



ENZYMES (2)

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Energy and biochemical reactions

ΔG = products' free energy - substrates' free energy

- Exergonic : favorable, Release energy, $-\Delta G$, spontaneous
- Endergonic : not favorable, Store energy, ΔG , not spontaneous

ΔG° is free energy when conditions are 25 C° , 1 a.t.m, 7 pH

$$\Delta G = \Delta H - T\Delta S$$

thermodynamic and kinetic theory

Topics discussed in this lecture

How do enzymes work (energy point of view)

Activation energy (ΔG^\ddagger): Energy needed to convert the reactant into the transition state

transition state: An unstable form of the reactant that will convert to the product spontaneously when formed

Enzymes reduce the activation energy by reducing the energy needed to form the transition state

Some reaction contain more than one intermediate between reactants and the products, the highest intermediate's energy is the transition state

How do enzymes work (mechanic point of view)

Proximity and orientation effect

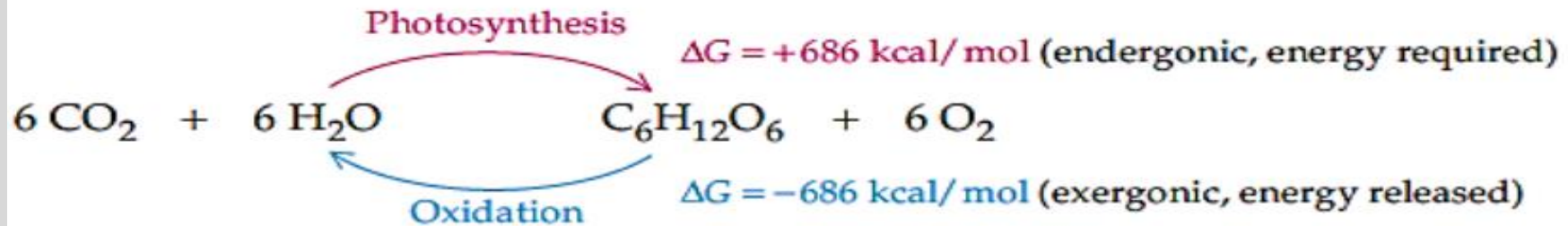
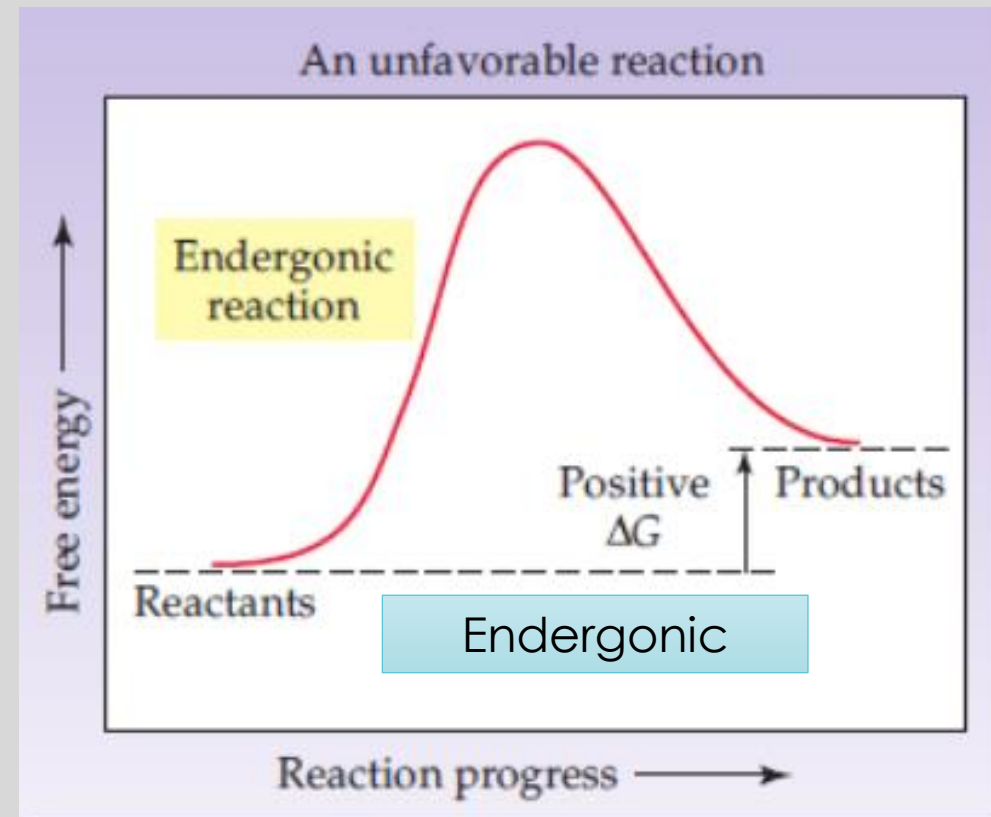
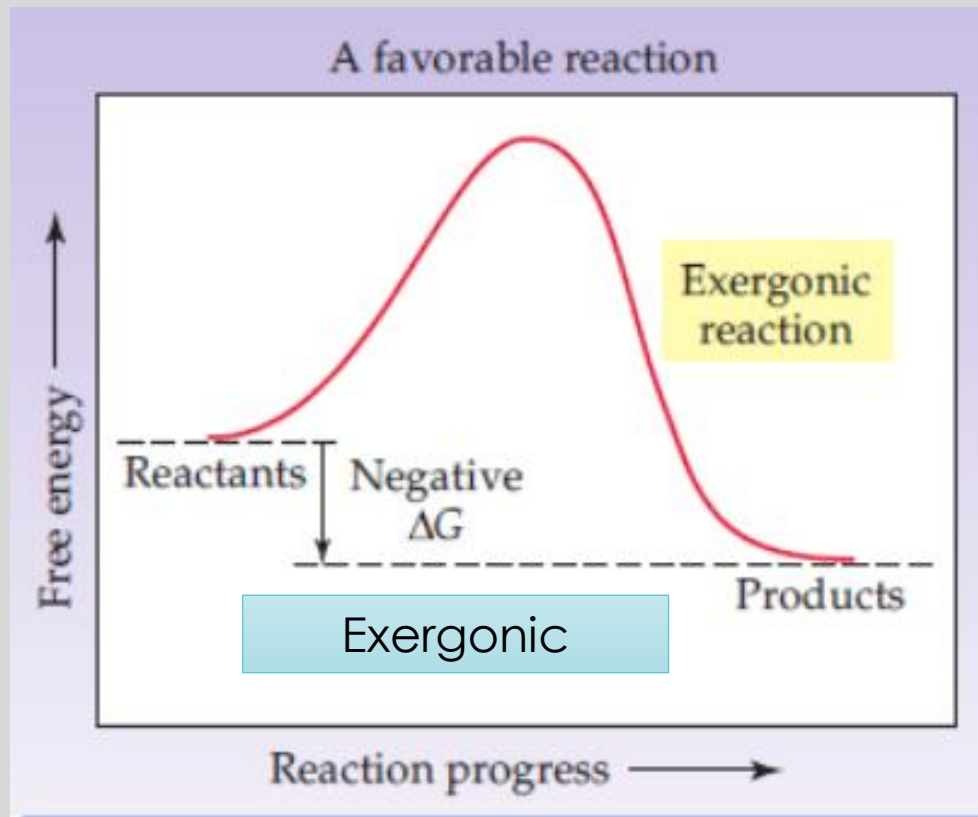
The orientation achieved after the proximity and orientation effect is called near-attack conformations (NACs),

Strain, ionic and covalent effect

Enzymes & biochemical reactions

- Every object have two types of energy: kinetic and potential
- Gibbs energy (free energy): Potential energy of the bonds between the atoms of the molecules' object
- Note: stability always has an inverse relation with respect to energy, objects want to reach stability
- Always: $\Delta = \text{final} - \text{initial}$
- this difference between the products and reactants energy is called ΔG
- $\Delta G = G_{\text{final}} - G_{\text{initial}}$

Enzymes & biochemical reactions



Enzymes & biochemical reactions

Compare / Type of reaction	Exergonic	Endergonic
Is it favorable?	Yes	No
Energy of products vs energy of reactants	Products < substrates	Products > substrates
Sign of ΔG	Negative	Positive
Release or require energy?	Release	Require
Is it spontaneous?	yes	No

Enzymes & biochemical reactions

- What is the difference between ΔG and ΔG° ?
 ΔG refers to the free energy of the reaction regardless to the conditions, so it may change, while ΔG° refers to the free energy of the reaction take into the consideration of the conditions, so it's constant
- ΔG° conditions are 25 C°, 1 a.t.m, 7 pH

Enzymes & biochemical reactions

- When we use the terms “exothermic” and “endothermic”?
- $\Delta G = \Delta H - T\Delta S$ (T: temperature)
- G = energy for bonds between atoms
- H = energy of the whole system
- T = temperature
- S = Entropy

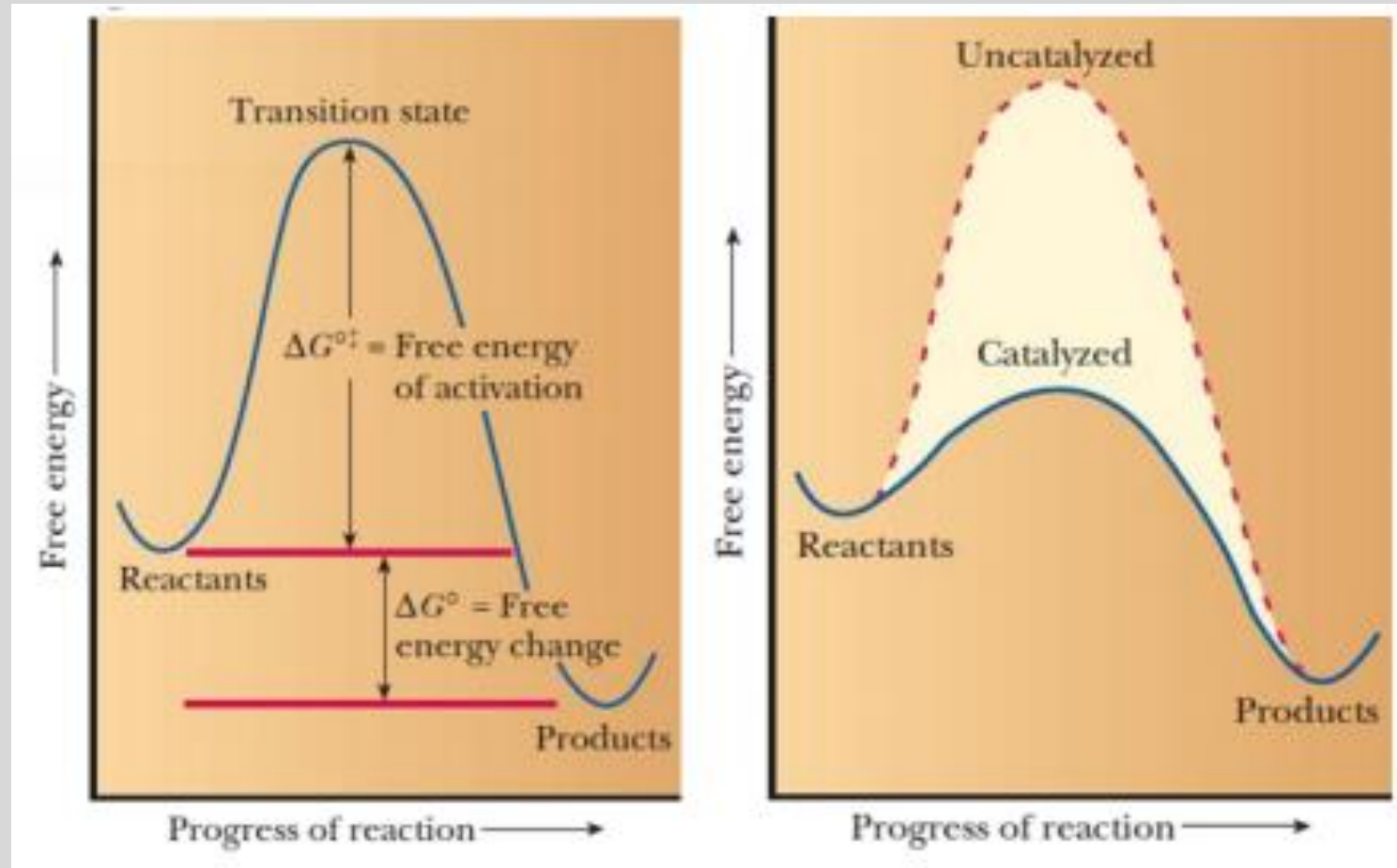
Enzymes & biochemical reactions



Enzymes & biochemical reactions

- We study any reaction from two point of views:
- 1- The kinetic theory (rate): we study the reaction during the pathway without looking at the starting and ending points.
And this is what enzymes do, we study enzymes at kinetic theory, they play with the rate of the reaction, but they don't change at all the level of energy for reactants or products.
- 2- The thermodynamic theory (favorability): concerned with the energy level within the reactants and products, without giving any concern to the road (pathway) in between reactants and products.

How do enzymes work (energy point of view)

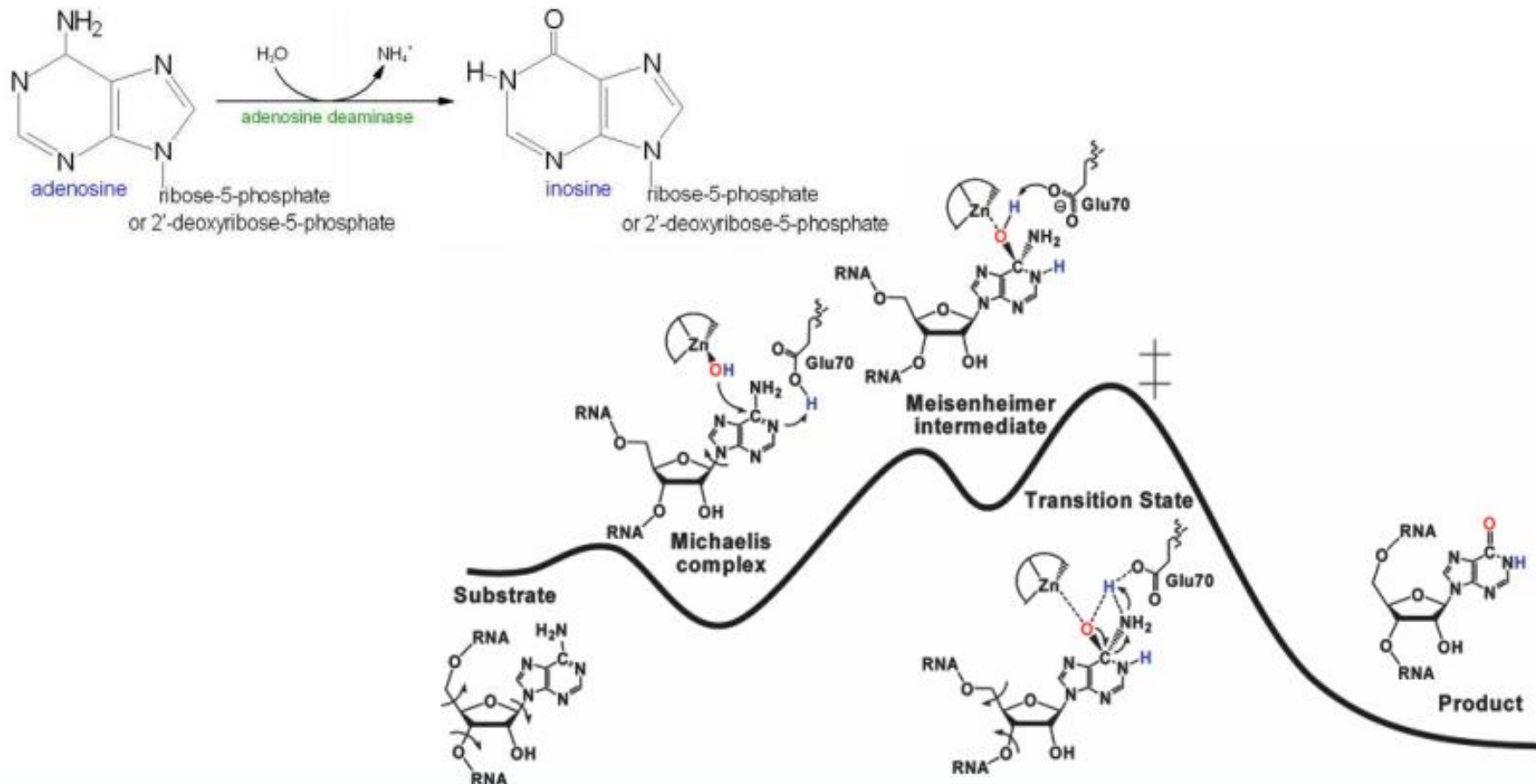


How do enzymes work (energy point of view)

- Activation energy (ΔG^{\ddagger}): Energy needed to convert the reactant into the transition state
- transition state: An unstable form of the reactant that will convert to the product spontaneously when formed
- For reactions to occur, we need a random collision between the reactants, this collision must produce enough energy to convert the reactants into the transition state that will convert into the products
- Usually the collision won't produce enough energy for the reaction to occur
- Enzymes reduce the activation energy by reducing the energy needed to form the transition state, so the energy released from most of the collisions will be enough for the reaction to occur, so the reaction will get faster

How do enzymes work (energy point of view)

→ Some reaction contain more than one intermediate between reactants and the products, the highest intermediate's energy is the transition state



How do enzymes work (mechanic point of view)

- Proximity effect: bring substrate(s) and catalytic sites together, so that reduces time to have a successful collision
- Orientation effect: hold substrate(s) at the exact distance and in the exact orientation necessary for the reaction, The nonpolar amino acids will bind the nonpolar parts of the substrate, while the polar amino acids will start doing the catalysis.
- Note: The orientation achieved after the proximity and orientation effect is called near-attack conformations (NACs), this orientation is a precursor for the transition state

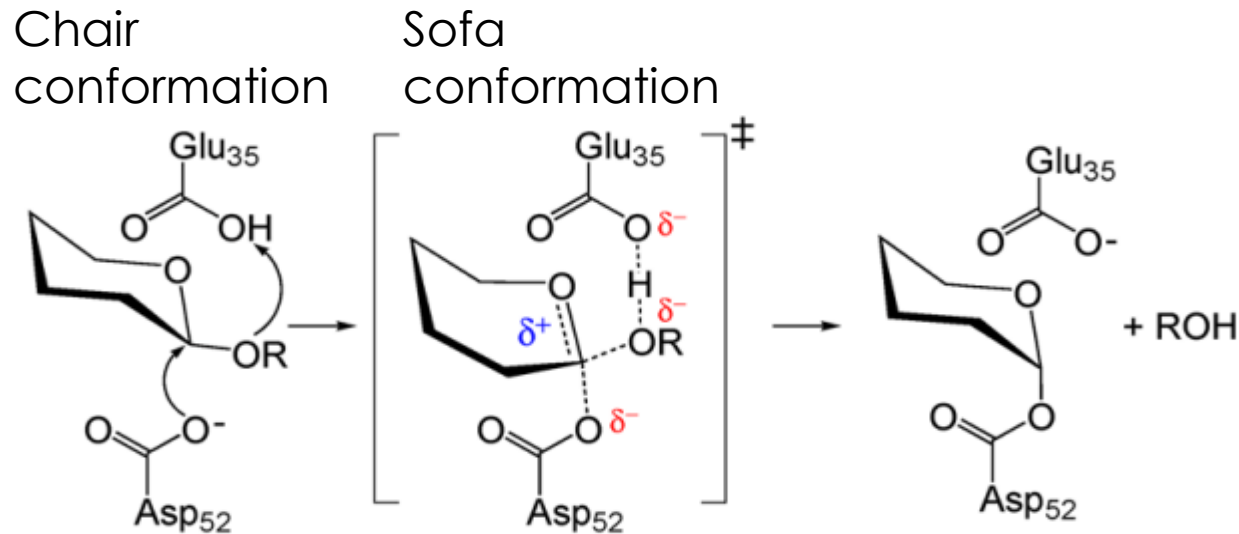
How do enzymes work (mechanic point of view)

◦ How do enzymes work after achieving NAC?

1. Energy effect (bond strain): Lower the energy barrier by inducing strain in bonds in the substrate molecule.

■ Example: lysozyme

The substrate, on binding, is distorted from the typical 'chair' hexose ring into the 'sofa' conformation, which is similar in shape to the transition state



How do enzymes work (mechanic point of view)

2. Catalytic effect (ionic) : Provide acidic, basic, or other types of groups required for catalysis

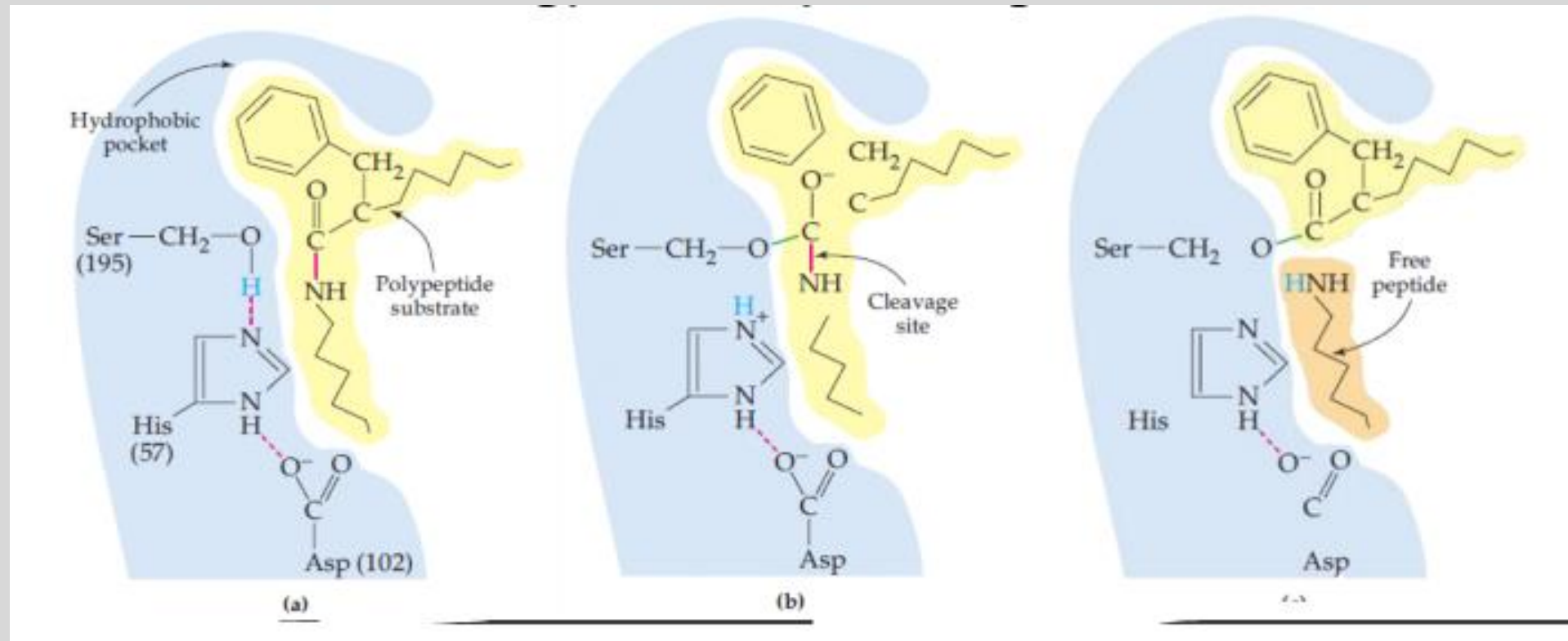
→ The R groups act as donors or acceptors of protons

→ Histidine is an excellent proton donor/acceptor at physiological pH

e.g. serine proteases

chymotrypsin is found that break proteins inside the intestine

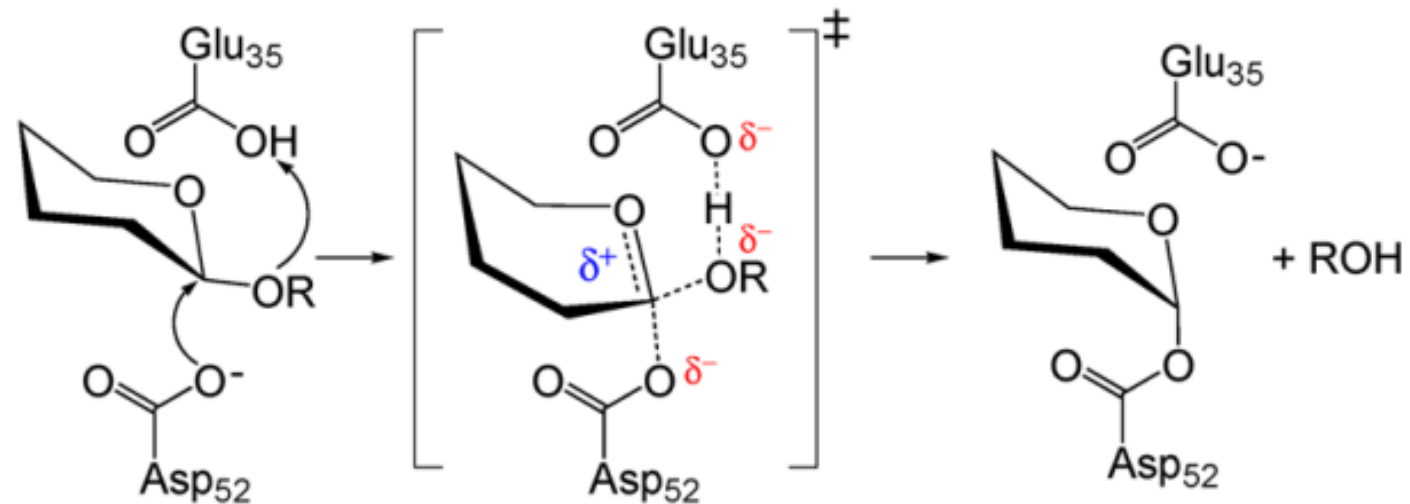
When we say "Catalytic effect" only, we mean the ionic effect



How do enzymes work (mechanic point of view)

- Example: lysozyme

The substrate, on binding, is distorted from the typical 'chair' hexose ring into the 'sofa' conformation, which is similar in shape to the transition state



How do enzymes work (mechanic point of view)

3. Catalytic effect (covalent)

- A covalent intermediate forms between the enzyme or coenzyme and the substrate
 - Examples of this mechanism is proteolysis by serine proteases, which include digestive enzymes (trypsin, chymotrypsin, and elastase)

