

## BB 422/622

### ANABOLISM I: Carbohydrates

#### PHOTOSYNTHESIS OUTLINE:

Overview of Photosynthesis

Key experiments:

Light causes oxygen, which is from water splitting (Hill)

NADPH made (Ochoa)

Separate from carbohydrate biosynthesis (Rubin & Kamen)

Light Reactions

energy in a photon

pigments

HOW

Light absorbing complexes—"red-drop expt."

Reaction center

Photosystems (PS)

PSII - oxygen from water splitting

(Cytochrome *b<sub>6</sub>f* Complex)

Photosystems (PS) (cont.)

PSI - NADPH

Proton Motive Force - ATP

Overview of light reactions

Carbon Assimilation - Calvin Cycle

Stage One - **Rubisco**

Carboxylase

Oxygenase

Glycolate cycle

Stage Two - making sugar

Stage Three - remaking Ru 1,5P<sub>2</sub>

Overview and regulation

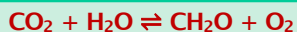
Calvin cycle connections to biosyn.

C4 versus C3 plants

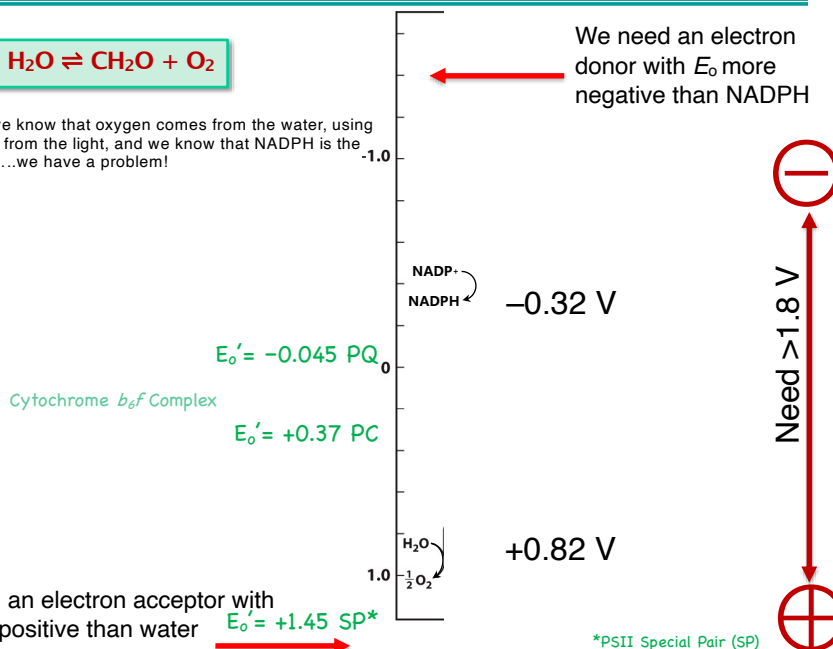
Kornberg cycle - glyoxylate

33

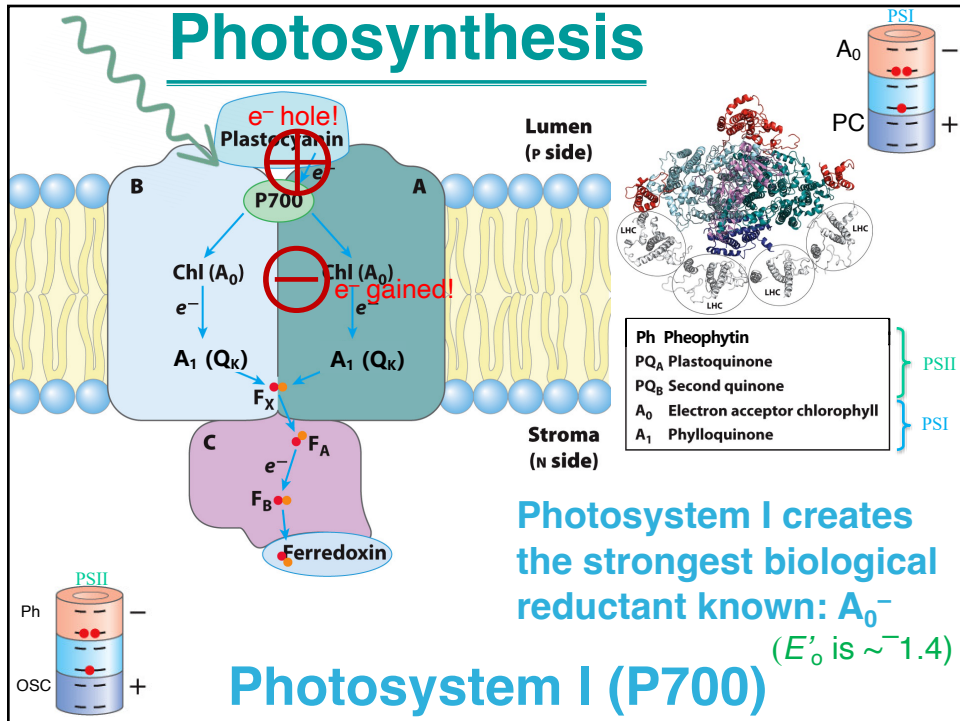
## Photosynthesis



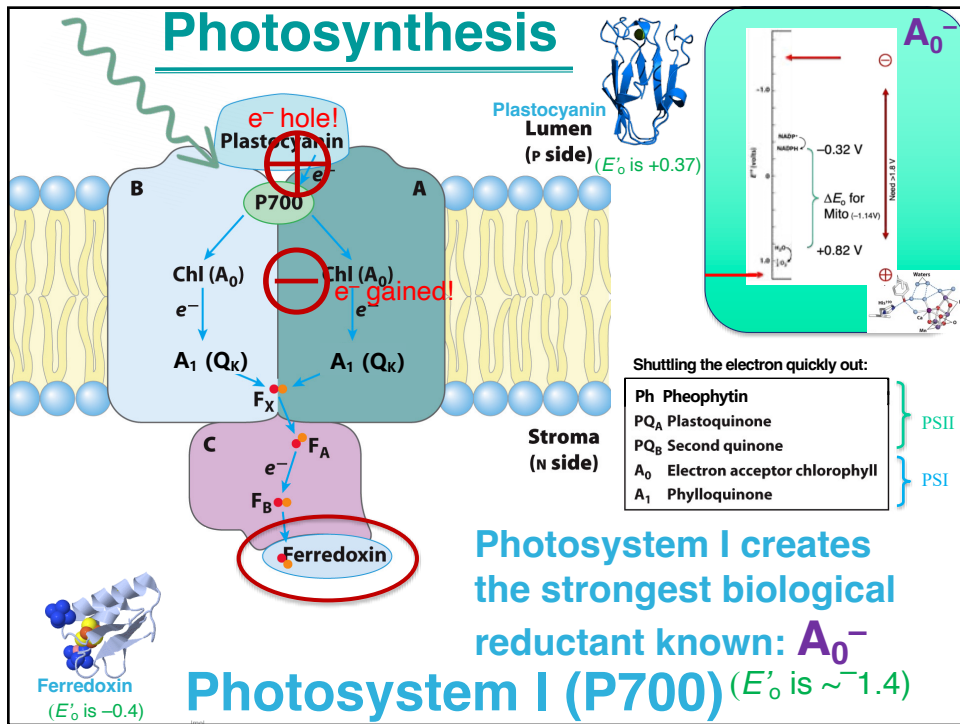
Because we know that oxygen comes from the water, using the energy from the light, and we know that NADPH is the reductant....we have a problem!



34



35

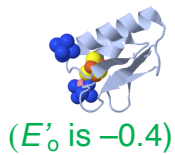


36

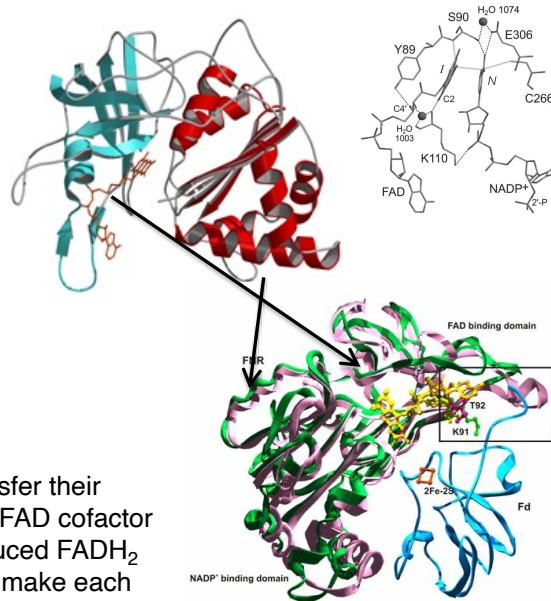
# Photosynthesis

**NADPH is produced by the NADPH Reductase in the Stroma**

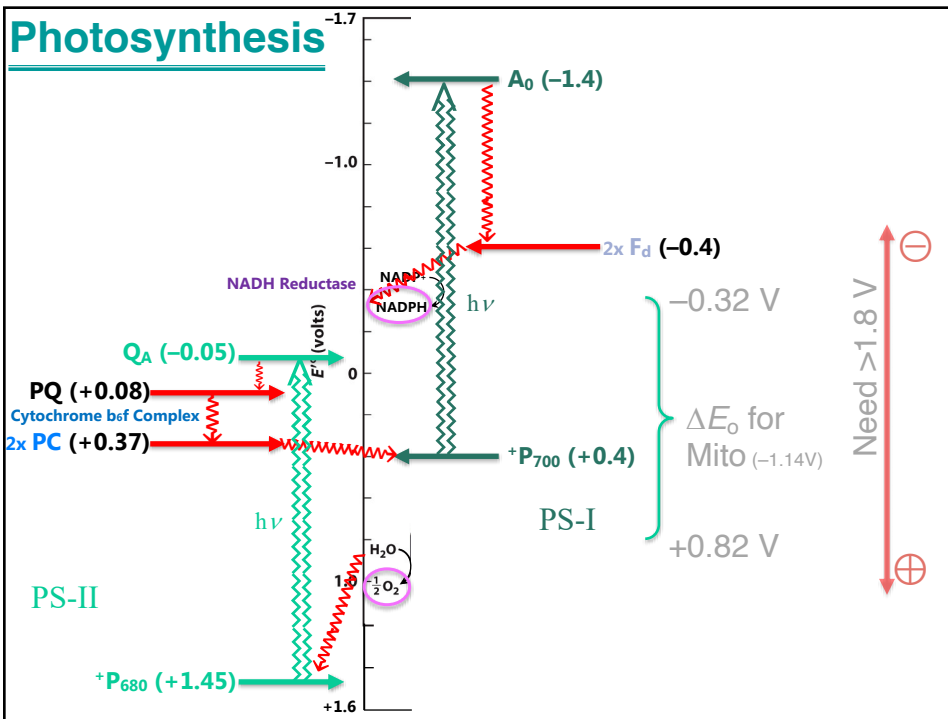
Photosystem I created reduced ferredoxin ( $F_d$ )



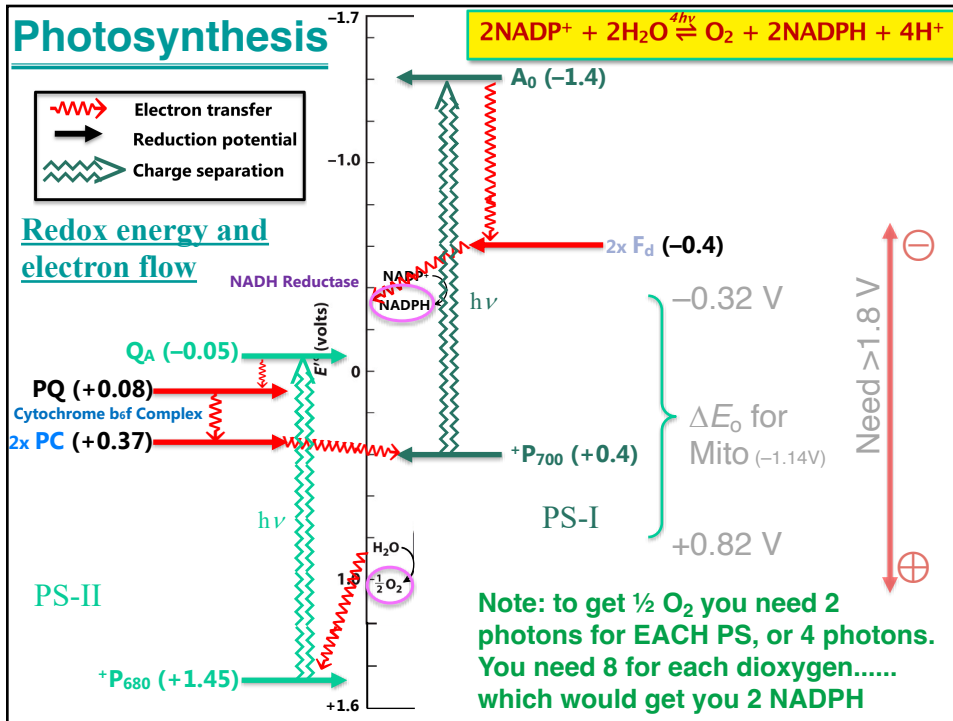
$F_d$  is a  $1-e^-$  carrier, so 2  $F_d$  transfer their electrons, one at a time, to the FAD cofactor in the reductase. The fully reduced  $FADH_2$  then transfers  $2e^-$  to  $NADP^+$  to make each NADPH.



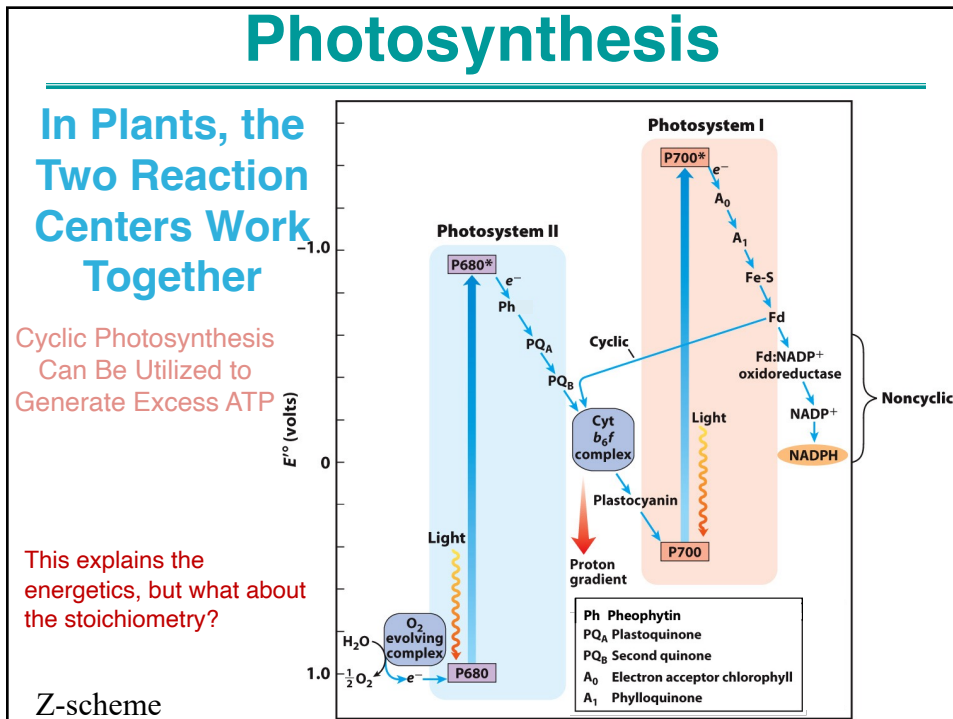
37



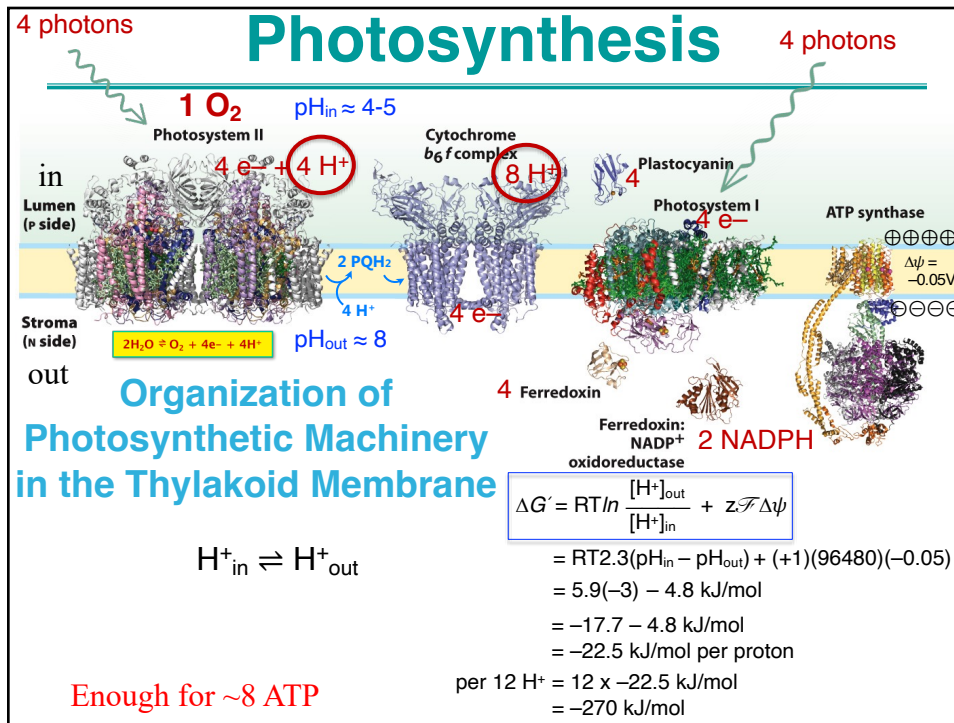
38



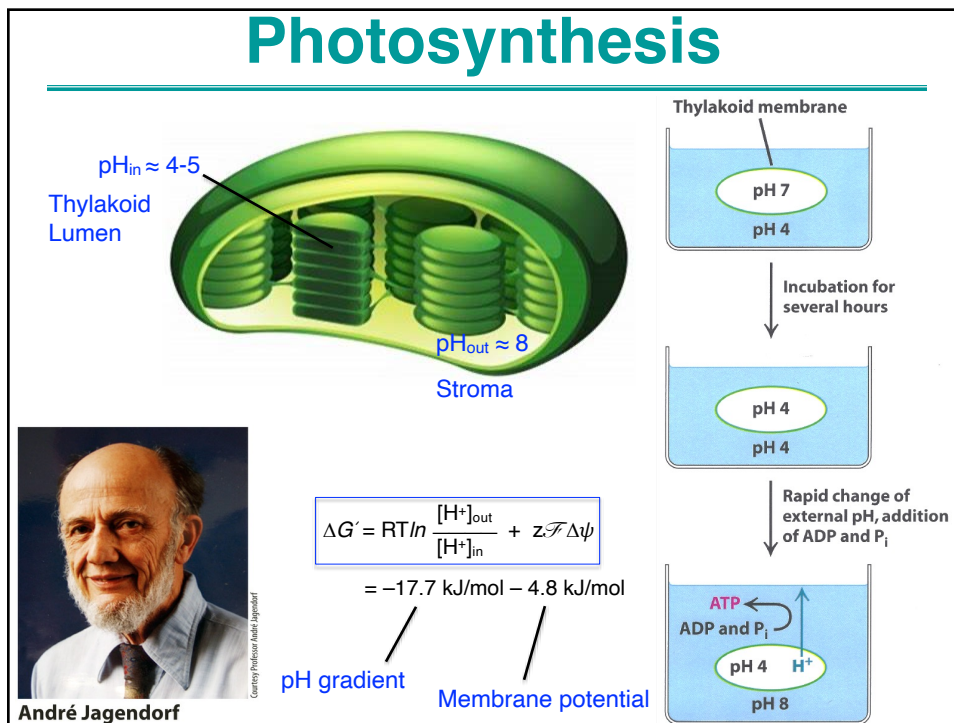
39



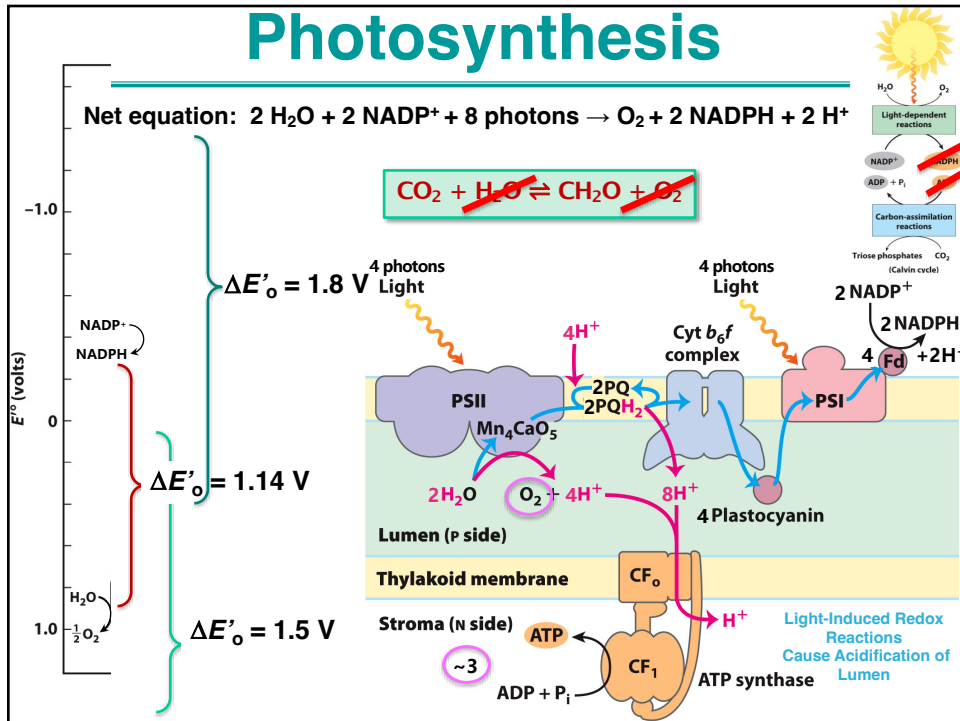
41



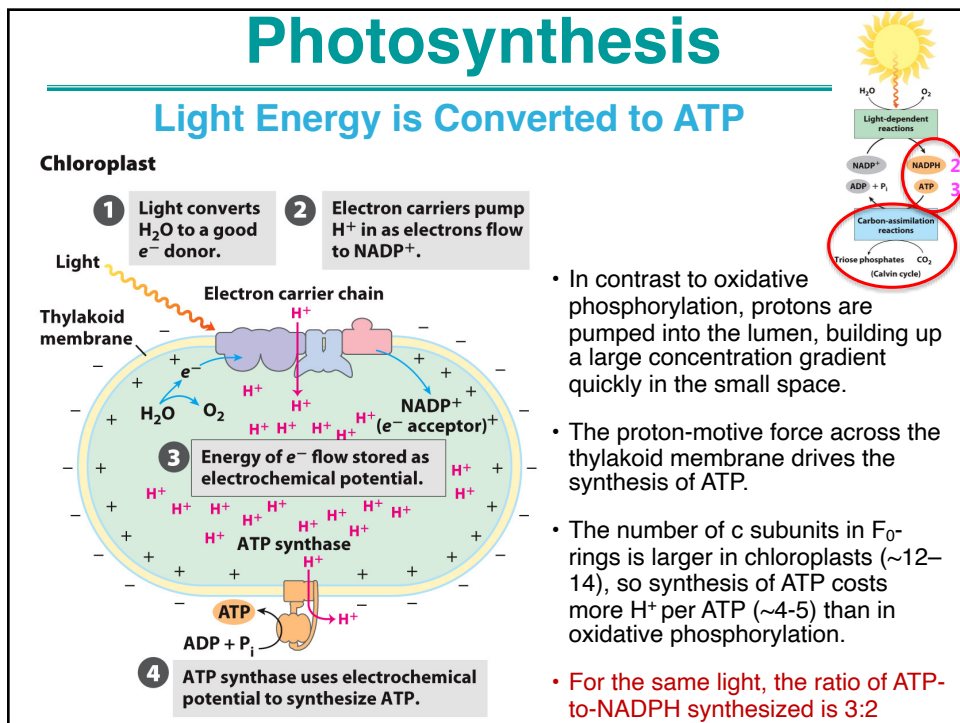
42



43



44



45

# Photosynthesis

## Summary of light reactions:

- Photosynthetic organisms capture energy from light ( $\lambda=350-750$  nm) and funnel it via excitons using accessory pigments to reaction centers: P680 & P700, where chemistry happens.
- In plants, electrons are freed from  $H_2O$ , which generates  $O_2$  and  $H^+$ . The electrons popping out of the reaction centers reduce PQ, which moves them through the thylakoid membrane to the electron-transport chain (cyt $b_6f$ ), ending up in plastocyanin.
- Per oxygen ( $O_2$ ) produced from 4 photons in PS-II, 12  $H^+$  are mobilized into the lumen from the  $2H_2O$  and cyt $b_6f$  (Q-cycle). This produces a proton-motive force sufficient for 3 ATPs
- The final electron acceptor for linear photosynthesis is  $NADP^+$ , which requires two electrons for conversion to NADPH. Per 8 photons (4 each to PS-I & PS-II), 2 NADPH are produced.
- When ATP stores are low, the electrons can be transported to cytochrome  $b_6f$  and cycled through the second half of photosynthesis. This cyclic photosynthesis resulting in an increased proton gradient and more ATP.

46

# ANABOLISM I

## Carbohydrates

### Photosynthesis and Carbohydrate Synthesis in Plants

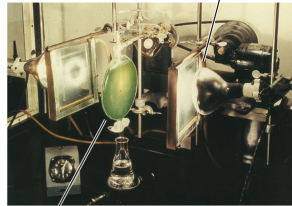
47

# Photosynthesis

## Assimilation of CO<sub>2</sub> by Plants

- Taking CO<sub>2</sub> into biological, more reduced, carbon intermediates is **CO<sub>2</sub> assimilation**.
- Question was: What is the first compound made by plants when they assimilated CO<sub>2</sub>?

Bright light source  
(energy for photosynthesis)



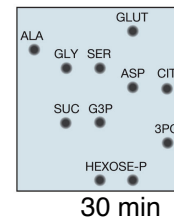
Thin flask of green algae

Calvin and Benson used the <sup>14</sup>C radioisotope to determine the sequence of reactions in CO<sub>2</sub> fixation.

They exposed *Chlorella* to <sup>14</sup>CO<sub>2</sub>, then extracted the organic compounds and separated them by paper chromatography.



Melvin Calvin, 1911–1997



48

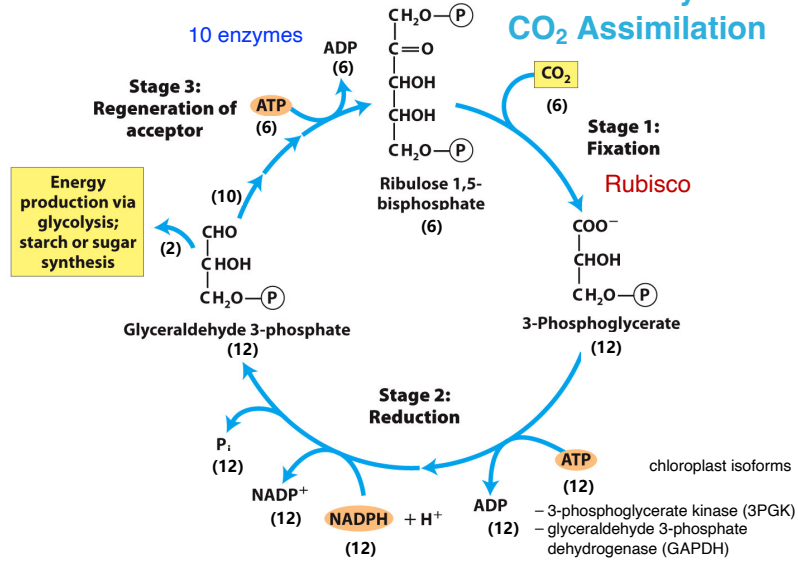
# Photosynthesis

- Plant cells: can also *make* 3-C intermediates for further synthesis
  - made from CO<sub>2</sub>, H<sub>2</sub>O, plus ATP and NADPH from photosynthesis
- It occurs in the **stroma of chloroplasts** via a cyclic process known as the **Calvin cycle**.
- Key intermediate **ribulose 1,5-bisphosphate** is constantly regenerated using **energy of ATP**.
- It produces **3-phosphoglycerate**, which is rapidly converted to **glyceraldehyde 3-phosphate** (GA3P) & **dihydroxyacetone phosphate** (DHAP), which are important intermediates for all other compounds.
- The net result is the **reduction of CO<sub>2</sub> with the NADPH** that was generated in the light reactions of photosynthesis.

49

# Photosynthesis

## The Three Stages of the Calvin Cycle of CO<sub>2</sub> Assimilation

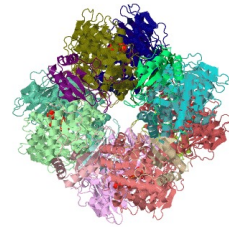


**Overall: 6 CO<sub>2</sub> + 12 NADPH + 10 H<sub>2</sub>O + 18 ATP → 2 glyceraldehyde 3-phosphate (GA3P) + 4 H<sup>+</sup> + 12 NADP<sup>+</sup> + 18 ADP + 16 P<sub>i</sub>**

\*Ribulose 1,5-bisphosphate carboxylase/oxygenase (also RuBisCo)

51

# Photosynthesis



# RUBISCO

52

**BB 422/622**

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**Clinical**  
**Correlations**  
**Friday**

53