Understanding How Living Things Obtain and Use Energy.

**Cell Energy: The Big Picture**
- Most **Autotrophs** produce food (sugar) using light energy during **Photosynthesis**
- Then, both Autotrophs and Heterotrophs break these sugars down to obtain ATP energy during **Cellular Respiration**

So, What Exactly is ATP
- The main energy storage molecule in living cells is ATP (Adenosine Triphosphate).
- Stored energy from ATP is released when one inorganic Phosphate group (P\(_i\)) breaks off from ATP to form ADP (Adenosine Diphosphate)
- [http://student.ccbcmd.edu/biotutorials/energy/adpan.html](http://student.ccbcmd.edu/biotutorials/energy/adpan.html)

**ATP**
- Adenosine Triphosphate
- Made up of Adenine, Ribose, and 3 Phosphate groups
- Phosphate groups can be broken off to release energy
- Some energy-releasing reactions:
  - ATP → ADP + P\(_i\) (inorganic phosphate) + energy
  - ADP → AMP + P\(_i\) (inorganic phosphate) + energy
- Cells regenerate ATP from ADP and AMP using energy from glucose

Your turn to Practice converting ATP to ADP:
- Click on the link below and complete the corresponding activity page.

**What is Cellular Respiration**
- Cellular respiration is a process where oxygen is used to break down glucose to produce ATP energy, the “rechargeable battery” that our cells use
- Happens in every cell.
- **Has the following formula**
  - \(\text{Reactants} \rightarrow \text{Product} \)
    - \(6\text{O}_2 + C_6\text{H}_{12}\text{O}_6 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{Energy}\)
  - Endergonic or Exergonic?
**Just the facts...**

- Respiration includes all metabolic pathways where carbohydrates and other macromolecules are broken down to make ATP.

  - **Aerobic** (requires Oxygen)
  - **Anaerobic** (Does not require Oxygen)

**Another Way to Look at It**

- Glucose is the splitting of sugar. In other words, you are taking one glucose (a six carbon sugar) and breaking it into two (2) molecules of pyruvic acid (a three carbon sugar).
  
  - This process does **not** require Oxygen.
  - Occurs in the **cytosol** outside of the Mitochondria.

  Note: a total of 4 ATP molecules are made, but since 2 ATP are used, then the net ATP gain is 2.

**Anaerobic Respiration**

- Occurs when oxygen is not available.
- After Glycolysis, organisms that do not have oxygen undergo **Fermentation**.
- 2 types of Fermentation:
  - Lactic Acid Fermentation
  - Alcoholic Fermentation

**Lactic Acid Fermentation**

- Occurs in animals and some bacteria in the absence of Oxygen.
- Pyruvic Acid from Glycolysis is converted to **Lactic Acid**.
- No ATP production.

**Alcoholic Fermentation**

- Used by yeast.
- Pyruvic Acid from Glycolysis is converted to **Ethyl Alcohol** and CO$_2$.
- No ATP production.
- Used to make wine, beer, and bread.
Aerobic Respiration

- Occurs when Oxygen is available after Glycolysis.
- Occurs in the Mitochondria of Eukaryotic organisms.
- Has 2 Stages: the **Krebs Cycle** and the **Electron Transport Chain**.

**Glycolysis**

- **Early Harvesting Steps**
- Occurs in the matrix of mitochondria.
- Acetyl-CoA (which is made in a transition reaction from the pyruvates made during glycolysis) are used to start the Krebs cycle.
- During this process, most of the electrons are accepted by NAD⁺ and FAD⁺ which act like electron carriers (buses) transporting electron from Krebs cycle to the electron transport chain (ETC).

**Steps of aerobic cellular respiration**

- Glycolysis
- Transition reaction
- Krebs cycle
- Electron transport system
- Oxygen
- Carbon Dioxide

**Inside The Mitochondria:**

- All other reactions take place here.
- Enzymes for Krebs Cycle are located in the fluid-filled matrix of the mitochondria.
**Electron Transport System**

- Occurs in the **cristae** (projections of the inner membrane) of the mitochondria.
- Consists of a series of carriers that pass electrons.
- Accounts for most of the ATP produced.
- NADH gives up electrons, turning back into NAD+.
  The carrier gains electrons and is reduced.

**Energy Yield From Glucose Metabolism:**

1. Glucose $\rightarrow$ 36-38 ATP molecules
2. 2 from glycolysis
3. 2 from Krebs
4. 32-34 from the Electron Transport chain

**Here's the VSN:**

- **Electron Transport Chain**/System is a series of carriers that accepts electrons removed from glucose, passes them to $O_2$ (eventually). Energy released during ETC results in the formation of 32-34 ATP molecules.
- **Happens** in the cristae of the mitochondria.

**But... Where did the Glucose use for cellular respiration come from?**

**Electron Transport Chain**

[Diagram of Electron Transport Chain]

**Glycolysis**

[Diagram showing Glycolysis and Electron Transport Chain]
How do plants change light energy into chemical energy?

- **Photosynthesis**
  - producers store energy from sunlight as chemical energy in organic molecules, mainly in carbohydrates

The chemical equation:

\[ 6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \]

Does this equation look familiar? It's the OPPOSITE of the one for aerobic cellular respiration!

What are the two parts of photosynthesis?

1. **Light-dependent reactions**
2. **Light-independent reactions**
   - (Light-independent reactions are also called the Calvin Cycle)

**Photosynthesis**

**Light Dependent Reactions**
- Requires sunlight in order for it to occur.
- Occurs in the Thylakoid membrane of the chloroplast.
- Here, the solar energy is used to make NADPH, ATP, and Oxygen.
- Note: the Oxygen we breathe comes from the light reactions of photosynthesis.

**Light Independent Reactions (Calvin Cycle)**
- Does not require sunlight.
- Uses the NADPH and ATP made in the light reactions to make the sugars.
What kinds of factors affect photosynthesis?

- Light intensity
- Temperature
- Color of light
- Availability of water & carbon dioxide