Name:_____

# Unit 5: Cell Energy

***Students will be able to:***

5.1 Understand the process of photosynthesis, which is the conversion of light energy to chemical energy:

- Describe the basic molecules:
  - ATP, Carbon Dioxide, Glucose, Oxygen, Hydrogen Ions
- Describe the structures involved:
  - Chloroplasts (chlorophyll), Thylakoids, Stroma
- Explain how environmental factors affect the rate of photosynthesis:
  - Light intensity, temperature, availability of water
- Compare light dependent and light independent reactions in terms of purpose and products produced

5.2 Understand the process of cellular respiration, which is the conversion of glucose to ATP

- Describe the basic molecules:
  - ATP, Carbon Dioxide, Glucose, Oxygen, Hydrogen Ions, Glucose
- Describe the structures involved: Mitochondria, Cristae, Matrix
- Trace the path of energy conversion from glucose to ATP.
  - Glycolysis: Purpose, start and end products, and number of ATP produced
  - Kreb's/Citric Acid Cycle: Purpose, start and end products, and number of ATP produced
  - Electron Transport Chain: Purpose, start and end products, and number of ATP produced
- Compare aerobic and anaerobic respiration in terms of purpose and products produced

**Keywords:**

- Monosaccharide
- Disaccharide
- Polysaccharide
- ATP
- ADP
- Mitochondria
- Cristae
- Matrix
- Glucose
- Glycolysis
- Krebs/Citric Acid Cycle
- Electron Transport Chain
- Aerobic
- Anaerobic
- Electron Carriers
- Pyruvate
- Fermentation
- Lactic Acid
- Electron
- Hydrogen Ion
- Chloroplast
- Thylakoid
- Grana
- Stroma
- Pigments
- Chlorophyll
- Photosystems
- Calvin Cycle

| Energy in the Cell Unit | |
|---|---|
| Date | Topic |
| 11/8 | Introduction to Photosynthesis Notes and Chloroplast Coloring Worksheet |
| 11/9 | Chromatography of Spinach Lab |
| **11/12** | **NO SCHOOL-Veteran's Day** |
| 11/13 | Light Dependent Reaction Notes and Diagram Worksheet |
| 11/14 | Calvin Cycle Notes and Diagram |
| 11/15 | Photosynthesis Virtual Lab |
| 11/16 | Photosynthesis Virtual Lab, Radiolab Podcast: From Tree to Shining Tree |
| **11/19-11/23** | **NO SCHOOL-Thanksgiving Break** |
| 11/26 | Cellular Respiration and Photosynthesis POGIL |
| 11/27 | Cellular Respiration Overview Notes and Mitochondria Coloring |
| 11/28 | Cellular Respiration: Crash Course and Practice |
| 11/29 | Muscle Fatigue Lab |
| 11/30 | Glycolysis and Fermentation Notes and Practice |
| 12/3 | Fermentation: Sugar and Yeast Lab |
| 12/4 | Kreb Cycle Notes and Diagram |
| 12/5 | Electron Transport Chain Notes |
| 12/6 | Electron Transport Chain Practice |
| 12/7 | Cellular Respiration Summary Diagram |
| 12/10 | Cellular Respiration Lab |
| 12/11 | Chicago 7 Case Study |
| 12/12 | Unit Review/FRQ Practice |
| **12/13** | **Energy in the Cell Unit FRQ** |
| **12/14** | **Energy in the Cell Unit Multiple Choice Test** |

**11/8//18**

Objective: Students will be able to describe the basic molecules of photosynthesis and the structure of the chloroplast.

Warm-Up:

1. What are two things that I want you to know by the end of this unit?

2. When is your unit test?

## 5.1 Photosynthesis Overview

**The Energy Cycle**

- Photosynthesis and Cellular Respiration are cyclical of each other.
- Photosynthesis is the process to create the energy from sunlight.
    - The energy is stored in the chemical bonds of sugars.
- Cellular Respiration is how living organisms use that energy.
    - Plants and animals break the bonds to use the energy.

**Photosynthesis:** _____

_____

- This means that sunlight is the ultimate energy for all life on Earth

Structure of Carbohydrates

- Simple = Monomer
  - _____: simple ring sugars
    - Ex: glucose and fructose
  - Formula: CHO in a 1:2:1 ratio
    - Ex: Glucose- $C_6H_{12}O_6$
  - _____: two monosaccharides combined
    - Ex: sucrose, maltose, and lactose
- Complex = Polymer
  - _____: polymers (long chains of repeating units) of monosaccharides
    - These are _____ molecules (when you create a bond, it stores energy)
      - Ex: starch (plants) and glycogen (animals)
    - Structural: cellulose (found in plants)

Function of Carbohydrates

- Source of _____
- _____materials in organisms

Adenosine Triphosphate: ATP

- ATP is an organic molecule that contains _____ phosphate bonds.
- It consists of one adenine, one sugar ribose, and _____.
- We can _____ a phosphate to _____ energy. The result is Adenosine Diphosphate or ADP.
- We can _____ a phosphate to ADP to _____ energy. The result is ATP!

Overall equation for Photosynthesis:

Reactions in Photosynthesis:

Two sets of reactions work together to capture sunlight and transform it into sugars.

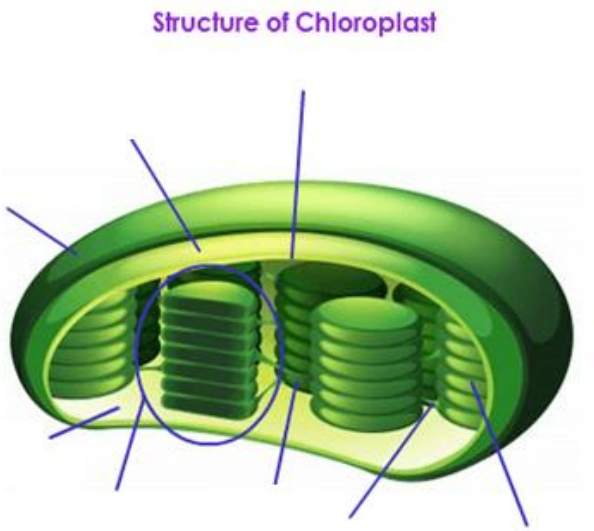
1. _____
   - Require direct involvement of light
   - Use sun's energy to produce ATP
   - Takes place in the thylakoids
   - Water is required as a source of electrons and hydrogen ions (H+)
   - Oxygen is released

2. _____
    - No light is required
    - ATP and NADPH are used to make sugars
    - Takes place in the stroma
    - Carbon dioxide is required

Where Photosynthesis Occurs

**Chloroplast:** _____

- Structure:
    - Contain an inner and outer membrane
    - _____: Saclike photosynthetic membranes
    - _____: Interconnected stacks of thylakoid
    - _____: Fluid outside thylakoid
    - Label the diagram:




Pigments

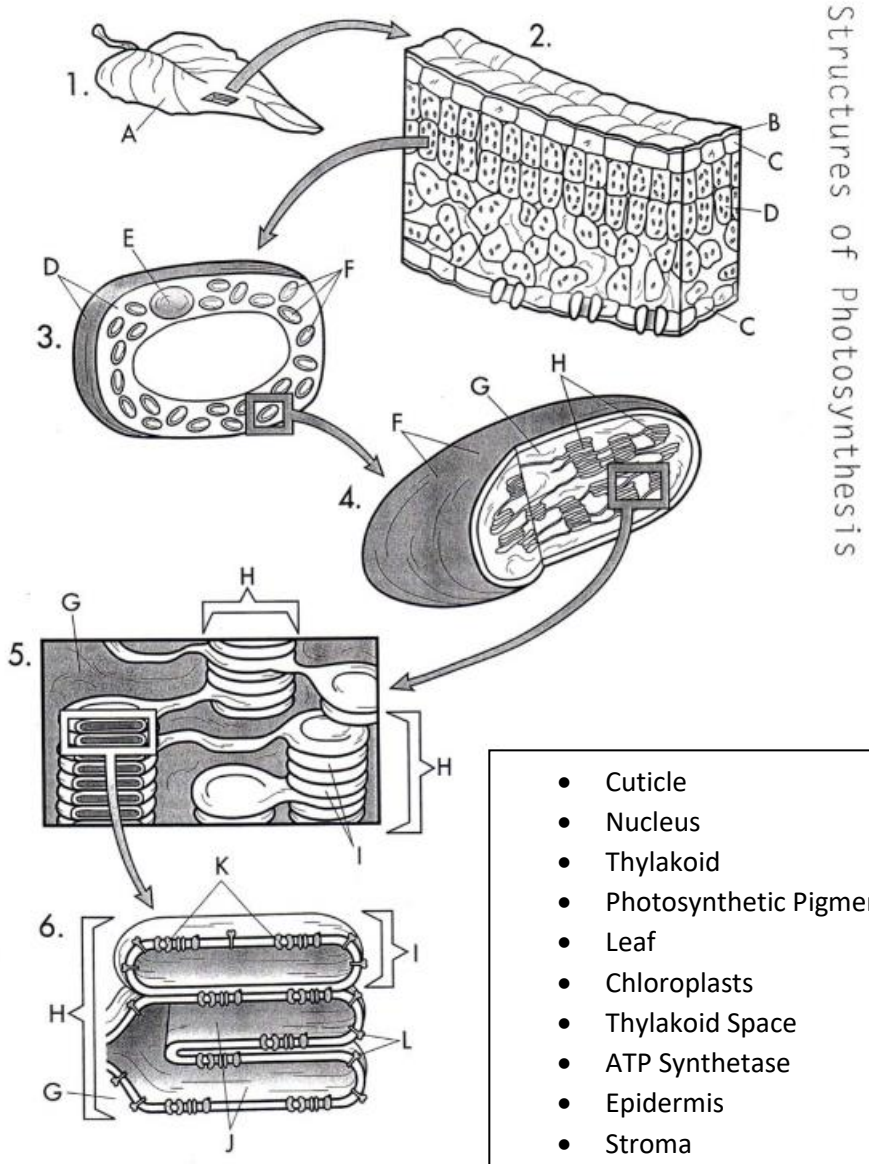
- Chloroplasts contain pigments!
- Pigments are _____
    - Pigments are located in the thylakoid membranes
- Sunlight is _____
  _____
    - Colors include red, orange, yellow, green, blue, indigo, and violet
    - The sun's energy travels to Earth as light
- The pigments in chloroplasts absorb the different wavelength's of light!
- **Chlorophyll:** _____
    - Chlorophyll absorbs visible light especially well
    - Chlorophyll absorbs _____and _____wavelengths of light best
    - Chlorophyll reflects green wavelengths, causing them to appear green
- Plants also contain red and orange pigments such as _____, that absorb light in other regions of the spectrum

- As temperatures drop later in the year, chlorophyll pigments break down first, leaving _____

**11/9/18**

Objective: Students will be able to separate the pigments found in the chloroplast by using paper chromatography.

Warm-Up: In the diagram below, label A-L next to the words in the structures of photosynthesis box below.




- Cuticle
- Nucleus
- Thylakoid
- Photosynthetic Pigments
- Leaf
- Chloroplasts
- Thylakoid Space
- ATP Synthetase
- Epidermis
- Stroma
- Mesophyll Cell
- Granum

**11/12/18-NO SCHOOL-Veteran's Day**

**11/13/18**

Objective: Students will be able to describe the first step (light dependent reactions) in the conversion of light energy to chemical energy in the process of photosynthesis.

Warm-Up:

1. What pigments did you see in your lab yesterday?

2. What do you think is the purpose of having many different pigments in plants?

3. If the bark of the tree is brown, we can assume that the cells in the bark contain very few of these organelles?

## 5.2 Light-Dependent Reactions

Light Dependent Reactions

- Two sets of chemical reactions that occur in the _____
- Light-dependent reactions use energy from sunlight to
    - Convert ADP into _____
    - Convert NADP+ into the high energy carrier _____
    - Produce _____ as waste

**Photosystems:** _____

_____

(Similar in structure to the cell membrane!)

- Absorb sunlight and generate high-energy electrons that are passed to a series of proteins embedded in the thylakoid membrane

Chemical Reaction #1: ***Photosystem II***

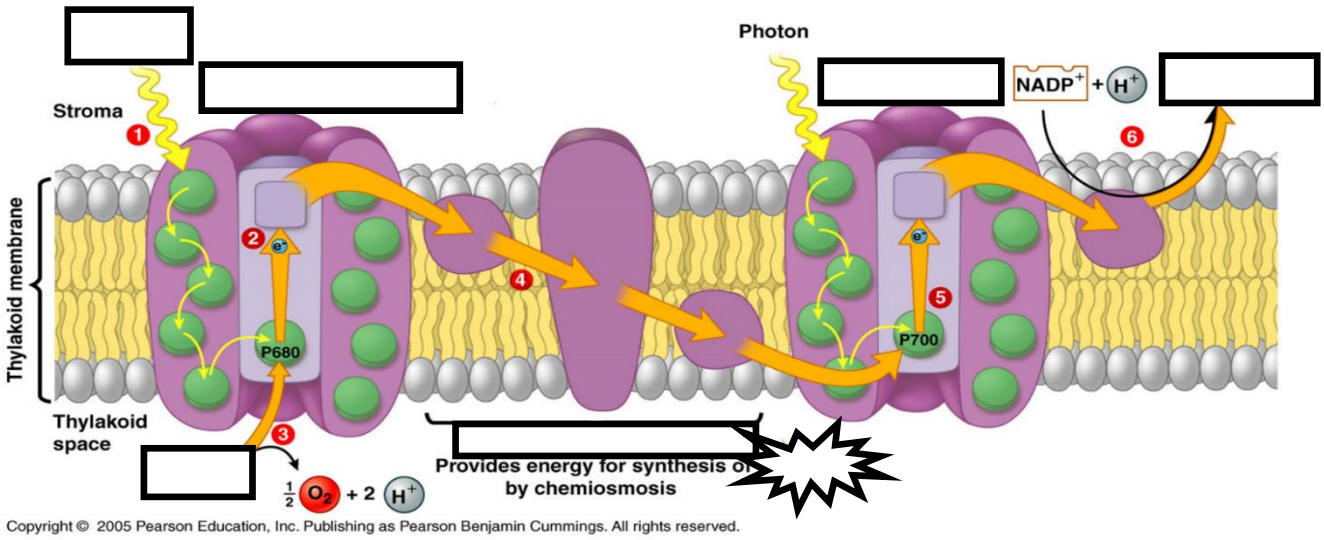
- Light energy is _____
- High energy _____ are produced and passed to the _____ _____
- Water molecules are _____ to replace those electrons
- H+ ions and _____ are released
- ATP is synthesized
- ***Electron transport chain***
    - A series of proteins that _____
    - Electrons _____ the chain to photosystem I

- Energy from electrons is used to pump H+ ions across the _____ and into the _____
- ATP Synthesis:
  - H+ then _____ back into the cell across the enzyme ATP synthase.
  - This causes ATP synthase to rotate, creating _____.
  - ATP synthase captures the energy and uses it to _____ between ADP and an additional phosphate.
  - This creates _____!

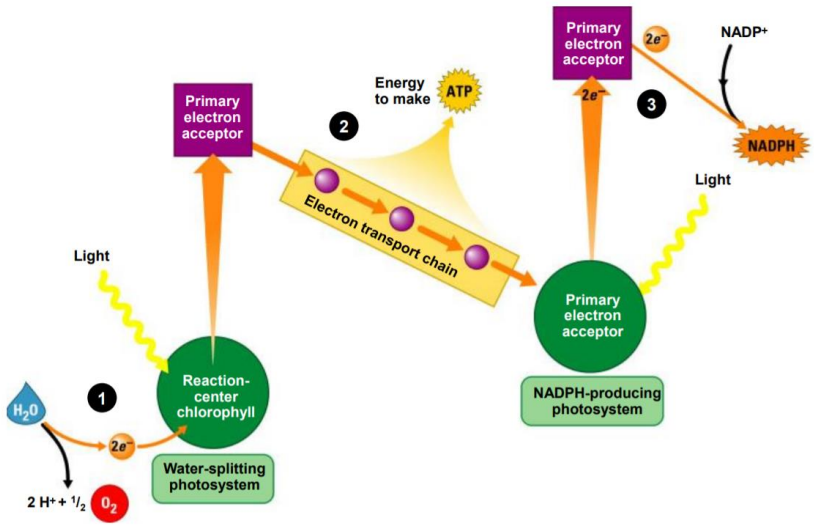
Chemical Reaction #2: ***Photosystem I***

- Electrons are _____ in photosystem I
- A _____ electron transport chain transfers these electrons to produce _____

Label the diagram below:







**11/14/18**

Objective: Students will be able to describe the second step (light independent reactions) in the conversion of light energy to chemical energy in the process of photosynthesis.

Warm-Up:

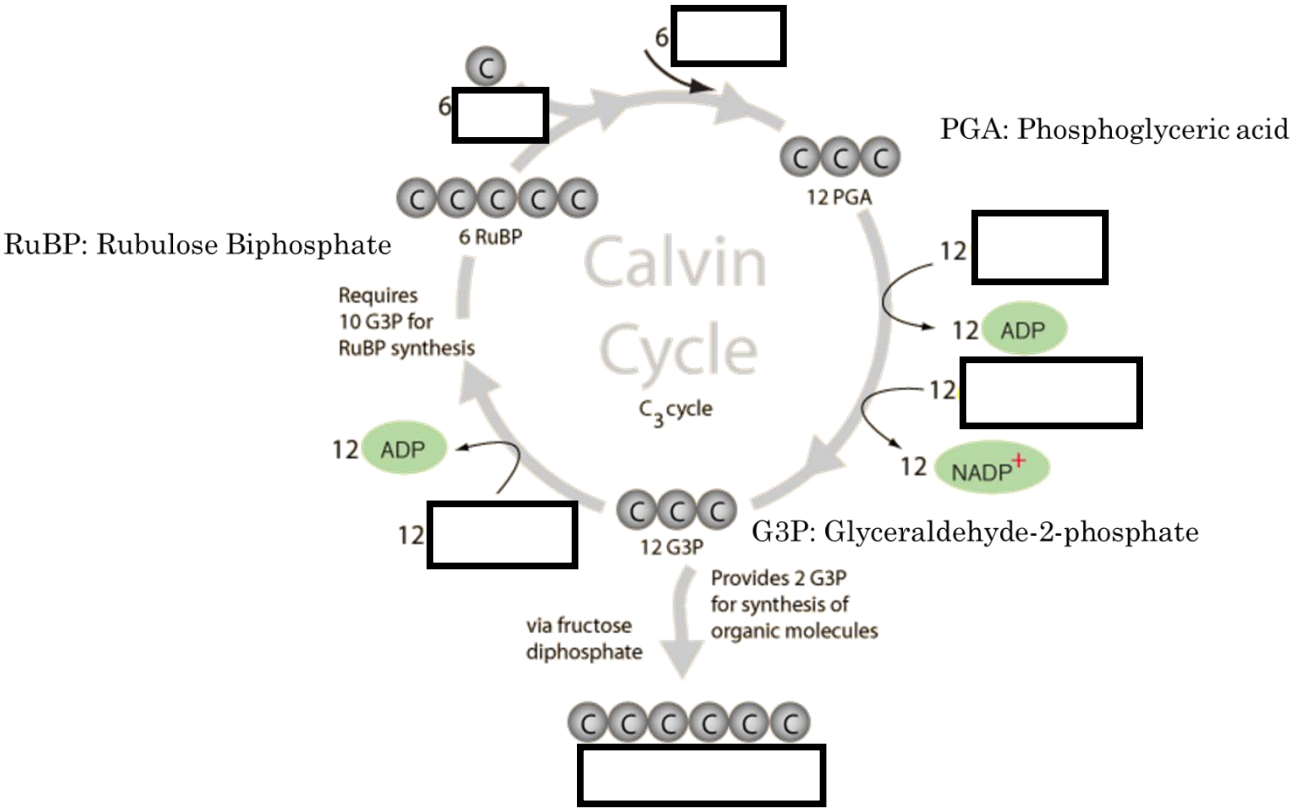
1. What is the purpose of water in the light dependent reactions?

2. Which comes first: photosystem I or photosystem II?

## 5.3 Light-Independent Reactions

During light-independent reactions, ATP and NADPH from light-dependent reactions are used to produce high-energy sugars

- Also known as the _____
- Summary:
    - No light is required
    - ATP and NADPH are used to make sugars
    - Take place in the stroma
    - Carbon dioxide is required
- ***Carbon Dioxide enters the cycle***
    - Six $CO_2$ molecules from the _____combine with six 5-carbon molecules
    - Produces twelve 3-carbon compounds
- ***Sugar Production***
    - Energy from _____ are used to convert the 3-carbon molecules
    - Two of the twelve _____ are removed from the cycle to produce sugars, lipids, amino acids, etc.
    - Remaining ten 3-carbon molecules are _____ into 5-carbon forms that _____
    - Label the diagram below:




Factors Affecting Photosynthesis

Many factors influence the rate of photosynthesis. The most important are:

- Temperature
  - Enzymes function best at _____
  - An increase or decrease in temperature will _____
- Light Intensity
  - High light intensity _____ of photosynthesis
  - At a certain level, the rate _____
- Availability of Water
  - Water shortage can _____
  - Water loss can _____ plant tissues
  - Plants living in dry conditions often have _____

**11/15/18**

Objective: Students will be able to describe the process of photosynthesis, which is the conversion of light energy to chemical energy and discover how environmental factors (like the amount of sunlight) affect the rate of photosynthesis.

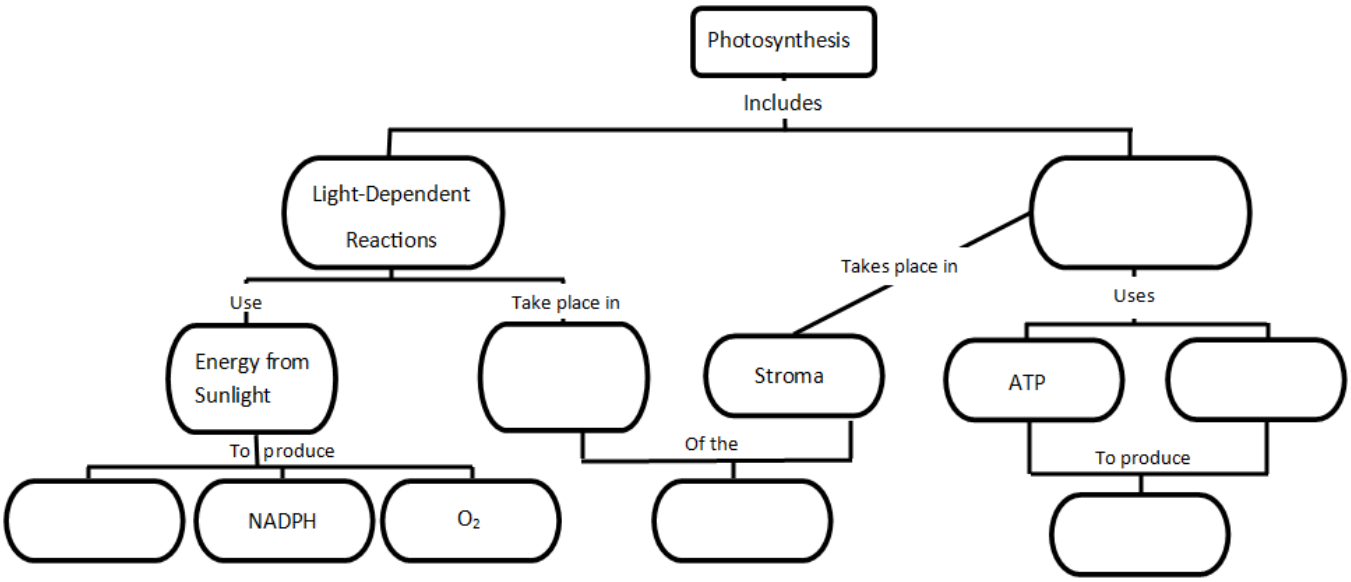
Warm-Up:

1. Photosynthesis Review Kahoot

**11/16/18**

Objective: Students will be able to describe the process of photosynthesis, which is the conversion of light energy to chemical energy and discover how environmental factors (like the amount of sunlight) affect the rate of photosynthesis.

Warm-Up: Use the word bank to complete the following flow chart.




**Word Bank**: ATP, Thylakoid Membrane, NADPH, Chloroplasts, High-energy Sugars, Light-Independent Reactions

**11/19/18-11/23/18-NO SCHOOL-Thanksgiving Break**

**11/26/18**

Objective: Students will be able to describe how photosynthesis and cellular respiration are related.

Warm-Up: Fill in the following table about photosynthesis.

| **Overall Equation:** | | | |
|---|---|---|---|
| Reaction | Where does it occur? | What goes in? | What comes out? |
| Light-Dependent Reactions | | | |
| Calvin Cycle | | | |

**11/27/18**

Objective: Students will be able to describe the structure of ATP and the Mitochondria and the role each plays in the creation of energy in the cell.

Warm-Up:

1. How are cellular respiration and photosynthesis related?

2. What is the form of energy needed in photosynthesis? What is the form of energy produced in cellular respiration?

## 5.4 Cellular Respiration Overview

**Cellular Respiration:** _____

_____

- Overall equation for Cellular Respiration:

- The same products as a "combustion reaction"
- The cell must slowly release energy/heat in a controlled series of reactions, or most energy would be lost in the forms of heat and light.

ATP: The Energy Currency of the Cell

**ATP:** _____

- Energy used by all cells
- Organic molecule containing _____ phosphate bonds.

How do we get energy from ATP?

- Cells get energy by breaking the _____ bonds to remove a phosphate.
  - The enzyme _____ speeds up the reaction
- The products of the reaction are _____and A**D**P,

  _____

How is ATP Re-made?

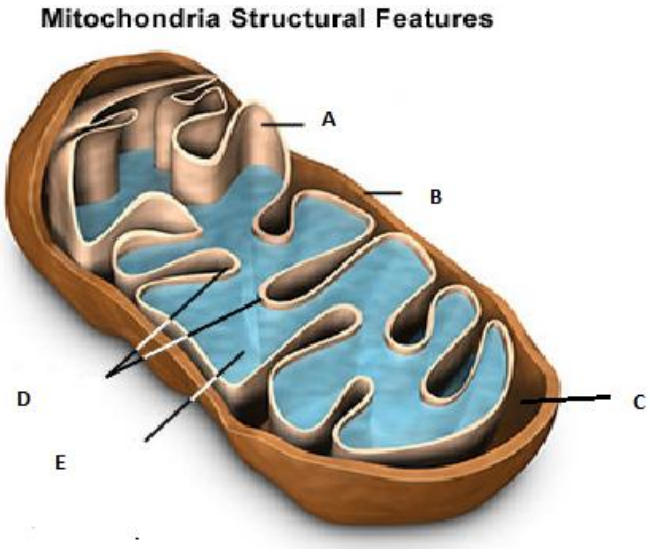
- The reverse reaction occurs and another _____
  - Phosphorylated: _____
  - The enzyme _____ speeds up the reaction
- ATP is made during the process of _____

Where is ATP made in the cell?

- ATP is made in the _____and the _____

Structure of the Mitochondria

- **Outer membrane**: _____
  _____
- **Inner membrane:** Highly folded membrane within the mitochondria
- **Intermembrane Space:** _____
  _____
- **Cristae:** Folds of the inner membrane
- **Matrix:** _____




3 Stages of Cellular Respiration

1. _____
2. _____
3. _____

Some stages are:

- **Aerobic:**_____
- **Anaerobic:**_____

Electron Carriers:_____
_____
_____

- Also known as intermediate energy carriers
- Electrons they hold are used to generate ATP
- Electron carrier molecules include:
  - NADP+ → NADPH
  - NAD+ → NADH
  - FAD → $FADH_2$

**11/28/18**

Objective: Students will be able to describe the structure of ATP and the Mitochondria and the role each plays in the creation of energy in the cell.

Warm-Up:

1. Why is the mitochondria called the "power house" of the cell?

2. Scientists believe that mitochondria were originally an independent cell that another cell ingested. Because the mitochondria were beneficial to the cell, over time, they became an organelle in all living cells today. What structures of the mitochondria might lead scientists to believe that they were once an individual cell?

**11/29/18**

Objective: Students will exercise their muscles to discover how the cells use energy over time and what happens when a muscle becomes fatigued.

Warm-Up: Match the word on the left with the definition on the right.

1. Chloroplast
2. Thylakoid
3. Grana
4. Stroma
5. Pigments
6. Chlorophyll
7. Photosystems
8. Calvin Cycle

A. Interconnected stacks of thylakoids
B. Light absorbing molecules that gather the sun's energy
C. Organelle where photosynthesis occurs
D. Fluid outside the thylakoid
E. Clusters of proteins surrounded by accessory pigments in the membrane of the thylakoid
F. Saclike photosynthetic membranes
G. A plant's principle pigment
H. The process where ATP and NADPH are converted to high-energy sugars

**11/30/18**

Objective: Students will be able to describe the first steps (glycolysis and fermentation) in the path of energy conversion from glucose to ATP.

Warm-Up:

1. What happened to your muscles as they got fatigued?

2. Why do you think this occurred?

## 5.5 Glycolysis and Fermentation

**Glycolysis:** _____

_____

_____

- Literally means: _____
- As sugar bonds are broken, energy is released.

Summary:

- Takes place in the _____
- Anaerobic
- Requires 2 ATP to begin process
- _____ a ***glucose*** (6 carbon molecule) and _____ ***2 pyruvate/pyruvic acid*** (3 carbon molecule), ***2 NADH***, and ***4 ATP***
- There is a NET GAIN of _____
- Draw the process:

If no oxygen is present, ***Fermentation*** occurs.

**Fermentation:** _____

_____

- There are 2 type of fermentation: Alcoholic Fermentation and Lactic Acid Fermentation.

1) Alcoholic Fermentation equation after glycolysis:

- _____use alcoholic fermentation
- Used to produce alcoholic beverages, $CO_2$ bubbles create carbonation
- Causes bread to dough to rise, $CO_2$ bubbles form spaces in bread
- NAD+ allows glycolysis to continue generating ATP

2) Lactic Acid Fermentation equation after glycolysis:

- Most organisms carry out this type of fermentation
- Used in the production of cheese, yogurt, buttermilk, pickles, etc.
- Regenerates NAD+ so glycolysis can continue

**12/3/18**

Objective: Students will be able to describe the first steps (glycolysis and fermentation) in the path of energy conversion from glucose to ATP.

Warm-Up:

1. What is the difference between aerobic and anaerobic cellular respiration?

2. What is the first step in cellular respiration? Does Oxygen have to be present in the cell for this process to occur?

**12/4/18**

Objective: Students will be able to describe the second step (Krebs/Citric Acid Cycle) in the path of energy conversion from glucose to ATP.

Warm-Up: Match the vocabulary term on the left with the definition on the right.

| Word | Definition |
|---|---|
| 1. Electron Carriers | A. Process that produces ATP without oxygen. |
| 2. Pyruvate | B. An atom of Hydrogen that has lost an electron. |
| 3. Fermentation | C. The molecule produced in glycolysis. |
| 4. Lactic Acid | D. The negatively charged particle that orbits the nucleus of an atom. |
| 5. Electron | E. The product that is produced when no oxygen is present; makes muscles sore. |
| 6. Hydrogen Ion | F. A compound that can accept a pair of high energy electrons and transfer them and the energy to another molecule. |

## 5.6 Krebs/Citric Acid Cycle

In the presence of oxygen, pyruvic acid produced in glycolysis passes to the second stage of the cellular respiration.

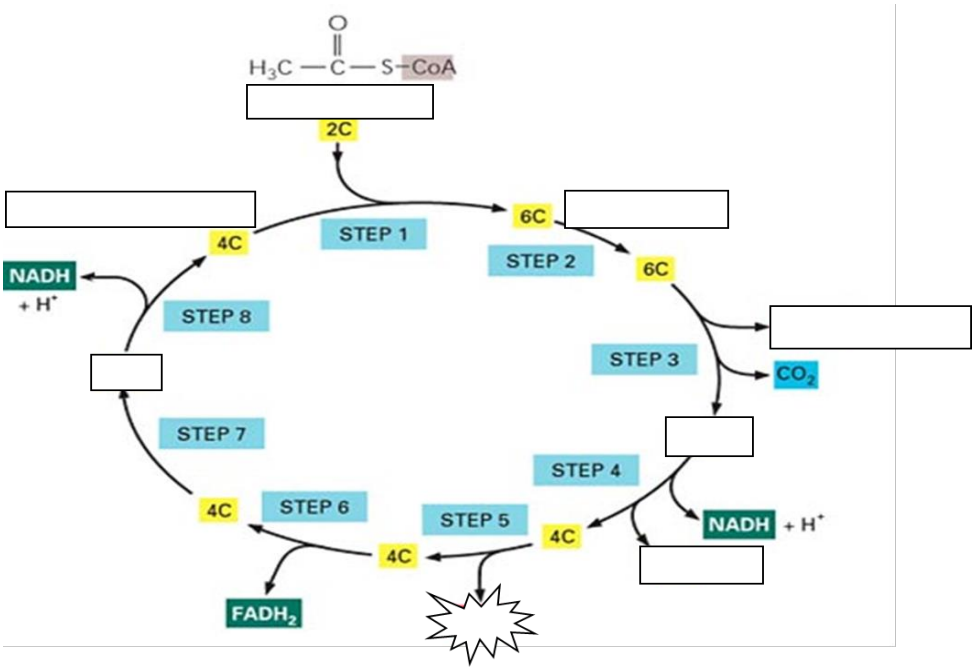
**Krebs/Citric Acid Cycle**:_____

_____

- Because citric acid is the first compound formed in this series of reactions, it is also known as the ***citric acid cycle.***

Summary:

- Takes place in the _____
- Aerobic
- _____ a ***pyruvic acid*** glycolysis
    - 1 carbon from _____ becomes part of carbon dioxide and is eventually released into the air
    - The other 2 carbons form acetic acid, which bonds to coenzyme A to product _____.
    - Acetyl CoA reacts to form _____ (6 carbon molecule)
- As the cycle continues, _____ (to a 4 carbon molecule)
    - Carbon dioxide and energy are released.
    - The molecule needed to start the reactions of the cycle is _____ _____
- Each starting molecule of glucose results in _____ of the Krebs Cycle
    - Glycolysis produces 2 molecules of pyruvic acid from 1 molecule of glucose, allow the cycle to run twice.
- One turn through the cycle produces:
    - ___ NADH
    - ___$FADH_2$
    - ___ ATP
    - ___$CO_2$
- Two turns through the cycle produces:
    - ___ NADH
    - ___$FADH_2$
    - ___ATP
    - ___ $CO_2$
- Label the diagram below:




**12/5/18**

Objective: Students will be able to describe the last step (electron transport chain) in the path of energy conversion from glucose to ATP.

Warm-Up:

1. Is the Krebs/Citric Acid Cycle aerobic or anaerobic?

2. Why does the Krebs Cycle/Citric Acid Cycle repeat twice?

## 5.7 Electron Transport Chain

Products from both the Krebs cycle and glycolysis feed into the last step of cellular respiration

**Electron Transport Chain**:_____

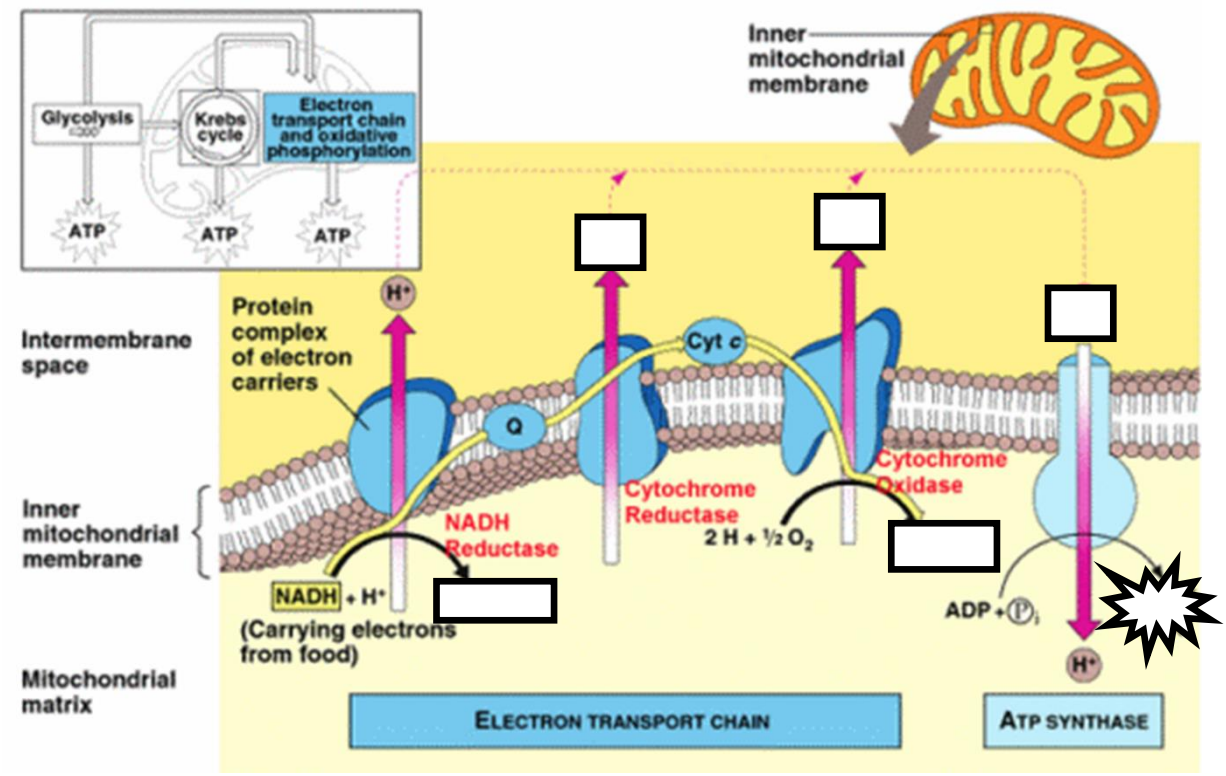
_____

- Electron carriers NADH and $FADH_2$ from glycolysis and the Krebs cycle pass their electrons to the electron transport chain.

Summary:

- Takes place in the _____
- Aerobic
- Uses _____and the enzyme _____ to make ATP

- Electrons/ Hydrogen ions from the _____are passed down the protein chain releasing energy.
- **Oxidative phosphorylation:** Energy generated by the electron transport change is used to move _____ across _____ and into the _____
- Hydrogen passes back across the membrane and ATP synthase _____ ATP from ADP
- Label the diagram below:




- Products:
  - Each NADH converts to _____
  - Each $FADH_2$ converts to _____
  - _____

Total ATP produced in Cellular Respiration per glucose molecule:

Glycolysis:

Krebs Cycle:

10 NADH:

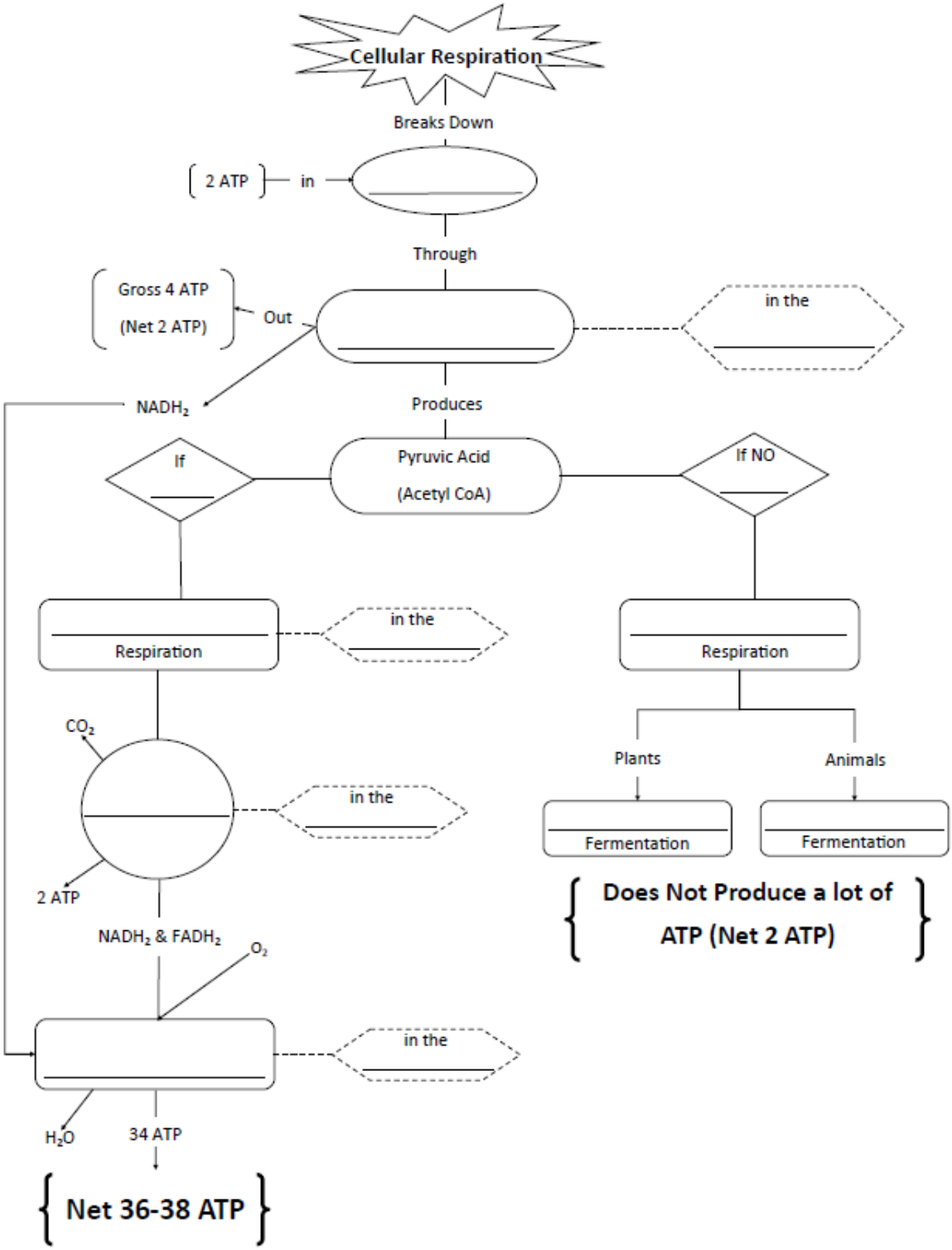
2 $FADH_2$:

_____

**12/6/18**

Objective: Students will be able to trace the path of energy conversion from glucose to ATP.

Warm-Up: Complete the following flow chart.



**12/7/18**

Objective: Students will be able to trace the path of energy conversion from glucose to ATP.

Warm-Up: Complete the flow chart on the following page.

**12/10/18**

Objective: Students will be able to see the process of cellular respiration in living organisms by using an indicator.

Warm-Up:

1. Compare and contrast aerobic and anaerobic cellular respiration in terms of purpose and products produced.

**Vocabulary Tic-Tac-Toe**

| | | |
|---|---|---|
| Define monosaccharide. | Draw a picture of Mitochondria. | Act Out Glycolysis. |
| Use Cristae in a Sentence. | Pair Glucose with another Vocabulary Word and explain why they go together. | Explain how you are going to remember the definition for ATP. |
| Draw a picture of Matrix. | Explain the Krebs/Citric Acid Cycle to your partner. | Define Electron Transport Chain. |

**12/11/18**

Objective: Students will be able to apply the concepts of cellular respiration to a real life example and be able to describe why cyanide is poisonous to humans.

Warm-Up:

1. How is the electron transport chain across the mitochondria membrane similar to solute pumping across the cell membrane?

2. What are the waste products in cellular respiration?

## Cellular Respiration

Glucose Enters the Cell

_____ (process) occurs in the _____ (organelle). Glucose is broken apart: _____ net ATP created, _____ Pyruvates, and $NADH^+$.

If **OXYGEN** is present:

Called: _____

2 Pyruvates enter the _____ (organelle)

_____ (process)

Pyruvates broken down and forms _____ ATP and _____.

_____ (process)

Where electrons bounce from one protein to another forming _____ ATP and _____.

If **NO OXYGEN** is present

Called: _____.

2 Pyruvates remain in the _____ (organelle) and go through:

_____ (process)

Pyruvates broken down, forming alcohol (in _____ cells)

***OR***

_____ (process)

Pyruvates broken down, forming Lactic (in _____ cells)

Overall Chemical Formula for Cellular Respiration:

_____ + _____ → _____ + _____ + _____

Reactants Products

## Photosynthesis

1. Light captured by _____ (organelle)
2. Energy Stored at ATP and NADPH
3. _____ (molecule) is made

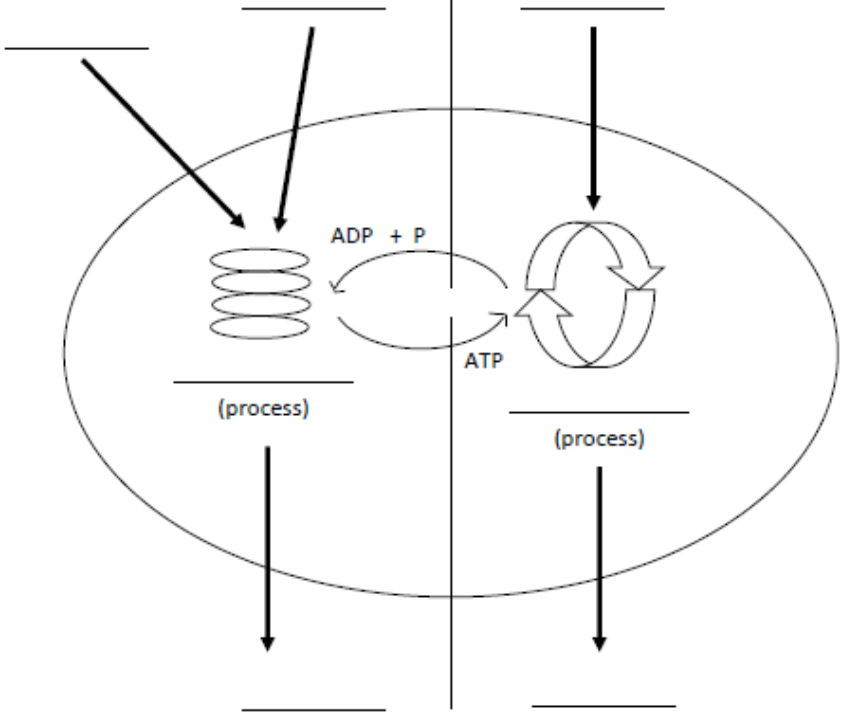
Takes place in two reactions

<u>Light Dependent</u>

Occurs in the _____ (organelle)

<u>Light Independent</u>

Occurs in the _____ (organelle)




Overall Chemical Formula for Cellular Respiration:

_____ + _____ + _____ → _____ + _____

Reactants Products

**12/12/18**

Objective: Students will be able to demonstrate their knowledge of photosynthesis and cellular respiration on a unit review.

Warm-Up:

1. Go back to the front page of this packet and read through the essential outcomes. Put a question mark next to the topics that you still have questions about. Put a check mark next to the topics that you feel confident about.
2. How are you going to go about learning those topics that have a question mark next to them?

**12/13/18**

Objective: Students will be able to demonstrate their knowledge of photosynthesis and cellular respiration on a unit test.

Warm-Up: None

**12/14/18**

Objective: Students will be able to demonstrate their knowledge of photosynthesis and cellular respiration on a unit exam.

Warm-Up:

1. Turn in your work and study guide to the basket.