

# ENZYMES

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# What is an Enzyme?

- Enzymes are types of Proteins!
- They end in “ase”
- **They speed up chemical reactions...**
  - Also Known As CATALYST



# ENZYMES are biological catalyst

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## ENZYME CHARACTERISTICS

- 1. The basic function of an enzyme is to increase the rate of a reaction*
- 2. Most enzymes act specifically with only one reactant (called a substrate) to produce products*
- 3. The most remarkable characteristic is that enzymes are regulated from a state of low activity to high activity and vice versa*

## CHARACTERISTICS

- Enzymes *speed up* the reaction by lowering the activation energy of the reaction.
- Their presence *does not effect* the nature and properties of *end product*.
- They are *highly specific* in their action that is each enzyme can catalyze one kind of substrate.
- Small amount of enzymes can accelerate chemical reactions.
- Enzymes are *sensitive* to change in pH, temperature and substrate concentration.
- *Turnover number* is defined as the number of substrate molecules transformed per minute by one enzyme molecule.

**Catalase turnover number =  $6 \times 10^6$ /min**



# Coenzymes and cofactors

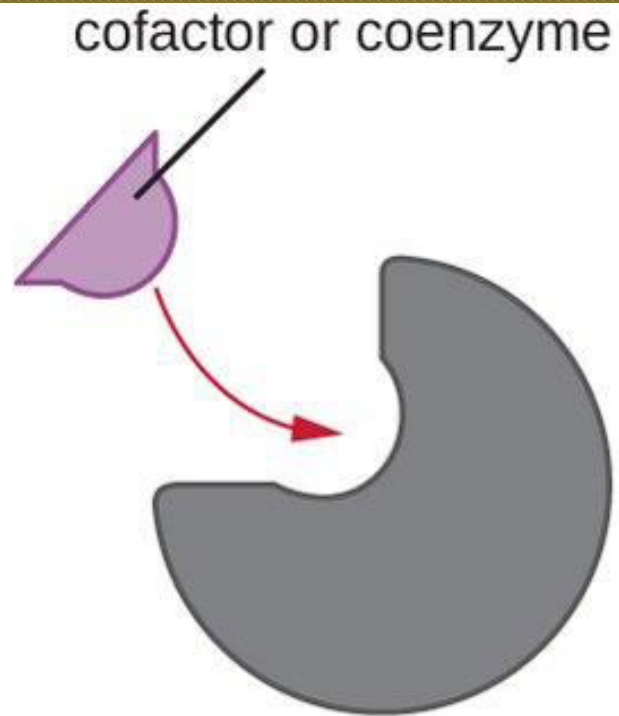
A large number of enzymes require an additional non-protein component to carry out its catalytic functions called as cofactors. A coenzyme or metal ion that is covalently bound to the enzyme protein is called prosthetic group

Cofactors-two types

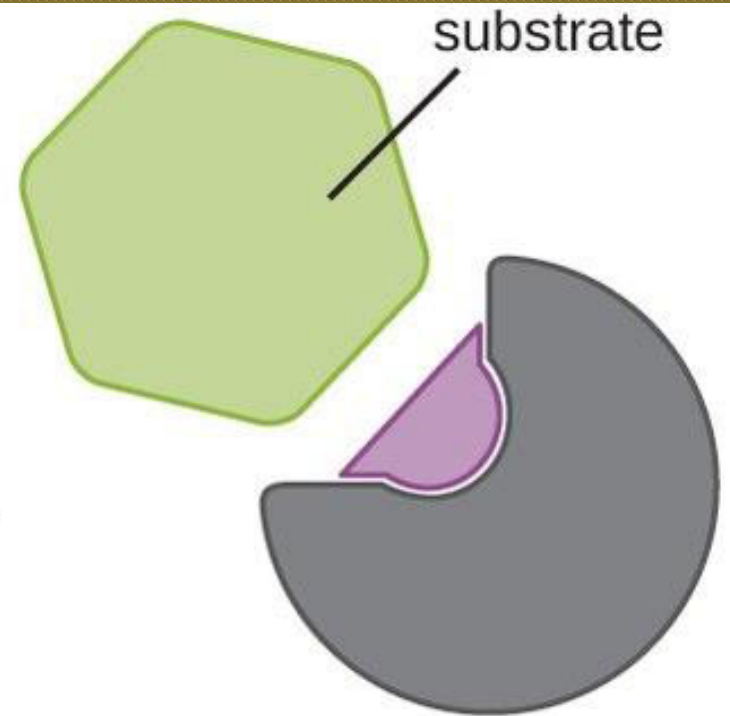
- 1) Inorganic ions such as  $\text{Fe}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Zn}^{2+}$
- 2) A complex organic molecule called coenzyme.

Some enzymes require both a coenzyme and one or more metal ions for their activity.

**Coenzymes function as transient carriers of specific functional groups.**



activation

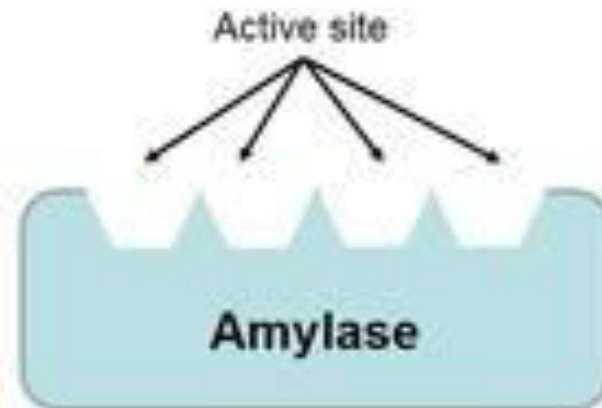


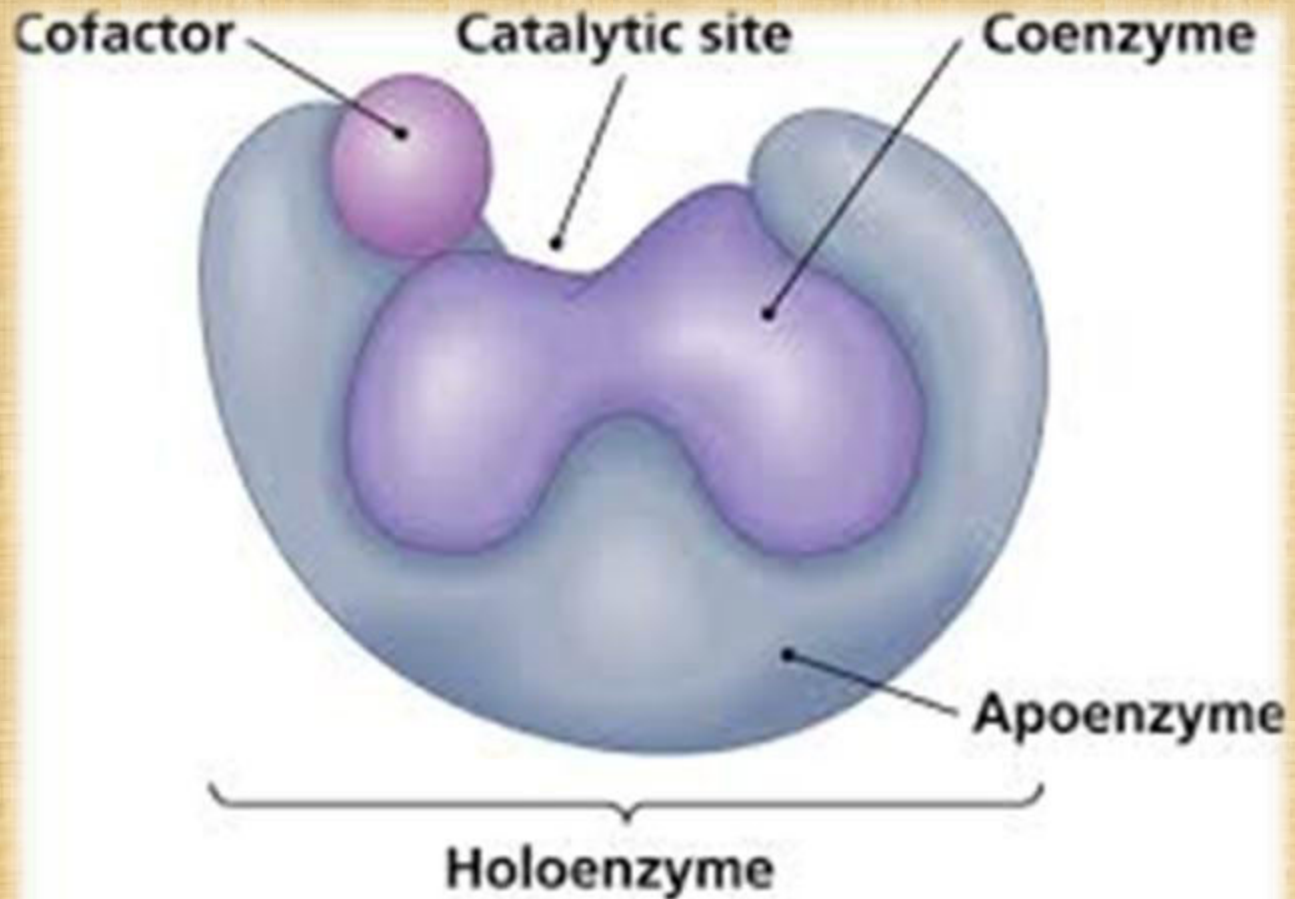
**1** Apoenzyme becomes active by binding of coenzyme or cofactor to enzyme.

**2** Holoenzyme is formed when associated cofactor or coenzyme binds to the enzyme's active site.

# Enzyme Structure

- Enzymes are proteins (chains of amino acids)
- Enzyme will twist and fold into a specific shape due to how the amino acids are attracted to each other
- Enzyme shape attracts specific molecules
  - Substrate: molecules that bind to the enzyme
- Active site: Location on the enzyme where the substrate(s) bind to the enzyme
- Enzyme weakens & breaks the bonds of the substrate
- Ex: Amylase & starch
  - Amylase = Enzyme
  - Starch = Substrate





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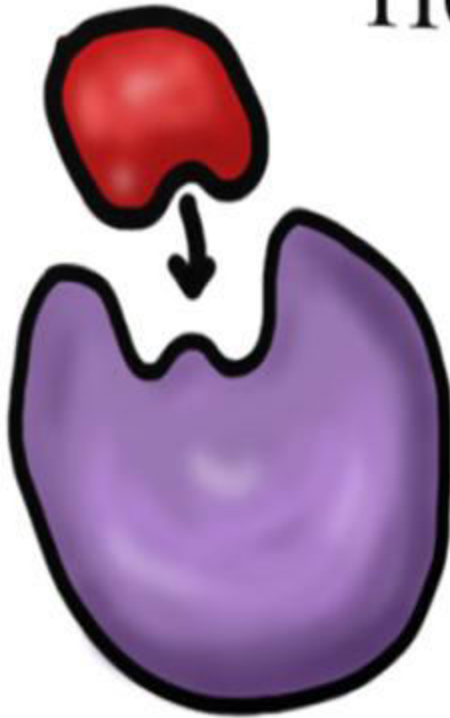




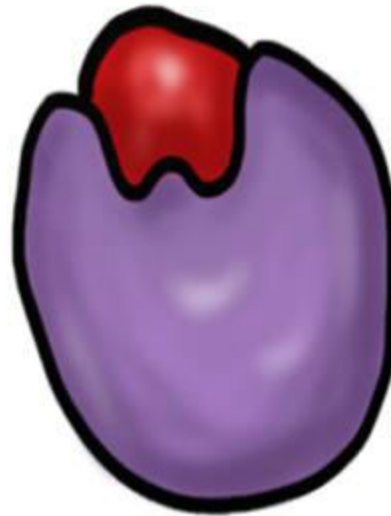
# Allosteric Enzymes

- Allosteric enzymes have one or more allosteric sites
- Allosteric sites are binding sites distinct from an enzyme's active site or substrate-binding site
- Molecules that bind to allosteric sites are called effectors or modulators
- Binding to allosteric sites alters the activity of the enzyme. This is called cooperative binding. Allosteric enzymes display sigmoidal plot of  $V_o$  vs  $[S]$
- Effectors may be positive or negative
- Effectors may be homotropic or heterotropic
- Regulatory enzymes of metabolic pathways are allosteric enzymes (eg: feedback inhibition)

# How Enzymes Work



The substrate (reactant) moves toward the enzyme's active site.



The chemical reaction is triggered by the enzyme.



The enzyme releases the products.

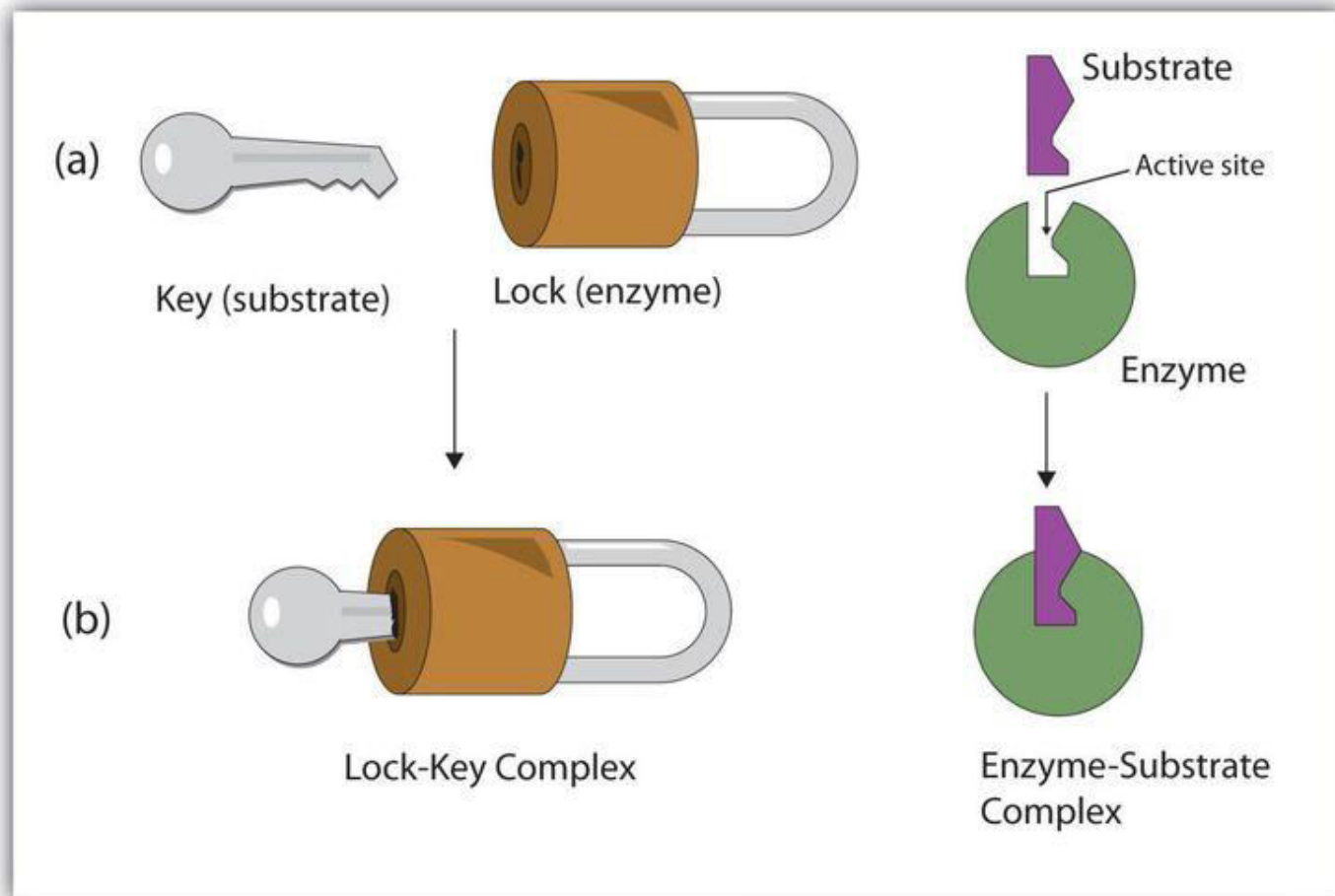
# Enzyme action

Like all catalysts, enzymes accelerate the rates of reactions while experiencing no permanent chemical modification as a result of their participation.

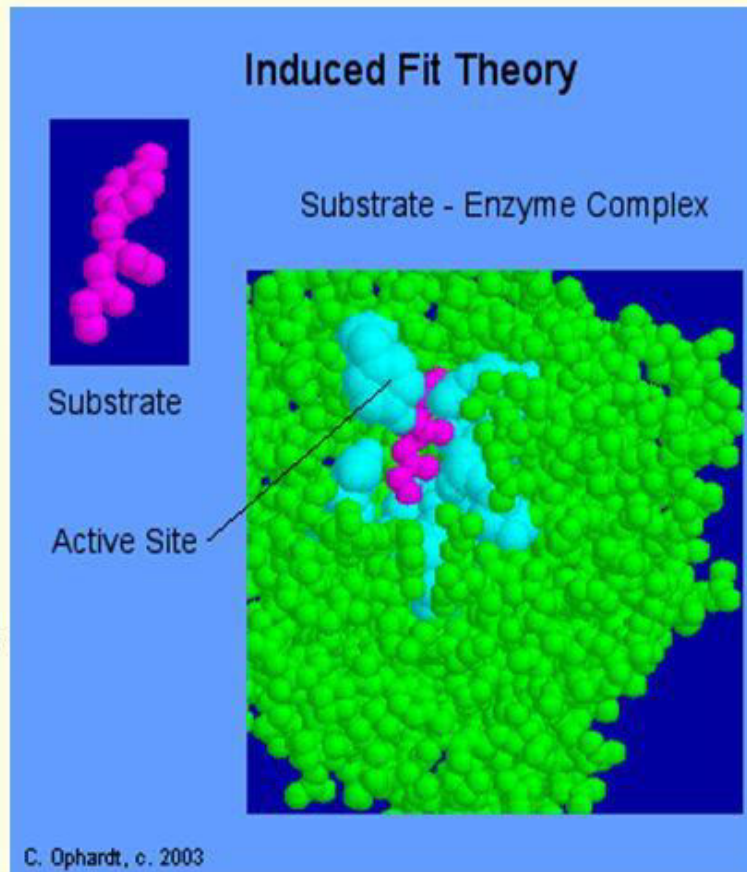
Enzymes can accelerate, often by several orders of magnitude, reactions that under the mild conditions of cellular concentrations, temperature,  $pH$ , and pressure would proceed imperceptibly in the absence of the enzyme.

# Mechanism of Enzyme Action

## Lock and Key Theory



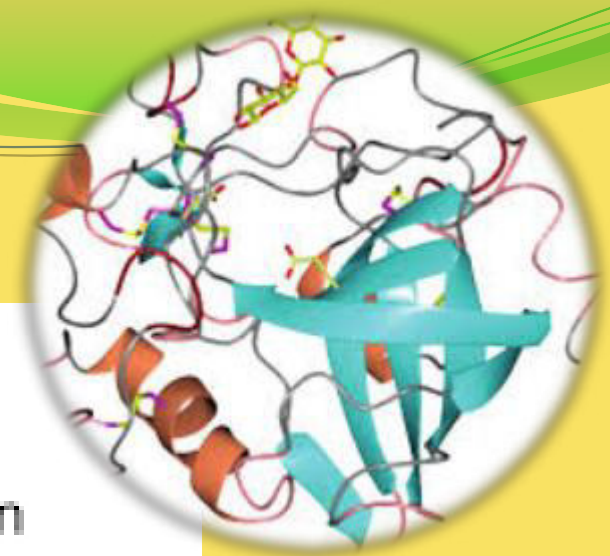
# The Induced Fit Theory



- Postulated by Daniel Koshland
- It states that, when substrates approach and bind to an enzyme they induce a conformational change
- This change is analogous to placing a hand (substrate) into a glove (enzyme)

## Enzyme Classification

1. **Oxidoreductases** - catalyzing oxidation reduction reactions.
2. **Transferases** - catalyzing transfer of functional groups.
3. **Hydrolases** - catalyzing hydrolysis reactions.
4. **Lyases** - catalyzing group elimination reactions to form double bonds.
5. **Isomerases** - catalyzing isomerizations (bond rearrangements).
6. **Ligases** - catalyzing bond formation reactions couples with ATP hydrolysis.



# Enzyme Kinetics

Enzyme kinetics is the study of the chemical reactions that are catalysed by enzymes.

In enzyme kinetics, the reaction rate is measured and the effects of varying the conditions of the reaction is investigated.

Studying an enzyme's kinetics in this way can reveal the catalytic mechanism of this enzyme

$$V_0 = \frac{V_{\max} [S]}{(K_M + [S])}$$

## Michaelis-Menten Analysis

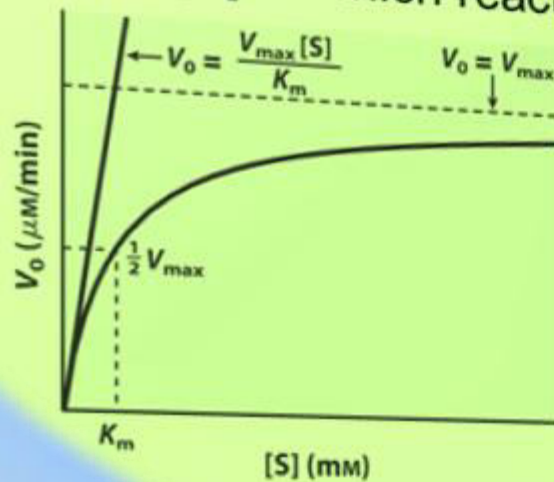
- Michaelis–Menten kinetics is one of the simplest and best-known models of enzyme kinetics.
- The model serves to explain how an enzyme can cause kinetic rate enhancement of a reaction and why the rate of a reaction depends on the concentration of enzyme present.



# Michaelis-Menten kinetics

- Michaelis-Menten equation 
$$V_o = \frac{V_{\max} \cdot [S]}{K_m + [S]}$$

–  $K_m = [S]$  at which reaction rate is  $\frac{1}{2} V_{\max}$



Michaelis curve

## The Michaelis-Menten Equation is the Fundamental Equation of Enzyme Kinetics



E = enzyme concentration.

S = Substrate concentration.

ES = Enzyme-substrate complex concentration (noncovalent).

P = product concentration.

$k_1$  = rate constant for formation of ES from E + S.

$k_{-1}$  = rate constant for decomposition of ES to E + S.

$k_2$  = rate constant for decomposition of ES to E + P.

# ISOENZYMES

- Isoenzymes or isozymes are multiple forms of same enzyme that catalyse the same chemical reaction
- Different chemical and physical properties:
  - Electrophoretic mobility
  - Kinetic properties
  - Amino acid sequence
  - Amino acid composition

# LDH isoforms

Isoenzymes of lactate dehydrogenase

Highest levels found in the following:

Isoenzymes of lactate dehydrogenase

Highest levels found in the following:



Heart, kidneys



Brain, lung, white blood cells



$H_4$  (LDH<sub>1</sub>)

$H_2M_2$  (LDH<sub>3</sub>)

Lung, skeletal muscle



$H_3M$  (LDH<sub>2</sub>)

Red blood cells, heart, kidney, brain



$HM_3$  (LDH<sub>4</sub>)

Skeletal muscle, liver

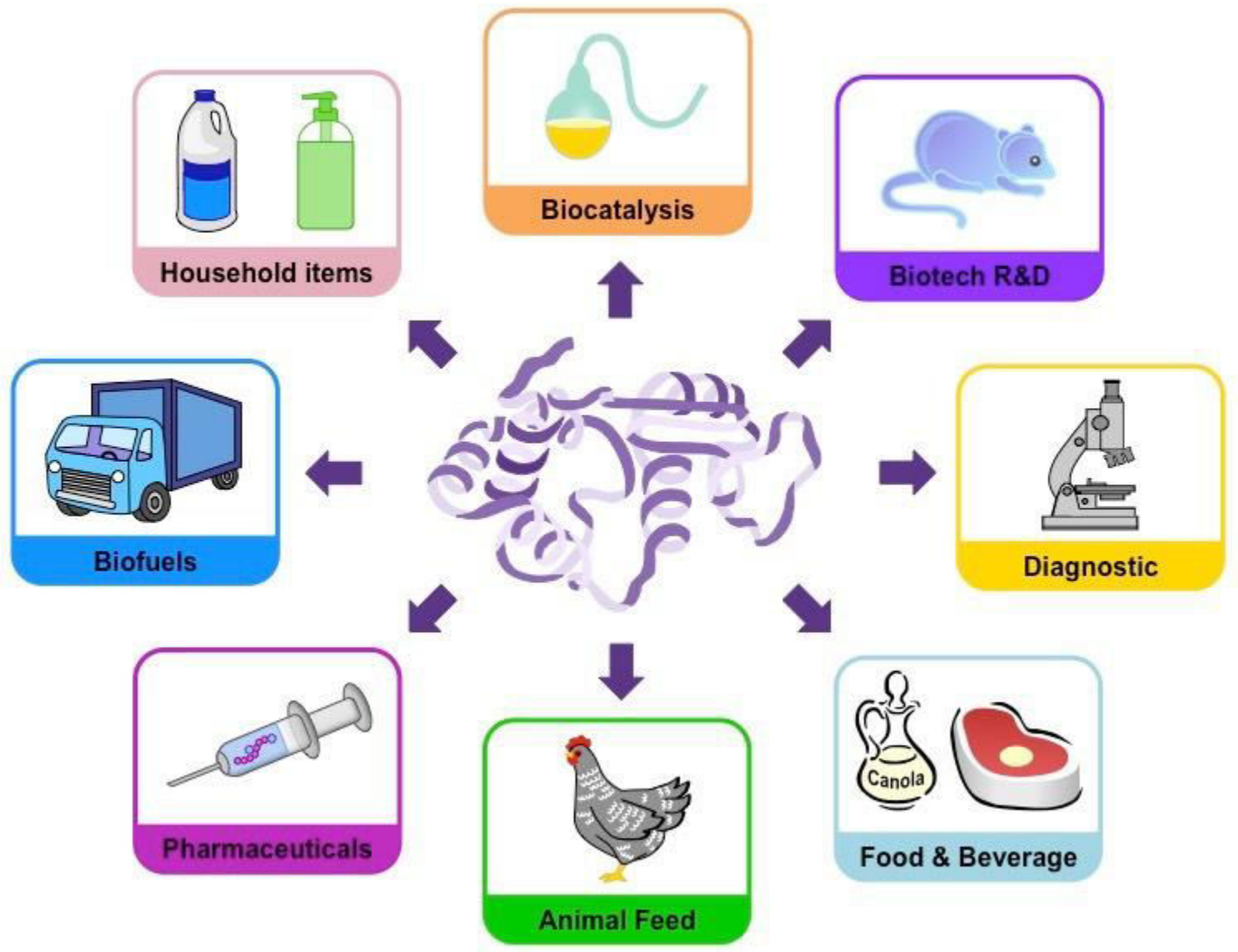


$M_4$  (LDH<sub>5</sub>)

# Uses of enzymes

1. Analytical Applications of Enzymes
2. The Animal Feed Industry
3. The Meat and Fish Processing Industry
4. The Dairy Industry
5. The Leather Industry
6. CIP and cleaning of microfilters -- Detergents

1. The modification of Fats and Oils
2. The Pulp and Paper Industry
3. The Fruit Juice Processing Industry
4. The Production of Bulk and Fine Chemicals
5. Enzyme-Replacement Therapy



# Uses of enzymes

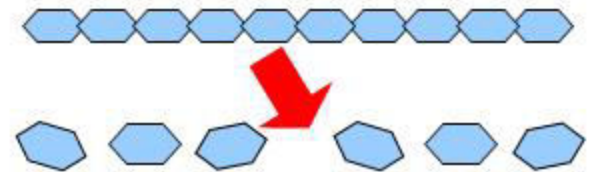
1) Enzymes are used in washing powders to help digest food stains. Biological washing powders will only work on 40°C or lower.



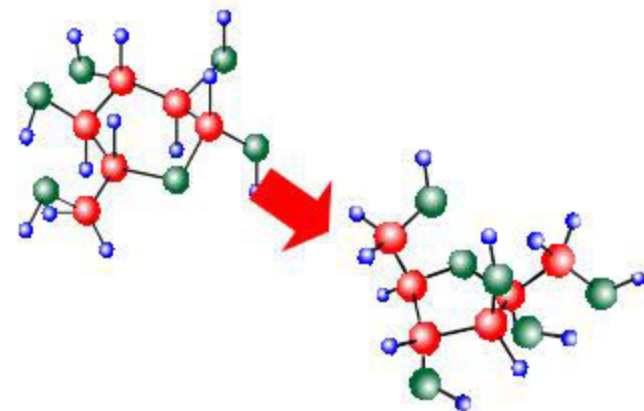
2) Enzymes are used in baby foods to "pre-digest" the proteins.



3) Enzymes are used to convert starch into sugar which can then be used in food.

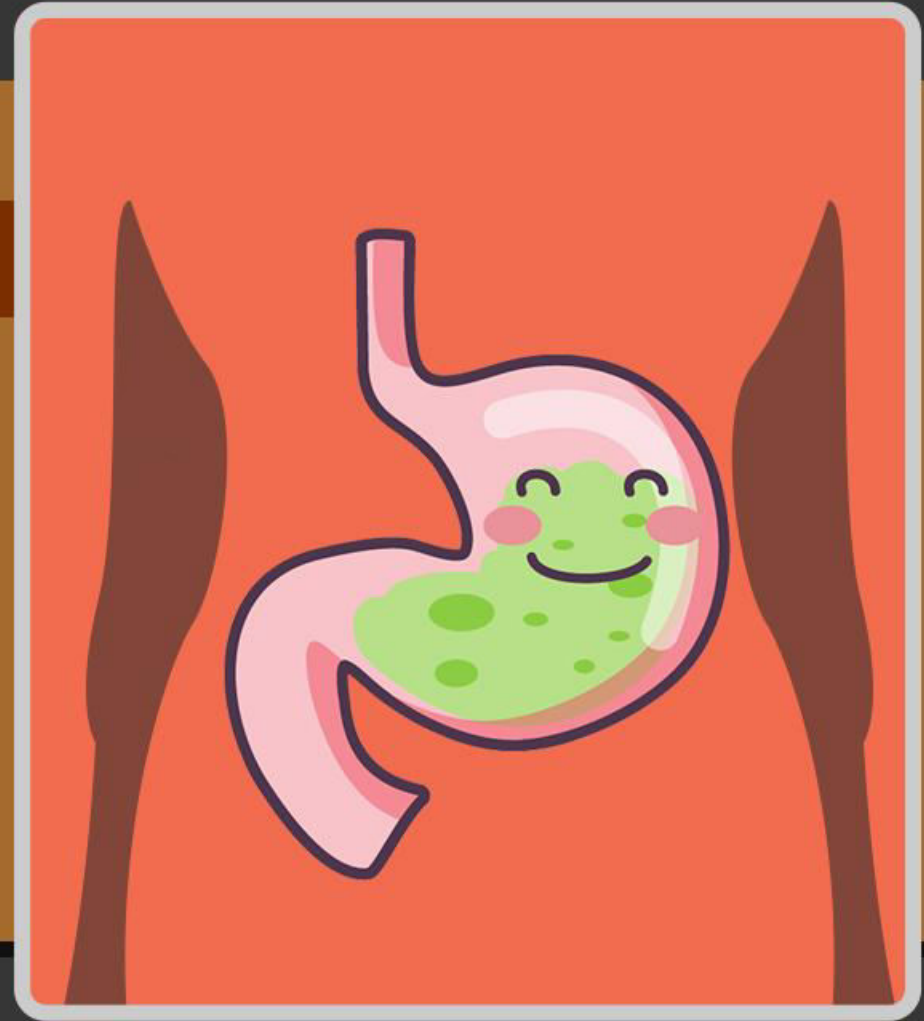


4) Conversion of glucose into fructose - glucose and fructose are "isomers" (they have the same chemical formula), but fructose is sweeter.



# The **ENZYME LIPASE**

breaks down  
and digests fat into  
simple, soluble  
fatty acid and  
glycerol molecules.





# What Do Enzymes Do for You?

<b>SECTOR</b>	<b>APPLICATION AREA</b>	<b>BENEFITS</b>
<ul style="list-style-type: none"><li>• <b>Detergents</b></li></ul>	Household washing and cleaning agents	Wash your clothes in cold water; make your teeth cleaner
<ul style="list-style-type: none"><li>• <b>Textiles</b></li></ul>	Denim washing, silk polishing, leather goods softening	Stonewash your jeans; make cotton look and feel like silk; make your leather soft
<ul style="list-style-type: none"><li>• <b>Food processing</b></li></ul>	Baking, brewing, fruit juice processing	Clarify your juice and beer; make bread better; turn corn starch into sugar syrup
<ul style="list-style-type: none"><li>• <b>Pulp and paper</b></li></ul>	Starch conversion, pitch control, bleach-boosting, deinking, stickies control, slime control	Reduce production costs and improve quality

# **SAMPLE QUESTIONS**

1. WHAT ARE ENZYMES?
2. HOW DOES ANY ENZYME WORK?
3. DEFINE THE STRUCTURE OF ENZYMES.
4. DEFINE ACTIVE SITE.
5. DEFINE COFACTORS AND COENZYPES.
6. EXPLAIN THE CLASSIFICATION OF ENZYMES.
7. WHAT ARE THE PROPERTIES OF ENZYMES?
8. WHAT ARE ISOENZYMES?
9. DEFINE ENZYME KINETICS.
10. WHAT ARE ALLOSTERIC ENZYMES?

11. DEFINE THE MECHANISM OF ENZYMES?
12. DERIVE THE MICHAELIS-MENTON EQUATION.
- 13 GIVE THE USES OF ENZYMES.
- 14 WHAT ARE THE FIVE ISOMERIC FORMS OF LDH?
- 15 WHY ARE ENZYMES KNOWN AS THE 'BIOCATALYST'?

**THANK YOU**

