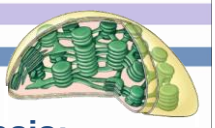
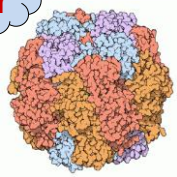


Photosynthesis: The Calvin Cycle

Life from Air



Remember what it means to be a plant…

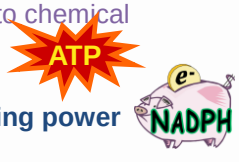
- Need to produce all organic molecules necessary for growth
  - carbohydrates, lipids, proteins, nucleic acids
- Need to store chemical energy (ATP) produced from light reactions
  - in a more stable form
  - that can be moved around plant
  - saved for a rainy day

carbon dioxide + water + energy → glucose + oxygen

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

Light reactions

- Convert solar energy to chemical energy
  - ATP → energy
  - NADPH → reducing power



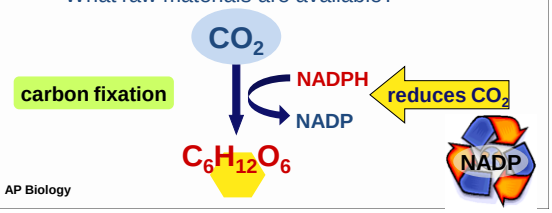
- What can we do now?

→ → build stuff !!

photosynthesis

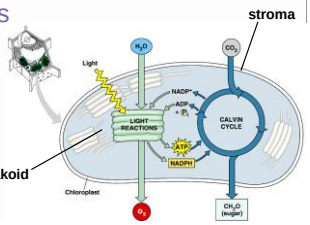
How is that helpful?

- Want to make $C_6H_{12}O_6$
  - synthesis
  - How? From what?
    What raw materials are available?

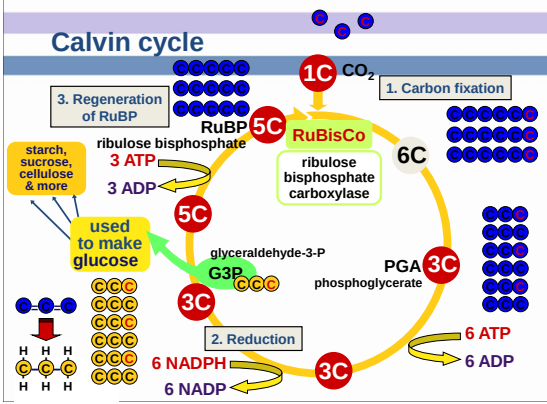


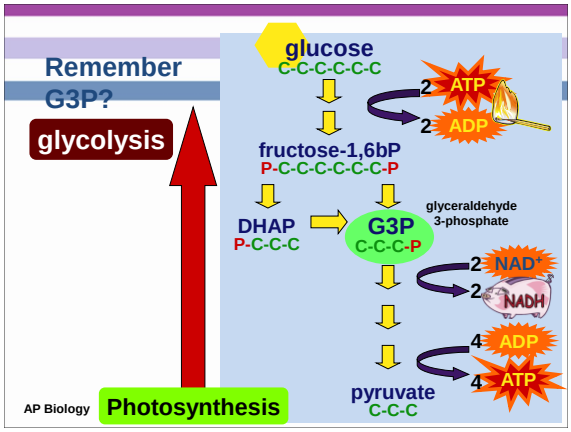
From Light reactions to Calvin cycle

- Calvin cycle
  - chloroplast stroma
- Need products of light reactions to drive synthesis reactions
  - ATP
  - NADPH



Calvin cycle





To G3P and Beyond!

- Glyceraldehyde-3-P
  - end product of Calvin cycle
  - energy rich 3 carbon sugar
  - "C3 photosynthesis"
- G3P is an important intermediate

  G3P → → glucose → → carbohydrates

  → → lipids → → phospholipids, fats, waxes

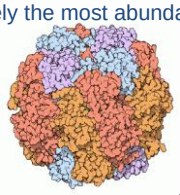
  → → amino acids → → proteins

  → → nucleic acids → → DNA, RNA

AP Biology

RuBisCo

- Enzyme which fixes carbon from air
  - ribulose bisphosphate carboxylase
  - the most important enzyme in the world!
    - it makes life out of air!
  - definitely the most abundant enzyme



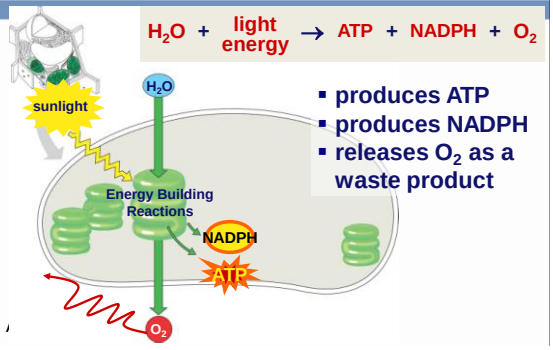
AP Biology

Accounting

- The accounting is complicated
  - 3 turns of Calvin cycle = 1 G3P
  - 3 CO_2 → 1 G3P (3C)
  - 6 turns of Calvin cycle = 1 $C_6H_{12}O_6$ (6C)
  - 6 CO_2 → 1 $C_6H_{12}O_6$ (6C)
  - 18 ATP + 12 NADPH → 1 $C_6H_{12}O_6$
  - any ATP left over from light reactions will be used elsewhere by the cell

Light Reactions

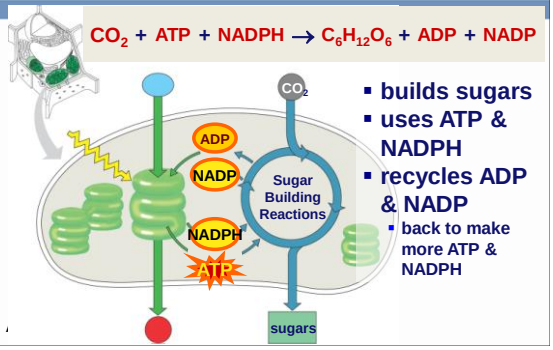
H_2O + light energy → ATP + NADPH + O_2



- produces ATP
- produces NADPH
- releases O_2 as a waste product

Calvin Cycle

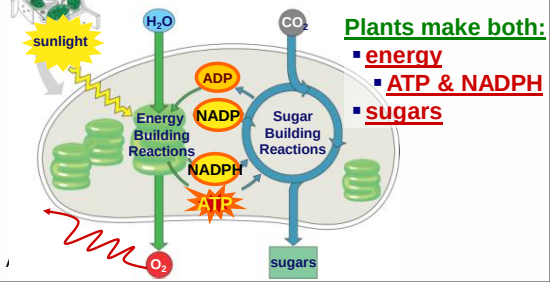
CO_2 + ATP + NADPH → $C_6H_{12}O_6$ + ADP + NADP



- builds sugars
- uses ATP & NADPH
- recycles ADP & NADP
  - back to make more ATP & NADPH

Putting it all together

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



Plants make both:

- energy
  - ATP & NADPH
- sugars

Energy cycle