

Photosynthesis: The Calvin Cycle

Life from Air

AP Biology

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

AP Bio $6\text{CO}_2 + 6\text{H}_2\text{O} + \text{light energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$

Light reactions

- Convert solar energy to chemical energy
 - ATP → energy
 - NADPH → reducing power
- What can we do now?
 - → build stuff !!
 - photosynthesis**

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How is that helpful?

- Want to make $\text{C}_6\text{H}_{12}\text{O}_6$
 - synthesis**
 - How? From what?
 - What raw materials are available?

carbon fixation

CO_2 → $\text{C}_6\text{H}_{12}\text{O}_6$

NADPH → reduces CO_2 → NADP

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From Light reactions to Calvin cycle

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

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Calvin cycle

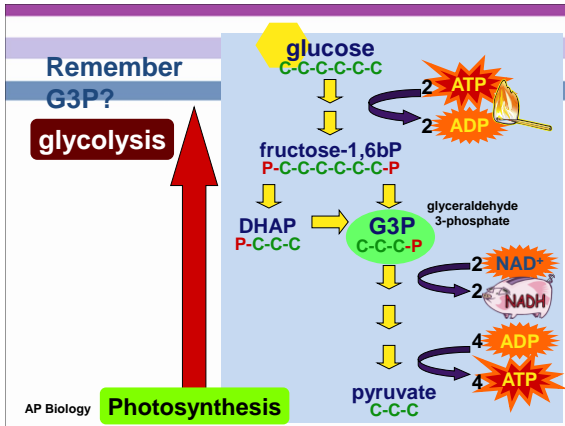
1. Carbon fixation: CO_2 (1C) + RuBP (5C) → RuBisCo → 6C → PGA (3C)

2. Reduction: PGA (3C) + 6 NADPH → G3P (3C) + 6 NADP

3. Regeneration of RuBP: G3P (3C) + 3 ATP → RuBP (5C) + 3 ADP

used to make glucose: starch, sucrose, cellulose & more

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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

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RuBisCo

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

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Accounting

- The accounting is complicated
 - 3 turns of Calvin cycle = 1 G3P
 - 3 CO₂ → 1 G3P (3C)
 - 6 turns of Calvin cycle = 1 C₆H₁₂O₆ (6C)
 - 6 CO₂ → 1 C₆H₁₂O₆ (6C)
 - 18 ATP + 12 NADPH → 1 C₆H₁₂O₆
 - any ATP left over from light reactions will be used elsewhere by the cell

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Light Reactions

$H_2O + \text{light energy} \rightarrow ATP + NADPH + O_2$

- produces ATP
- produces NADPH
- releases O₂ as a waste product

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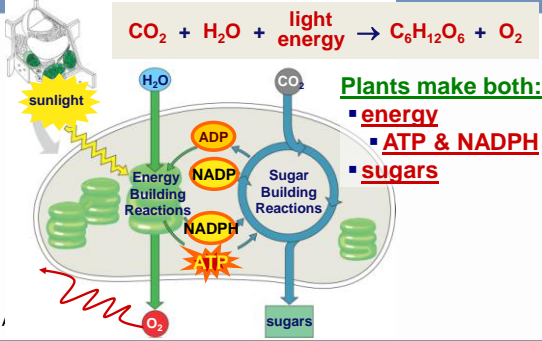
Calvin Cycle

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

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

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Putting it all together



Plants make both:

- **energy**
- **ATP & NADPH**
- **sugars**

Energy cycle

