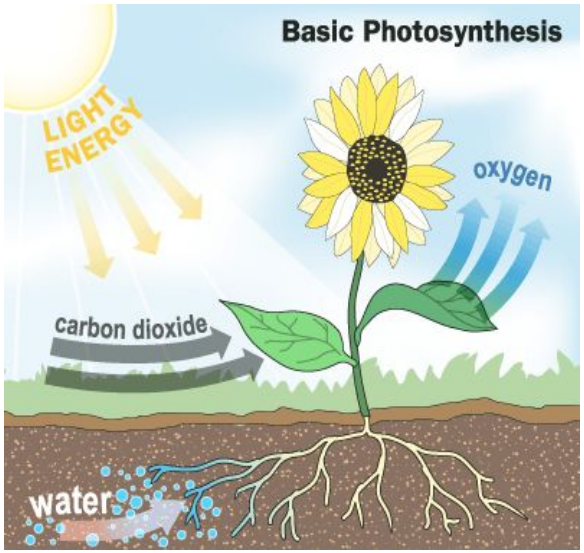
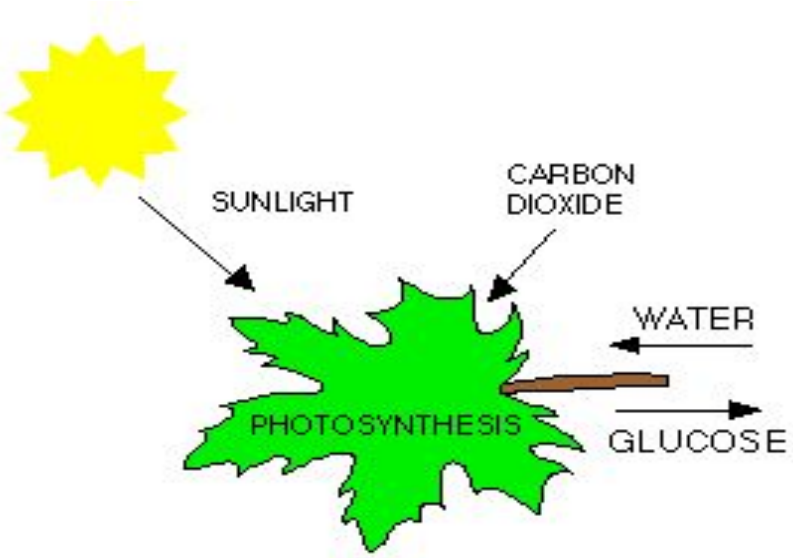
PHOTOSYNTHESIS

PHOTOSYNTHESIS

- The process by which plants make their food/energy (glucose) from sunlight.
- Stored as carbohydrate in their bodies.
- $6CO_2 + 6H_2O + \text{sunlight} \rightarrow C_6H_{12}O_6 + 6O_2$

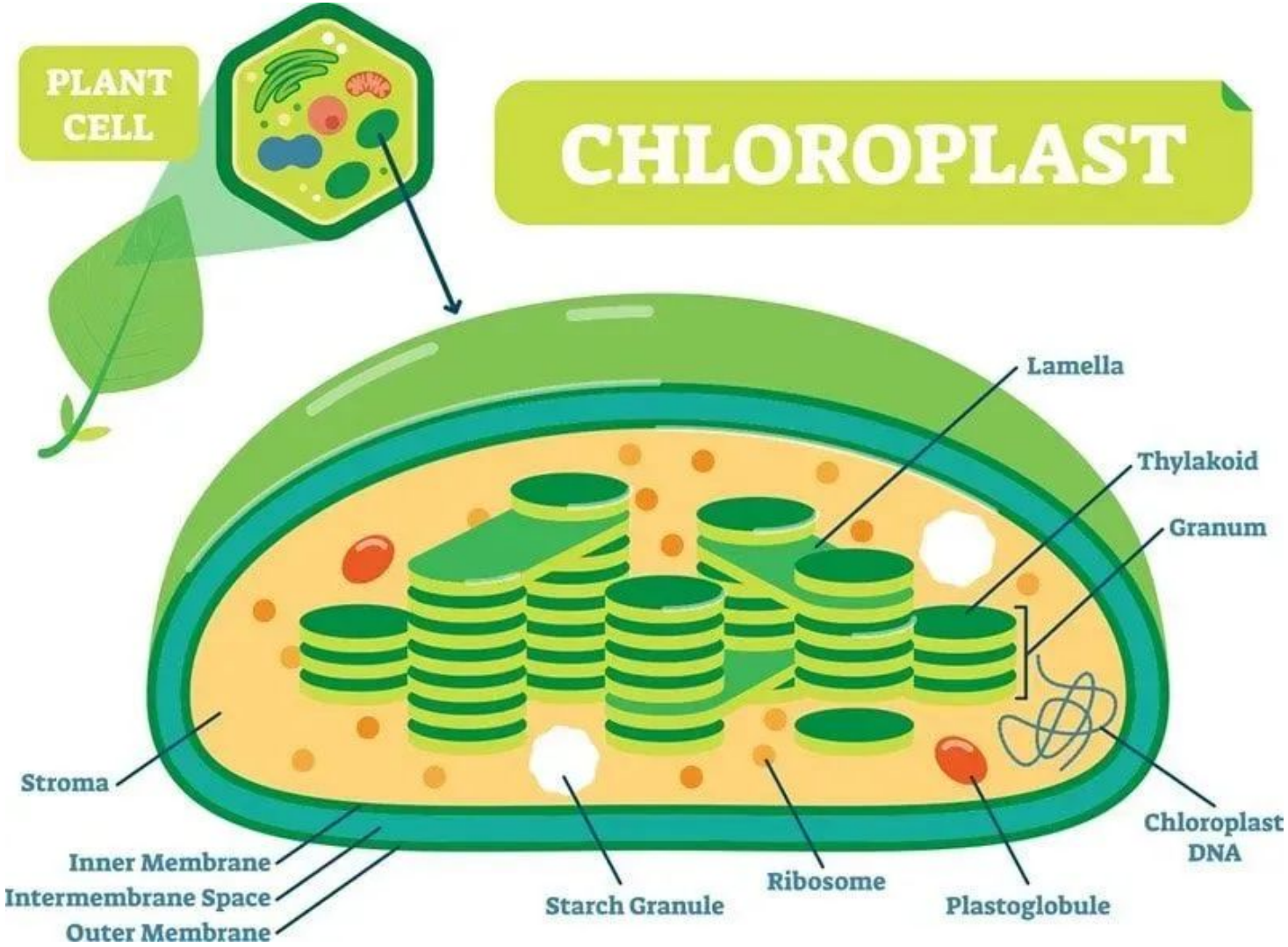




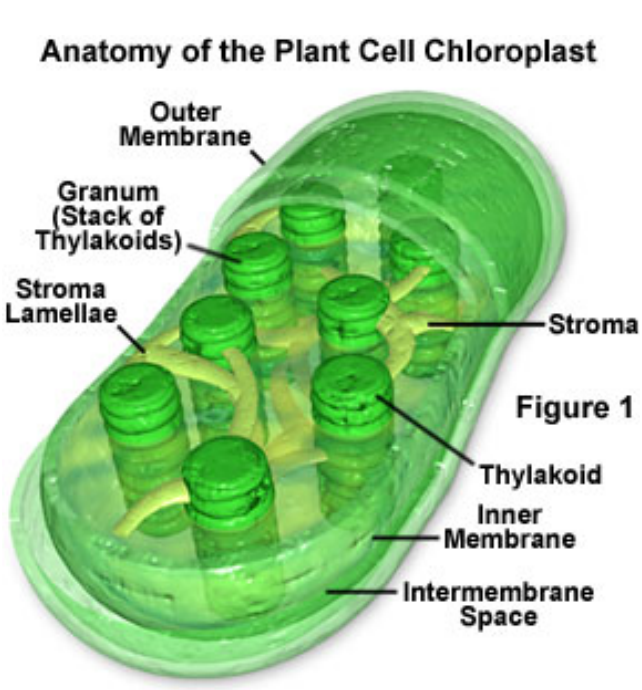
Why is Photosynthesis important?

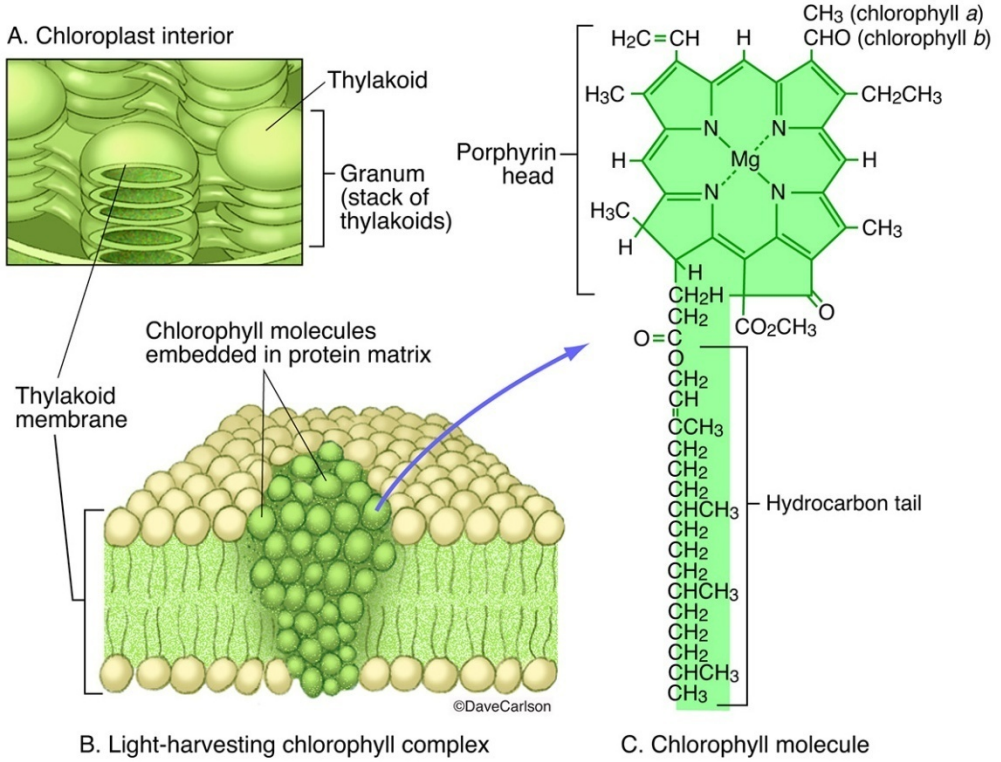
- Makes organic molecules (glucose) out of inorganic materials (carbon dioxide and water).
- It begins all food chains/webs. Thus all life is supported by this process.
- Autotrophs make glucose and heterotrophs are consumers of it.
- It also makes oxygen gas!!

Where Photosynthesis takes place?



Chloroplast contain chlorophylls as the key energy trapping molecule

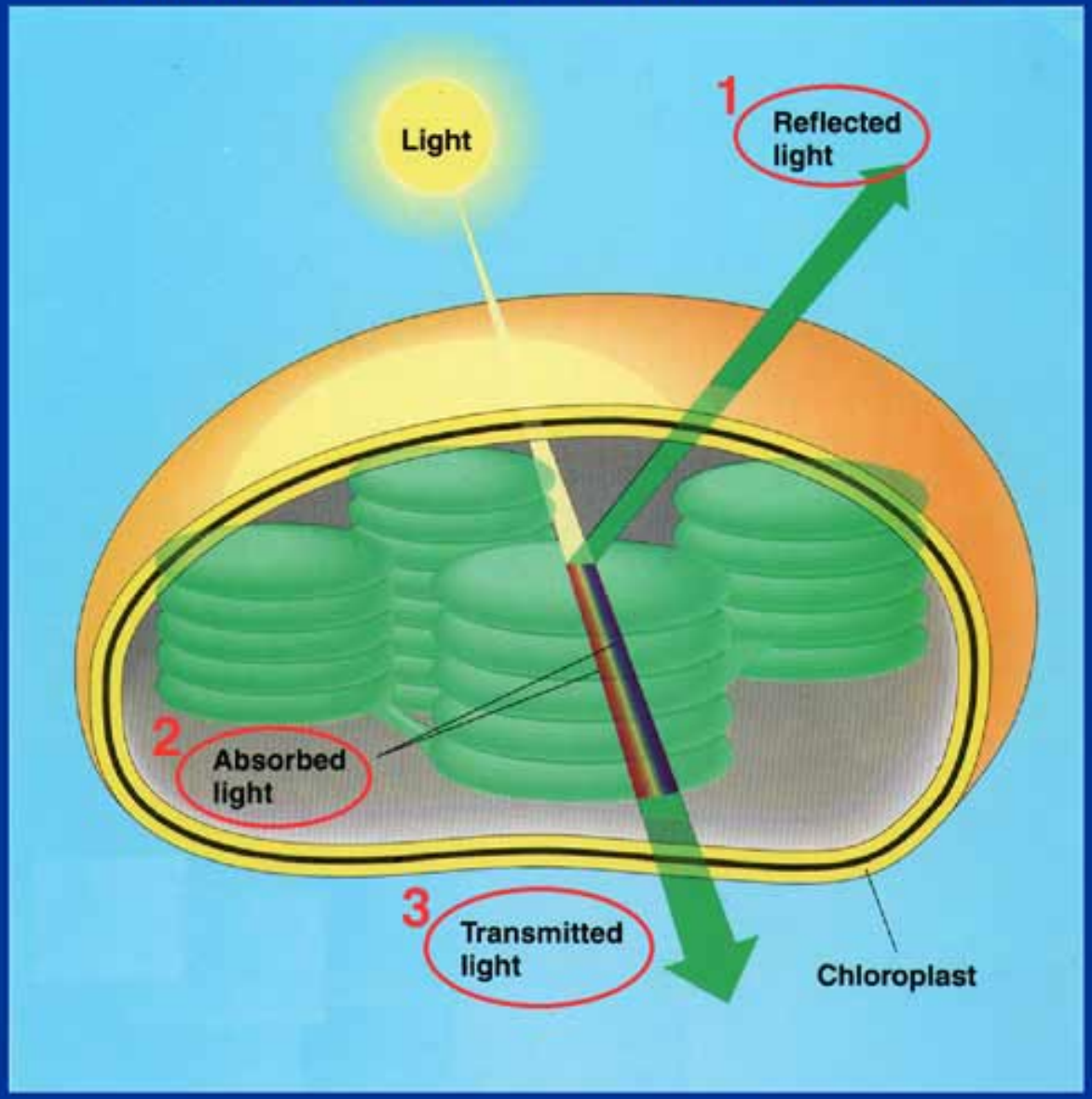




[Chlorophyll](): A Light Absorbing Pigment

The Solar Panel Chemical!

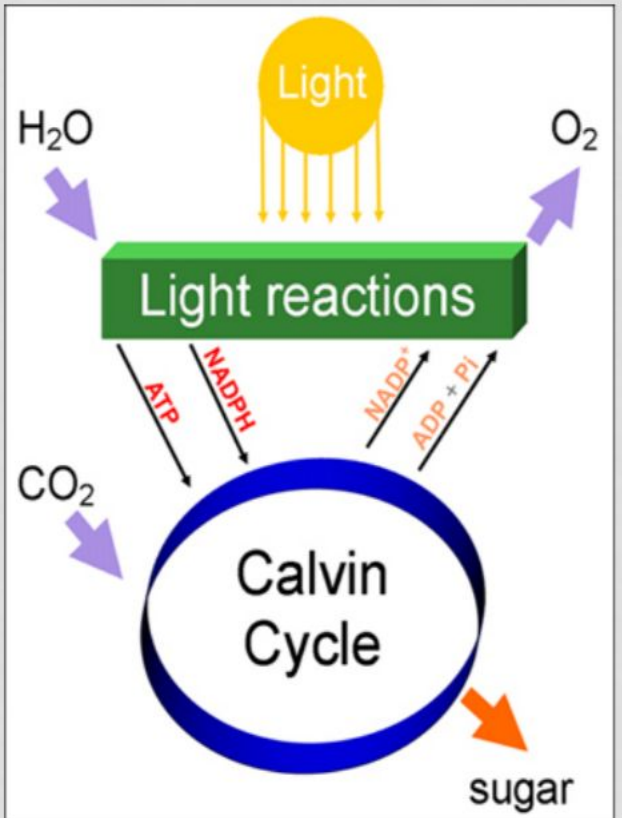
INTERACTION OF LIGHT WITH MATTER IN CHLOROPLAST; LIGHT DIVIDED INTO THREE PARTS



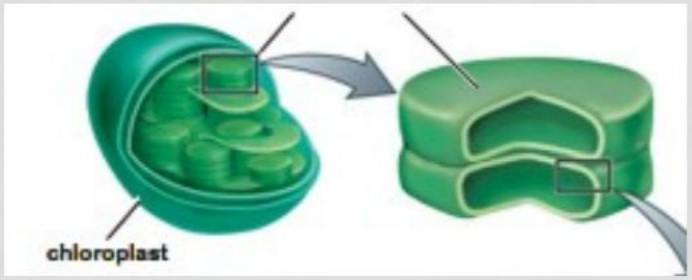
Red and Blue

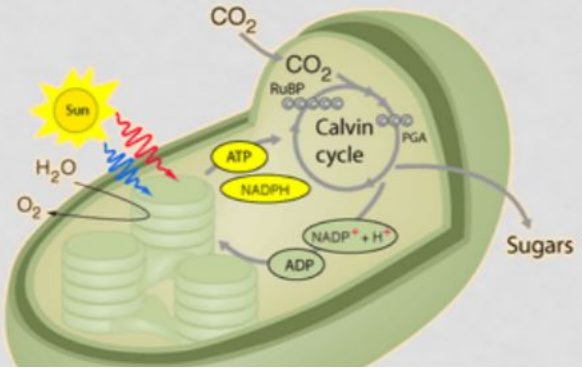
2 PROCESSES OF PHOTOSYNTHESIS

- Photosynthesis is actually 2 processes:
  - **light reactions** - convert solar energy (sunlight) to chemical energy (ATP & NADPH)
  - **dark reactions (Calvin cycle)** - light independent reactions; use energy produced & stored during light reactions (ATP & NADPH) & incorporates CO_2 from air into organic molecules (PGAL), which are converted to sugar (glucose)

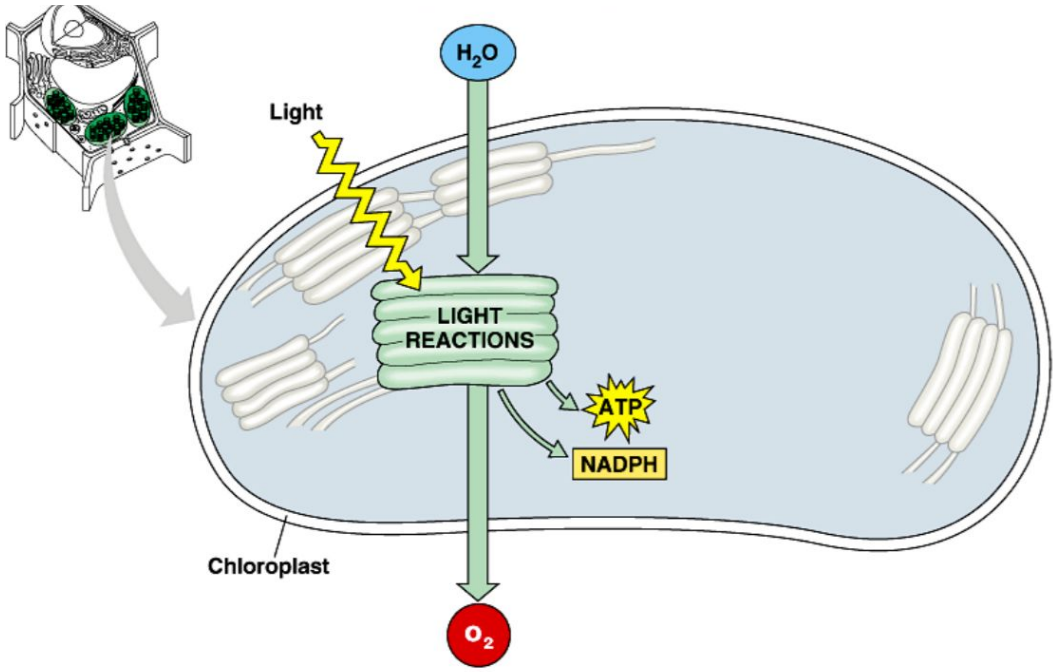


- light reactions take place in **photosynthetic membranes (thylakoids)**
- dark reactions take place **outside photosynthetic membranes (stroma)**





Light Reaction



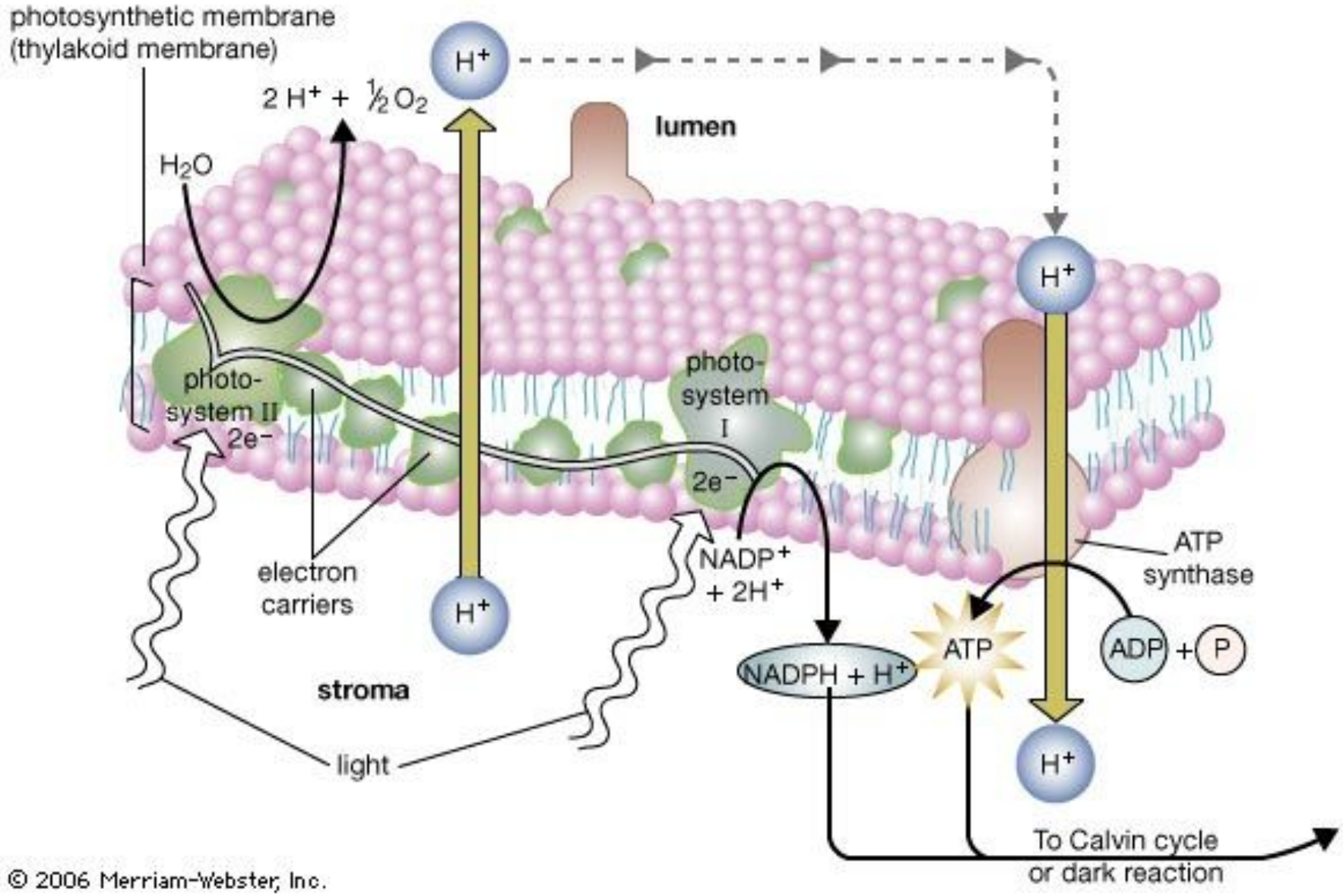
Reactants:

- H_2O
- Light Energy

Energy Products:

- ATP
- NADPH

LR: 8 hv + $2H_2O$ + 3 ADP + 2 $NADP^+$ → O_2 + 3 ATP + 2 NADPH

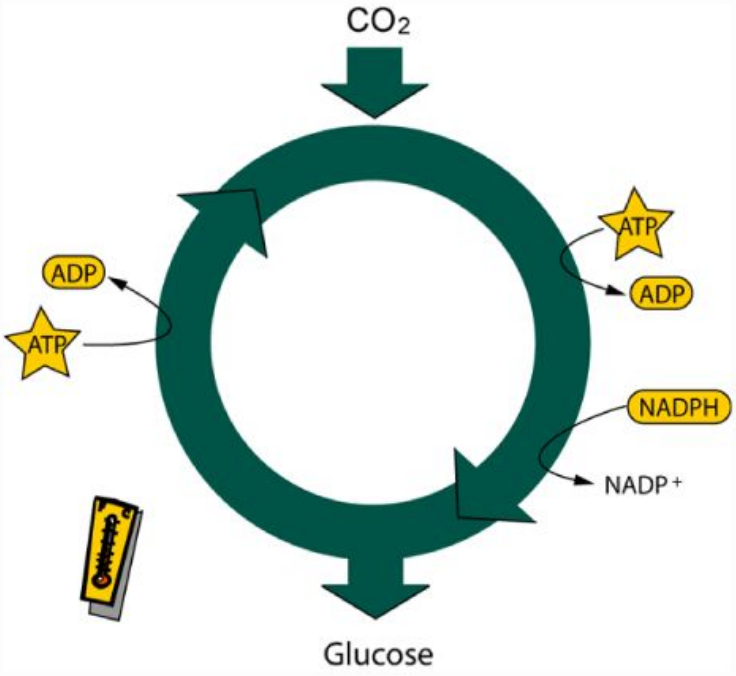


LIGHT-INDEPENDENT REACTIONS
THE CALVIN CYCLE

- ATP & NADPH can only store the chemical energy for a few minutes
- The Calvin cycle uses the energy from ATP & NADPH to make high-energy compounds that can store the energy longer (sugars)
- Light independent reaction = **does NOT require light**

DARK REACTIONS

- **Calvin cycle** – name given to the cycle of dark reactions in photosynthesis
- **Inorganic molecule CO_2 is used to make a complex organic molecules (i.e. glucose).**
- **enzyme** (rubisco) speeds up this reaction.
- this complex organic molecule can be considered a building block that can be used to make other biologically important molecules, including glucose



The purpose of the Carbon-fixation (Calvin Cycle) Reactions

$$CO_2 + NADPH + H^+ + ATP \rightarrow C_6H_{12}O_6 + NADP^+ + ADP + P_i$$

carbohydrate

Note: synthesis of carbohydrate from CO_2 is favorable only because coupled to very favorable reactions

NADPH to $NADP^+$

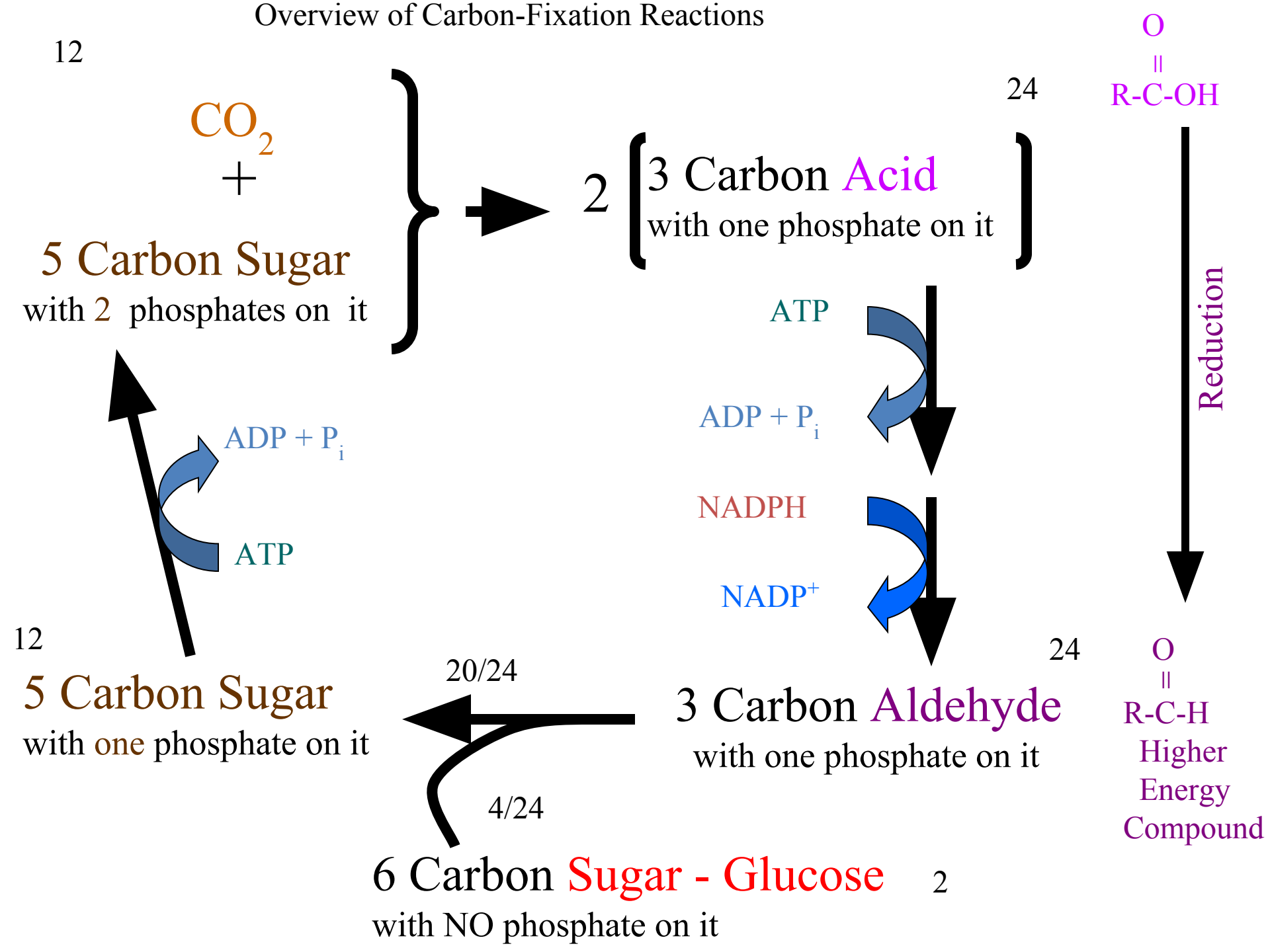
And ATP to ADP + P_i

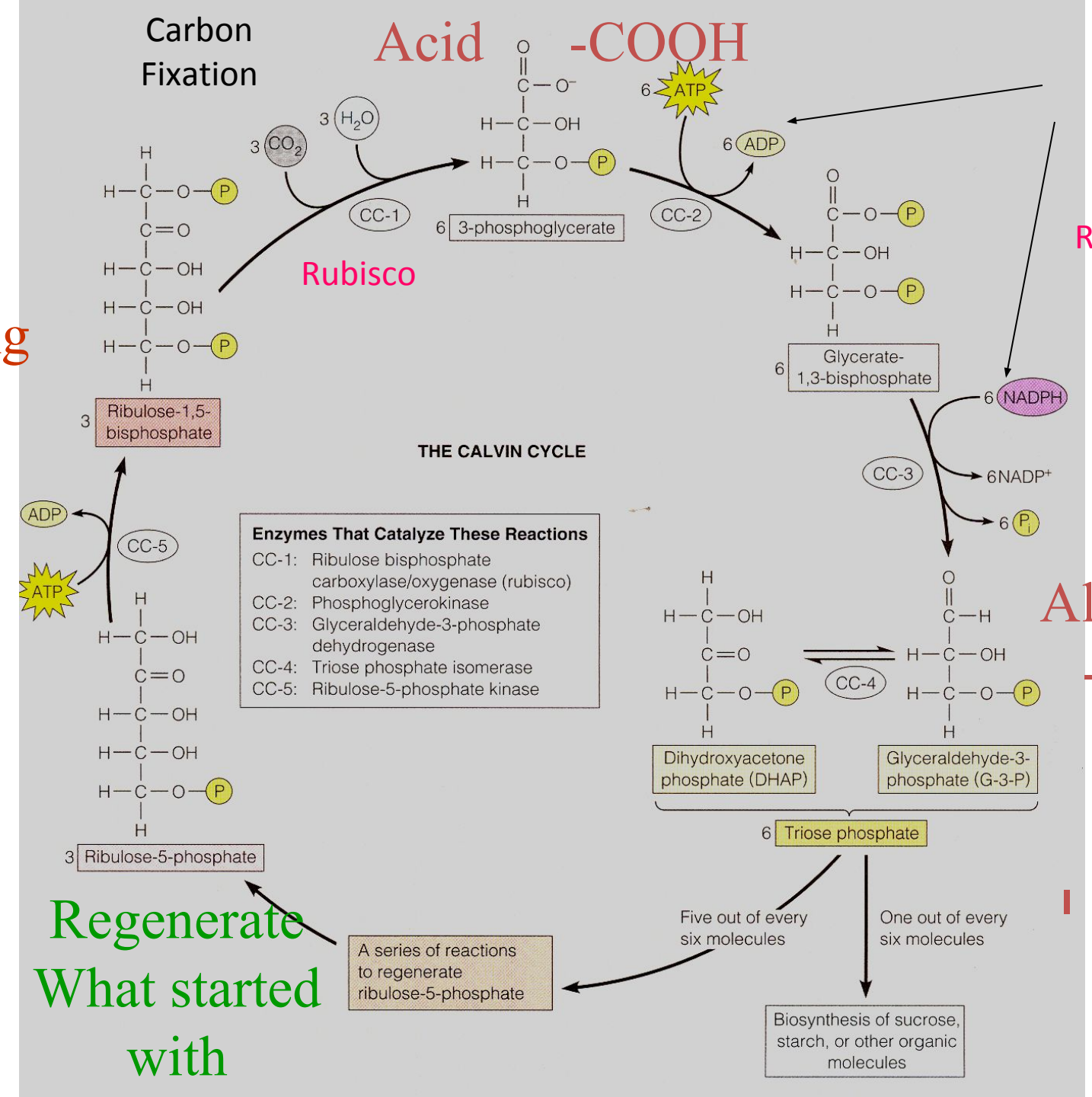
energy released is greater than it costs to make carbohydrate

The Calvin cycle has three phases

- Carbon fixation
- Reduction (energy input, reducing equiv input)
- Regeneration of the CO_2 acceptor (energy input – "priming step")

DR: 6 CO_2 + 6H_2O + 18 ATP + 12 NADPH → $C_6H_{12}O_6$ + 18 ADP + 12 $NADP^+$


Overview of Carbon-Fixation Reactions
12
CO_2
+
5 Carbon Sugar
with 2 phosphates on it
2
3 Carbon Acid
with one phosphate on it
24
O
||
R-C-OH
Reduction
ATP
$ADP + P_i$
$ADP + P_i$
ATP
NADPH
$NADP^+$
12
5 Carbon Sugar
with one phosphate on it
20/24
4/24
24
3 Carbon Aldehyde
with one phosphate on it
O
||
R-C-H
Higher Energy Compound
6 Carbon Sugar - Glucose
with NO phosphate on it
2


Carbon Fixation
Acid -COOH
Input of energy
Priming Step
Rubisco
Reduction
THE CALVIN CYCLE
Enzymes That Catalyze These Reactions
CC-1: Ribulose bisphosphate carboxylase/oxygenase (rubisco)
CC-2: Phosphoglycerokinase
CC-3: Glyceraldehyde-3-phosphate dehydrogenase
CC-4: Triose phosphate isomerase
CC-5: Ribulose-5-phosphate kinase
3 CO2
3 H2O
CC-1
6 3-phosphoglycerate
6 ATP
6 ADP
CC-2
6 Glycerate-1,3-bisphosphate
6 NADPH
CC-3
6 NADP+
6 Pi
3 Ribulose-1,5-bisphosphate
ADP
ATP
CC-5
3 Ribulose-5-phosphate
Dihydroxyacetone phosphate (DHAP)
CC-4
Glyceraldehyde-3-phosphate (G-3-P)
6 Triose phosphate
Five out of every six molecules
One out of every six molecules
A series of reactions to regenerate ribulose-5-phosphate
Biosynthesis of sucrose, starch, or other organic molecules
Aldehyde -C=O H
Regenerate What started with

LR: $8\ hv + 2H_2O + 3\ ADP + 2\ NADP^+ \rightarrow O_2 + 3\ ATP + 2\ NADPH$

DR: $6\ CO_2 + 6H_2O + 18\ ATP + 12\ NADPH \rightarrow C_6H_{12}O_6 + 18\ ADP + 12\ NADP^+$

Net Photosynthetic Rn: $48\ hv + 12H_2O + 6\ CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$