solution.
Demonstrate fluorescence: with EtOH extract of dried spinach leaves, show with UV lamp too, fluorescein.
Spectroscope with fluorescent lights: Hg emission: 436, 546, 577 nm (phosphors spread it out)

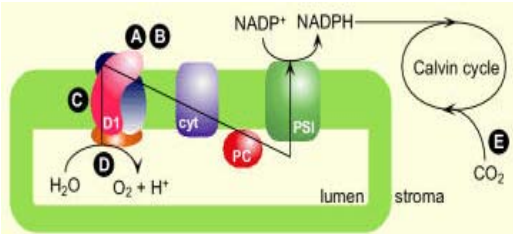
LIGHT REACTIONS: OXIDATION OF WATER (p 192, 194: voltage & 197: membrane)

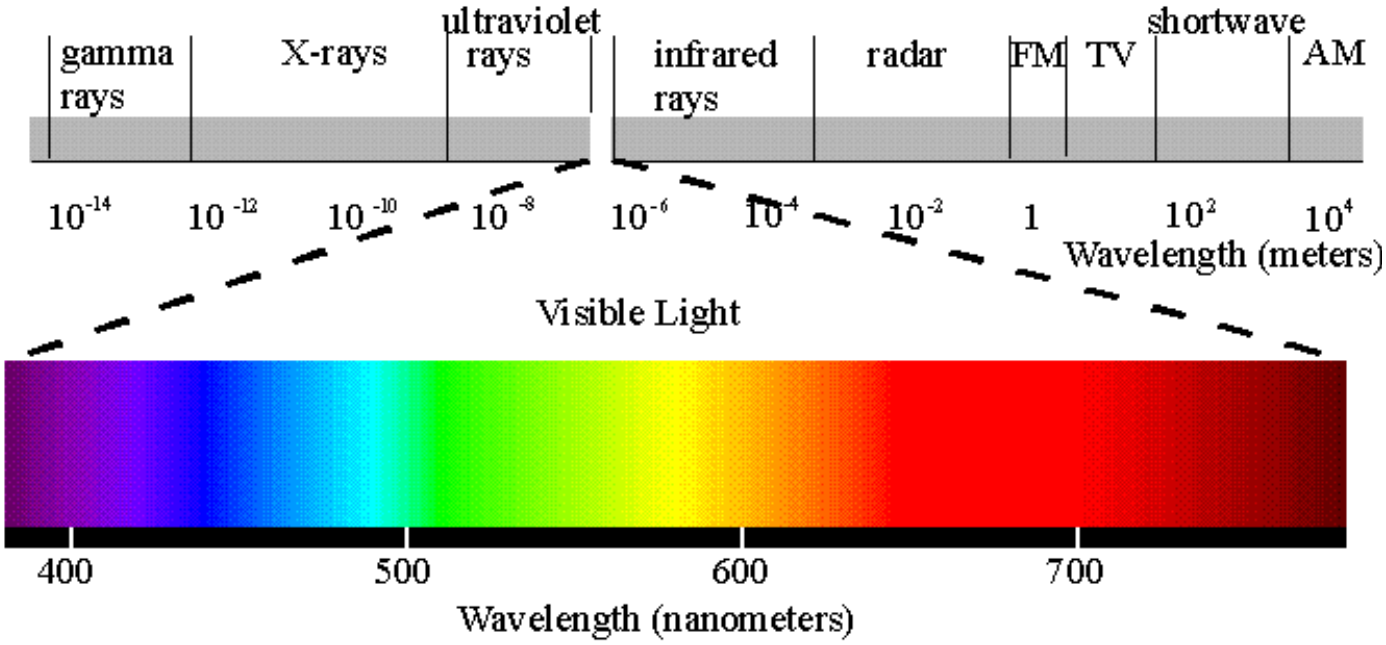
PSII:	H_2O:	+0.816	releases **oxygen** and **H^+ into thylakoid lumen**	
P680	**PS II (680)**:	[+0.9]	[I do not understand, thought 1 volt max/photon?]	
	PS II activated:		-0.8	transfers to pheophytin
Ph	**pheophytin** (dusky)		**1° electron acceptor** (a modified chlorophyll, has 2 H^+ not Mg)	
Q_A, Q_B	**plastoquinones**:		-0.1	quinone to quinol reduction
b_6/f	**cytochrome b_6-b_f cmplx**		+0.3	uses energy to pump **H^+ into thylakoid lumen**
			(Note similarity to complex III in mitochondria0	
PC	plastocyanin	+0.4	mobile peripheral membrane protein, contains Cu	
PS I:	**P700**	**PS I (700)**	[+0.45]	receives e^- from plastocyanin
	PS I (700) activated	-1.3	**1° electron acceptor** (active e^- accepted by A_0 (modified chlorophyll)	
	phylloquinone		-1.0	transfers to FeS centers:
	bound **ferredoxin**:	-0.6	(donate to cyt b_6/f complex = cyclic phosphorylation)	
	$NADP^+$:	-0.32	releases NADPH into stroma, to be used for dark rxns	

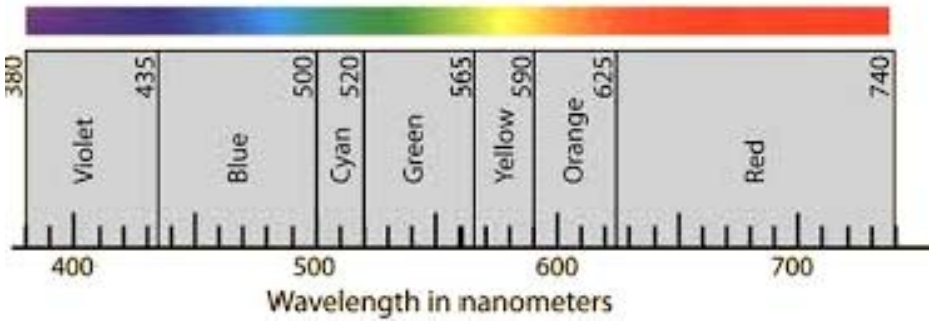
video: http://www.youtube.com/watch?v=eY1ReqiYwYs

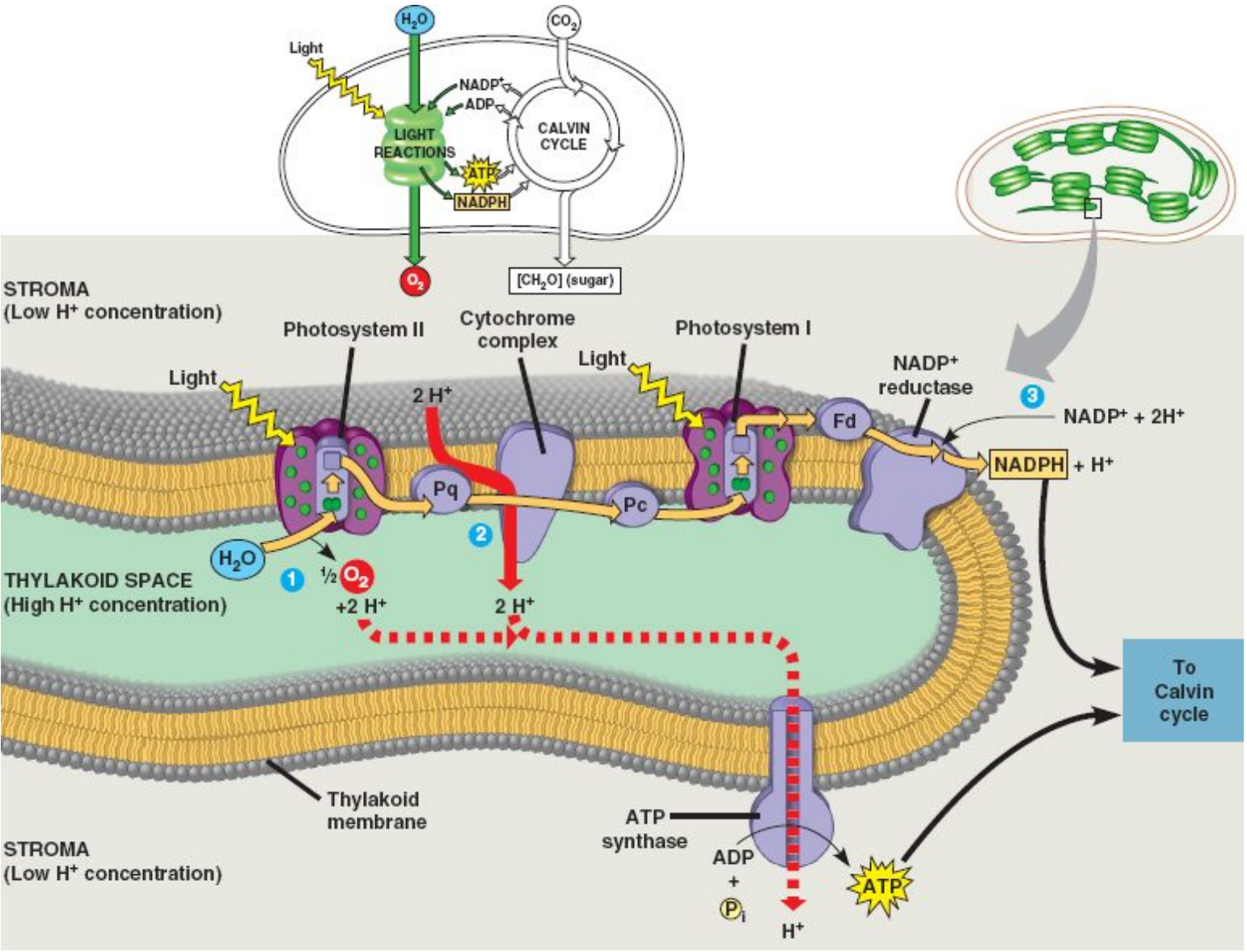
ATP SYNTHESIS: NONCYCLIC (P 198)
H+ accumulates in the thylakoid lumen (from oxidation of water and cytochrome activity) drives ATP synthase to make ATP as in mitochondria

CYCLIC PHOSPHORYLATION: (196)
If no $NADP^+$ available, electron can be passed from Fd to cytochrome b6/f. There, H^+ pumped out, setting up synthesis of ATP.




gamma rays
X-rays
ultraviolet rays
infrared rays
radar
FM
TV
shortwave
AM
10^{-14}
10^{-12}
10^{-10}
10^{-8}
10^{-6}
10^{-4}
10^{-2}
1
10^{2}
10^{4}
Wavelength (meters)
Visible Light
400
500
600
700
Wavelength (nanometers)


380
435
500
520
565
590
625
740
Violet
Blue
Cyan
Green
Yellow
Orange
Red
400
500
600
700
Wavelength in nanometers


H_2O
CO_2
Light
$NADP^+$
ADP
LIGHT REACTIONS
CALVIN CYCLE
ATP
NADPH
O_2
$[CH_2O]$ (sugar)
STROMA
(Low H^+ concentration)
Photosystem II
Cytochrome complex
Photosystem I
Light
Light
$2\ H^+$
$NADP^+$ reductase
Fd
$NADP^+ + 2H^+$
NADPH + H^+
Pq
Pc
H_2O
1
$\frac{1}{2}\ O_2$
$+2\ H^+$
2
$2\ H^+$
THYLAKOID SPACE
(High H^+ concentration)
To Calvin cycle
Thylakoid membrane
ATP synthase
ADP
+
P_i
ATP
H^+
STROMA
(Low H^+ concentration)