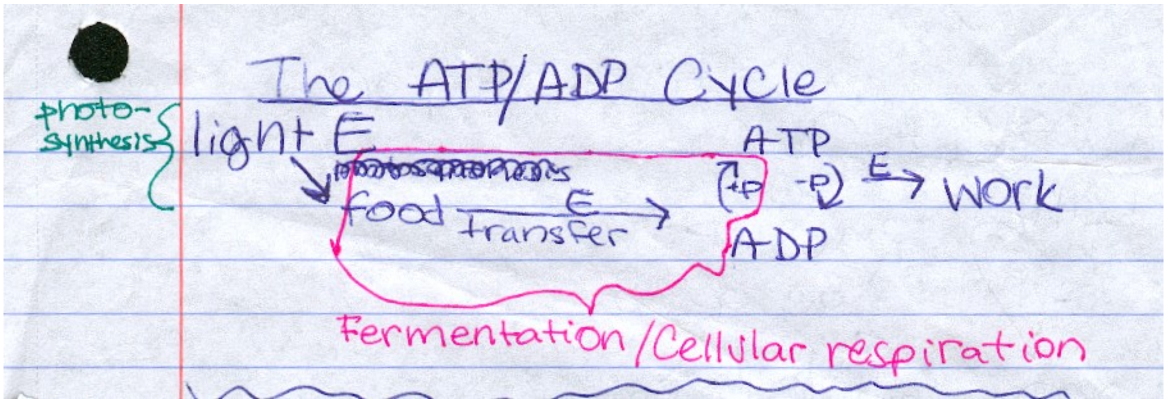
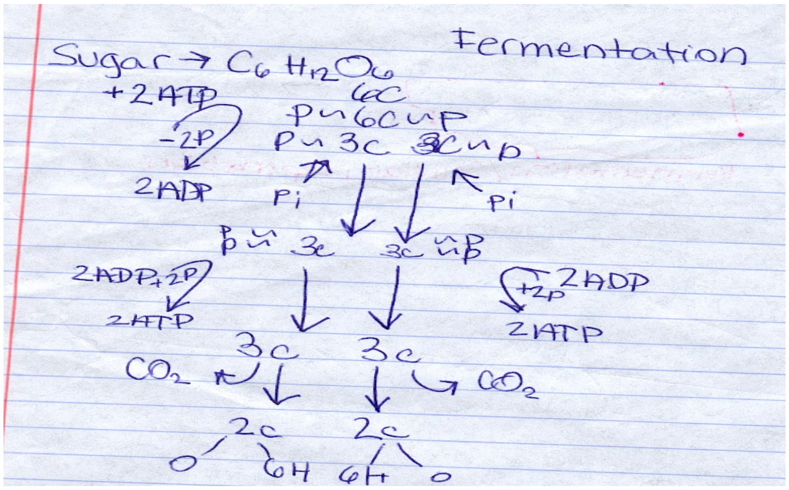
Bio Study Guide- Photosynthesis, Fermentation, Cellular Respiration



Fermentation/Anaerobic Respiration

Why?	To produce ATP
Whom?	All anaerobes (organisms that do not use oxygen) 1. Yeast/fungi 2. Bacteria
Where?	Cytoplasm
When?	Constantly
What?	Food [is being fermented]
Define fermentation.	Fermentation is a process by which food is broken down without oxygen, in living organisms, to produce ATP.
What industries use fermentation?	1. Baking (CO_2) 2. Brewing (Alcohol and CO_2) 3. Dairy (Lactic Acid)
What are the raw materials?	One sugar ($C_6H_{12}O_6$) (and a 2ATP investment).
What is the net gain of fermentation?	2ATP and [$2CO_2$, 2 Ethanol] OR [2 lactic acid]

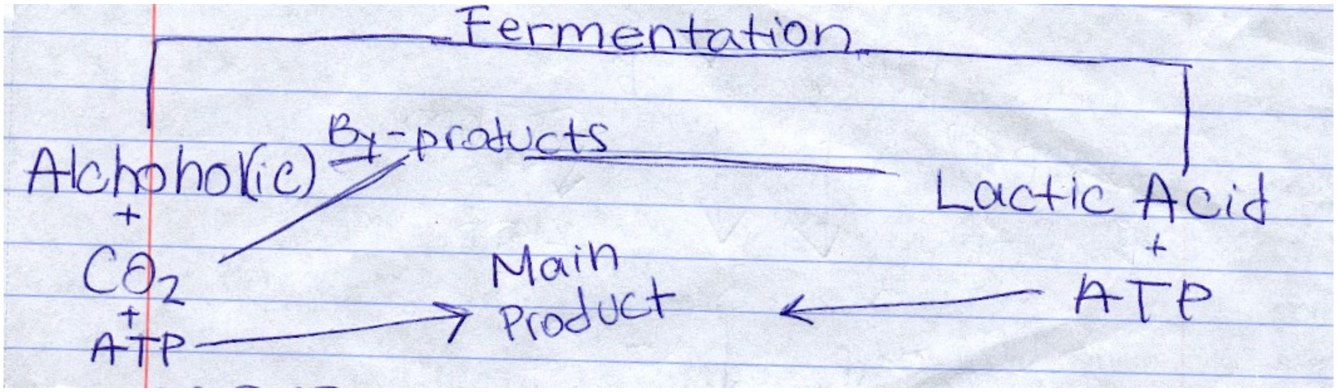


1. Start with a 6-carbon sugar. 2ATP are dephosphorylated in the beginning (like an investment.) The 2P form high-energy bonds with the sugar, and the sugar becomes energized and splits in two.

2. (Taken twice) Another P, this time from a source besides ATP, is added to this 3C compound. Energy is transferred from the compound to a high-energy bond with the second P. 2ADP come in and are phosphorylated.

3. (Taken twice) This 3C compound is pyruvic acid. Enzymes dispose of it quickly because the pH change is harmful to the cell.

A. (Taken twice) CO_2 is extracted. This remanning 2C compound is ethanol, or ethyl alcohol. Its formula is C_2H_6O. It is drawn C_2H_5OH. **This is alcoholic fermentation.**
OR
B. (Taken twice) Lactic acid is extracted. **This is lactic acid fermentation.**

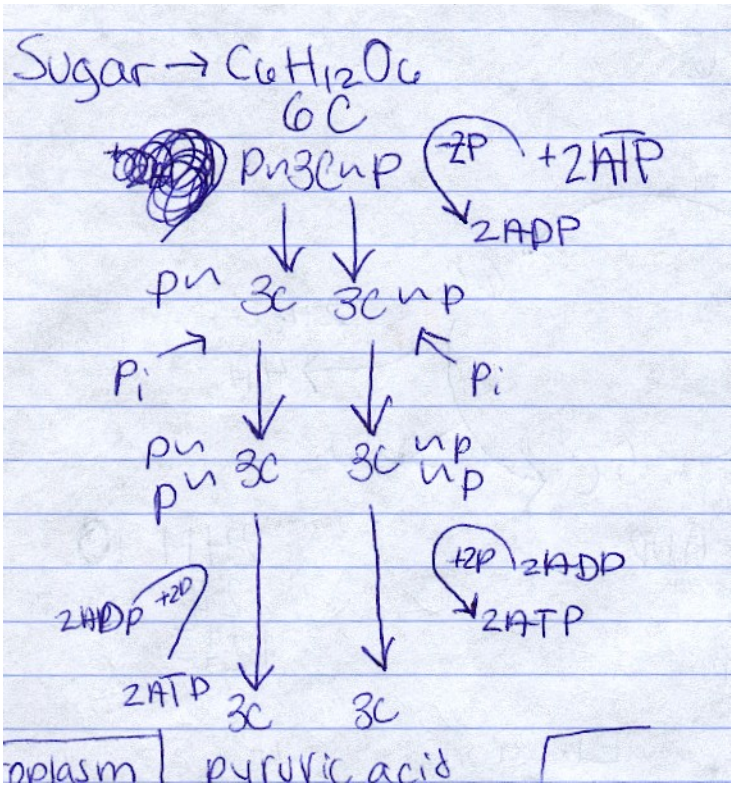


Cellular Respiration/ Aerobic Respiration

Why?	To produce ATP.
Whom?	All aerobes (organisms that require oxygen)
When?	Constantly.
Where?	In the cytoplasm and the mitochondrion.
What?	Food.

Glycolysis

What happens?	Sugar is dismantled.
What are the raw materials for glycolysis?	$C_6H_{12}O_6$ (and a 2ATP investment).
Where does glycolysis take place?	The cytoplasm.
What is the net gain?	2 Pyruvic Acid, 2ATP, 8H
What is a coenzyme?	An enzyme with a vitamin or mineral component.



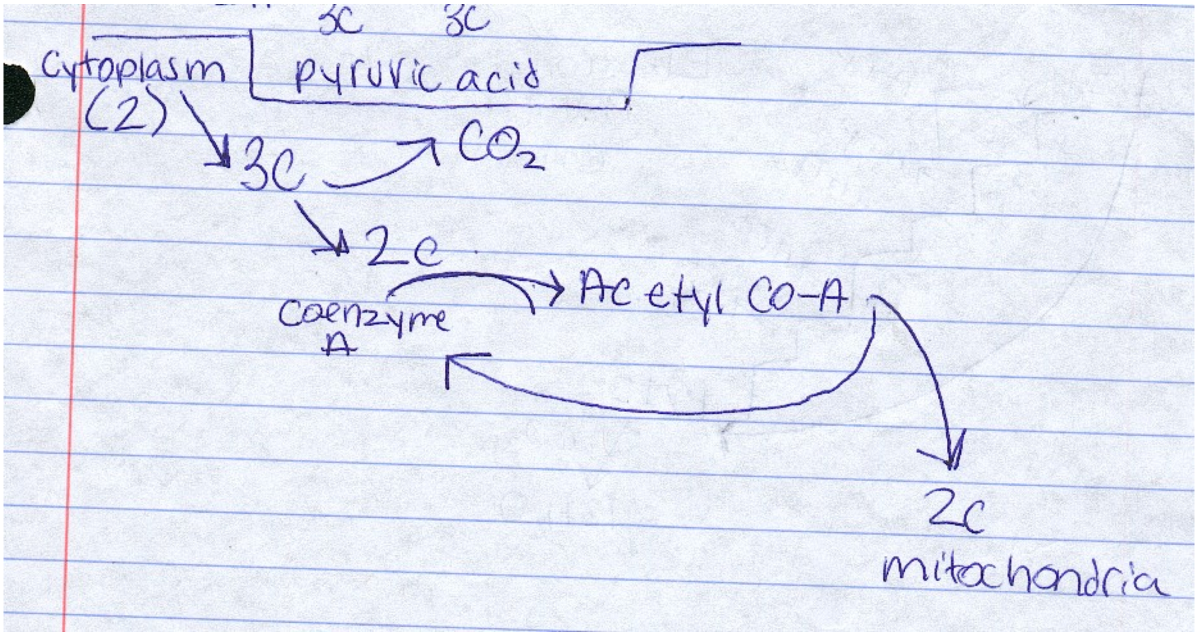
1. Start with a 6-carbon sugar. 2ATP are dephosphorylated in the beginning (like an investment.) The 2P form high-energy bonds with the sugar, and the sugar becomes energized and splits in two.

2. (Taken twice) Another P, this time from a source besides ATP, is added to this 3C compound. Energy is transferred from the compound to a high-energy bond with the second P. 2ADP come in and are

phosphorylated. 4H are released.

3. (Taken twice) The remaining 3C compound is known as pyruvic acid.

Diffusion of pyruvic acid to mitochondria

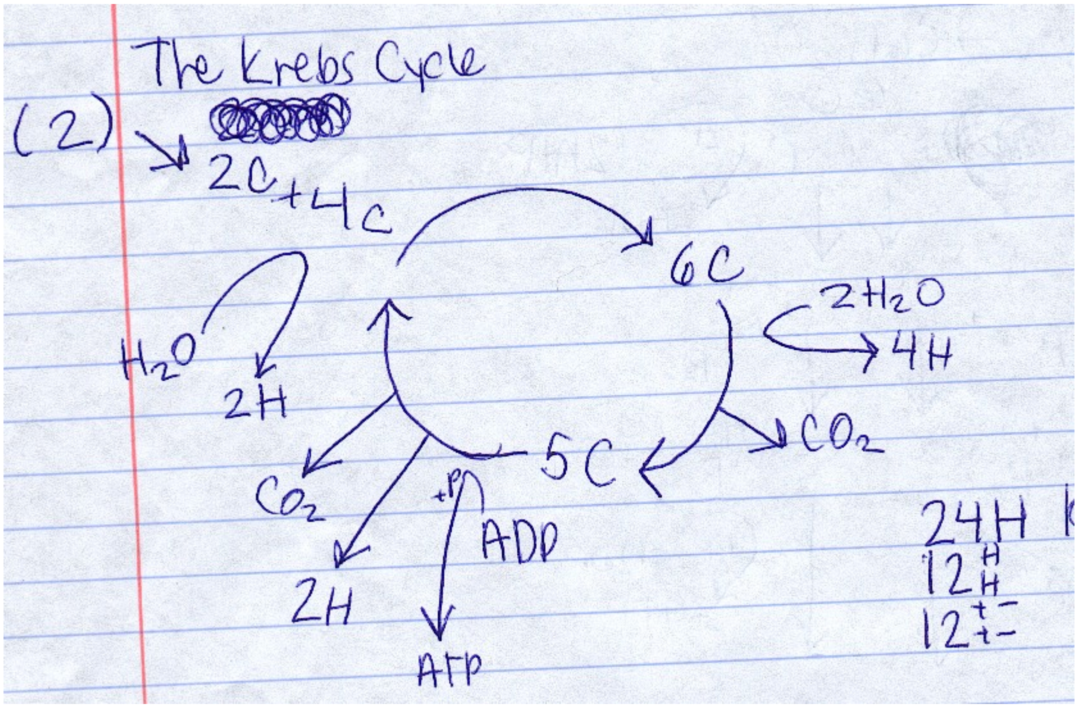


1. (Taken twice) CO_2 is released from pyruvic acid, creating a 2C compound, acetic acid (vinegar).

2. (Taken twice) This bonds with a coenzyme, which is a an enzyme with a vitamin or mineral component. This coenzyme, coenzyme A, is used as a transport molecule. It bonds with the acetic acid to form acetyl co-A. The acetic acid goes to the mitochondria and is released from the coenzyme, which cycles back to pick up more acetic acid. (Shuttle bus metaphor).

The Krebs Cycle

What are the raw materials for the Krebs Cycle?	$6H_2O$, 2 Acetic acid, and 4C.
Where does it take place?	The fluid portion of the mitochondria.
What are the end products?	16H and 2ATP.
What are the by-products?	$2CO_2$



1. (Taken twice) As the 2C acetic acid enters the mitochondria, a 4C compound attaches to it, forming citric acid. H_2O is attached to this, and 4H are removed.

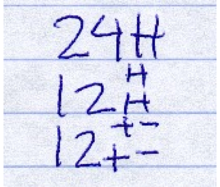
2. (Taken twice) $2H_2O$ are attached, and 4H are removed. CO_2 is extracted, and the molecule becomes a 5C compound.

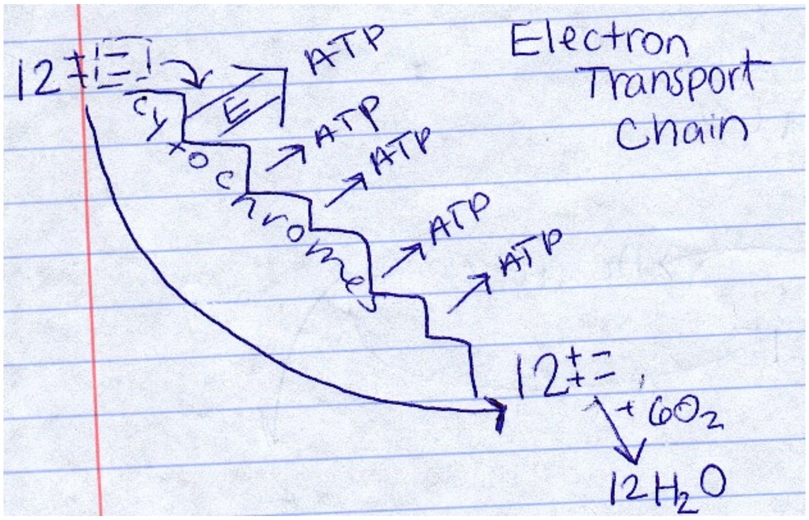
3. (Taken twice) CO_2, 2H, and enough energy to phosphorylate 1 ADP are extracted.

4. The remaining 4C compound cycles back to greet the next acetic acid.

The Electron Transport Chain

What are the raw materials?	24H and $6O_2$.
Where do the H come from?	8 from glycolysis and 16 from the Krebs cycle.
What is the end product?	32 ATP.
What is the by-product?	$12H_2O$.
What is the ETC made up of?	Cytochromes (enzymes).

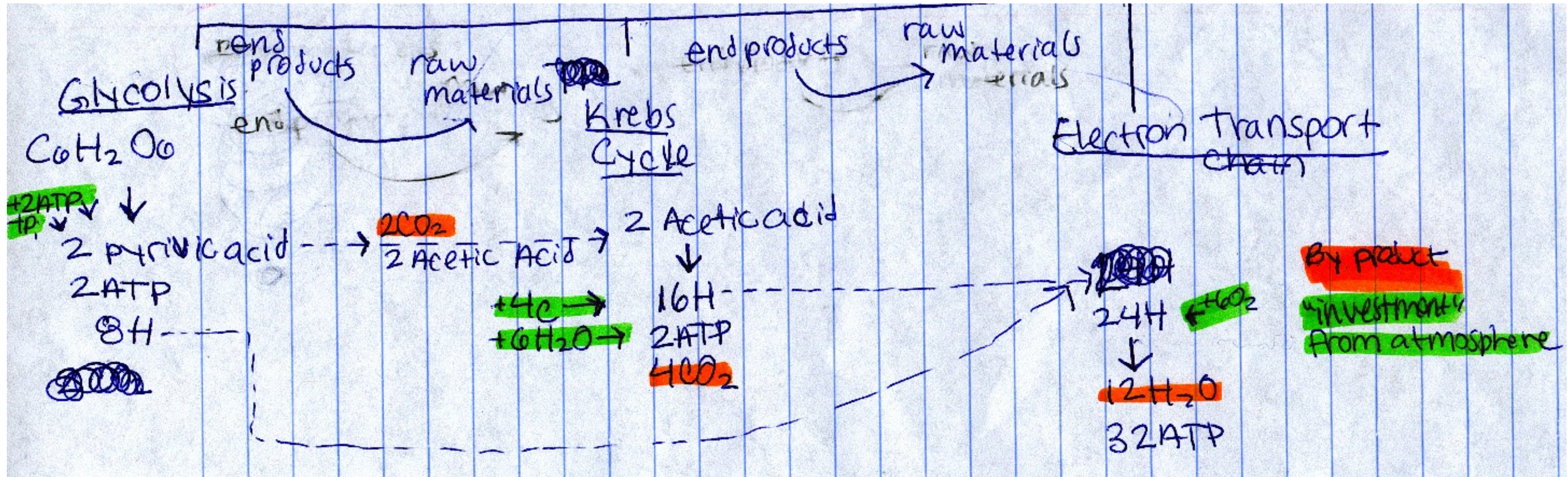




1. The 12 electron pairs are moved down the electron transport chain. At each step, one ADP is phosphorylated.

2. In the end, the 12 proton pairs come to meet the 12 electron pairs. This makes 24H again.

3. $6O_2$ come in and form $12H_2O$ with the 24H.



Net product: 36ATP

By-products: $12H_2O$
$6CO_2$

$C_6H_{12}O_6 + 6O_2 + 6H_2O \rightarrow 36ATP + 12H_2O + 6CO_2$

glycolysis

electron transport chain

Krebs cycle

Photosynthesis

Why?	To convert solar energy into chemical energy.
Whom?	All autotrophs- 1. Chemothrops 2. Phototrophs a. Bacteria b.Protozoa c. Algae d. Green plants
When?	During daylight hours, seasonally
What?	Sugar [is being produced]
Where?	Chloroplasts.
What was an early experiment with a bell jar, and what did it show?	An airtight bell jar over a candle caused the candle to go out. The jar over a mouse caused the mouse to die. When a plant was added to the mouse, the mouse lived relatively longer. The conclusions drawn were that something was taken out and being produced, and that a plant converted bad air into good air. This substance is, of course, oxygen.

<u>What was Blackman's experiment? What did it show?</u>

Blackman graphed the rate of photosynthesis in comparison to the intensity of light. He found the threshold, which was the minimum amount of light needed to cause photosynthesis, as well as the optimal intensity of light, at which the rate of photosynthesis begins to plateau. It does not matter how much more light is available above this point, because plants cannot absorb light any faster than it does at the optimal intensity.

Next, he compared the rates of photosynthesis at high intensity and low intensity lights as temperature rose. When the light intensity was low, the rate of photosynthesis remained the same until about 30 degrees, where it dropped. When the light intensity was high, the rate of photosynthesis increased until about 30 degrees, where it plummeted.

At both intensities of light, the rate of photosynthesis plummeted at 30 degrees because of temperature's relation to the “dark stage” of photosynthesis, which depends on enzymes. 30 degrees is too hot of a temperature for the enzymes, so they are unable to work.

When the intensity of light is high, the light stage of photosynthesis happens constantly and quickly, and raw materials for the dark stage are produced constantly and quickly. And, at a high intensity of light, the rate of photosynthesis increases as temperature increases because, as the lower extreme temperature is left, it is easier for enzymes to work. (This is comparable to a conveyer belt moving just *too* quickly- there is always more to do.)

When the intensity of light is low, regardless of how easy or hard it is for enzymes to work, the light stage happens constantly but slowly, and raw materials for the darks stage of photosynthesis are produced just as slowly. (This is a comparable to a conveyer belt moving constantly, but slowly.)

What did Van Neil do?

Van Niel took the accepted equation for photosynthesis, CO_2+H_2O---CH_2O+O_2. Two things were obvious: the C from CO_2 was the C in CH_2O, and the H in H_2O was the H in CH_2O, because there was only one source for either of them. However, he didn't know where the O in either product came from.

To figure this out logically, he looked at photosynthesis in bacteria. CO_2+H_2S---CH_2O+S_2. Here, everything has one source and product (as is color coded).

According to this logic, photosynthesis in plants worked out as CO_2+H_2O---CH_2O+O_2.

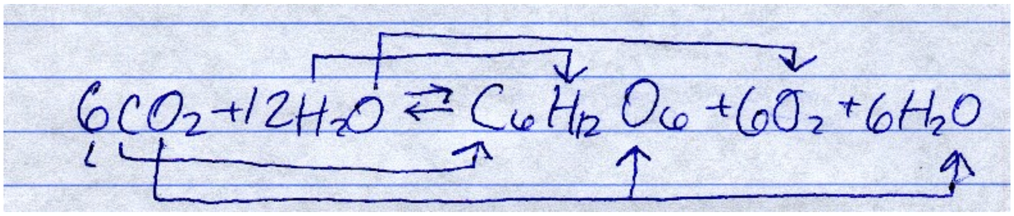
Van Niel was unable to prove his hypothesis, but it was proved three ways.

First of all, he assumes that the water goes through photolysis- is broken down by the sun's energy. If he were incorrect, than the carbon dioxide would be broken down. In that case, carbon would bond with water, forming molecules of CH_2O, and six of these would make up a sugar molecule. However, this compound is formaldehyde, which is harmful to the cell. It would not be created, even for a second. Therefore, it can be assumed that the water goes through photolysis.

When the photosynthesis equation is quantified, the equation looks like this: $6CO_2$+$6H_2O$---$C_6H_{12}O_6$+$6O_2$. However, this equation is not balanced. There are 6 carbons and 12 hydrogens on each side, but there are 12 oxygen molecules in the carbon dioxide and only 6 in the glucose, and there are 6 oxygen molecule in the water and 12 in the oxygen.

The equation was revised, to look like this: $6CO_2$+$12H_2O$---$C_6H_{12}O_6$+$6O_2$. This also proved problematic. There are 6 carbons on each side of the equation and 12 oxygen molecules in both the water and the oxygen gas, but there are 24 hydrogens in the water when there are only 12 in the glucose, and there are 12 oxygens in the carbon dioxide when there are only 6 in the glucose.

The final equation looks like this: $6CO_2$+$12H_2O$---$C_6H_{12}O_6$+$6O_2$+$6H_2O$.



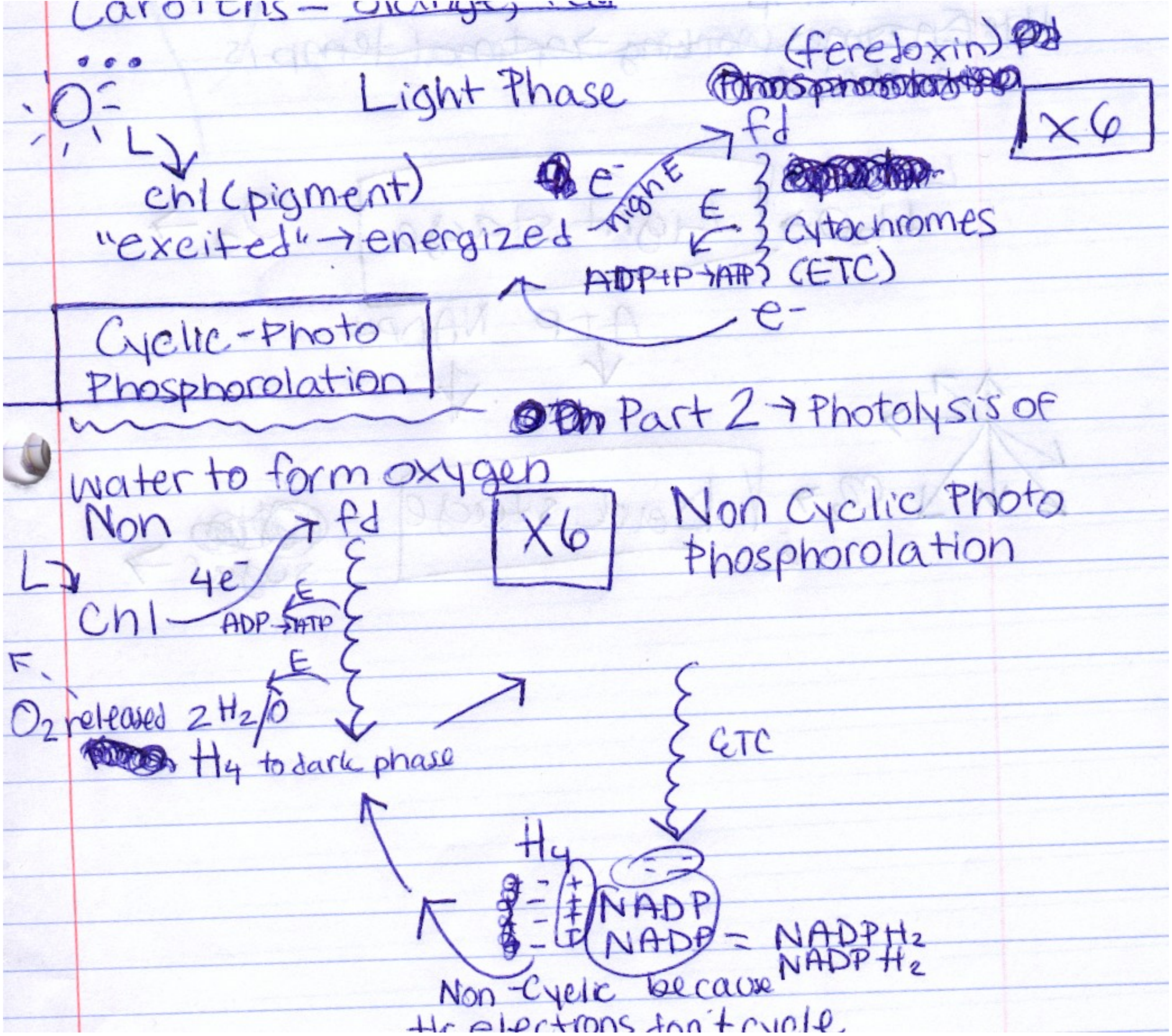
This is a balanced equation. There are 6 carbons in the carbon dioxide and in the glucose. There are 12 oxygen molecules in the carbon dioxide, 6 of which are in the glucose and 6 of which are in the water. There are 24 hydrogens in the water, 12 of which are in the glucose and 12 of which are in the water. There are 12 oxygen molecules in the water, all of which are in the oxygen gas. Van Niel's hypothesis works out.

A last way Van Niel's hypothesis was proven was by using radioactive isotopes (*atoms that are unstable because they have a large number of neutrons. They are traceable because they are unstable and break down at a steady rate over time)* to trace the oxygen in carbon dioxide. When a radioactive isotope of oxygen was used in carbon dioxide, both the sugar and the water had that radioactive isotope of oxygen.

What did Engleman prove?

Engleman shined white light through a prism- which separates the colors in light, ROYGBIV. He looked at oxygen-loving algae above this prism, and saw that the algae went to the ends of the spectrum, away from green, where the most photosynthesis occurred and where the most oxygen was released. Chlorophyll, the pigment that is instrumental in photosynthesis, is green because it absorbs the other wavelengths (colors) of light, which are better for photosynthesis, and reflects the least productive light, green light. Other pigments absorb green light, such as xanthophylls, which absorb everything but yellow light, or carotens, which absorb everything but orange and red light.

The Light Phase

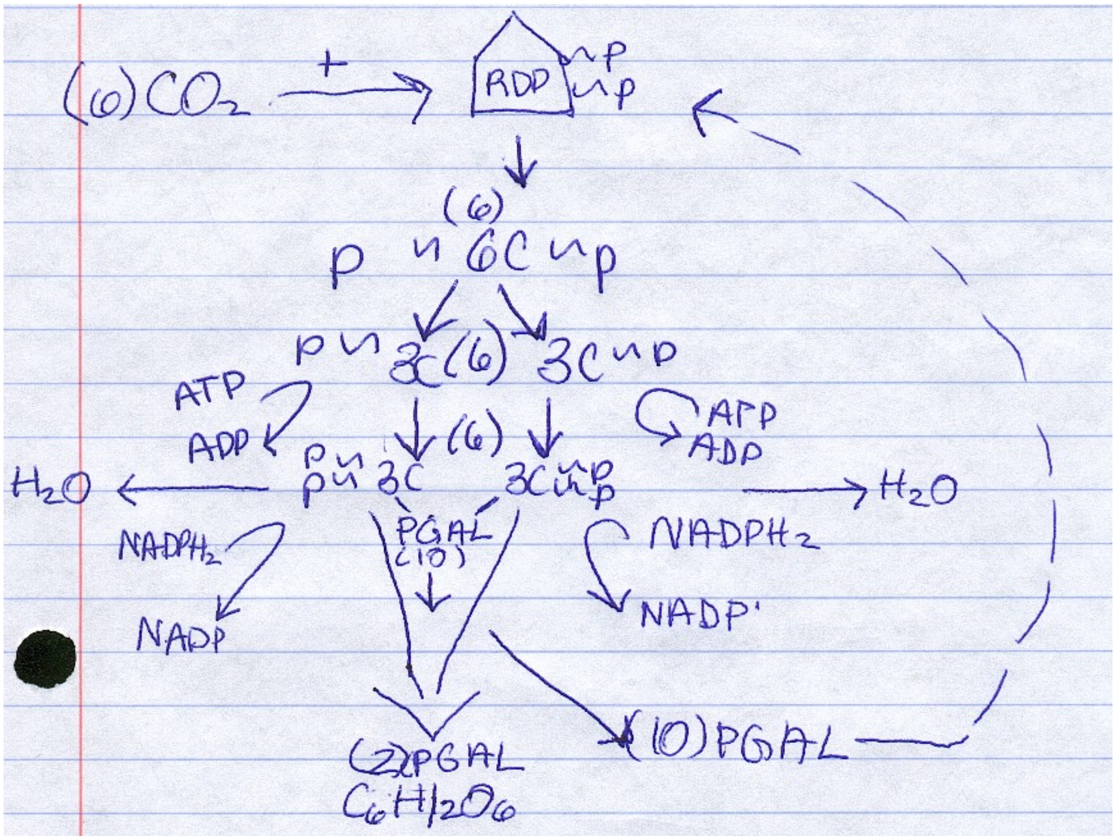


1. The first part of the light phase is cyclic-photo phosphorylation. As sunlight energy is absorbed by

the chlorophyll, the chlorophyl uses it to energize electrons.
2. (Taken six times) A high-energy electron goes to a substance known as feredoxin and then down an electron transport chain. Energy is released and ADP is phosphorolysed.
3. (Taken six times) This electron returns to the chlorophyll to be energized again.

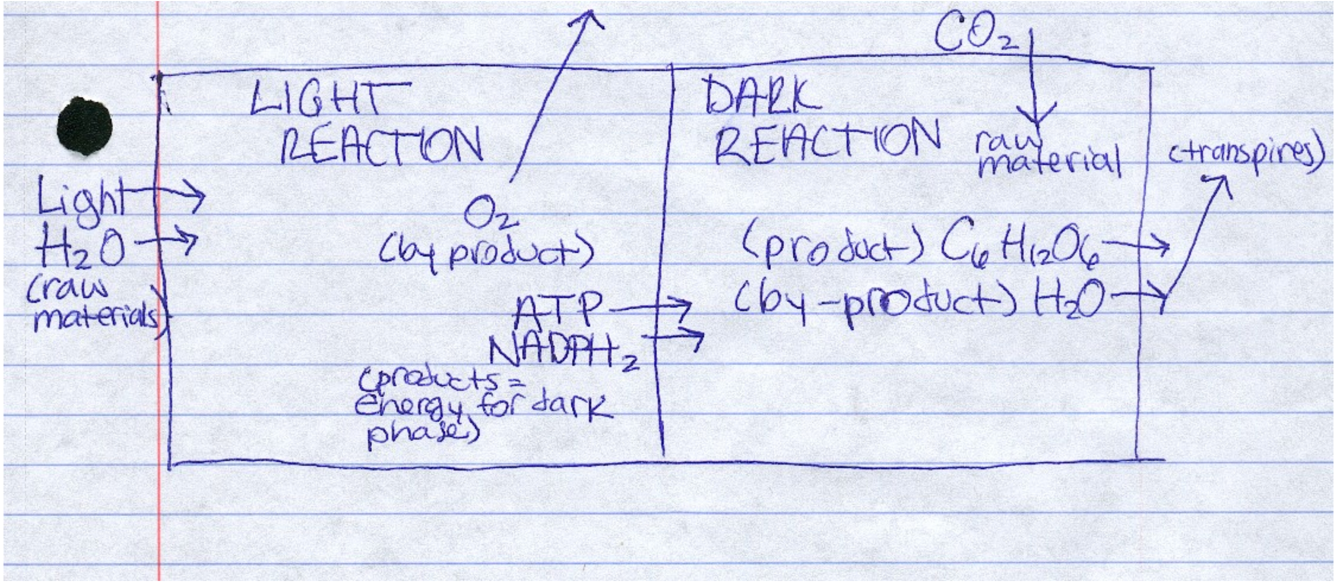
4. (Taken six times) The second part of the light stage is non-cyclic photo phosphorolation; the photolysis of water to form oxygen. Four electrons are energized by the chlorophyll as it captures sunlight energy.
2. (Taken six times) These four high energy electrons go to the feredoxin and down the electron transport chain. ATP is phosphorolysed.
3. (Taken six times) 2 water molecules are also split. Oxygen gas is released.
4. (Taken six times) The 4 hydrogens from the water and the 4 electrons that have been down the electron transport chain are collected by 2NADP, which becomes 2NADPH$_2$. The 4 remaining electrons, from the hydrogens, go to the chlorophyll, to be energized. This part is "non-cyclic" because different electrons are energized each time, rather than the same ones being cycled through.

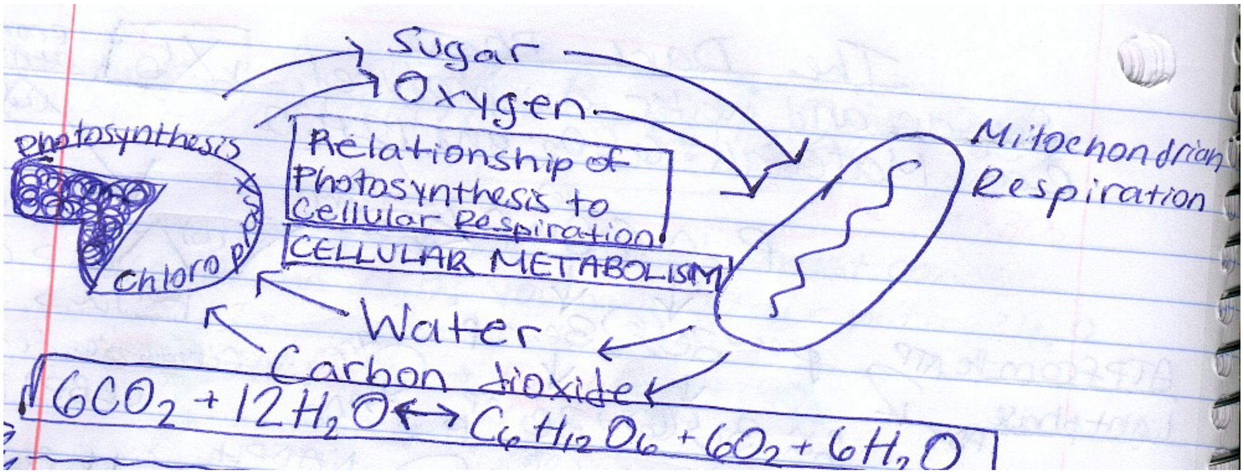
Dark Phase



1. 6 molecules of carbon dioxide enter and are attached to 6 riboses, known as RDP. These riboses are already energized, with two phosphates each.
2. (Taken six times) The 6C, 2P molecules that are formed split into two 3C, 1P molecules.
3. (12 3C molecules) The energies contained within ATP and NADPH$_2$ are added.
4. (12 3C molecules) These highly energized molecules are known as PGAL.
5. 2 PGAL are bonded together to form one molecule of sugar.

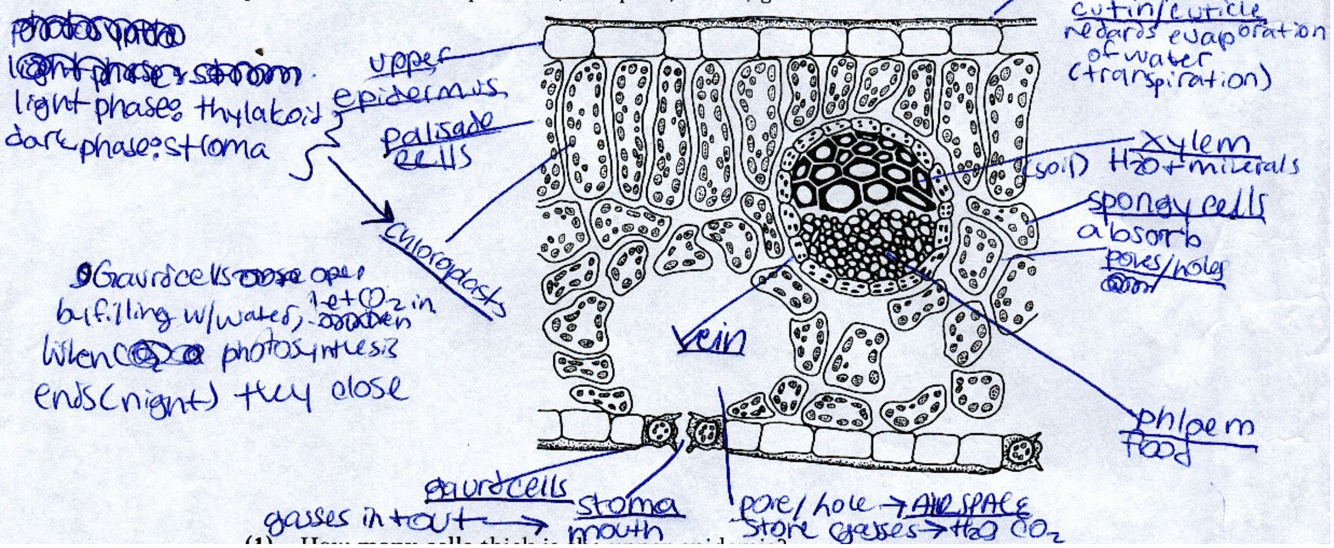
6. The remaining 10 PGAL are rearranged to form the 5 RDP that are in the beginning of the cycle.
7. 12 H_2O is released as a by-product.





$6CO_2 + 12H_2O \leftrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$

phloem cells, lower epidermis, air space, stoma, guard cells.



light phase: thylakoid
dark phase: stroma

Gaurdcells open by filling w/water, let O_2 in
when photosynthesis ends (night) they close