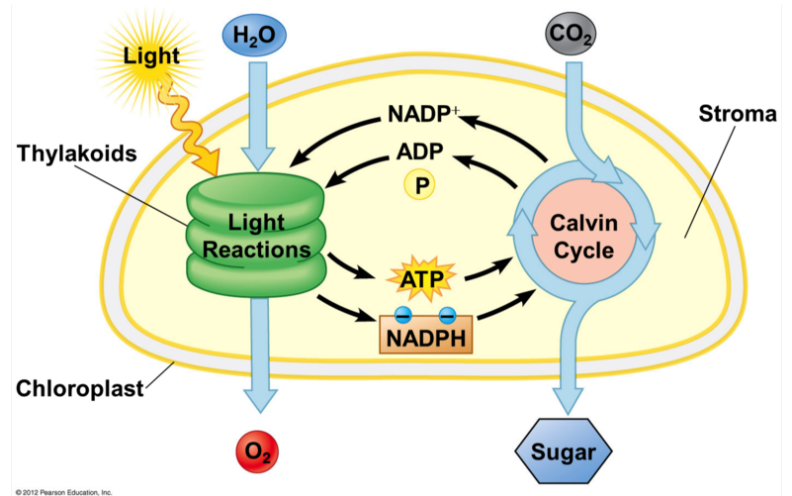
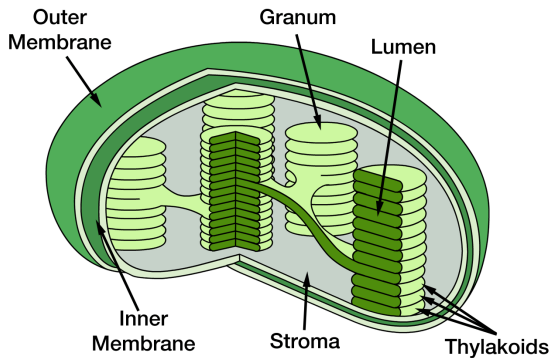


SBI4U: Photosynthesis & Comparisons Review Questions

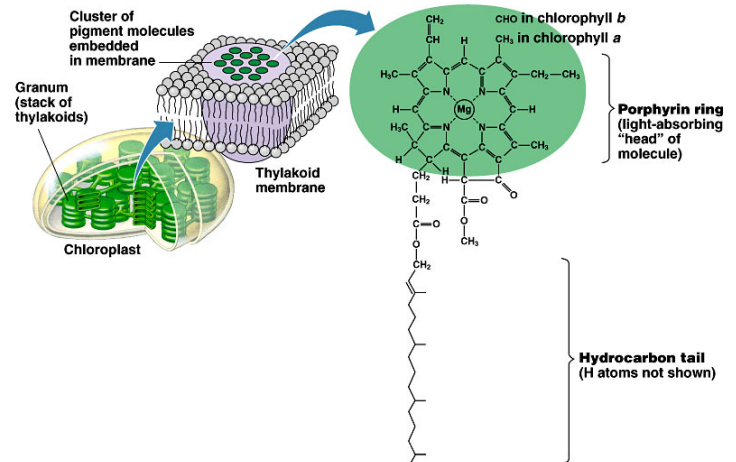
1. Sketch a diagram of a chloroplast and label it. Indicate where the processes of photosynthesis occur.

Chloroplast



2. Describe a photosynthetic pigment (ie chlorophyll). Why do photosystems use groupings of more than one type of pigment?

Allows for more photons to be absorbed and increase the amount of light reactions occurring. Each pigment absorbs a certain wavelength of light, by combining them more of the light energy can be absorbed/used by the plant.



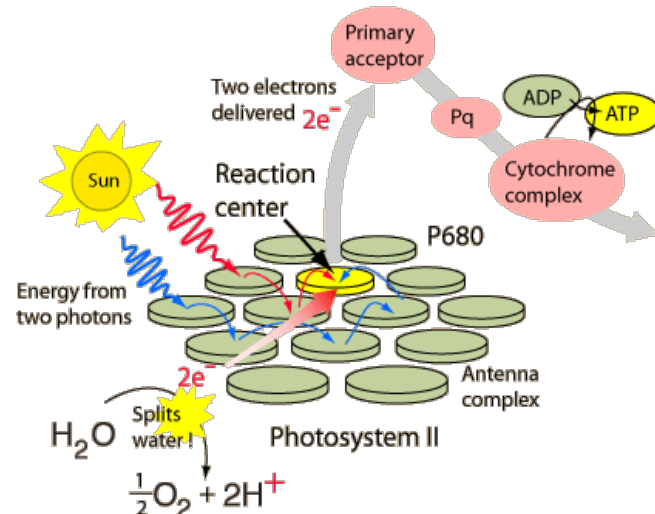
3. Define: complex/antenna complex, reaction centre, photosystem, primary electron acceptor.

antenna complex: an array of protein and chlorophyll molecules embedded in the thylakoid membrane of plants, which transfer light energy to one chlorophyll a molecule at the reaction center of a photosystem

reaction centre: is where the electrons are transferred from the photosystem to the primary electron acceptor.

photosystem: functional and structural units of protein complexes involved in the absorption of light and the transfer of energy and electrons.

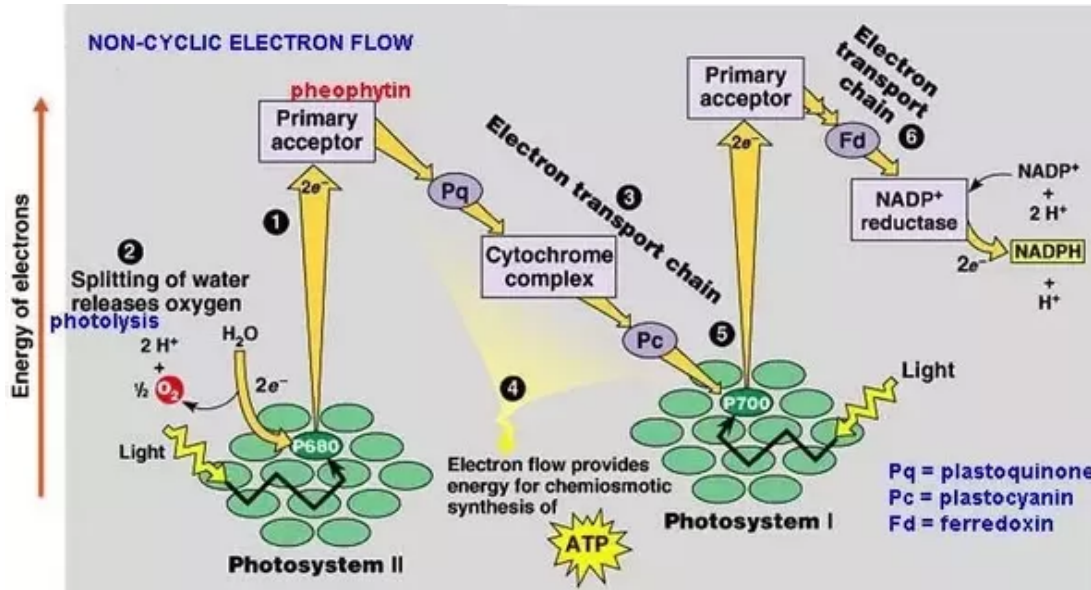
primary electron acceptor: absorbs high energy electrons that leave the photosystem.



4. Summarize the key events of Non-cyclic electron flow. Why is it so-called?

Uses both photosystems. Electrons finish in a different location than where they begin.

See outline posted in Edsby – “Circus script”



5. Explain the similarities and differences between the electron transport chains occurring in the mitochondria with the electron transport chain associated with photosystem II.

Mitochondria:

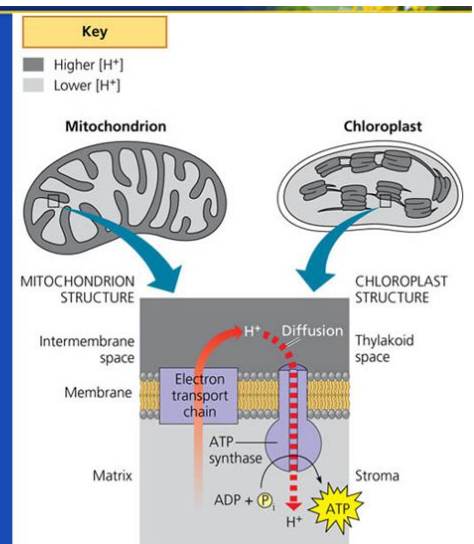
- always non-cyclic
- driven by Oxygen
- Oxidation of NADH & FADH₂
- electrons come from NADH & FADH₂
- Pumps multiple H⁺ per cycle
- produces water

Chloroplast:

- cyclic & non-cyclic
- Non-cyclic produces ATP & NADPH
- Cyclic produces ATP only
- Driven by excitation of electrons by light
- electrons come from water
- reduction of NADP^+ to NADPH
- Uses water as reactant
- Uses photosystems

In both organelles

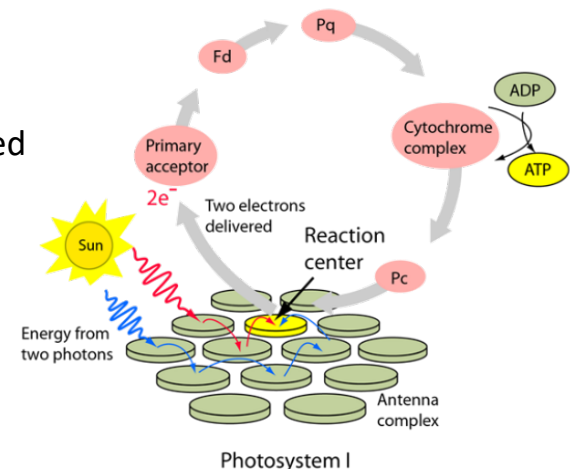
- Electron transport chains pump protons (H^+) across a membrane
- Protons go from a region of low H^+ concentration (light gray in this diagram) to one of high H^+ concentration (dark gray)
- Protons then diffuse back across the membrane through ATP synthase
- Produces ATP



6. Summarize cyclic electron flow. Why does a plant need cyclic electron flow?

Needed to produce ATP as Calvin cycle needs more ATP than NADPH

Only uses photosystem I



7. Outline the 3 Phases of the Calvin Cycle. What is the end product of photosynthesis?

1. Carbon fixation
2. Reduction
3. RuBP regeneration

G3P molecule is the results of 1 turn of the Calvin cycle. Is used to make glucose and other carbohydrates needed by plants.

8. What forms can it (molecule from above) be in and what does the plant do with the different forms?

2 G3P molecules can be combined to make glucose which is used in the mitochondria to make ATP energy for plants
Several G3P molecules can be combined to make cellulose for structural support, starch for energy storage....

9. How are the Light reactions and the Calvin cycle linked?

The products of one are the reactants for the other

Light reactions produce ATP & NADPH, need ADP & NADP+

Calvin cycle oxidized NADPH so it can be used in light reactions and dephosphorylates ATP into ADP to be used again in light reactions.

10. Why is the Calvin cycle called “dark reactions” or light independent reactions?

It does not directly need light to proceed, but it does need the products from the light reactions to work.

11. Energy changes forms twice during photosynthesis. What are these changes?

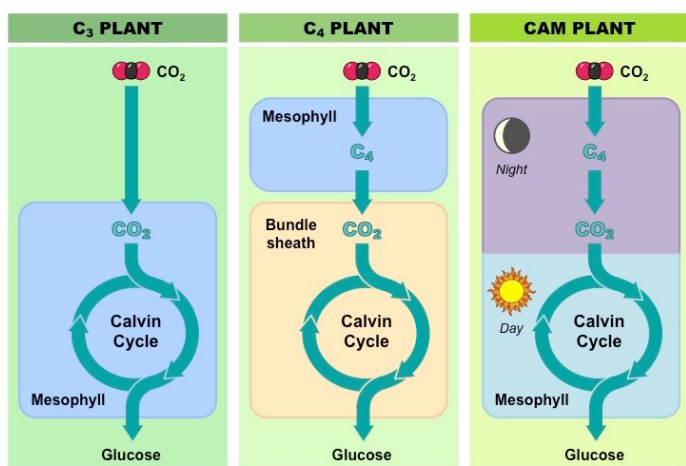
Photosynthesis converts **solar** energy into **chemical** energy using electrons and protons from water in the light reactions.

Mechanical energy is also created in the chemiosmosis driving ATP synthase to create ATP.

12. What are 3 ways you could you limit the rate of photosynthetic activity?

- decrease the amount of light
- decrease the amount of CO₂
- decrease temperature

13. Explain the main differences between C₃ and C₄ plants. Explain the differences exhibited by CAM plants.



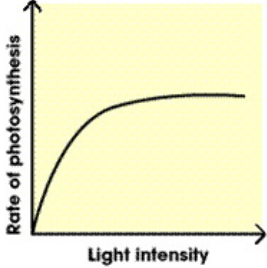
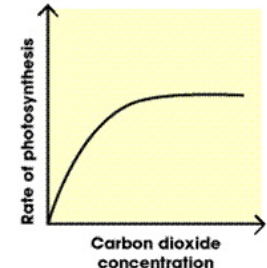
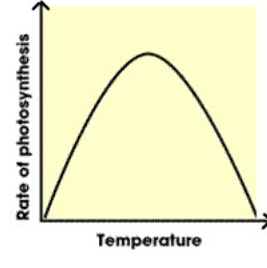
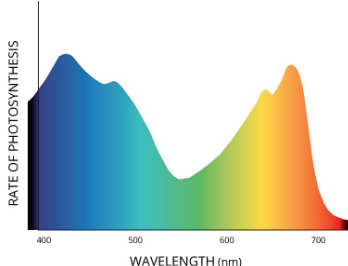
C ₃ plants	C ₄ plants	CAM plants
Most plants	Tropical grasses like corn, sugarcane	Succulents, pineapple, agave
Fix carbon in Calvin cycle - attach CO ₂ to RuBP	Fix carbon in cytoplasm - attach CO ₂ to PEP	Fix carbon at night only, fix it to organic molecules
Enzyme - Rubisco	Enzyme - PEP-ase	Enzyme - PEP-ase
Most energy efficient method	1/2 way between these two	Best water conservation
Loses water through photorespiration	Loses less water	Loses least water

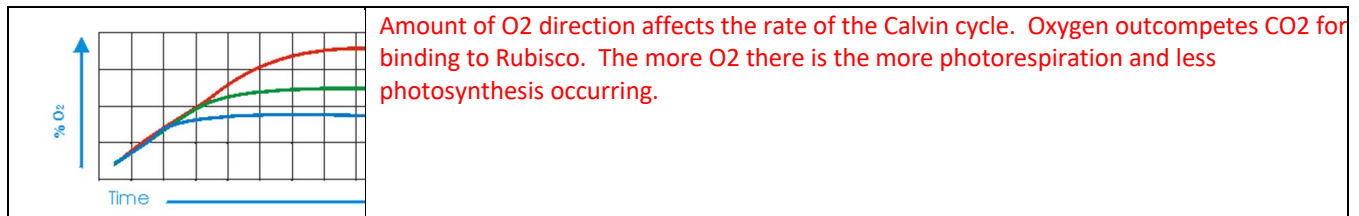
14. What is the significance of stomata?

Stomata allow for gas exchange in the leaves – CO₂ into the leaf & O₂ out

They close to conserve water when it is too hot – this can cause an increase in photorespiration which is not desired.

15. How do various environmental conditions such as temperature, light colour, light intensity, CO₂ and O₂ concentration levels affect the rate of photosynthesis? Explain why each affects photosynthesis the way it does.

 <p>A line graph with 'Rate of photosynthesis' on the y-axis and 'Light intensity' on the x-axis. The curve starts at the origin, rises steeply, and then levels off into a horizontal line, indicating that the rate of photosynthesis is no longer limited by light intensity at higher levels.</p>	<p>The amount of light directly affects the speed at which the light reactions can occur. The more light the more electrons excited from the photosystems, the more reactions occur. Light saturation occurs when no more light can be absorbed as the processes are being limited by speed at which they can transfer electrons & the Z-proteins ability to split water</p>
 <p>A line graph with 'Rate of photosynthesis' on the y-axis and 'Carbon dioxide concentration' on the x-axis. The curve starts at the origin, rises steeply, and then levels off into a horizontal line, indicating that the rate of photosynthesis is no longer limited by CO₂ concentration at higher levels.</p>	<p>The amount of CO₂ directly affects the speed at which the Calvin cycle can occur. The more CO₂, the more can bind to Rubisco and the faster the cycle happens. However, like all enzymes it can reach substrate saturation so there is a maximum amount of CO₂ that can be fixed in the cycle.</p>
 <p>A line graph with 'Rate of photosynthesis' on the y-axis and 'Temperature' on the x-axis. The curve starts at the origin, rises to a peak, and then falls back down to the x-axis, forming an inverted U-shape. This shows that there is an optimal temperature for photosynthesis, above which the rate decreases due to denaturation of enzymes.</p>	<p>Temperature affects the cycle in 2 ways:</p> <ol style="list-style-type: none"> 1- Both light reactions & Calvin cycle are enzyme driven and depend on molecule collisions. The lower the temperature the fewer collisions, the slower the reactions. Reaction speed will increase with temperature until enzymes begin to denature. 2- As temperature increase plants close their stomata to conserve water. This decreases the amount of photosynthesis and CO₂ cannot get into the leaf and O₂ is still being produced in light reactions so plants begin to undergo more photorespiration rather than photosynthesis.
 <p>A line graph with 'RATE OF PHOTOSYNTHESIS' on the y-axis and 'WAVELENGTH (nm)' on the x-axis. The x-axis is marked with 400, 500, 600, and 700 nm. The curve shows two distinct peaks: a higher one in the blue region (around 430 nm) and a slightly lower one in the red region (around 660 nm). The rate is lowest in the green region (around 500 nm).</p>	<p>Wavelengths affect the rate of photosynthesis as the pigments are responsible for absorbing light energy in the light reactions. Different pigments can absorb different wavelengths. Green is the least absorbed so it will have the slowest rate of photosynthesis.</p>



What Would Happen to the Photosynthesis Process, and the Plant as a Whole If...

1. The temperature around a C₃ plant was raised to 40 °C for one hour, and then increased again to 60 °C for three hours?

Photosynthesis would come to a halt because the enzymes required in the Calvin cycle have optimal temperatures between 10°C and 30°C. As temperatures approach and rise above 40°C the enzymes become denatured and can no longer function. Eventually the plant would die.

2. A C₃ plant was exposed to an atmosphere with 78 % oxygen, and 22 % Carbon Dioxide?

Oxygen has an inhibitory effect on photosynthesis. It binds more readily to rubisco. When oxygen binds, photorespiration occurs reducing the rate of photosynthesis. When carbon dioxide binds, it is fixed into carbohydrates by photosynthesis. If exposed to his environment for a long period of time it would die.

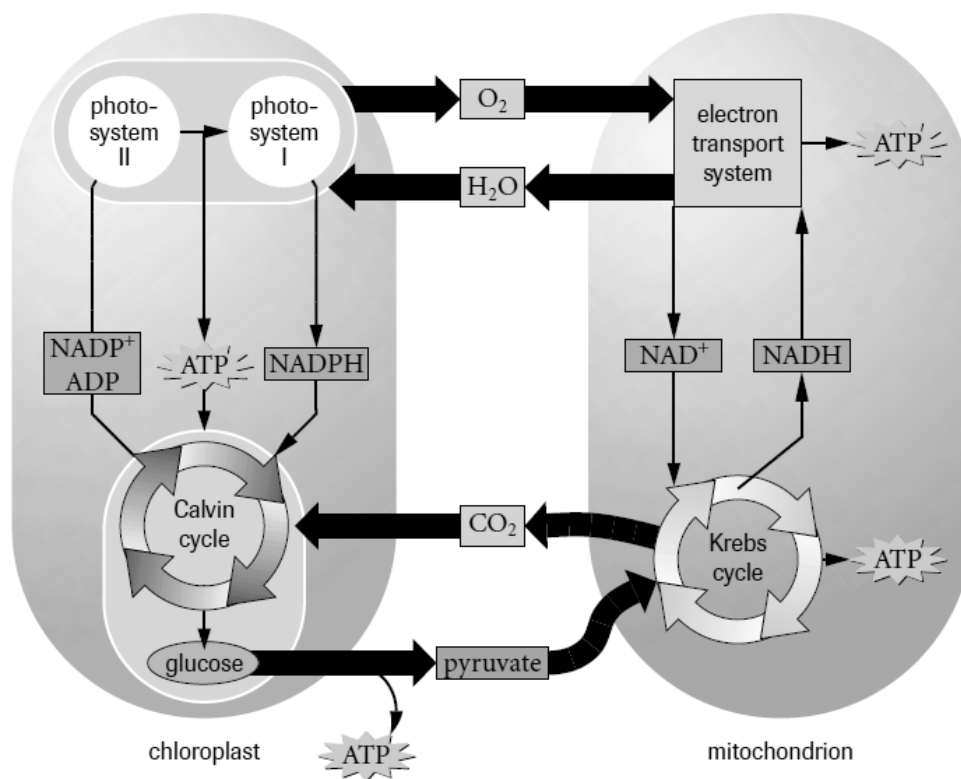
3. All of the stomata on a C₄ plant closed during the day?

C₄ plants have an alternative mechanism of carbon fixation, so they are resistant to lower levels of CO₂ that would occur if the stomata were closed during the day. However, if all stomata were closed there would eventually not be enough CO₂ available to be pumped into the mesophyll to allow this process to continue. Eventually the plant would die.

Tougher Photosynthesis & the Environment Questions

1. A plant completes the light reactions of photosynthesis and produces ATP and NADPH. However, the enzyme Rubisco is ineffective as it has been denatured. What do you suspect has happened to this plant? What makes you think this? The plant has most likely been exposed to high temperatures which have caused the enzyme to denature. This is because Rubisco is an enzyme which is a protein and is dependent upon its shape to function properly. If proteins are heated they will lose their tertiary (and quaternary if applicable) structure as molecular movement due to increased kinetic energy (from thermal energy) increases and prevents hydrogen bonding from maintaining the structure.
2. There are two plants growing in your backyard. Plant A grows really tall in the spring, and then shrivels during the summer. Plant B grows a little bit in the spring, and then shoots up in the summer. What type of plants do you suspect they are? Plant A is most likely a C₃ plant as it grown well in spring conditions. Ideal temperatures for C₃ plants is between 10 - 30°C. C₃ plants close their stomata in the warmer weather to reduce water loss which will decrease growth due to decreased production of carbohydrates. Plant B is most likely a C₄ plant as it grows well in warmer conditions. C₄ plants have mechanisms to keep CO₂ concentrations high despite having increased closed stomata in an effort to conserve water.
3. You examine two leaves under a microscope. One has significantly more chlorophyll than the other. What do you suspect about these two plants? The plant with increased chlorophyll is most likely a shade plant. This is because they have more chlorophyll to ensure that they are as efficient as possible with the limited amount of light that does hit the leaves. The other plant is most likely a sun plant. Sun plants do not need as many chlorophyll as the majority of leaves will be exposed to sunlight making the chlorophyll that are present continuously active.

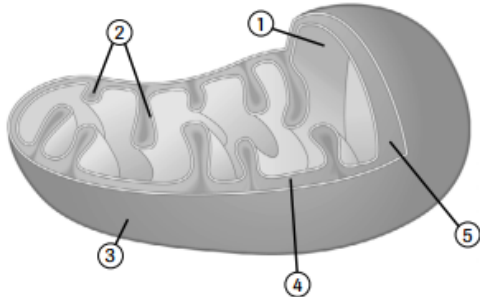
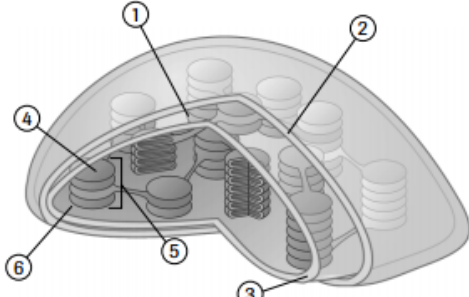
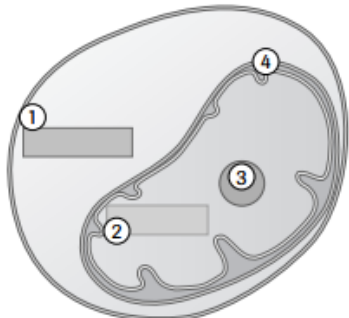
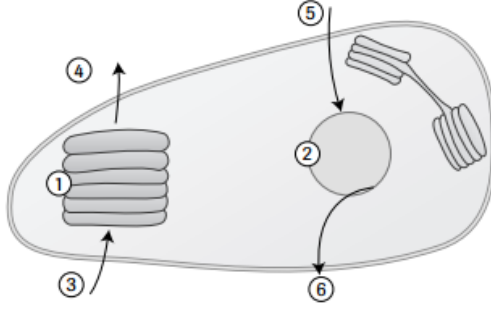
Comparing Cellular Respiration & Photosynthesis



	Criteria	Photosynthesis	Respiration
Overall	Reactants	H ₂ O & CO ₂	Organic molecules (ex. glucose) & O ₂
	Products	Organic molecule & O ₂	H ₂ O & CO ₂ & ATP
	Energy	Absorbed	Released
e-	Electron Source	H ₂ O	Organic molecule
	Electron Carriers	NADP ⁺ / NADPH	NAD ⁺ / NADH & FAD/FADH ₂
ETC	Electron Profile	Z-pattern & Cyclic	Linear
	Electron Source	H ₂ O	NADH & FADH ₂
	Electron Sink	NADPH	Oxygen
	Products	ATP & NADPH	ATP & H ₂ O

ATP Synthesis	Molecule pumped to create gradient	H ⁺	H ⁺
	Membrane-embedded molecule	ATP Synthase	ATP Synthase
	Location of H ⁺ reservoir	Thylakoid Interior	Intermembrane Space
	Location of ATP synthesis	Stroma	Matrix

Comparing Chloroplasts & Mitochondria

Criteria	Mitochondria	Chloroplast
Diagrams		
	1 Matrix	1 Intermembrane Space
	2 Cristae	2 Outer Membrane
	3 Outer Membrane	3 Inner Membrane
	4 Inner Membrane	4 Thylakoid
	5 Intermembrane Space	5 Granum / Grana
Structural Comparisons		6 Stroma
	<ul style="list-style-type: none"> - double phospholipid membrane - contain folding innermembrane (cristae) - matrix 	<ul style="list-style-type: none"> - double phospholipid membrane - contain thylakoids with pair of membranes - stroma
Overview of Metabolic Process		
	1 Glycolysis	1 Light Reactions
	2 Pyruvate Oxidation	2 Light Independent Reactions (Calvin Cycle)
	3 Kreb Cycle	3 H₂O
	4 Electron Transport Chain	4 O₂
Reactants	Glucose & O₂ (if aerobic)	H₂O & CO₂
Products	H₂O & CO₂ & ATP	Glucose & O₂
Pathways / Location	Prokaryotes & Eukaryotes	Plants, algae, protists, cyanobacteria

