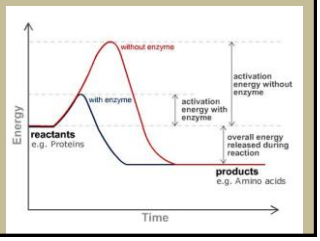
Enzymes

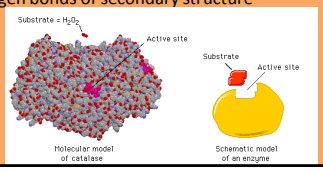
Enzymes

- speed up metabolic reactions by lowering activation energy (EA)
- do not change the nature of the reaction
- very specific for reactions to catalyze
- mostly composed of amino acids or pieces of RNA (ribozymes)



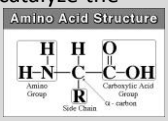
Active Sites

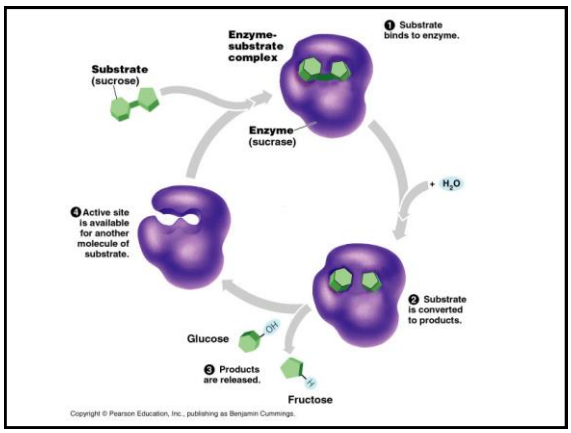
- enzymes are specific to a particular substrate
  - dependent upon 3D shape of protein
  - "induced fit"
- active site is the region of the enzyme that binds with the substrate
- only involves a few amino acid of the enzyme
  - hydrogen bonds of secondary structure



How it Works

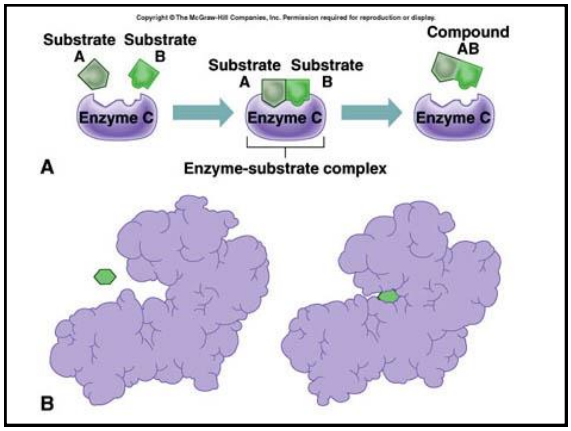
- as a substrate binds to the active site (usually on the R groups of those amino acids) it induces the enzyme to change its shape which brings the chemical groups close enough to interact with the substrate and catalyze the reaction
- when the product leaves the enzyme emerges in its original form which can be used over and over





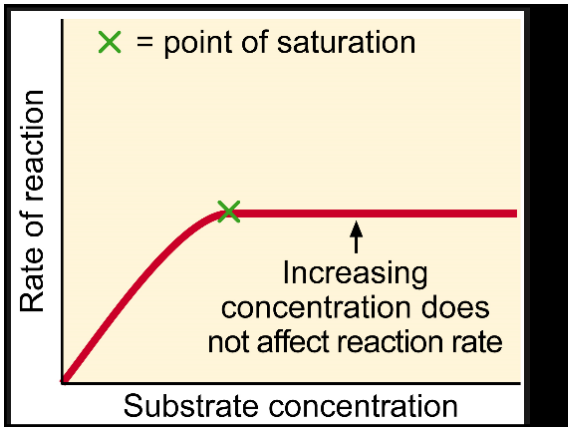
How it Works

- active site holds 2+ reactants in place so they can react
- the induced fit distorts the substrate's chemical bonds so less thermal energy is needed to break the bonds
- active site causes a favorable environment
- side chains may be directly involved
- enzyme-substrate complex usually held together by weak Hydrogen bonds, Ionic bonds or Van der Waals Interactions



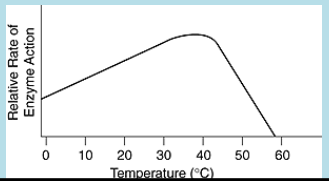
Rates of Enzymatic Reactions

1. Concentration of the Substrate
   - ↑ substrate concentration, the faster the reaction (up to a limit)
   - if the enzymes becomes saturated the reaction rate will become dependent on how fast the active sites can convert the substrate into product



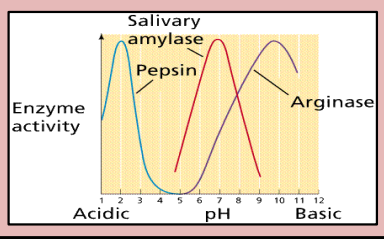
Rates of Enzymatic Reactions

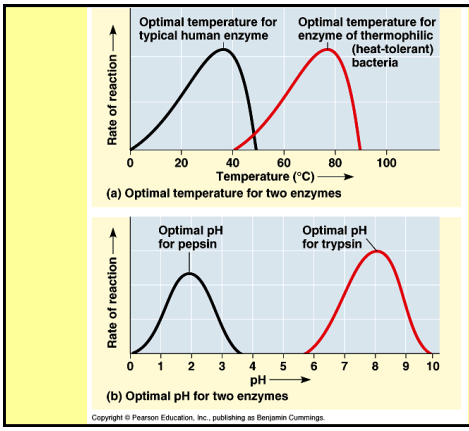
2. Temperature
   - ↑ temperature will ↑ the enzyme reaction rate because kinetic energy ↑ the amount of collisions between enzyme and substrate (up to a limit)
   - enzymes optimally perform at certain temps
     - beyond optimal temp, the enzyme may denature



Rates of Enzymatic Reactions

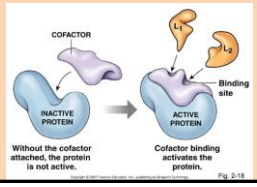
3. pH
   - optimal range for most enzymes is somewhere between 6 and 8
   - some enzymes work best at extremes (Pepsin – 2)





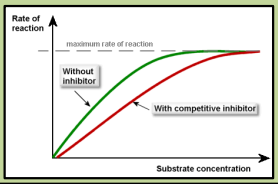
Cofactors

- small, non-protein molecules required for proper enzyme catalysis
- bind to active site
- some are inorganic (ex. Zinc)
- some are organic (ex. Coenzymes or vitamins)



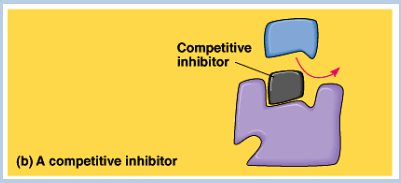
Inhibitors

- chemicals that inhibit enzyme catalysis
- may be irreversible if attaches by covalent bonds
- may be reversible if attaches by weak bonds
- may regulate metabolic activity



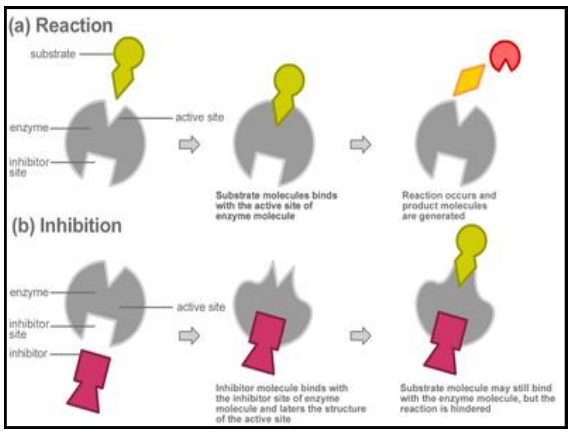
Competitive Inhibitors

- resemble normal substrate
- compete for active site
- if reversible, these may be overcome by an increase in the substrate



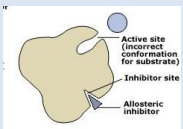
Non-Competitive Inhibitors

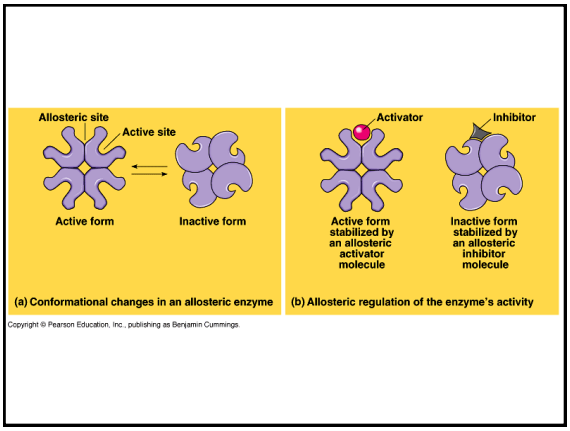
- bind to another part of the enzyme (not the active site)
- changes shape of the enzyme so active site is no longer available
- Ex. DDT and antibiotics



Allosteric Regulation

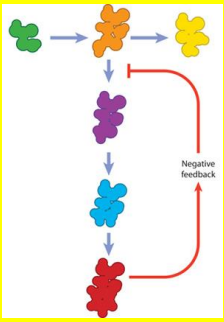
- allosteric site is a receptor site on some part of the enzyme besides the active site
  - often where 2 polypeptides are joined
- acts as an *on/off switch* for that enzyme
- binding of an <u>activator molecule</u> stabilizes the active conformation (turn on) whereas the binding of an <u>inhibitor</u> stabilizes the non-active conformation (turn off)

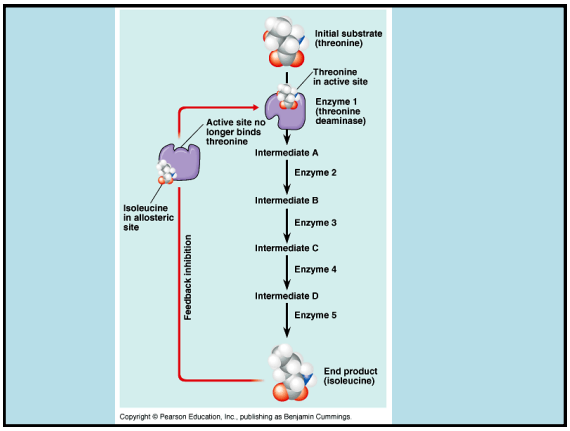




Control of Metabolism

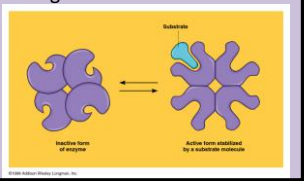
1. Feedback Inhibition
   - regulation of a metabolic pathway by its end product, which inhibits an enzyme within the pathway
   - prevents cell from wasting chemical resources





Control of Metabolism

2. Cooperativity
   - substrate molecules enhance the enzymes activity
   - substrate binding at one active site induces conformational change that enhances substrate binding at the active sites of other subunits
   - Ex. oxygen binding to hemoglobin
     - binding of one oxygen molecule allows the binding of the second molecule to occur more easily



Control of Metabolism

3. Specific Locale
   - enzymes have fixed locations in the cell
   - may be located in the organelle or a membrane