Enzymes

Ch 3: Macromolecules

- Living things use different chemical reactions to get the energy needed for life

Chemical Reactions

- Reactants = substance that is changed
- Products = new substance that forms
  - Ex: ATP ←→ ADP + P + energy
  - Ex: H_2O←→ H + OH
    - The double arrow means the reaction build and then break down (can do forward and reverse reactions)

- Types
  - Exothermic = releases energy (breaks down)
  - Endothermic = absorbs energy (builds)

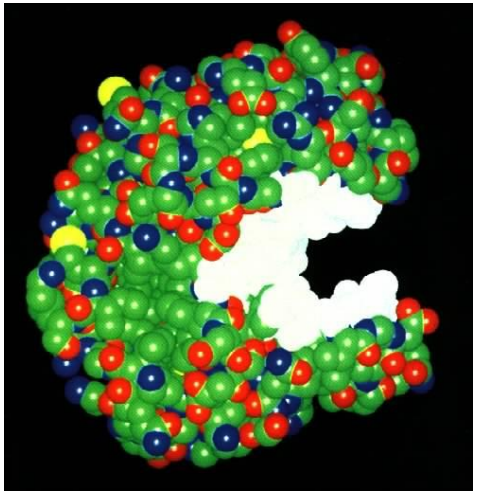
Chemical Reactions

- Activation Energy = energy needed to start a chemical reaction
  - Ex: A ball on top of a hill will not start rolling unless someone pushes it (input of energy), just like reactions will not occur unless energy is added to start it

- Normally, our body can't wait for molecules to build up enough energy on their own in order to combine or break apart
- So, reactions require enzymes

Enzymes

- Enzymes = a protein molecules that acts as a catalyst in living things



  - Enzymes help to start chemical reactions by lowering the activation energy
    - THIS IS HOW ENZYMES FUNCTION!!

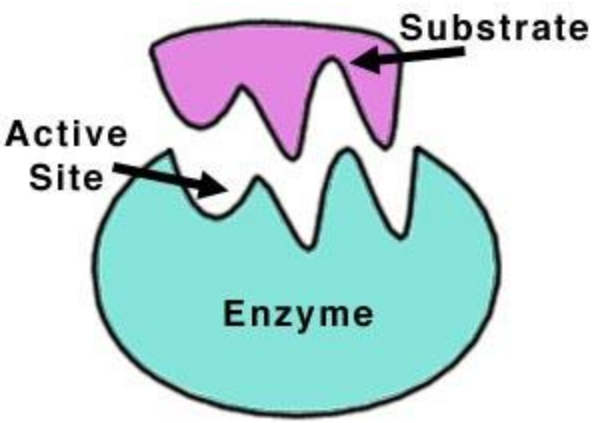
Protein Review

- Elements: C, H, O, N
- Functions: structure and chemical reactions
- Monomer: amino acid
- Polymer: polypeptide

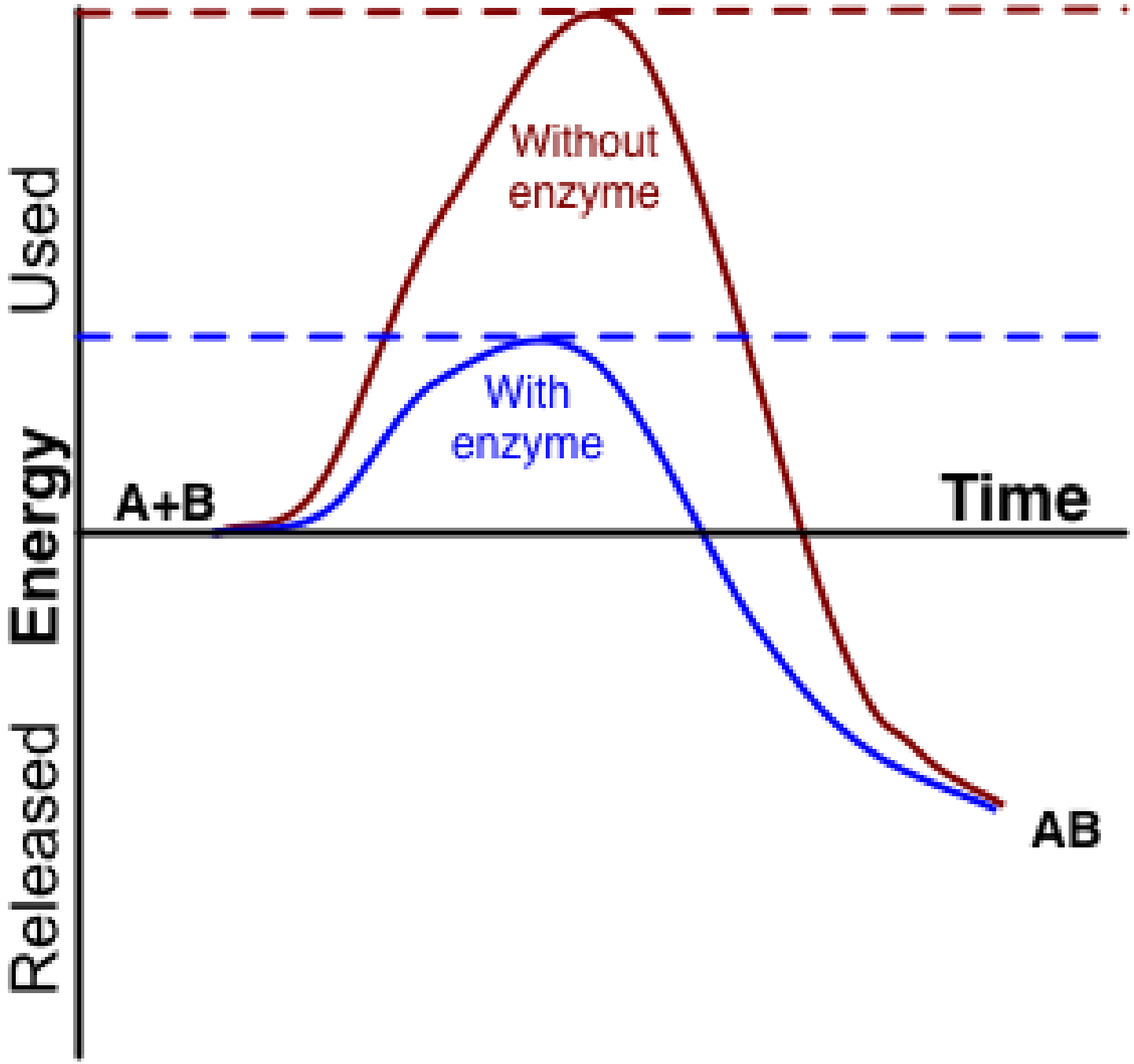
- 4 levels of protein structure
  - Primary – peptide bonds
  - Secondary – hydrogen bonds (protein starts to fold)
  - Tertiary and Quaternary – all other types of bonds create the final functional shape of the protein

Enzymes

- Substrate = molecule that binds to a specific enzyme



- Active site = place on the enzyme where substrate binds

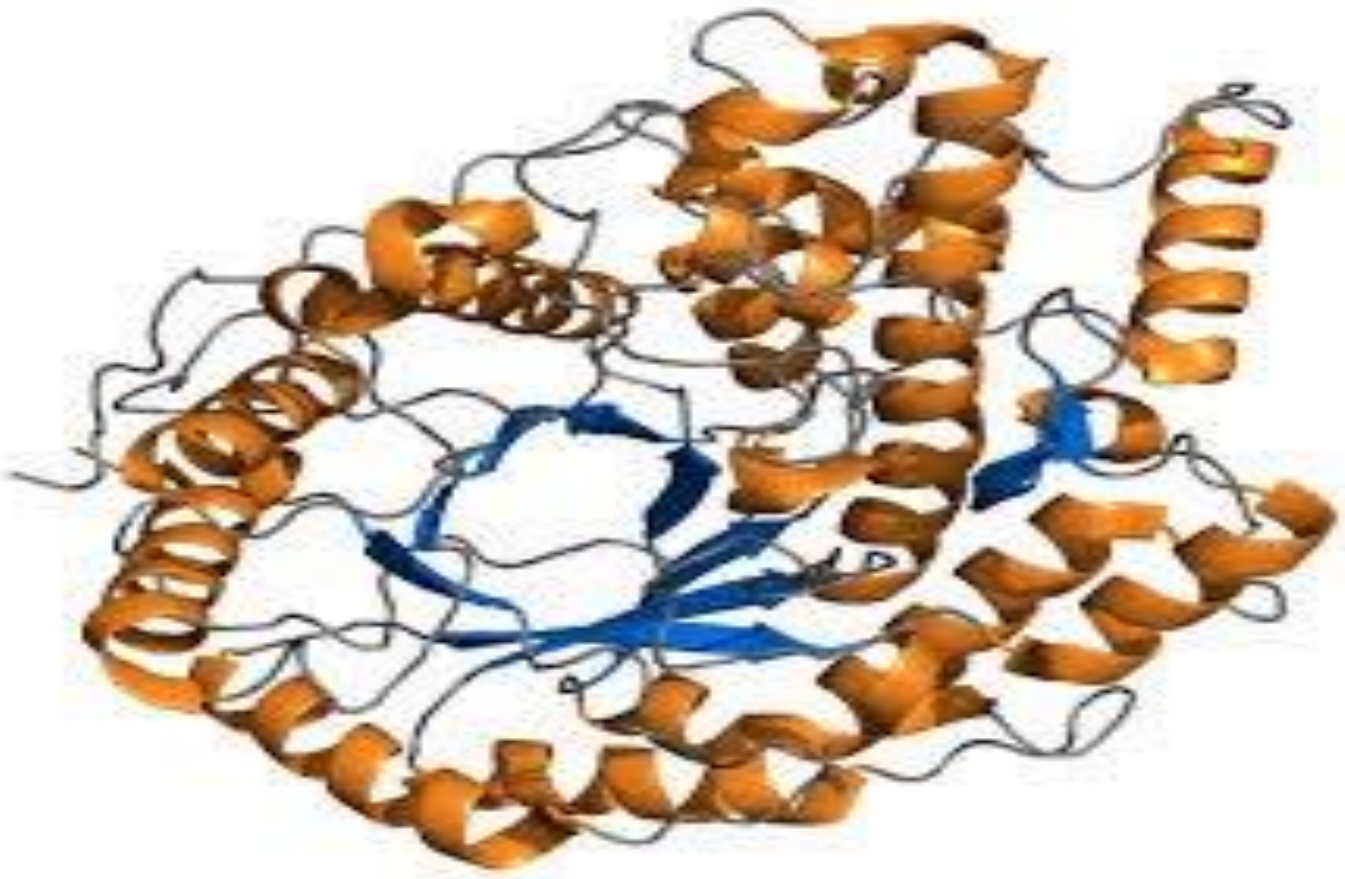

Used
Energy
Released
Without
enzyme
With
enzyme
A+B
Time
AB

- Video: Activation Energy
- Video: Enzyme Characteristics
- Video: Amoeba Sisters
- Video: How Enzymes Work

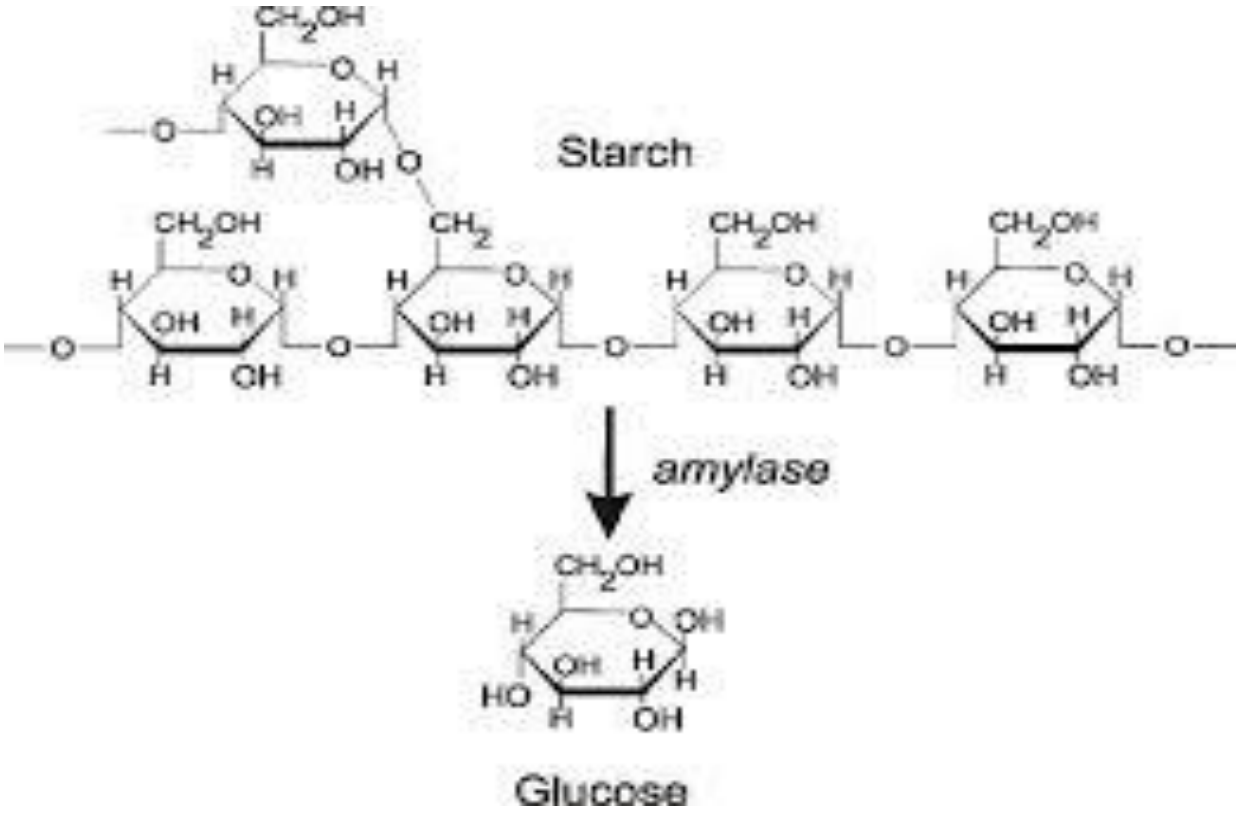
Examples of Enzyme Reactions

1. Enzymes in your mouth called amylase speed up the chemical reaction for breaking down sugars.
2. Enzymes in your small intestines called proteases speed up the reaction for breaking down proteins.
3. Enzymes called lactase speed up the chemical reaction for breaking down the milk sugar called lactose.
4. Enzymes in the mitochondria called ATPase speed up the chemical reaction of breaking down ATP to release energy.

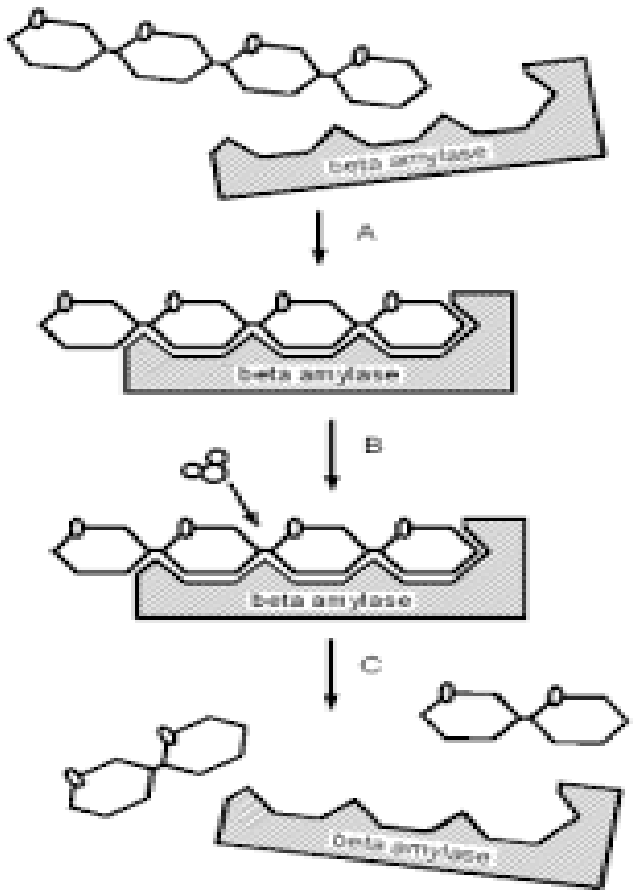
Amylase protein Structure



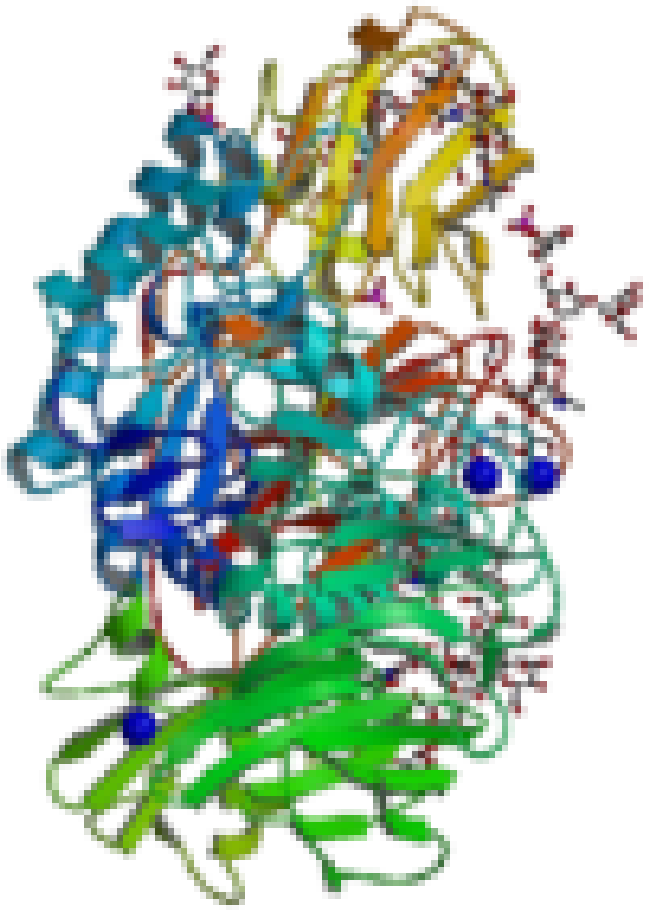
Amylase Reaction



Amylase Enzyme Diagram

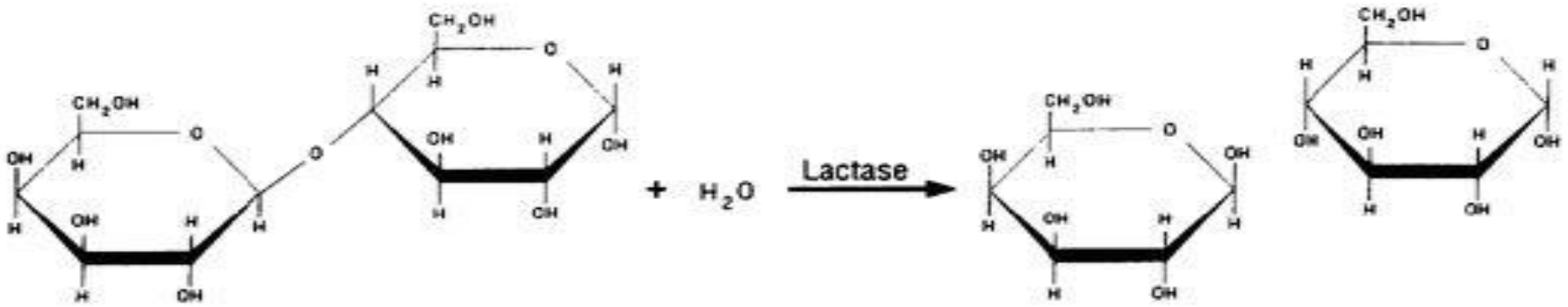


Lactase Protein Structure



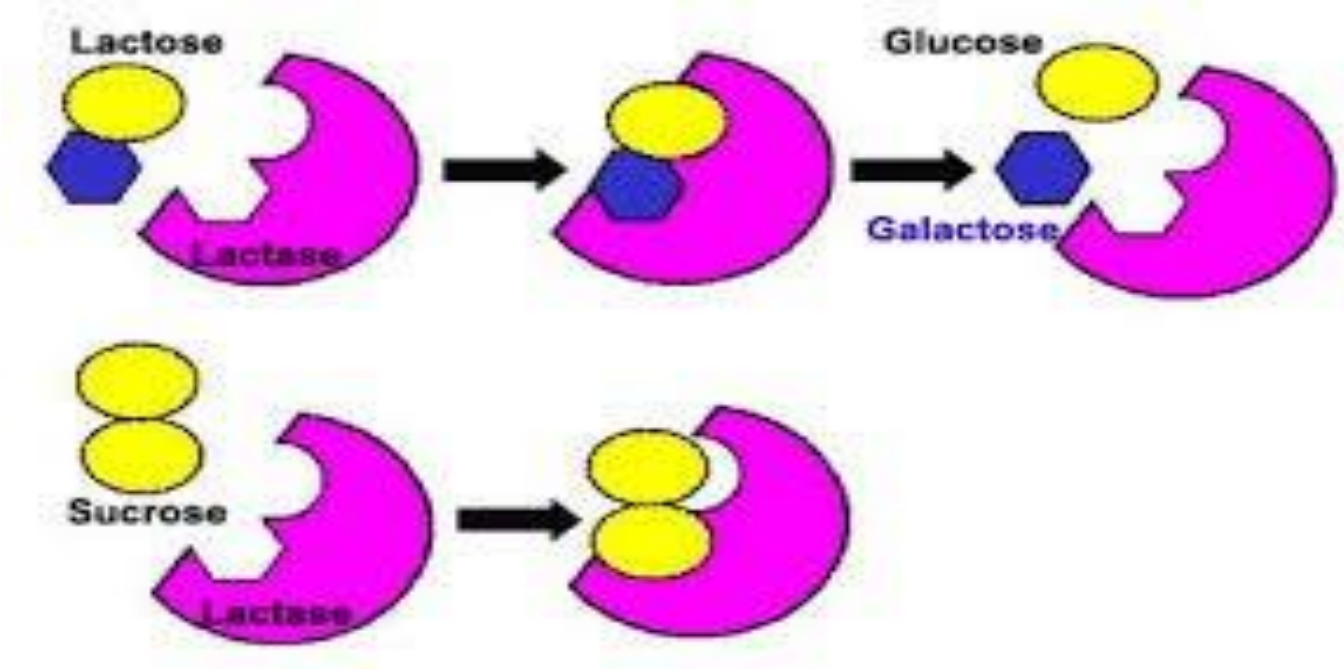
Reaction Catalyzed by Lactase

$$C_{12}H_{22}O_{11} + H_2O \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

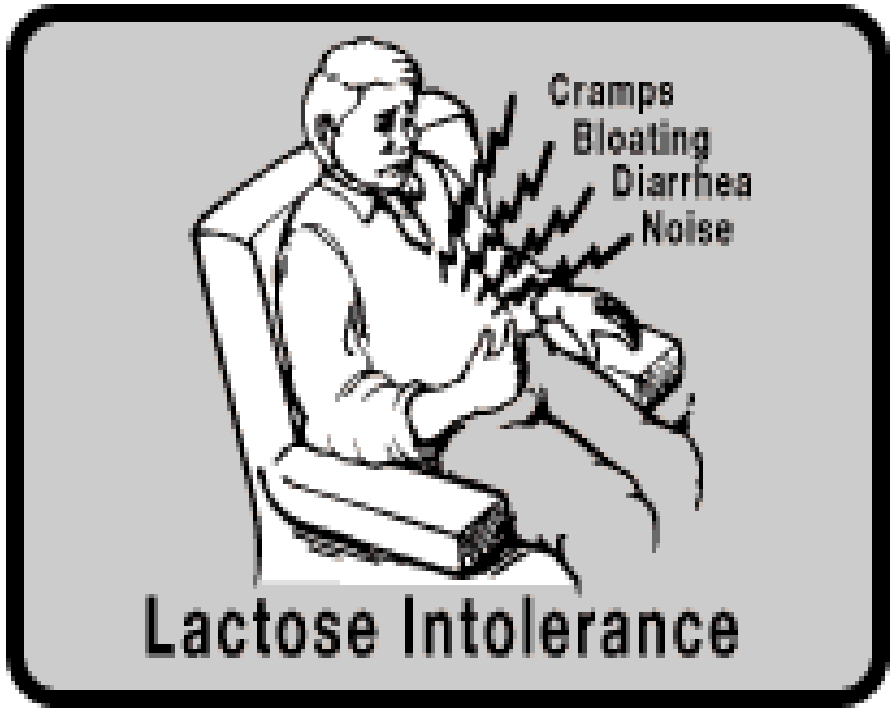


Lactose + Water = Galactose + Glucose

Diagram of Lactase Catalyzing



Lactose Intolerance



Enzyme names

- Lipase
- Protease
- Amylase
- ATPase
- Lactase
- Cellulase

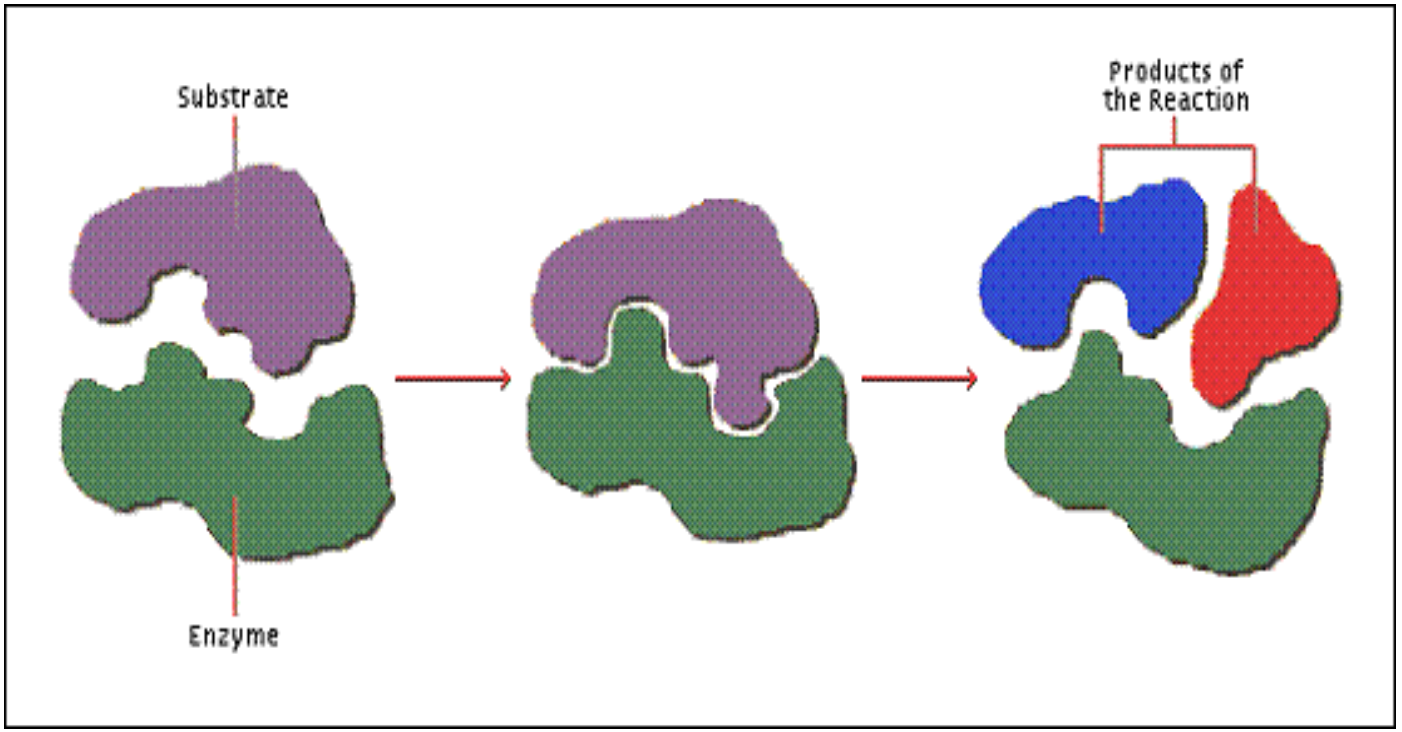
Do you see a pattern?

Characteristics of Enzymes

- Speed up reactions that would otherwise take a long time to start by lowering the activation energy
- Not used up and can react over and over
- Same enzyme does building and breaking down (forward and reverse reaction)
- Highly selective to what substrate it binds to (lock and key mechanism)

Steps of Enzyme Activity

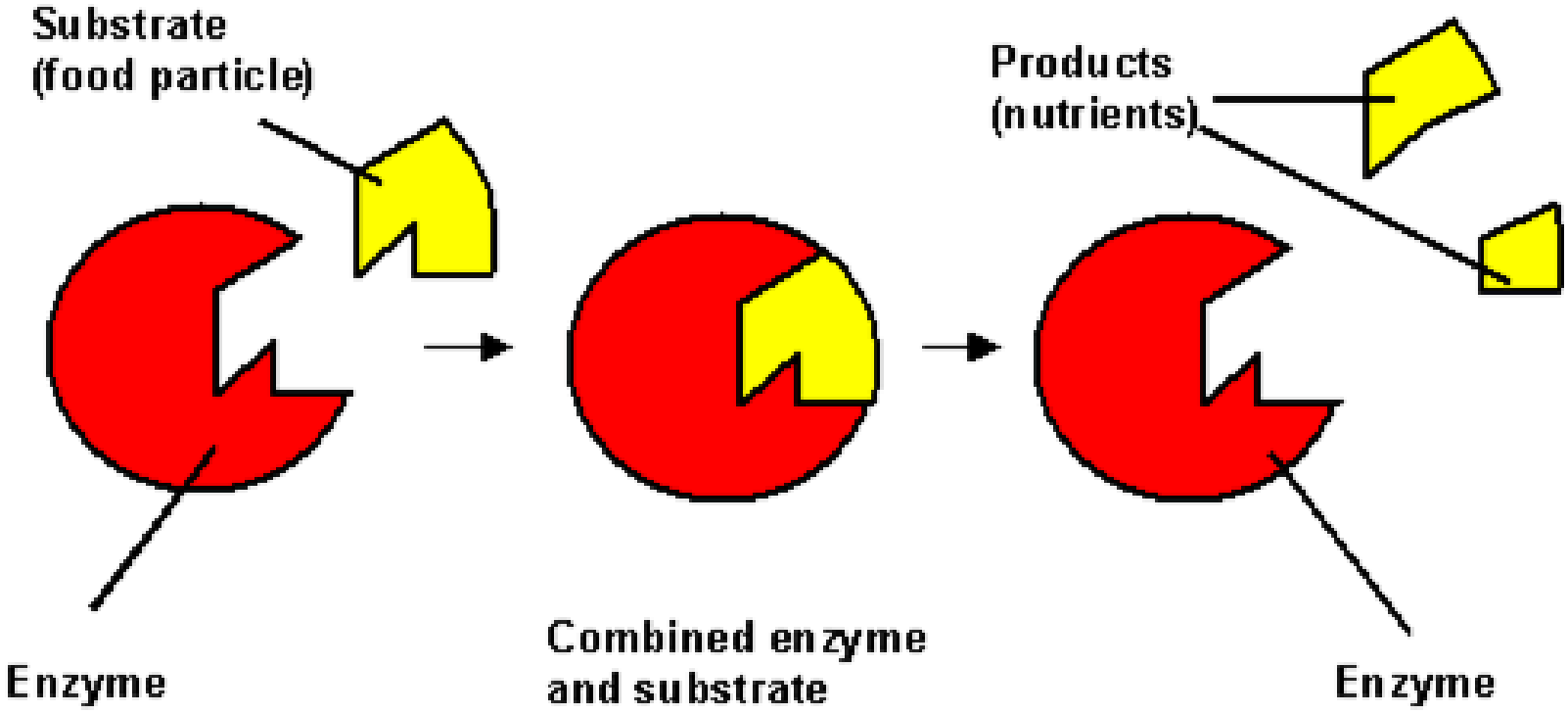
1. Substrate binds to an enzyme's active site like a key in a lock (**Lock and Key Mechanism**)



Steps of Enzyme Activity

2. Enzyme holds the substrate in place by changing its shape slightly (**Induced Fit Model**), which causes some bonds to break or new ones to form in the substrate

3. The unchanged enzyme releases the product when the reaction is over and binds to the next substrate



How enzymes break down food into nutrients

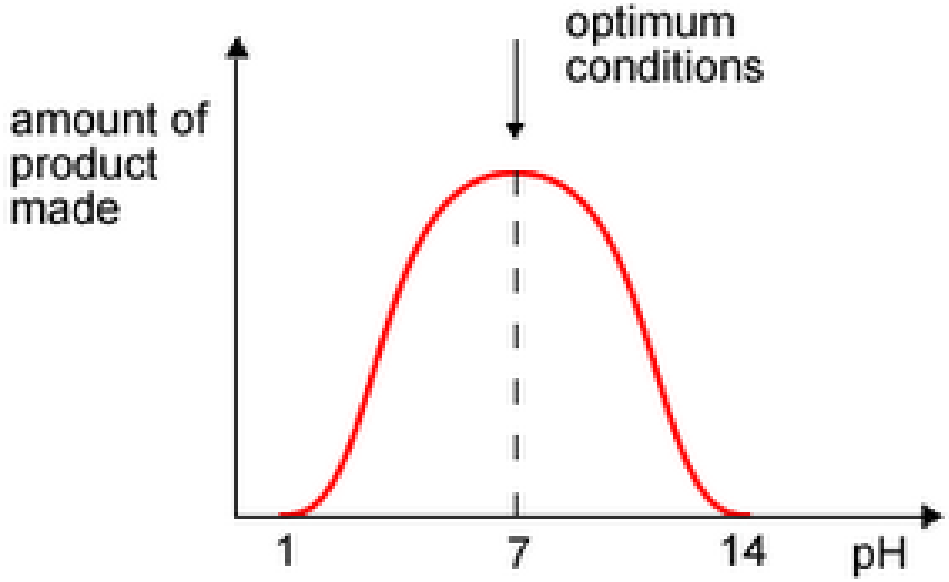
Factors Affecting Enzyme Function

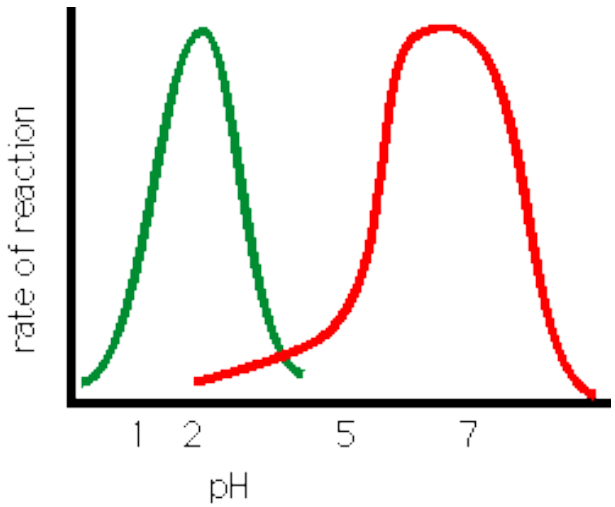
- Increase in temperature = enzyme denatures (breaks bonds) which changes the shape of the enzyme
  - The enzyme can no longer bind to substrates

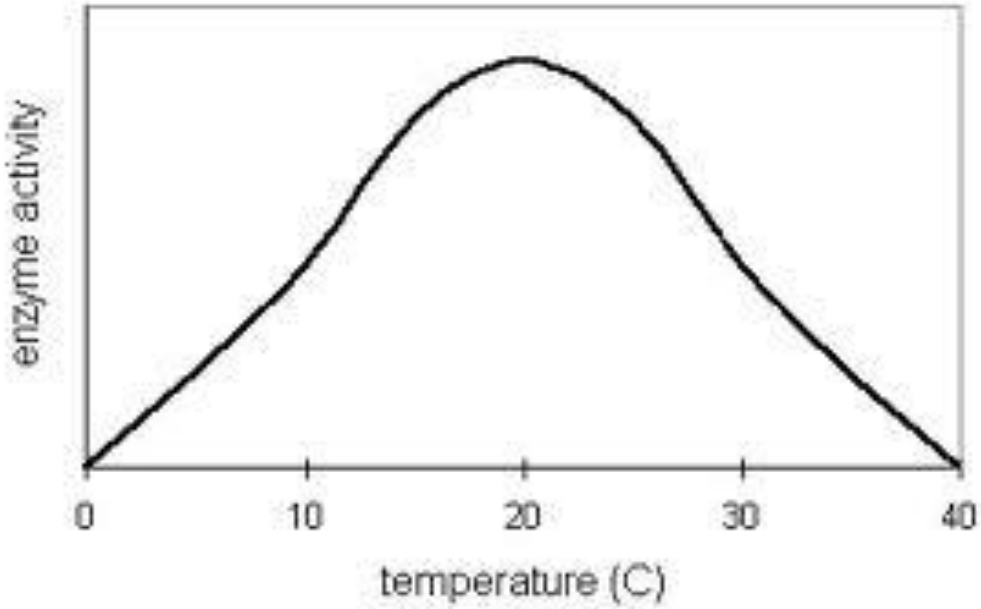
- Decrease in temperature = slows molecular movement and causes less collisions and reactions to occur
  - Does not denature the enzyme

Factors Affecting Enzyme Function

- Change in pH to more acidic or more basic = enzyme denatures
  - The exception are enzymes in the stomach that need an extremely acidic environment to function properly


optimum
conditions
amount of
product
made
1
7
14
pH


rate of reaction
1
2
5
7
pH


enzyme activity
0
10
20
30
40
temperature (C)

- Increase enzyme or substrate concentration = rate (speed) of reactions increases
  - More people working to clean up, means the clean up happens faster

- Addition of inhibitors (molecules that cause the substrate not to bind to the enzyme = decreases the rate of the reaction
  - **Competitive inhibitors** will bind to the active site instead of the substrate
  - **Noncompetitive inhibitors** will bind to another place on the enzyme, but will cause a change in the shape of the active site

Figure 6.14 Enzyme inhibition

(a) Substrate can normally bind to active site of enzyme.

(b) Competitive inhibitor mimics substrate and competes for active site.

(c) Noncompetitive inhibitor alters conformation of enzyme so active site is no longer fully functional.