PHOTOSYNTHESIS

Autotrophs (producers) manufacture their own food from inorganic substances and energy

Heterotrophs (consumers) obtain food by eating autotrophs or other heterotrophs

Cellular respiration – both autotrophs & heterotrophs

Photosynthesis – autotrophs (plants, algae and some bacteria) In plants it occurs in leaves & stems. Typical mesophyll cell has 30-40 chloroplasts.

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

Anabolic - endergonic (energy absorbing)

Water is oxidized and CO_2 is reduced (in Calvin cycle)

2 Separate Processes:

1. Light Dependent (Energy fixing) Reactions
   Energy-rich electrons flow through a series of coenzymes and other molecules. This electron energy is trapped. ATP and NADPH are formed (both are rich in energy) and O_2 is produced. ATP and NADPH are used in the second process.

2. Light Independent / Dark (Carbon fixing) Reactions (CALVIN CYCLE)
   Carbon dioxide molecule are bound into carbohydrates to form organic substances.

Electromagnetic Spectrum

Low energy/Long wavelength — High energy/Short wavelength

Infrared | ← Visible Light → | Ultraviolet

R O Y G B I V

750 nm — 380 nm

Color you see is not absorbed, but what is reflected back. Leaves are green, green light is reflected back (green has little to do with photosynthesis…chlorophyll absorbs mainly red & blue)

Light Dependent Reactions (thylakoid membrane) Energy fixing
Uses: Water, ADP and NADP
Produces: O_2, NADPH and ATP

1. Light excites electrons in chlorophyll *a* molecules of photosystem II (photosystems contain chlorophyll & pigments, light traps, reaction centers)
2. These electrons move to a primary electron acceptor

3. The electrons are then transferred along the Electron Transport Chain

4. Light excites electrons in chlorophyll *a* molecules of photosystem I. As these electrons move to another primary electron acceptor (ferredoxin), they are replaced by electrons from photosystem II. **replacement electrons from photosystem II are provided by water molecules (or both ETC would stop)
   $2\,H_2O \rightarrow 4\,H^+ + 4\,e^- + O_2$

5. The electrons from photosystem I are transferred along a second ETC. At the end of this chain, they combine with $NADP^+$ and H^+ to make NADPH. In chemosmosis, ATP synthase makes ATP by adding a group of phosphate to ADP

   NADPH and ATP are used in Light Independent Reactions.
   O_2 is produced as well.

Light Independent Reactions (stroma of chloroplast) CALVIN CYCLE
Carbon fixation (incorporation of CO_2 into organic compounds)
USES: ATP and NADPH

3 Major Steps:
1. CO_2 diffuses from cytosol into stroma. CO_2 combines with RuBP to form 2 molecules of PGA
2. Each molecule of PGA is converted into a molecule of PGAL
3. Most of the PGAL is converted back into RuBP, but some PGAL can be used to make a variety of organic compounds (amino acids, lipids, carbohydrates)

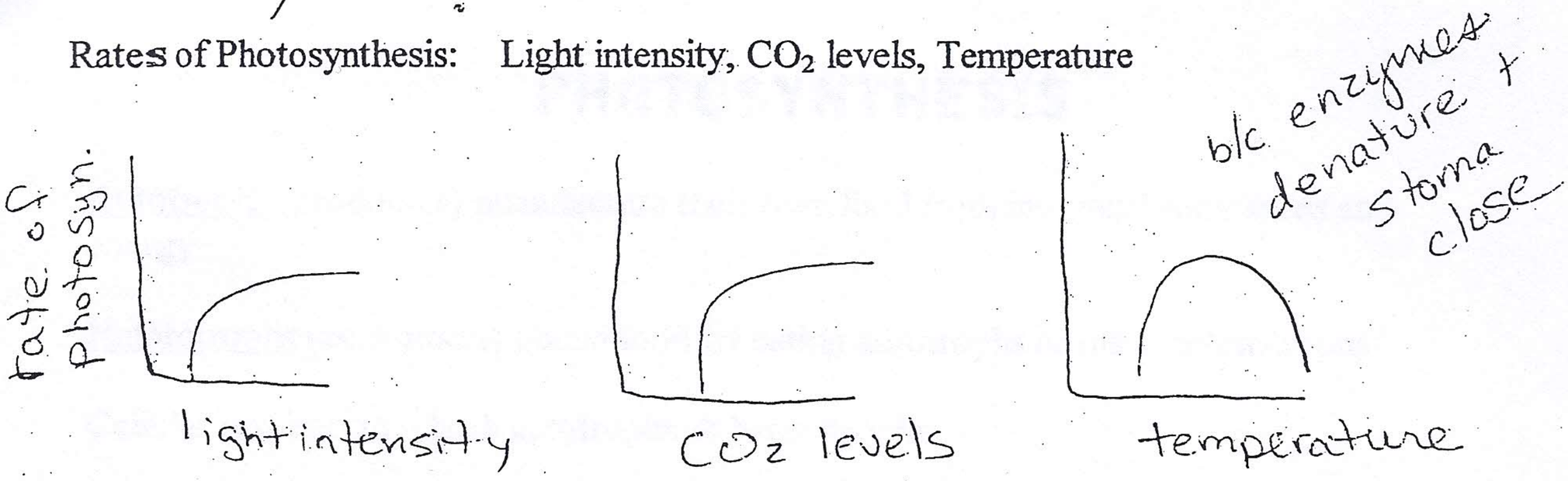
Each turn of the Calvin cycle fixes 1 CO_2 molecule. Since PGAL is a 3-C compound, it takes 3 turns to produce each PGAL.

1 turn: 3 ATP (two in step 2 and one in step 3) and 2 NADPH

3 turns: 9 ATP and 6 NADPH

Y X

Rates of Photosynthesis: Light intensity, CO_2 levels, Temperature



C_3 Plants – fix carbon exclusively through the Calvin cycle (3C PGA)

Examples: soybeans, oats, wheat, rice

Alternative Pathways

In Hot, Dry Climates…….

Water loss is through Stomata (singular) stoma pl. (pores on the underside of leaves)
Plants close stomata when the air is hot & dry to reduce water loss.

Stoma are also where CO_2 enters and O_2 leaves the plant.

When stoma close - low CO_2 level and high O_2 level inhibits carbon fixation in the Calvin cycle.

C_4 Pathway (4C Compounds)

C_4 Plants have enzymes to fix CO_2 into 4C compounds even when CO_2 level is low and O_2 level is high

Examples: corn, sugar cane, crab grass

They lose about half the water as C_3 plants do making the same amount of carbohydrate.

CAM Pathway (crassulacean acid metabolism)

Stomata open at night, close during day (opposite of C_3 plants) At night, take in CO_2 and fix it.

Day, CO_2 is released from the nightly made compoiunds and enters the Calvin cycle.
They lose less water than either C_3 or C_4 plants.

Examples: cactuses, pineapples