

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 + water + energy → glucose + oxygen
dioxide



Light reactions

- Convert solar energy to chemical energy
 - ATP → energy
 - NADPH → reducing power
- What can we do now?

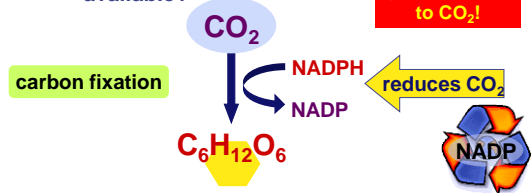
→ → build stuff !!

photosynthesis

How is that helpful?

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

Remember what Respiration ultimately is—**OXIDIZING** glucose down to CO_2 !

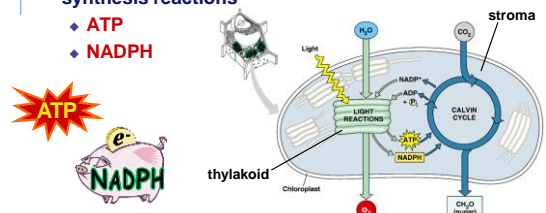


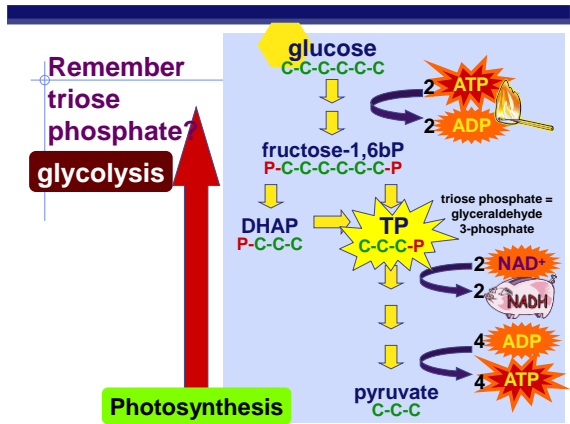
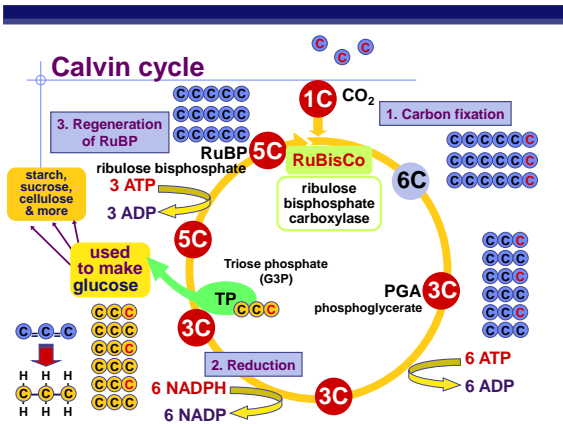
From $\text{CO}_2 \rightarrow \text{C}_6\text{H}_{12}\text{O}_6$

- CO_2 has very little chemical energy
 - fully oxidized
- $\text{C}_6\text{H}_{12}\text{O}_6$ contains a lot of chemical energy
 - highly reduced
- Synthesis = endergonic process
 - put in a lot of energy
- Reduction of $\text{CO}_2 \rightarrow \text{C}_6\text{H}_{12}\text{O}_6$ proceeds in many small uphill steps
 - each catalyzed by a specific enzyme
 - using energy stored in **ATP & NADPH**

From Light reactions to Calvin cycle

- Calvin cycle, the light independent reactions. **NOT THE DARK REACTIONS!**
 - chloroplast **stroma**
- Need products of light reactions to drive synthesis reactions
 - ATP
 - NADPH



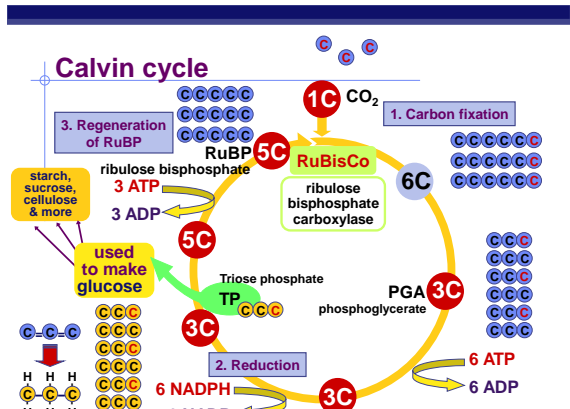


- ### To TP and Beyond!
- Triose Phosphate = Glyceraldehyde-3-P
 - end product of Calvin cycle
 - energy rich 3 carbon sugar
 - "C3 photosynthesis"
 - TP is an important intermediate
 - TP → → glucose → → carbohydrates
 - TP → → lipids → → phospholipids, fats, waxes
 - TP → → amino acids → → proteins
 - TP → → nucleic acids → → DNA, RNA
-

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

- ### 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



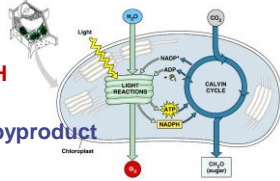
Photosynthesis summary

Light reactions

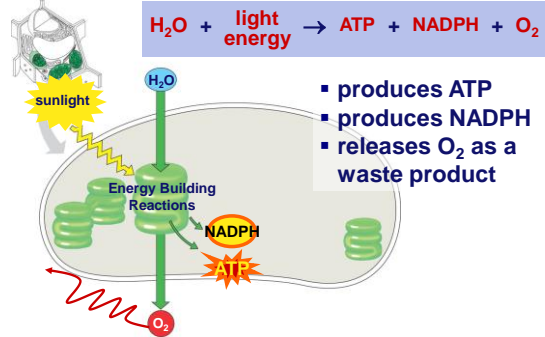
- produced **ATP**
- produced **NADPH**
- consumed **H₂O**
- produced **O₂** as byproduct

Calvin cycle

- consumed **CO₂**
- produced **TP (sugar)**
- regenerated **ADP**
- regenerated **NADP**

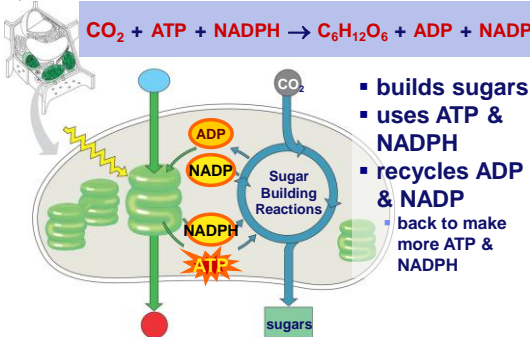


Light Reactions



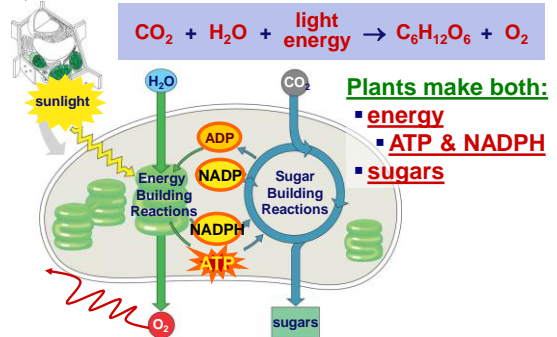
- produces **ATP**
- produces **NADPH**
- releases **O₂** as a waste product

Calvin Cycle



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

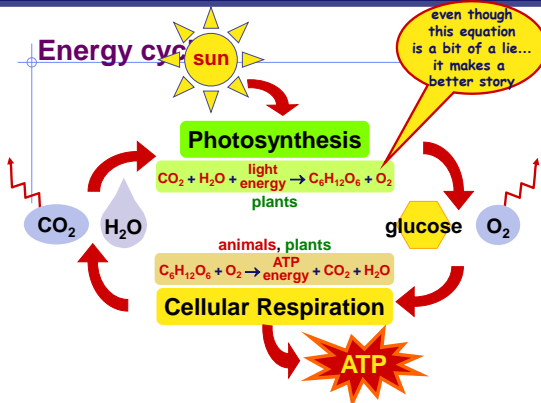
Putting it all together



Plants make both:

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

Energy cycle



Supporting a biosphere

- On global scale, photosynthesis is the most important process for the continuation of life on Earth



- each year photosynthesis...
 - captures 121 billion tons of **CO₂**
 - synthesizes 160 billion tons of carbohydrate
- heterotrophs are dependent on plants as food source for fuel & raw materials

The poetic perspective...

- All the solid material of every **plant** was built by sunlight out of thin air
- All the solid material of every **animal** was built from plant material

air

Then all the plants, cats, dogs, elephants & people ... are really particles of air woven together by strands of sunlight!

sun

If plants can do it...
You can learn it!
Ask Questions!!



Summary of photosynthesis



- Where did the CO_2 come from?
- Where did the CO_2 go?
- Where did the H_2O come from?
- Where did the H_2O go?
- Where did the energy come from?
- What's the energy used for?
- What will the $\text{C}_6\text{H}_{12}\text{O}_6$ be used for?
- Where did the O_2 come from?
- Where will the O_2 go?
- What else is involved...not listed in this equation?