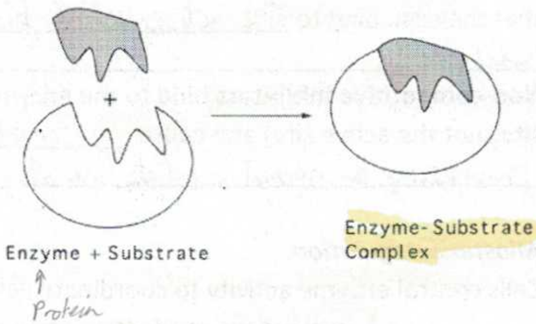
ENZYMES

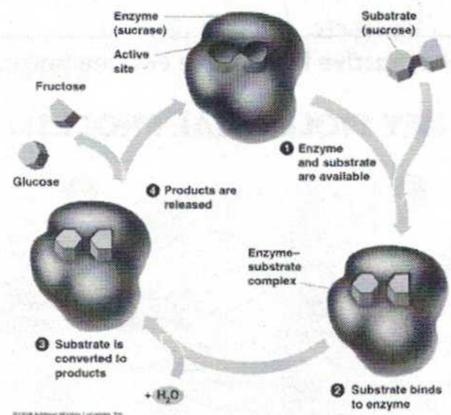
What is an Enzyme?

- Enzymes are protein catalysts
    - A catalyst speeds up chemical reactions without being consumed in the process
- Enzymes are NOT used up during a reaction.
- Enzymes are specific to a particular substrate (reactant).
- Enzyme names usually end in 'Ase'



Enzyme Terminology

- The substrate is the reactant that an enzyme acts on when it catalyzes a chemical reaction
- Substrates bind to a region on the surface of enzymes known as the active site, to form an enzyme-substrate complex
- Once the substrate is catalyzed, the enzyme takes its original form and can be used again … and again
- On the diagram above, label the substrate, enzyme, and active site



In the enzyme-substrate complex, the chemical bonds in the substrate are stressed or weakened and the stress will force the bonds between the substrates to break (or cause bonds to form, depending on the function of the enzyme)

<u>How Active Sites Work (Two Models)</u>:

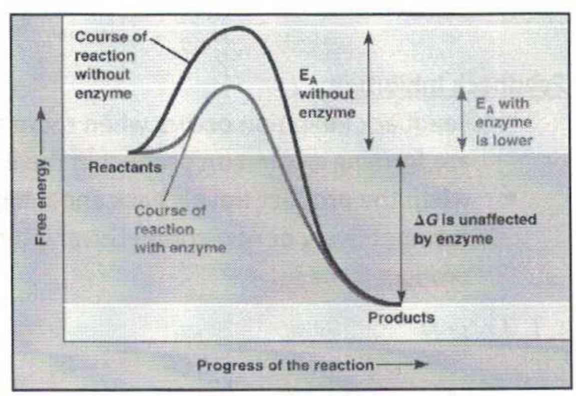
1. LOCK AND KEY MODEL:
   Active site matches substrate exactly
2. INDUCED FIT MODEL:
   - Active site sort of fits substrate
       - Once substrate binds, functional groups of various amino acids react and shift, allowing the enzyme to change its shape to better accommodate the substrate

How Does an Enzyme Work?

- The enzyme provides a site that the substrate can attach to so they are correctly aligned and can easily be broken down
- Enzymes lower the Activation Energy (E_A) required

What is Activation Energy?

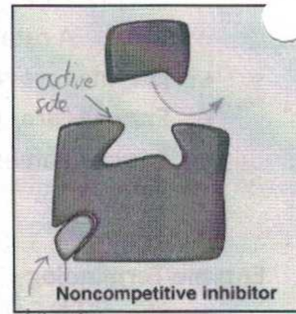
- The energy that is required to 'kick start' a chemical reaction
- Heat is often the 'kick start' a reaction needs, however if too much heat is applied, the proteins in the body will denature.
    - Enzymes speed up the rxn by decreasing E_A while keeping the temperature stable so the proteins are not denatured



- Enzymes do not change the overall reaction:
  They speed up the reaction, allowing for more collisions and a greater number of products

Enzyme Inhibition

Enzyme inhibitors prevent enzymes from carrying out their functions of catalyzing reactions. There are two general types:



Allosteric

Competitive Inhibitors are so similar to an enzyme's substrate that they can bind to the active site & block the normal substrate.

Non-competitive Inhibitors bind to the enzyme at an **allosteric site** (not the active site) and cause a conformational change in the enzyme, preventing the normal substrate from binding.

Allosteric Regulation:

Cells control enzyme activity to coordinate cellular activities:

- Restrict the production of an enzyme
- Inhibit the action of an enzyme that is already produced

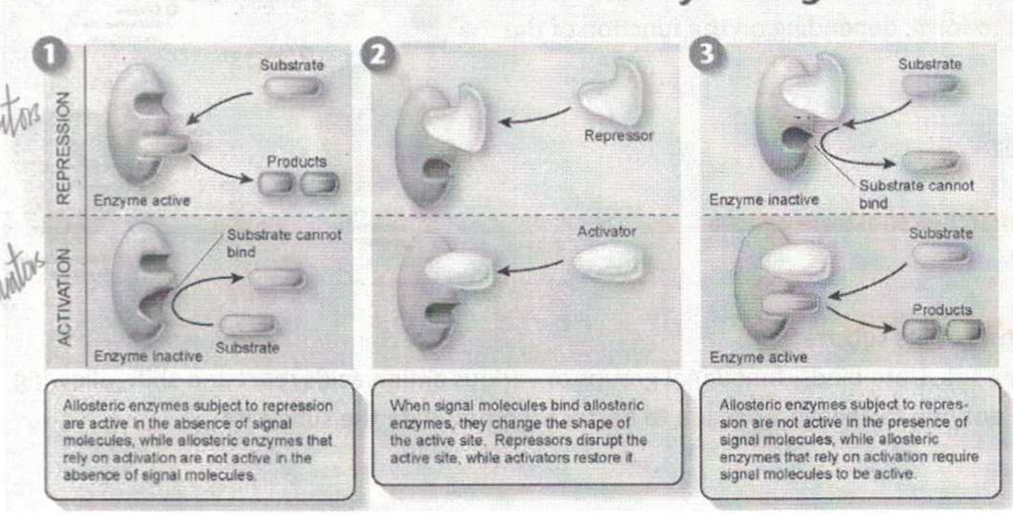
Activators may bind to allosterically controlled enzymes to stabilize its shape and keep all active sites ***available*** (meaning they make it so the enzyme can function).

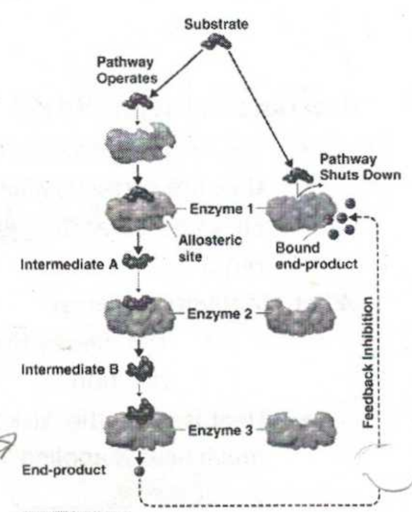
Allosteric Inhibitors may bind to allosterically controlled enzymes to stabilize the ***inactive*** form of the enzyme (meaning they make it so the enzyme cannot function).

KEY BIOLOGICAL PROCESS: Allosteric Enzyme Regulation

Inhibitors

Activators



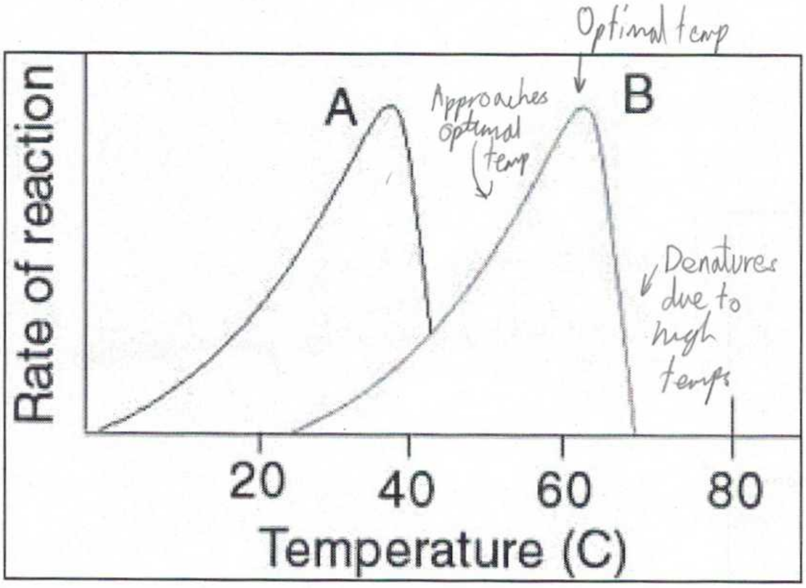


Feedback Inhibition:

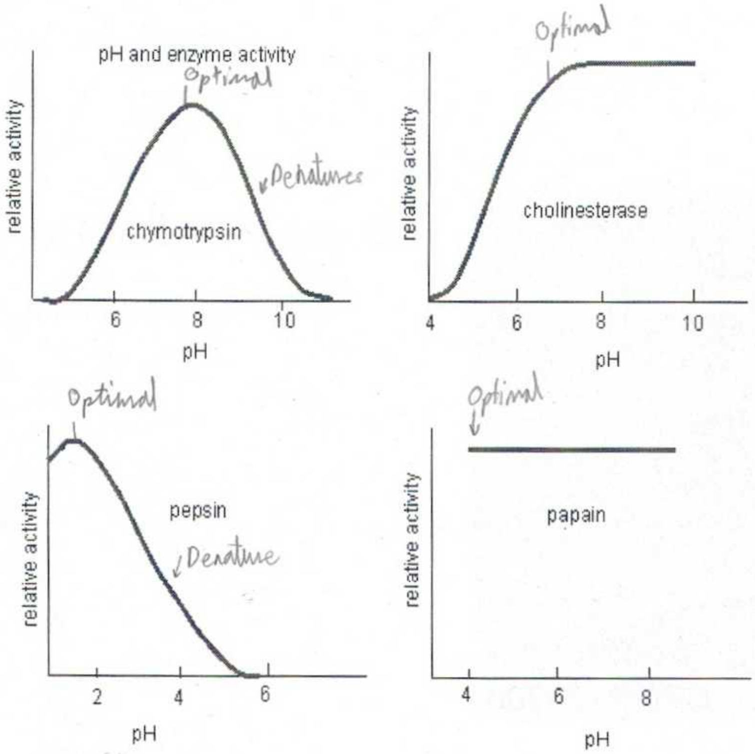
- Feedback inhibition occurs when there is a sequence of chemical reactions that are forming a common product in the end
- when the product travels back and inhibits an earlier enzyme in the reaction (competitively or non-competitively) the pathway is interrupted, and no more product is made.

Metabolic Pathway
↳ set of enzymes in series to transform substrate

Temperature



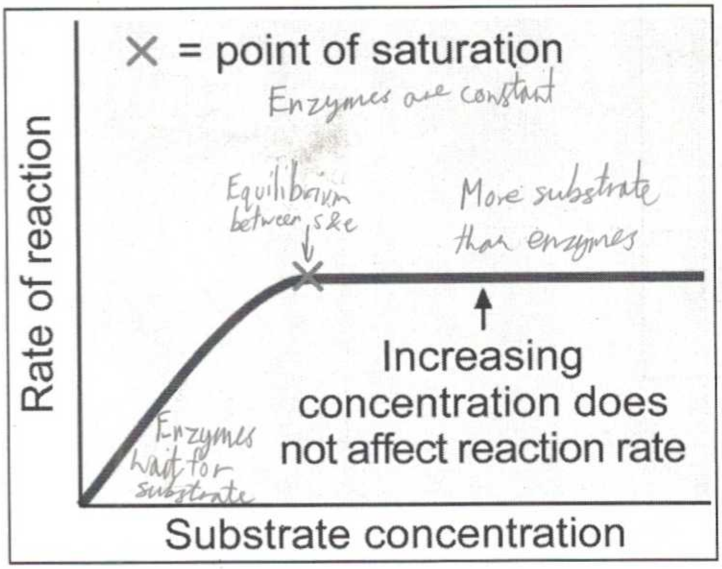
pH



Each enzyme has an optimal pH. Too high/low & it'll denature.

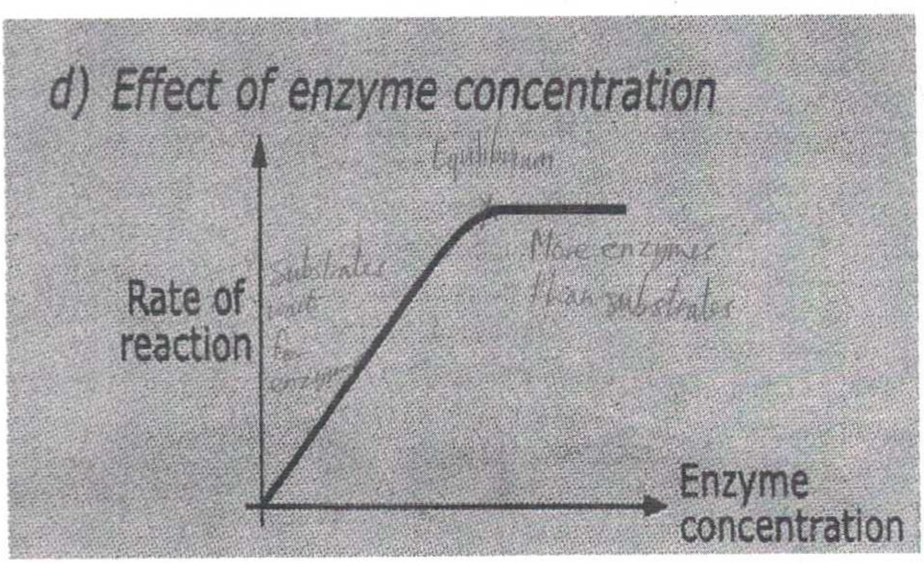
Factors that Affect Enzyme Activity

Substrate Concentration



As substrate $\rightarrow \infty$, RoR $\rightarrow$ X
Will eventually plateau after point of saturation

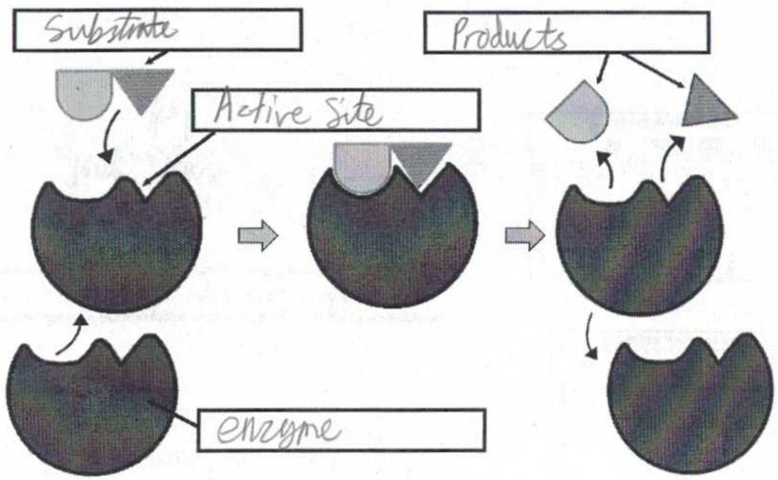
Enzyme Concentration



As enzyme $\rightarrow \infty$, RoR $\rightarrow$ X

Enzymes

1. **Enzymes act on substrates.** Label the enzyme, substrate, active site, and products on diagram.



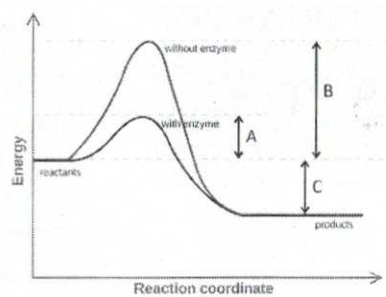
Answer true or false to the following statements based on the graphic:

a. __F__ Enzymes interact with many different substrate types.
b. __F__ Enzymes changes to a new shape after a reaction occurs.
c. __T__ An enzyme can be reused with a new substrate of the same type.
d. __T__ The substrate is changed in the reaction.
e. __T__ If an enzyme is denatured, it would no longer work.
f. __T__ When all substrates are used, the reaction stops.

2. **Enzymes speed up the reaction** by lowering the activation energy needed for the reaction to start. Compare the activation energy with and without the enzyme.

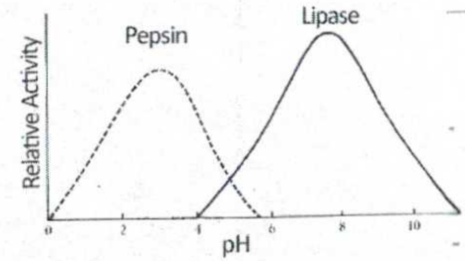
Identify the part of the graph that shows:

a) _C_ Overall energy released during reaction
b) _A_ Activation energy with enzyme
c) _B_ Activation energy without enzyme



3. **Enzymes work best at optimal temperature and pH values.** For example, the enzyme, pepsin, in your stomach must be able to function in a highly acidic environment to break peptide bonds found in proteins.

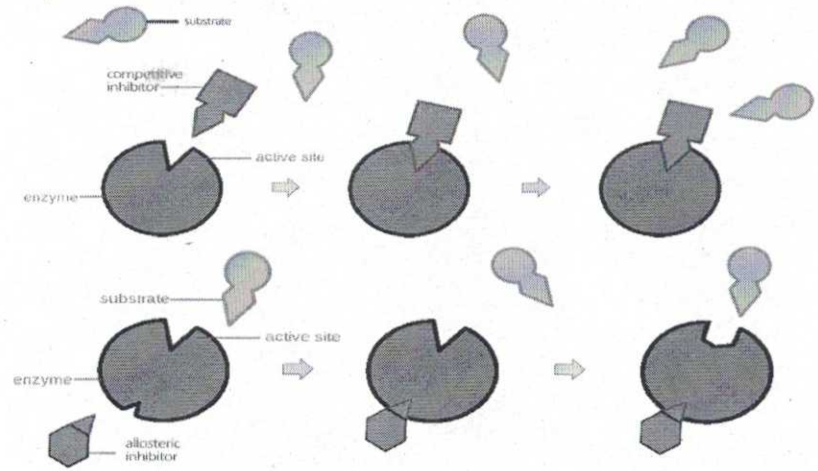
Acidic or basic conditions can disrupt the hydrogen bonds between the loops of the protein chains. If this disruption occurs near the active site, the enzyme can become distorted and not fit the substrate perfectly. The rate of reaction is reduced as more enzymes become denatured.



a) What is the optimal pH for pepsin? __3__ For lipase? __8__

b) Do you think lipase is an enzyme that is found in the stomach? Why or why not?

4. **Enzymes can be inhibited.** Inhibitors can slow down or stop enzymatic reactions. There are two types of inhibition: competitive and allosteric.



Answer true or false to the following statements based on the graphic:

a) __T__ Increasing the number of inhibitors will decrease the overall rate of reaction.
b) __F__ Allosteric inhibitors block the active site.
c) __T__ Allosteric inhibitors change the shape of the enzyme.
d) __F__ Adding a competitive inhibitor will increase the number of products in the reaction.
e) __F__ Competitive inhibitors bind to the substrates.

5. Define what a catalyst is in terms of its chemical composition as well as its biological role.

Speeds up rxns

6. How do catalysts compare to enzymes?

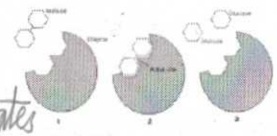
7. The figure to the right is a standard diagram that illustrates the functioning of an enzyme.

Label/define: *active site, substrate, enzyme-substrate complex*

AS: Where substrates bind w/ enzymes

Substrate: Reactants

Enzymes: Speeds up rxns with substrates



8. Compare and contrast the **lock and key** and **induced fit** models of enzyme function.

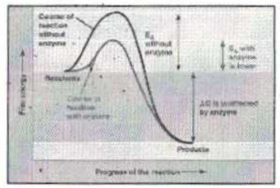
Exact vs close enough

9. Why would an enzyme be unable to catalyze many different types of reactions?

Has a specific structure

10. Define **Activation Energy** and briefly explain how an enzyme works to kick start a reaction (diagram to the right).

The energy required to start a reaction. Enzymes will speed up the rxn by lowering E_A



11. . Why are enzymes important to biological systems if the reactions they facilitate will occur naturally with or without the presence of enzymes? Uses less E_A, more collisions ∴ more product

12. Describe the general nature of **enzyme inhibitors**.

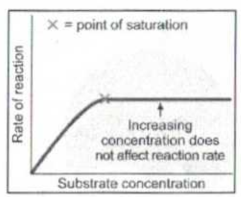
a) Differentiate between competitive and non-competitive inhibitors (include a definition of the term **allosteric**)

b) Distinguish between **allosteric activators** and **allosteric inhibitors**

Activates vs shuts off

13. Explain why the rate of reaction levels off in the graph to the right.

Amount of substrate exceeds enzymes



14. Explain the effect of temperature on the rate of reaction of an enzyme.

Speeds up / slows down

15. What is meant by 'optimal temperature'? Is it the same for all enzymes?

No

Temperature in which enzyme has peak

Rxn