

# ENZYMES

Unit 3 - Energy

# What is an enzyme?

- What do they do?

# What is an enzyme?



- What do they do?
- Key Things to remember:
  - ▣ They are proteins
  - ▣ They are catalysts
  - ▣ They are reusable - not consumed in reaction
- Basically, they speed up chemical reactions in living systems

# Why do chemical reactions need help?

- Spontaneous vs. Non-spontaneous
- Very few reactions just happen by themselves
  - If they do, it's very slow.
  - Why is there resistance?
  - What is another way to speed up a reaction?



# Enzymes!

- Enzymes catalyze reactions by assisting molecules into the transition state
  - Assist energy absorption = unstable
- Do not change the overall  $\Delta G$  of the reaction
  - They only speed up reactions that would happen anyway



# Transition state



- How does a molecule reach the transition state?
  - Molecules must absorb energy from their surroundings
  - The increased energy makes the molecule unstable
  - Bonds are more likely to break
  
- This energy is called the activation energy

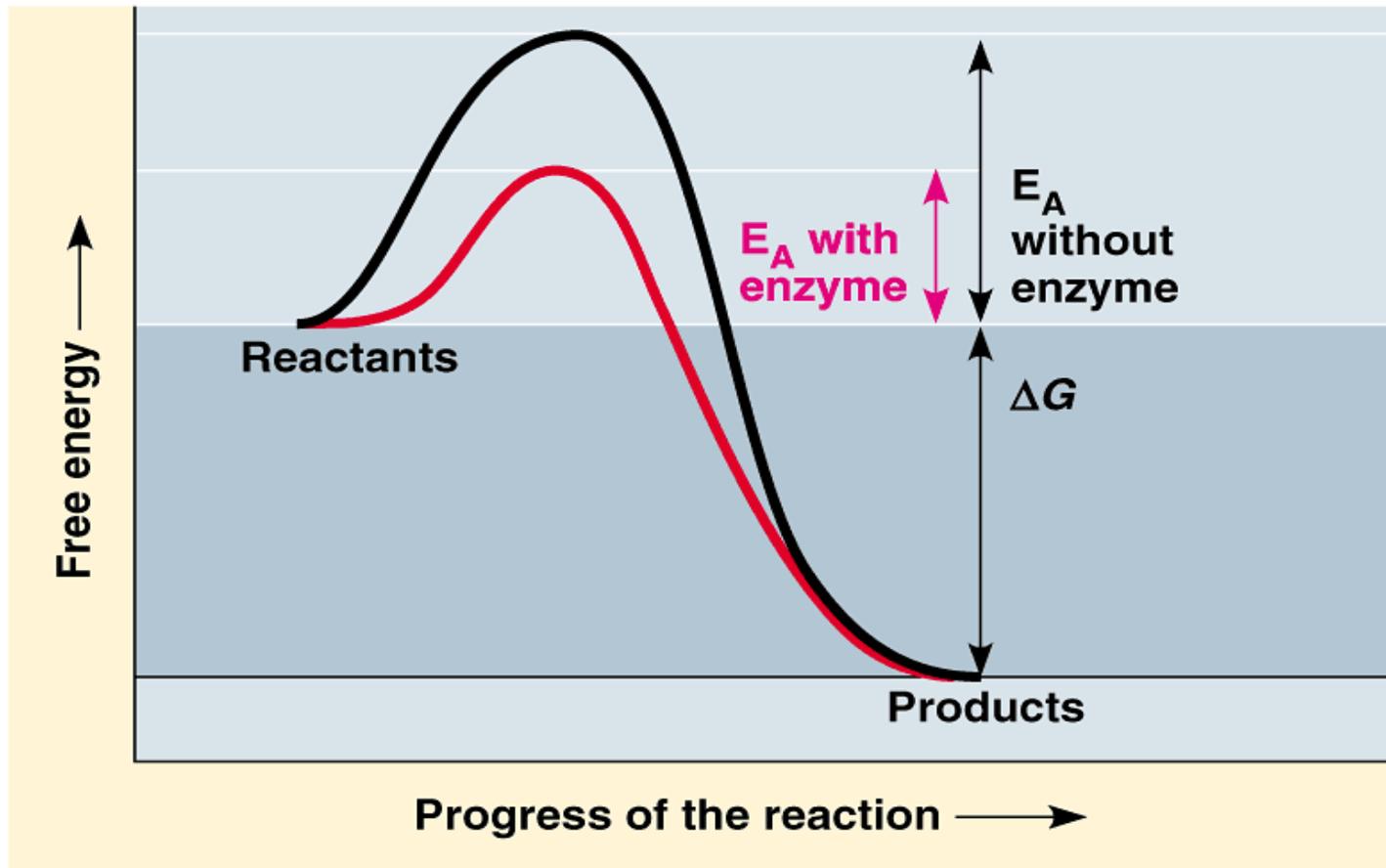
# How are they helping in chemical reactions?

- Made from protein = specific shape
  - Only specific molecules can bind to specific enzymes
    - Shape
    - Charge



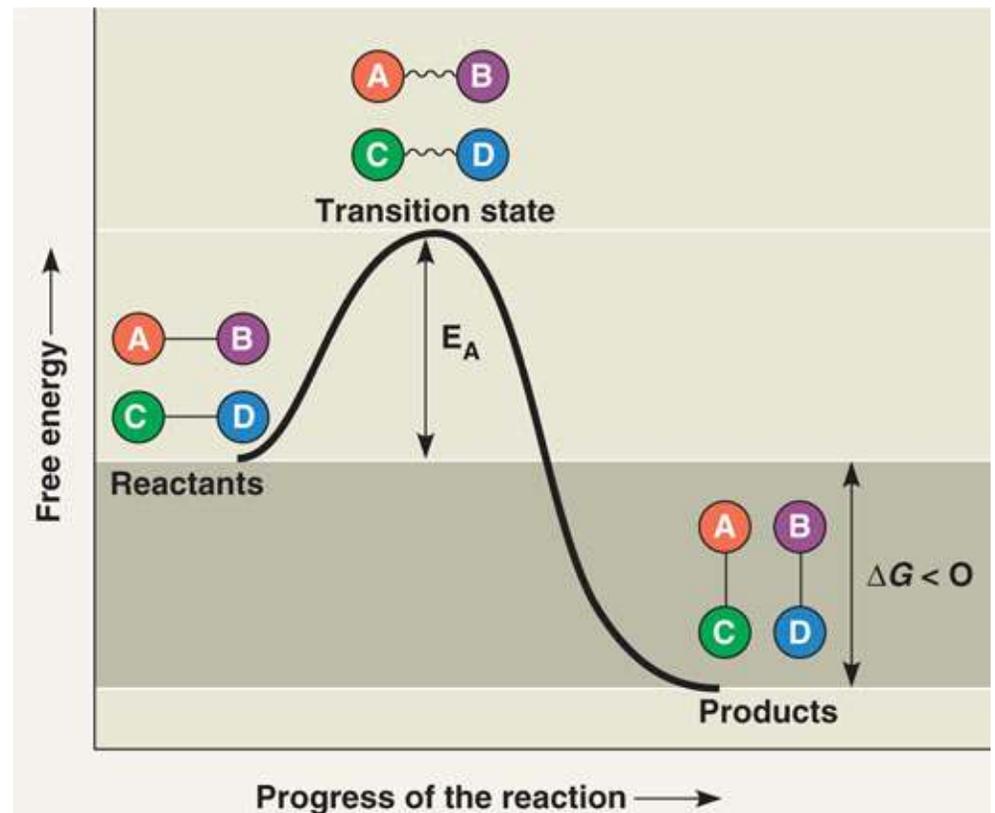
# How do enzymes actually work?

- Enzymes decrease the amount of Activation energy ( $E_a$ ) needed for a reaction to occur



# Activation energy ( $E_A$ )

- $E_A$ : Amount of energy needed for a reaction to occur
- Energy to break or rearrange chemical bonds
  - Heat can do it – faster moving atoms



# Why do we need enzymes?



- Heat is a poor catalyst for living organisms
  - Why?
- If we heated everything up, all the reactions would happen simultaneously
  - Denature
  - A bad fever and regulated body temp
- Living organisms need something that is less destructive and controllable

# Enzyme Specificity



- **Substrate:** the reactant that an enzyme acts on
- The enzyme binds to the substrate, forms the enzyme-substrate complex and creates a product
- Substrates are specific

1 Substrates enter active site; enzyme changes shape such that its active site enfolds the substrates (induced fit).

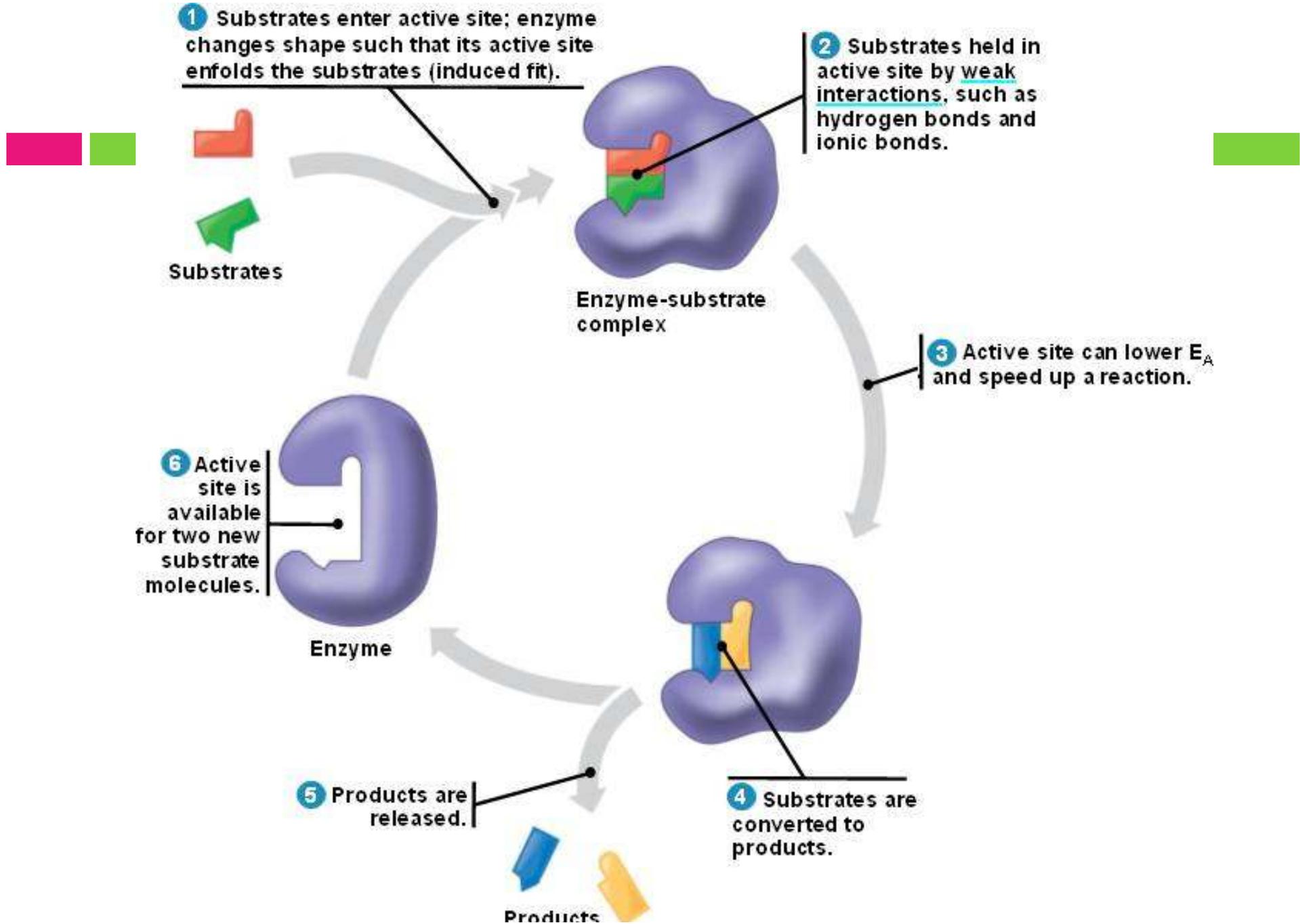
2 Substrates held in active site by weak interactions, such as hydrogen bonds and ionic bonds.

3 Active site can lower  $E_A$  and speed up a reaction.

4 Substrates are converted to products.

5 Products are released.

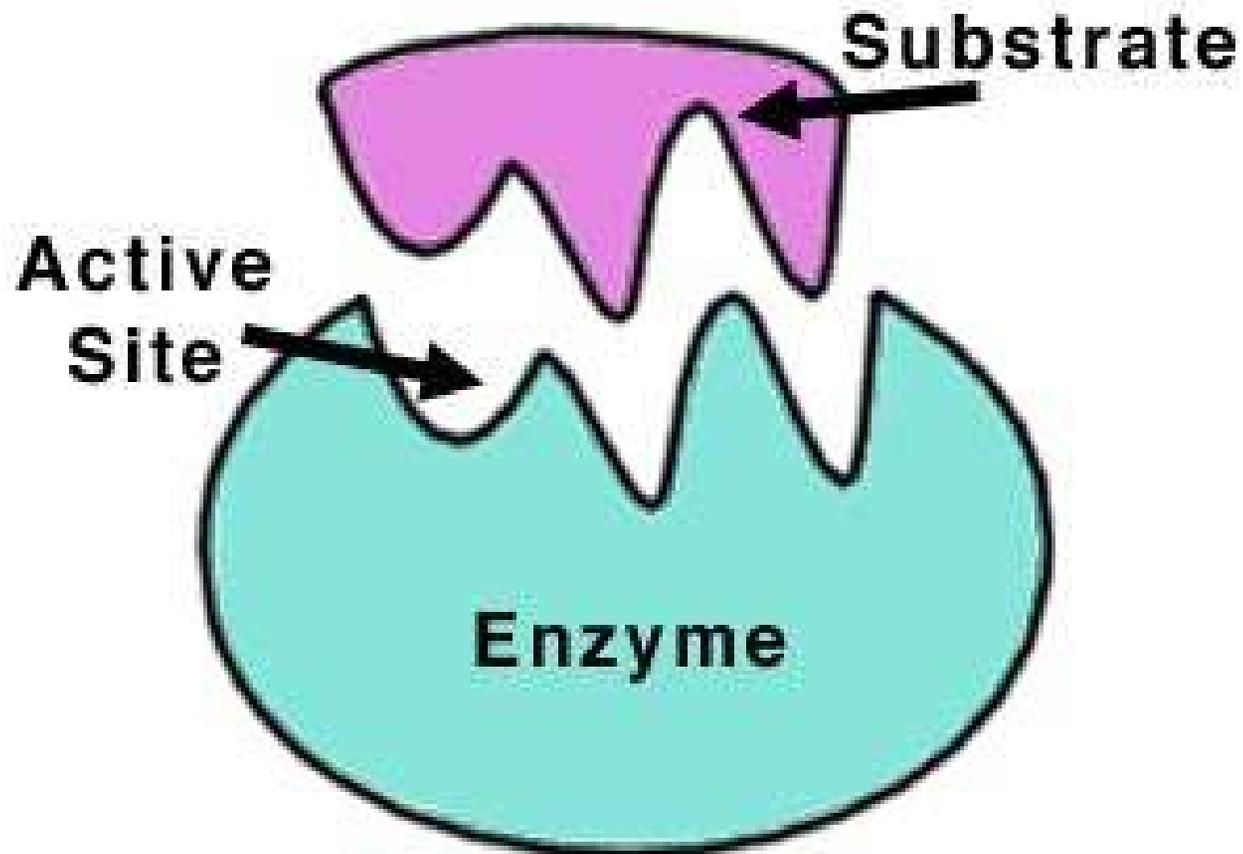
6 Active site is available for two new substrate molecules.



# Enzyme Specificity

- The specificity of enzymes is directly related to their shape and the shape of the substrate.
- Remember protein shape?
- Only part of the enzyme actually binds to the substrate: **active site**
- The specificity of an enzyme is due to a compatible fit between the active site and the substrate. (**Lock and Key**)

- The substrate fits into the active site



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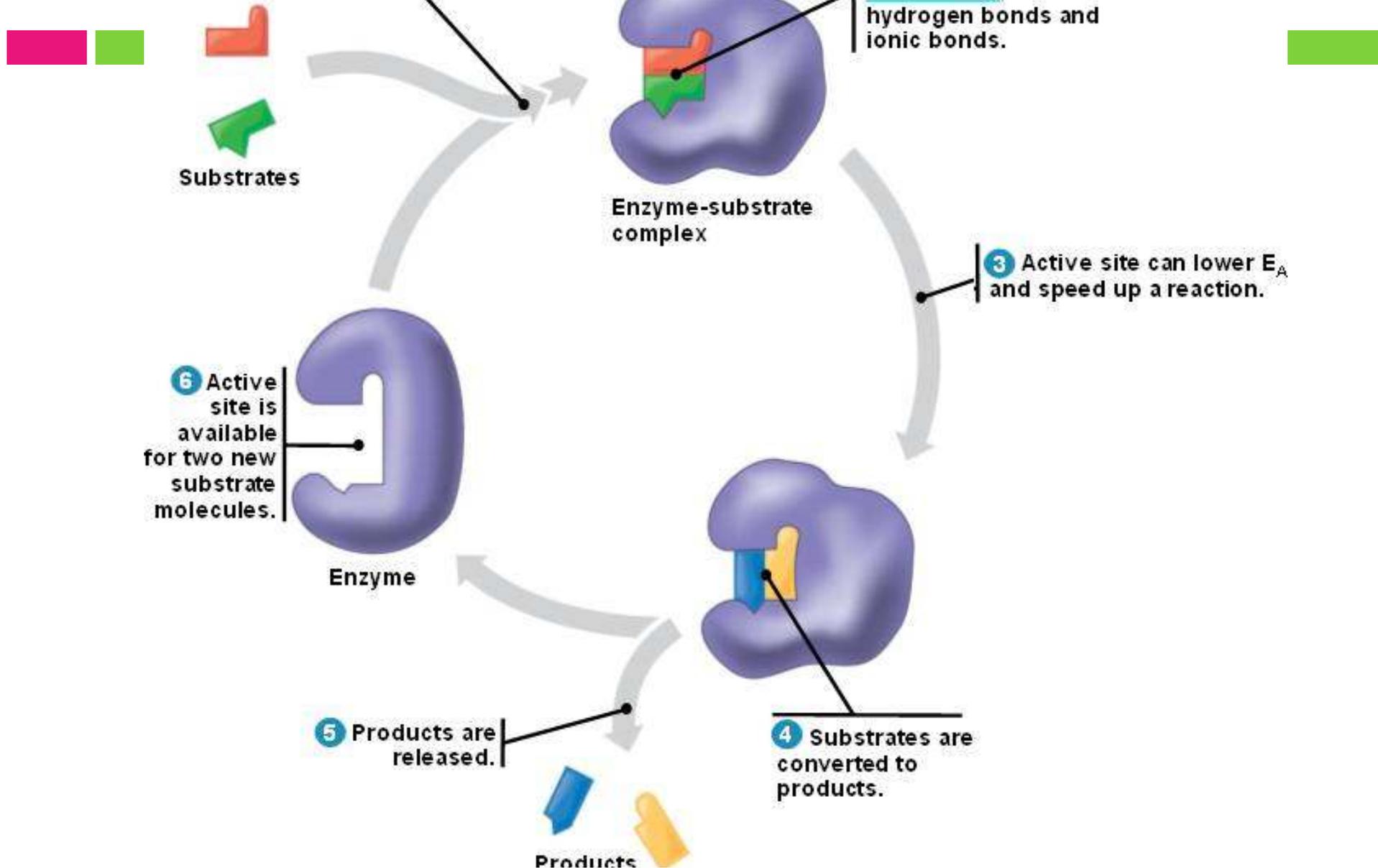
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# Enzyme-Substrate Complex



- When the substrate binds to the active site, the enzyme changes shape: **Induced fit**
- Like a handshake
- Why does this happen?

# Enzyme-Substrate Complex

- Interactions between the enzyme amino acids and substrate a.a. cause even more change
  
- Then what?
- Reaction changes the substrate
- Weak interactions end- product released
- Enzyme remains unchanged and finds another substrate
  - Can catalyze reversible reactions
  - Always goes towards equilibrium

# How do enzymes actually work?



- We know what they do... but how do they do that?
  1. Template for substrate orientation
  2. Physically stretch substrates
  3. Provide specific microenvironment (pH etc)
  4. Participate directly by assisting bonding

# Enzyme Regulation



- What are some things that affect how an enzyme works?

# Factors Affecting Enzymes

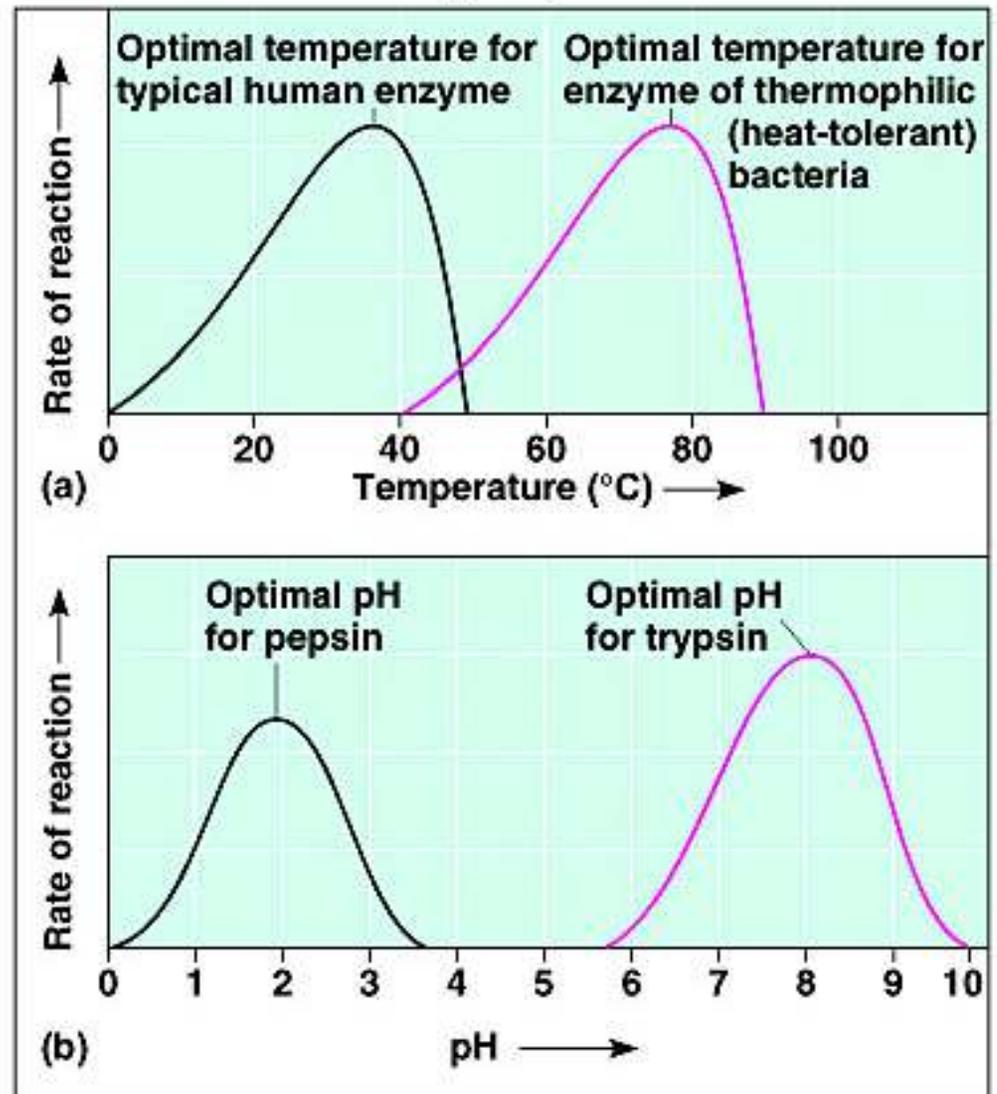


- Reaction rate depends on substrate concentration
  - More substrate = more reaction
- Saturation can occur
  - All enzymes occupied, = max level of reaction
- Other factors
  - pH
  - Temperature
  - Cofactors
  - Enzyme inhibitors

# Temperature and pH

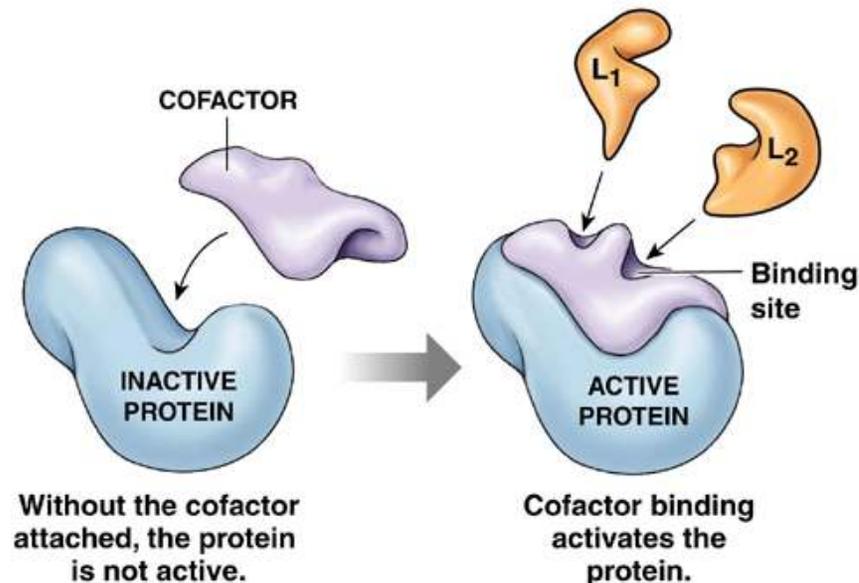
□ Enzymes have an optimal range

- What evidence does the graph give us?
- Why do we see those trends?



# Cofactors and Coenzymes

- Some enzymes need an “add on” to function
- Cofactors (inorganic): Zn, Fe, Cu
- Coenzymes (organic) – vitamins B<sub>1</sub> B<sub>12</sub> B<sub>6</sub>, C, D



# Enzyme Regulation



- The cell has to control when and where enzymes are active and working
- Why?
- How? Any ideas?

# Ways to regulate



□ 1. Stop an enzyme from working after it is already made

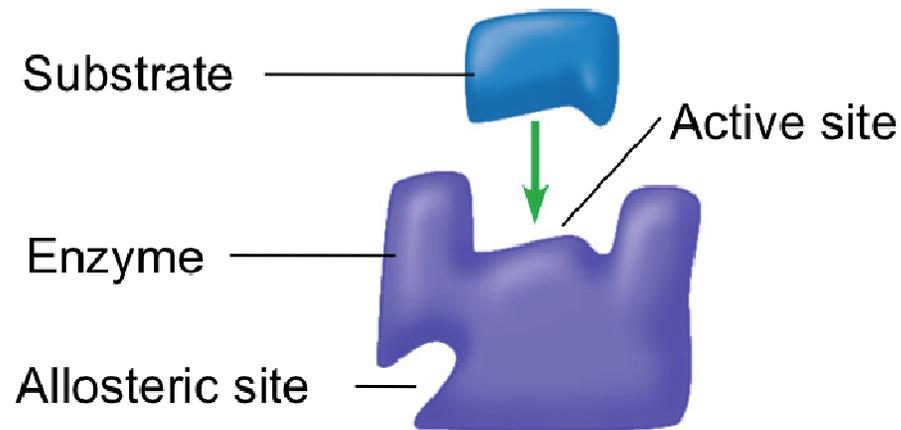
□ 2. Turn off a gene so an enzyme is not produced

# Enzyme Inhibition #1.

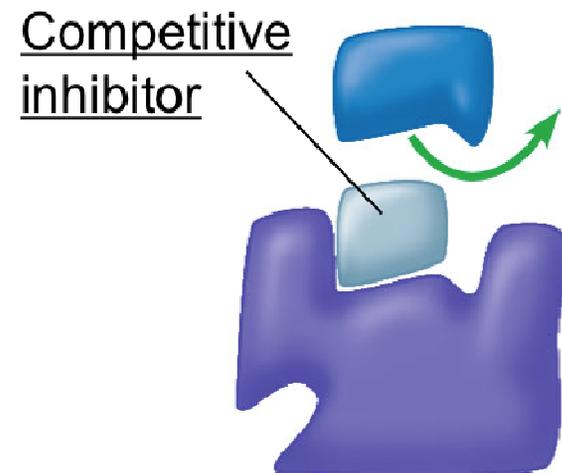
- Turning off enzymes
  - Specific molecules can block action
    - Some permanent
    - Some are reversible

# Competitive inhibition

- Mimic molecules compete with the substrate and bind to the active site
- Results?

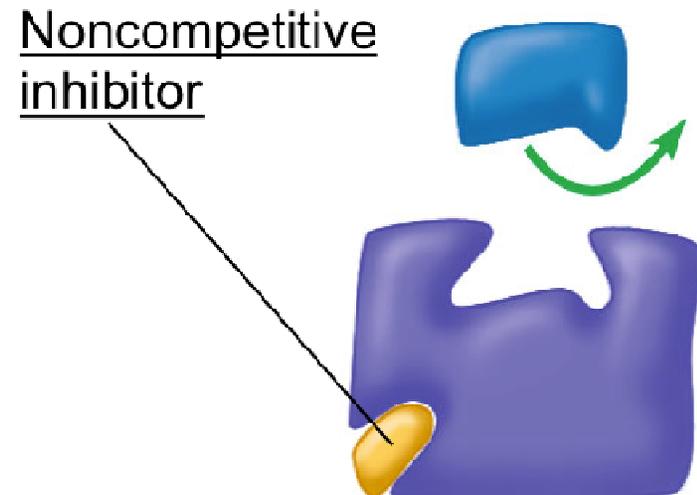
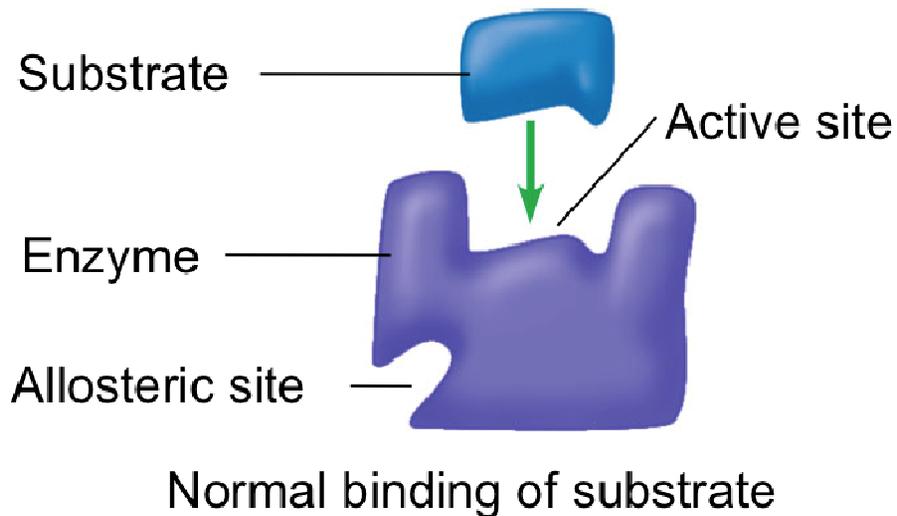


Normal binding of substrate



# Noncompetitive inhibition

- A molecule binds to another part of the enzyme
  - Not active site
  - Causes the enzyme to change shape
  - Results?

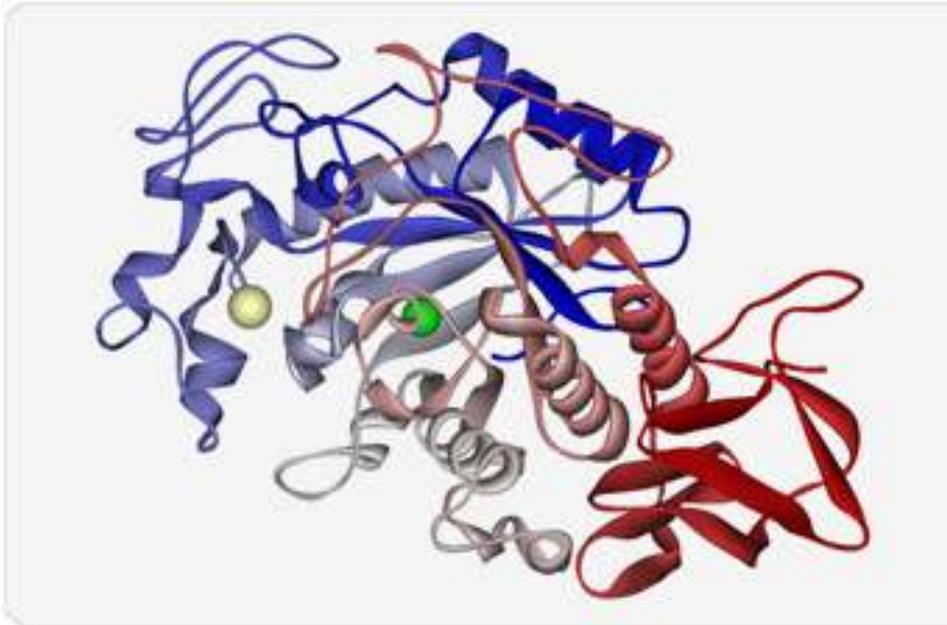


# Is inhibition a bad thing?

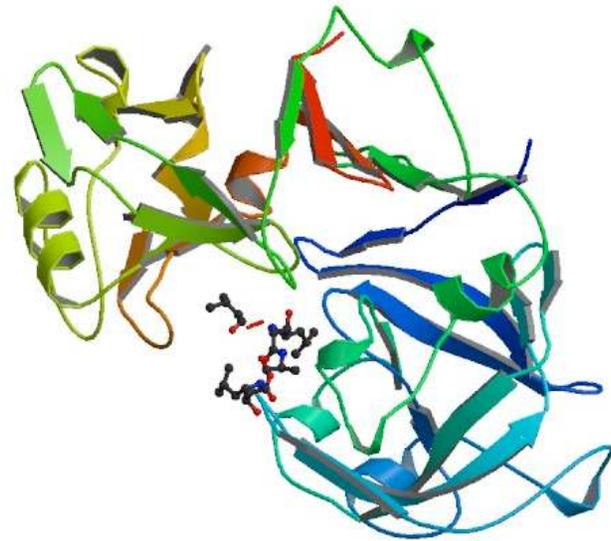


- Many drugs, toxins and poisons work this way
- Cells naturally produce molecules that do the same things
- Many types of inhibition are permanent
- In the cell, most are reversible

□ Amylase

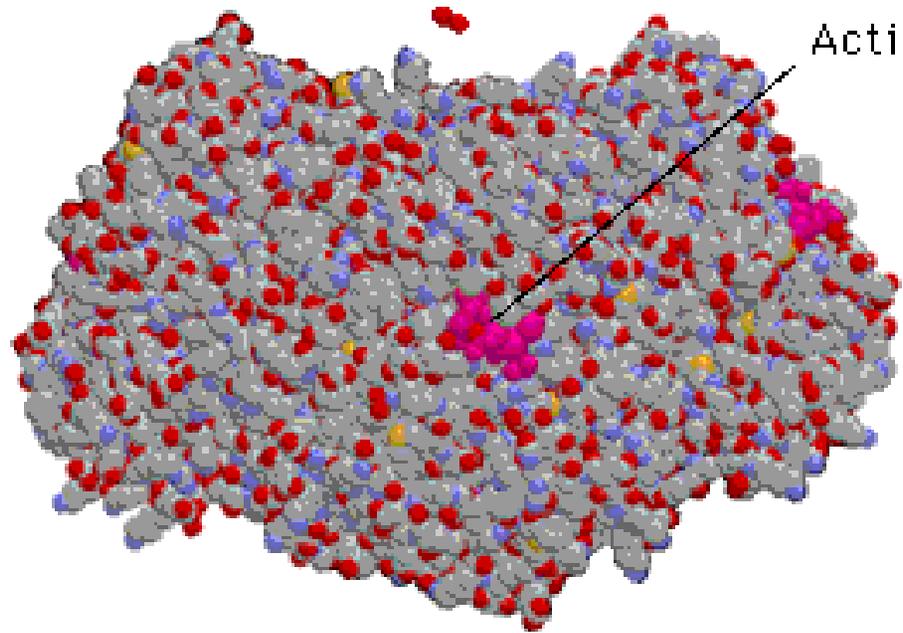


□ Pepsin





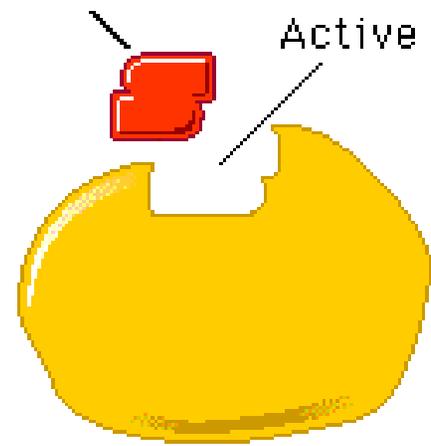
Substrate =  $H_2O_2$



Active site

Molecular model  
of catalase

Substrate

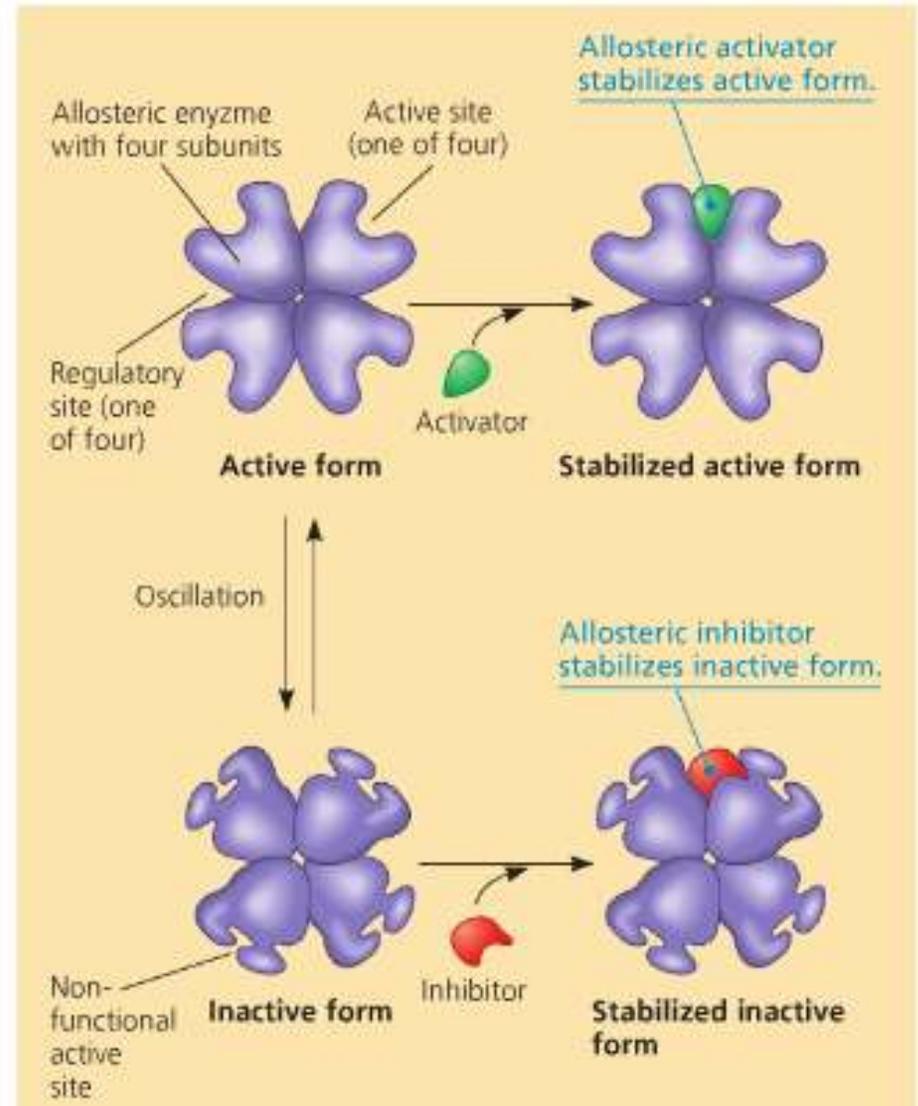


Active site

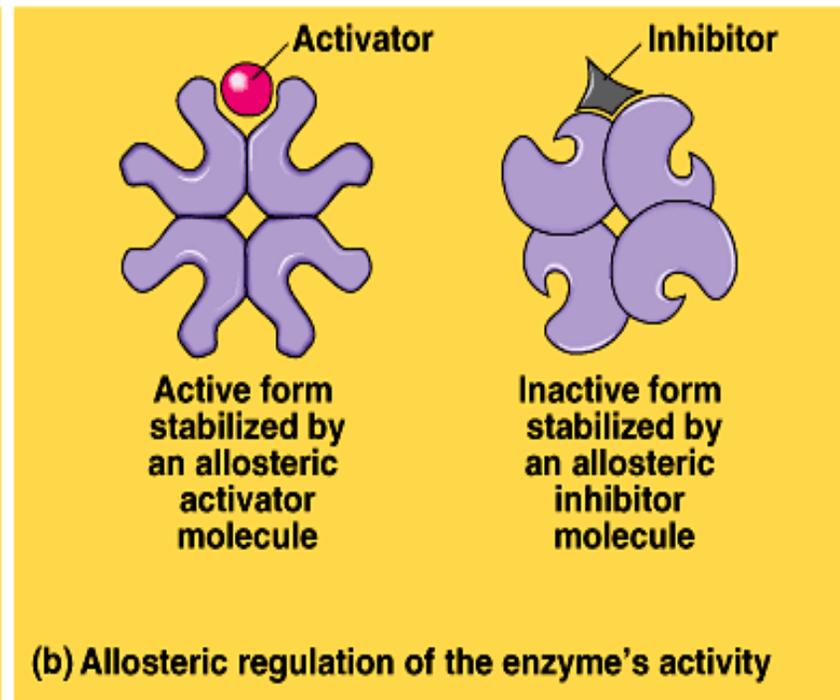
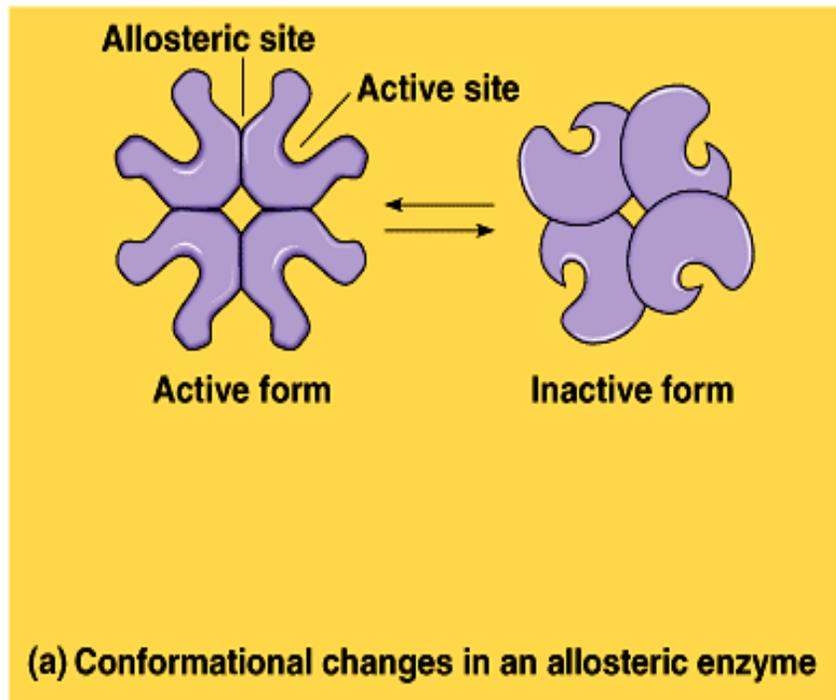
Schematic model  
of an enzyme

# Cellular enzyme regulation: Turning enzymes on or off

- Allosteric Regulation
- Activation or inhibition where a molecule binds to some place other than the active site
- Allosteric enzymes alternate between active or inactive forms
- Molecule binds and stabilizes either position

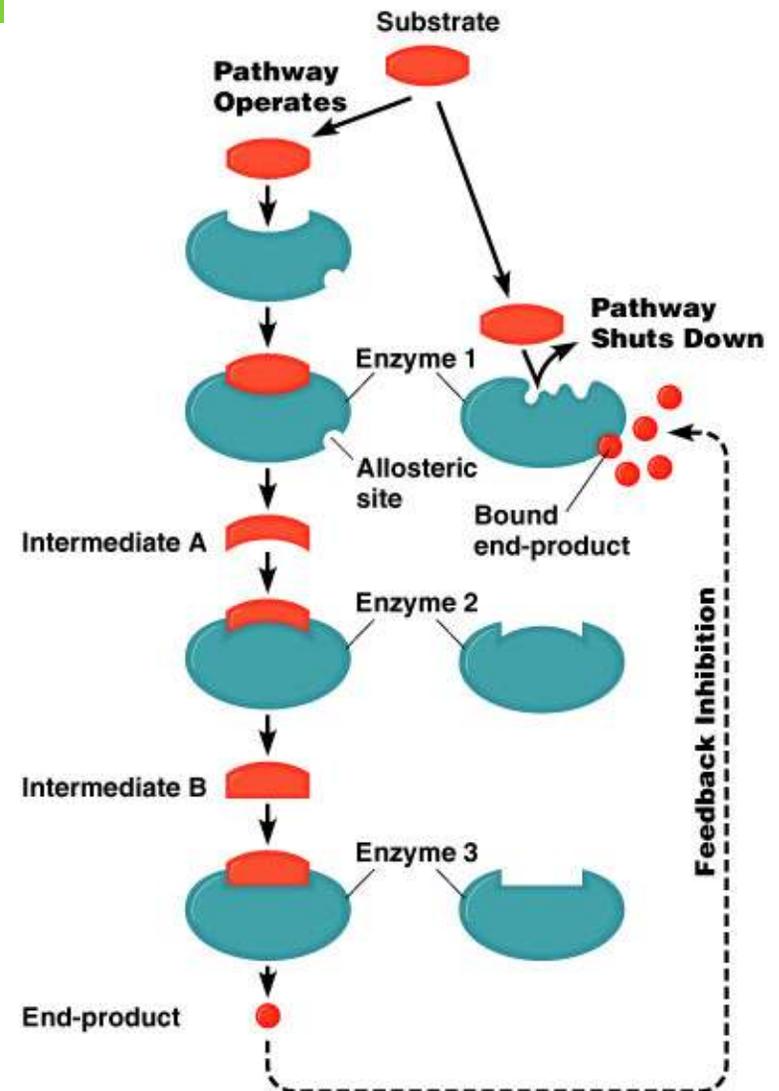


# Allosteric Regulation



# Cellular enzyme regulation: Turning enzymes on or off

- Feedback Inhibition
- The end-product of a reaction acts as an inhibitor on previously used enzymes
- Saves resources
  - Based on product concentration



# Ways to regulate



- We'll look at #2 in another unit
- 2. Turn off a gene so an enzyme is not produced