Metabolism and Enzymes

I. Metabolism and Enzymes

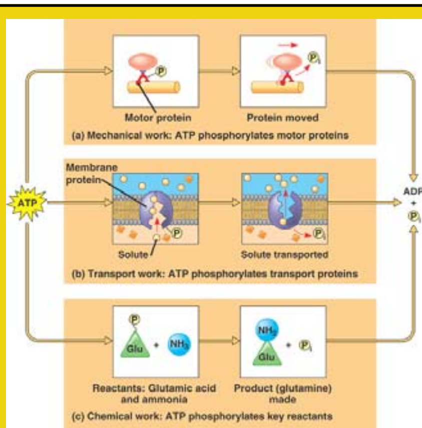
A. Metabolism: The sum of an organism's chemical reactions.
   1. An emergent property.

B. Metabolic Pathways
   1. Catabolic
      a. Release energy by breaking down molecules.
      b. Enzymes are used for each step.
      c. Example: Cellular Respiration

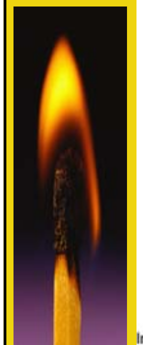
2. Anabolic Pathways
   a. Use energy to produce more complex molecules.
   b. Enzymes are used in every step.
   c. Example: Calvin Cycle/Sugar production in autotrophs.

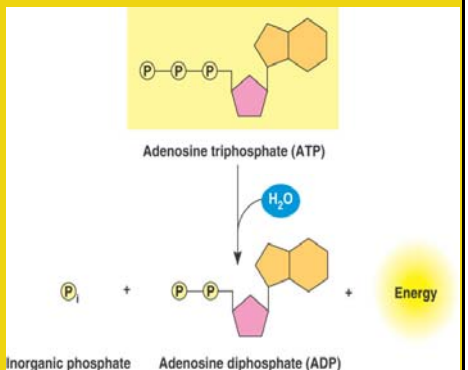
II. ATP and Cellular Work

A. Three types of work
   1. Mechanical work
      a. beating of cilia, muscle contraction, movement of chromosomes.
   2. Transport work
      a. The pumping of substances into or out of the cell against spontaneous movement.
   3. Chemical work
      a. Driving endergonic reactions such as building polymers.



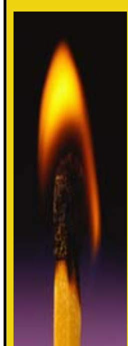
B. ATP: molecule that living organisms use for energy.
   1. A nucleotide that is made of adenine, ribose, and three phosphate groups.
   2. Phosphate groups
      a. Are negatively charged and repel each other.
         -They are easily separated allowing them to be more stable.
   3. ATP ⟶ ADP + P
      a. Releases -13 kcal in the cell.

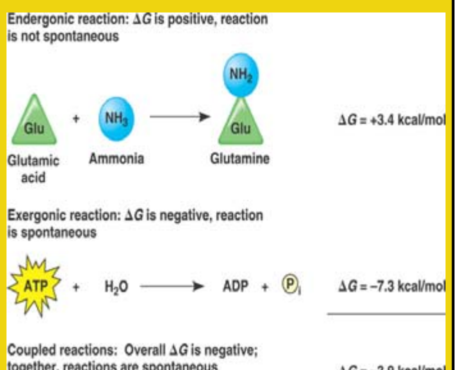




4. Energy Coupling
    a. In order to receive the energy from ATP a phosphate is transferred to the molecule that needs energy.
        -This molecule is now phosphorylated and less stable, therefore more reactive.

5. General
    a. ATP is used for all types of cell work.
    b. ATP is recycled.
    c. More than 10 million ATP molecules are consumed and regenerated per second.





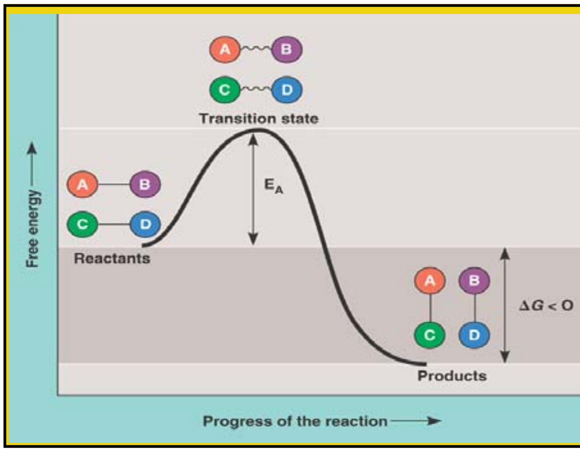
III. Enzymes and Activation Energy

A. Activation Energy
1. Most exergonic reactions need catalysts to start the reaction.
2. Catalyst: a chemical agent that speeds up the rate of reaction without being consumed by the reaction.
    a. Enzyme: Biological catalyst.
3. Chemical reactions involve the breaking and reforming of bonds.
    a. In order to break bonds the molecules must absorb a certain amount of energy.
        -This is called activation energy.

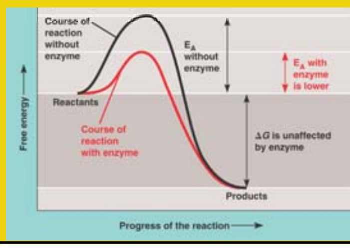
- Activation energy allows molecules to reach the transition state.
    *This energy may come from the environment in the form of heat.

- Transition state is unstable and therefore more reactive.

-As the molecules complete their reaction, they are more stable, and will release energy into their surroundings.

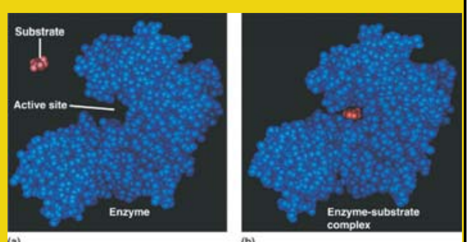


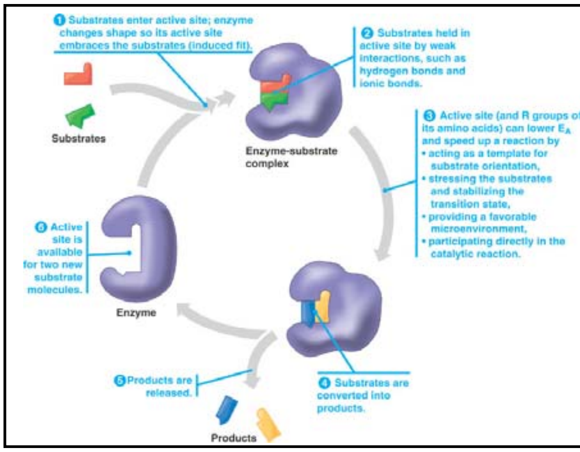
4. Enzymes and activation energy
   - a. Enzymes work by lowering the activation energy.
   - b. They do not change the amount of free energy released.



B. Enzyme Specificity
   1. Enzymes only bind/bond with specific substances or substrates.
      - a. They can bond with one or more at a time.
   2. When they bind to their substrate it is called an enzyme-substrate complex.
   3. Only a portion of the enzyme will bind with the substrate.
      - a. This is called the active site.
         - -This is like a pocket or groove.

4. As the substrate enters the active site, chemical reactions between the amino acids in the active site and the substrate occur causing the protein to change shape slightly.
   - -This is called the induced fit model.





C. Specifics on Active Site
   1. Substrates are usually held in place by weak bonds.
   2. Enzymes are unaffected and can be reused.
      - -Can catalyze thousands of reactions a second.
   3. Most enzymes can work catabolically or anabolically.
      - -Depends on the concentration of reactants v/s products.
      - -Enzyme tries to reach equilibrium.

4. Enzymes lower activation energy by:
   - a. Placing the molecules in the correct position.
   - b. Putting stress on the bonds, causing substrate to reach the transition state.
   - c. Active site may create a microenvironment.
      - -Lower or higher pH.

5. Rate of Reaction
   - a. The higher the substrate concentration the faster the reaction.
   - b. Every reaction will reach a saturation point.
      - -The only way to make the reaction occur faster is by adding more enzyme.

D. Controls on Enzyme Activity

1. Temperature

a. Must have the correct temperature.

-Warm temps. increase collision rate.

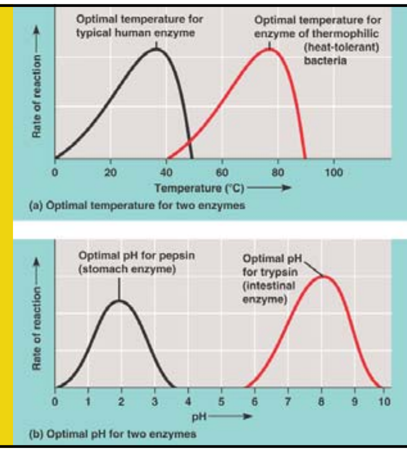
-Cool temps will decrease collision rate.

-Hot temps will denature the enzyme.

b. Each enzyme has a specific temp that it works best at.

-Human enzymes=35-40 C

-Bacteria in hot springs = 70 C



2. pH

a. Each enzyme has an optimal pH.

b. Usually between 6-8.

3. Cofactors

a. Nonprotein helpers

b. Can bind permanently or be reversible.

c. Examples: zinc, iron and copper

d. Organic cofactors=coenzymes

- Vitamins

4. Inhibitors

a. Can be reversible or permanent.

b. Competitive inhibitors

-Attach in the active site.

c. Noncompetitive inhibitors

- Attach somewhere other than the active site.

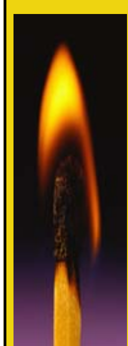
- Causes a chemical reaction that changes the active site so the substrate can't bind correctly.

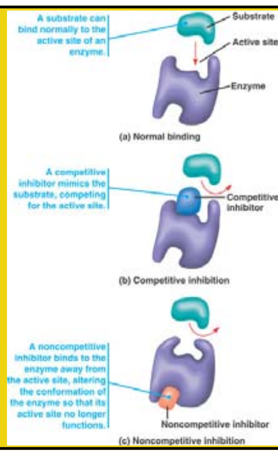
d. Examples

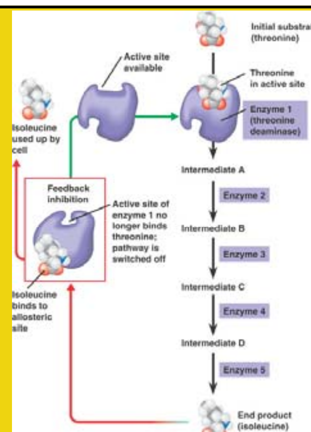
-Toxins and poisons are often irreversible inhibitors.

-DDT

-Used in antibiotics







5. Locations of Enzymes within a Cell
   a. Several enzymes that function in one pathway may be placed in a multienzyme complex.
      -Allows for the product of one enzyme to quickly function as the reactant/substrate of the next.
   b. Some enzymes have a fixed position.
      - Cell membranes
      - Organelle membranes