Cellular Respiration

- Before food can be used to perform work, its energy must be released through the process of respiration.
- Two main types of respiration exist in living things. Both begin with glycolysis.
  - Glycolysis: a process by which one glucose molecule is broken down into two pyruvic acid molecules.
  - Fermentation: pyruvic acid is broken down without the use of oxygen
  - Oxidative Respiration (aerobic respiration): pyruvic acid is metabolized using oxygen

Glycolysis

- Glycolysis occurs in the cytoplasm. It does not require oxygen.
- **Steps:**
  1. One molecule of glucose is split into two smaller molecules of pyruvic acid.
  2. This releases energy stored as ATP and hydrogen atoms and electrons that are accepted by NAD to form NADH.

Fermentation (Anaerobic Respiration)

- Fermentation is the breakdown of pyruvic acid without the use of oxygen.
- Glycolysis + Fermentation = Anaerobic Respiration
- **The metabolism of pyruvic acid during fermentation does not produce any ATP. Instead, the function of fermentation is to break down pyruvic acid and regenerate NAD^+ for reuse in glycolysis.**
- There are two forms of fermentation:
  - Lactic Acid Fermentation
    - Lactic acid fermentation occurs in animal cells and some unicellular organisms when O_2 is in short supply.
    - Lactic Acid forms when pyruvic acid accepts hydrogen from NADH:
      - pyruvic acid + NADH → lactic acid + NAD
    - Lactic acid accumulates in body tissues and makes muscles feel tired and sore.
    - Lactic acid is then transported to the liver where it is converted to glucose.

  - Alcoholic Fermentation
    - Alcoholic fermentation occurs in some plant cells and some unicellular organisms (yeast).
    - In alcoholic fermentation pyruvic acid is converted to ethyl alcohol (ethanol- found in beer and wine):
      - PA + NADH → ethanol + CO_2 + NAD

Aerobic Respiration

- The result of glycolysis and aerobic respiration is shown by the reaction:
  - $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ H_2O + 6\ CO_2 + 38$ ATP
- Aerobic respiration occurs in the mitochondria
  - outer and inner membrane
  - matrix: dense solution enclosed by inner membrane
  - cristae: the folds of the inner membrane that house the electron transport chain and ATP synthetase
- The first step of aerobic respiration is the conversion of pyruvic acid to a 2-C fragment.
  - This process also results in the production of NADH and CO_2.

The Krebs Cycle

- The Krebs Cycle is the central biochemical pathway of aerobic respiration. It is named after its discoverer, Sir Hans Krebs. Because citric acid is formed in the process, it is also known as the Citric Acid Cycle.
- **Steps:**
  1. The 2-C fragment enters the Krebs Cycle and combines with a 4-C molecule to form Citric Acid.
  2. Additional reactions produce NADH, ATP, CO_2, and regenerate the starting material for the cycle to continue.

Electron Transport Chain

- **Steps:**
  1. NADH formed during the Krebs Cycle takes electrons and hydrogen atoms to the Electron Transport Chain.
  2. ATP is generated, and the electrons and hydrogen atoms join with oxygen to form water.

Energy Yield

- Aerobic respiration produces a maximum of 38 ATP.
  - 2 ATP from Glycolysis
  - 2 ATP from Krebs
  - 34 ATP from ETC