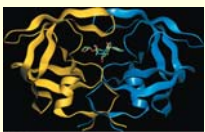


## General Chemistry II



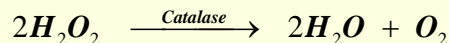
### Chapter 23 Enzymes

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OF CHARLOTTE

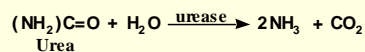
Thrive

## Enzymes

- **Enzyme:** a biological catalyst



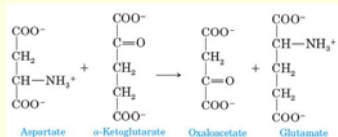
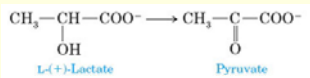
- Enzymes can increase the rate of a reaction by a factor of  $10^9$  to  $10^{20}$  over an uncatalyzed reaction.
- Most enzymes are extremely specific



23-1

## Enzyme Classification

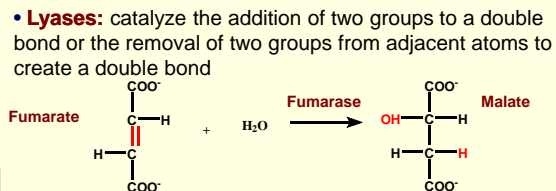
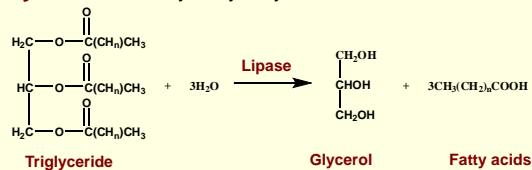
- **Enzyme:** -ase suffix, means a compound is an enzyme
- **Oxidoreductases:** catalyze oxidations and reductions
- **Transferases:** catalyze the transfer of a group of atoms from one molecule to another



23-2

## Enzyme Classification

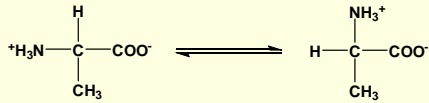
- **Hydrolases:** catalyze hydrolysis reactions
- **Lyases:** catalyze the addition of two groups to a double bond or the removal of two groups from adjacent atoms to create a double bond



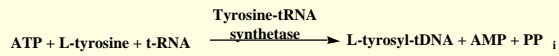
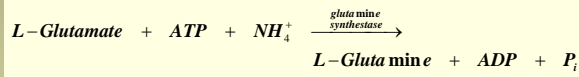
23-3

## Enzyme Classification

- Isomerases:** catalyze isomerization reactions

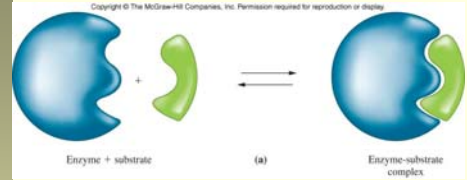


- Ligases:** catalyze the joining of two molecules

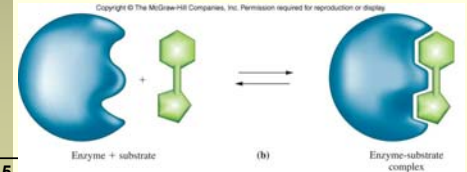


23-4

## Enzyme-Substrate Complex



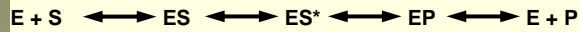
Lock and Key Model



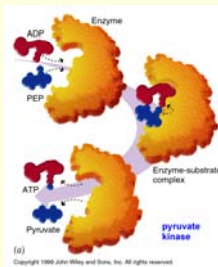
Induced Fit Model

23-5

## Enzyme-Substrate Complex



Enzyme + substrate  $\rightleftharpoons$  Enzyme-substrate complex  $\rightleftharpoons$  Transition state  $\rightleftharpoons$  Enzyme-product complex  $\rightleftharpoons$  Enzyme + Product



23-6

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1. An enzyme with a coenzyme positioned to react with two substrates.

2. Coenzyme picks up a functional group from substrate 1.

3. Coenzyme transfers the functional group to substrate 2.

4. Products are released from enzyme.

Functional group (F)

Substrate 2 (S<sub>2</sub>)

Substrate 1 (S<sub>1</sub>)

Coenzyme (C)

Enzyme (E)

Apoenzyme + substrate

Cu<sup>2+</sup> Cofactor

Functional enzyme with active binding site

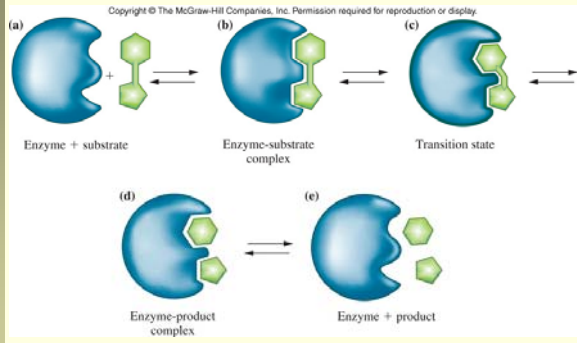
Enzyme-substrate complex

No enzyme-substrate complex. No reaction.

Reaction occurs.

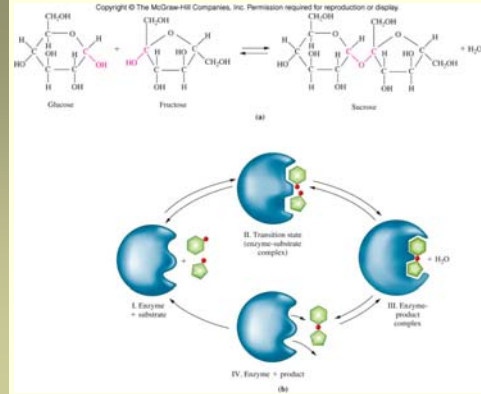
23-6b

## Enzyme-Substrate Complex

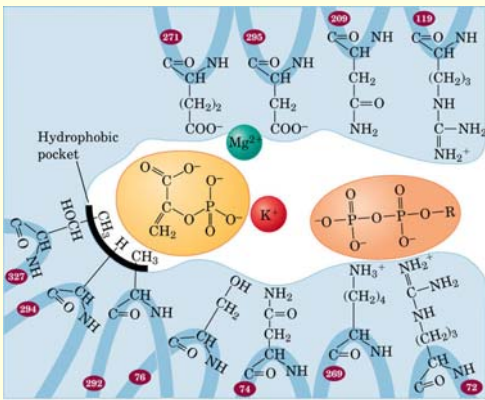


23-6c

## Enzyme-Substrate Complex

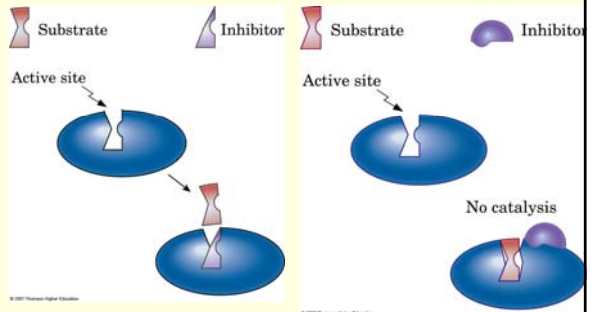


## Enzyme-Substrate Complex



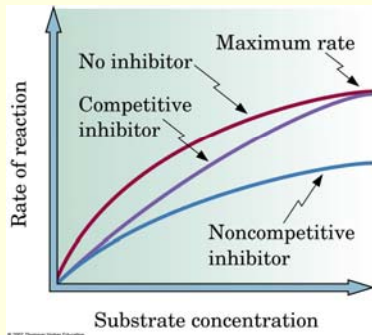
23-7

## Enzyme-Substrate Inhibition



23-8

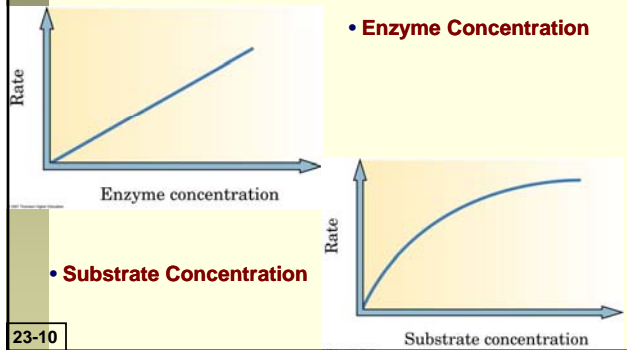
## Enzyme-Substrate Inhibition



23-9

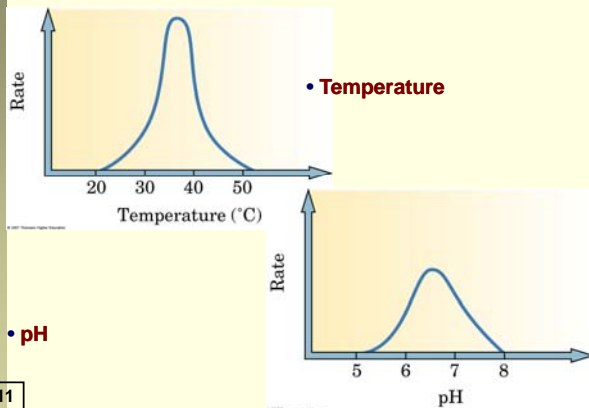
## Enzyme Activity

- **Enzyme activity:** a measure of how much a reaction rate is increased.



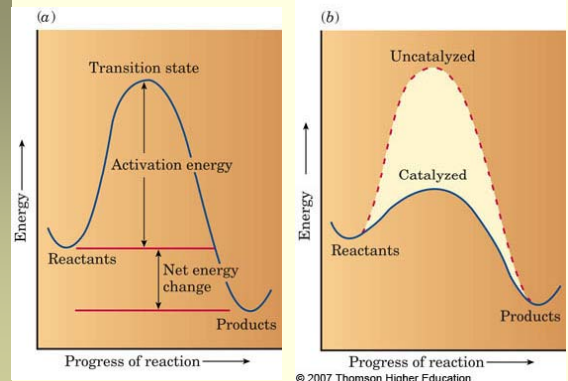
23-10

## Enzyme Activity



23-11

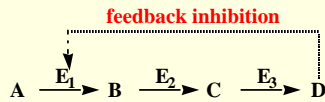
## Enzyme Activity



23-12

## Enzyme Regulation – Feedback

- **Feedback control (inhibition)**



23-13

## Enzyme Regulation – Proenzymes



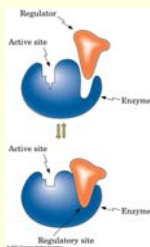
**Trypsinogen (zymogen)**



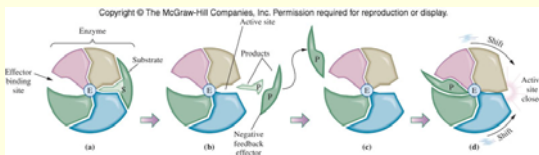
**Trypsin**

23-14

## Enzyme Regulation – Allosterism



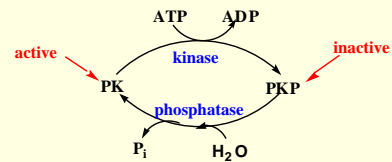
- **Allosteric enzyme:** enzymes with extra binding sites (other than the active site)
- **Negative modulation:** inhibition of enzyme action
- **Positive modulation:** stimulation of enzyme action



23-15

## Enzyme Regulation – Protein Modification

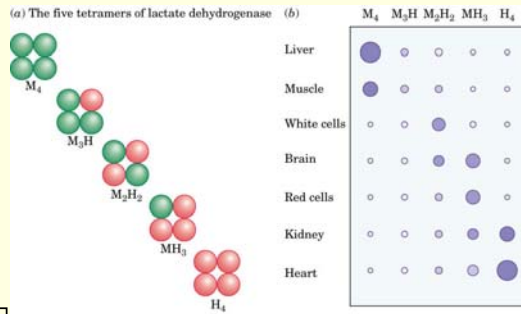
- **Protein modification:** the process of affecting enzyme activity by covalently modifying it.
  - The best known examples of protein modification involve phosphorylation/dephosphorylation.
  - Example: pyruvate kinase (PK) is the active form of the enzyme; it is inactivated by phosphorylation to pyruvate kinase phosphate (PKP).



23-16

## Enzyme Regulation – Isoenzyme

- **Isoenzyme:** an enzyme that occurs in multiple forms; each catalyzes the same reaction.



23-17

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## Enzymes and Medicine

Enzyme	Body Fluid	Disease Diagnosed
Alanine aminotransferase (ALT)	Serum	Hepatitis
Acid phosphatase	Serum	Prostate cancer
Alkaline phosphatase (ALP)	Serum	Liver or bone disease
Amylase	Serum	Pancreatic disease
Aspartate aminotransferase (AST)	Serum, Cerebrospinal fluid	Heart attack or hepatitis
Lactate dehydrogenase (LDH)	Serum	
Creatine phosphokinase (CK)	Serum	Heart attack
Phosphohexose isomerase (PHI)	Serum	Heart attack

23-18