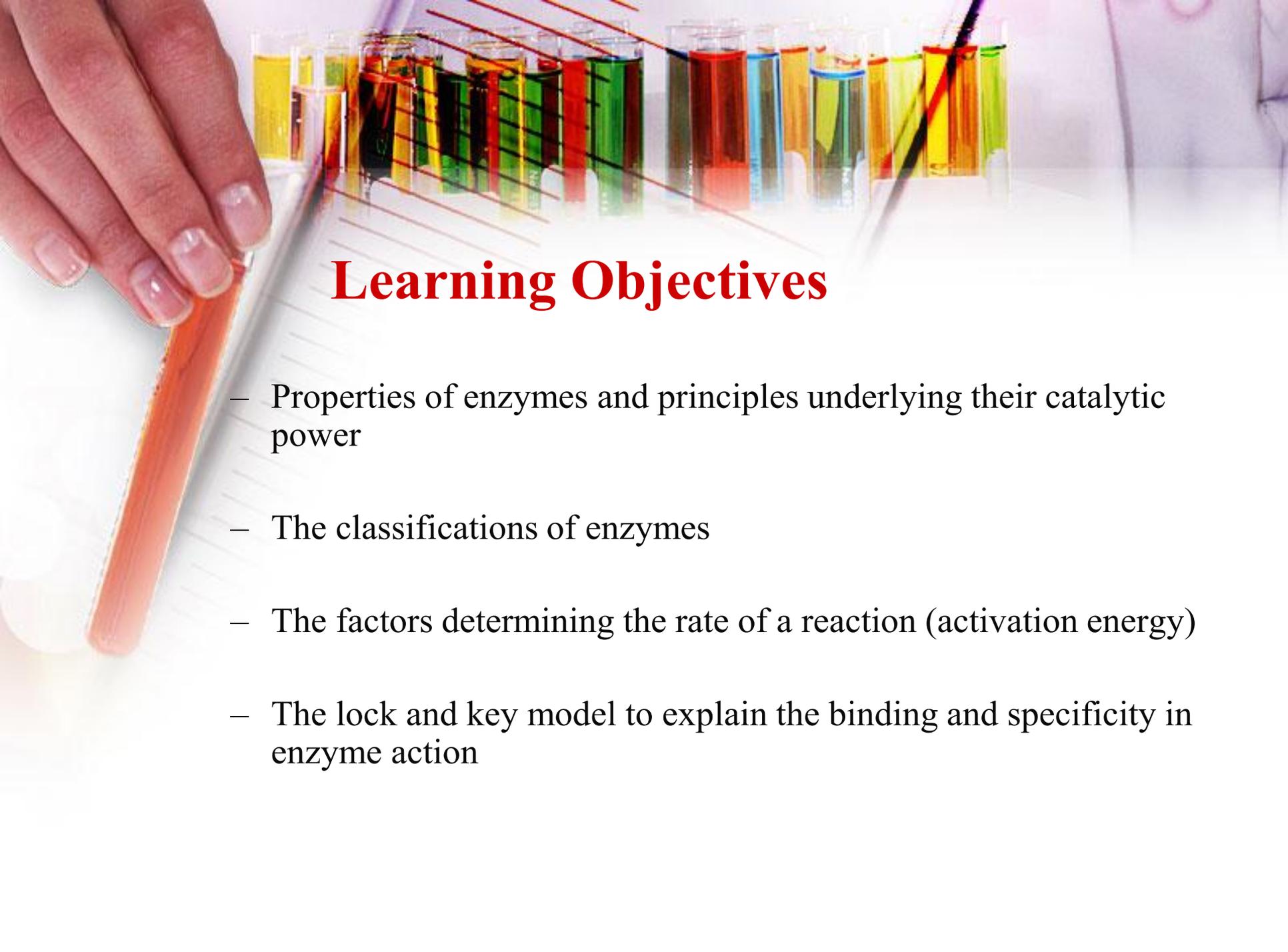


Tishk International University
Faculty of Applied Science
Nutrition and Dietetics Department
Nutritional Biochemistry II
2nd Grade

Enzymes

Lecturer: Amani Tahsin



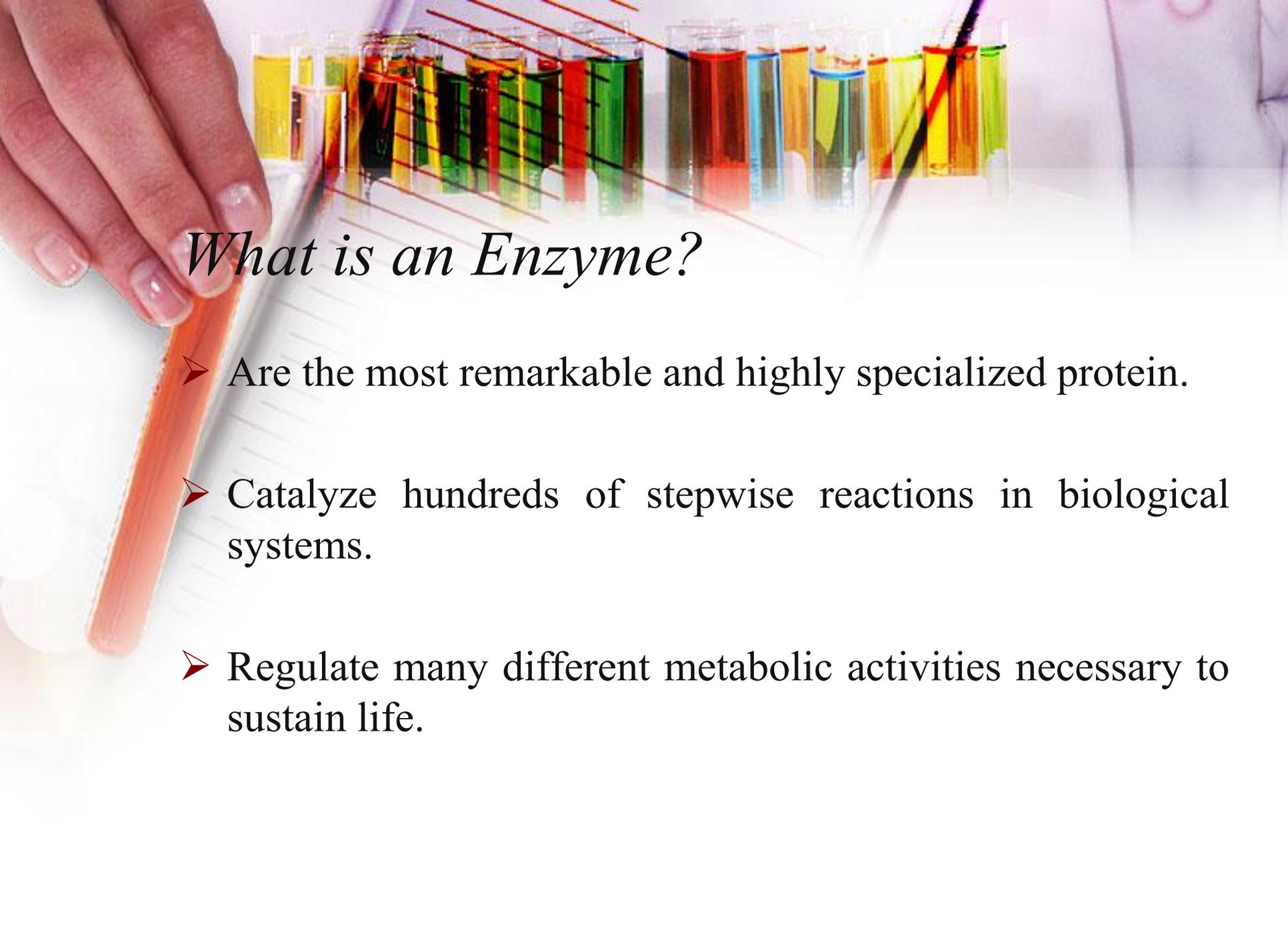
Learning Objectives

- Properties of enzymes and principles underlying their catalytic power
- The classifications of enzymes
- The factors determining the rate of a reaction (activation energy)
- The lock and key model to explain the binding and specificity in enzyme action



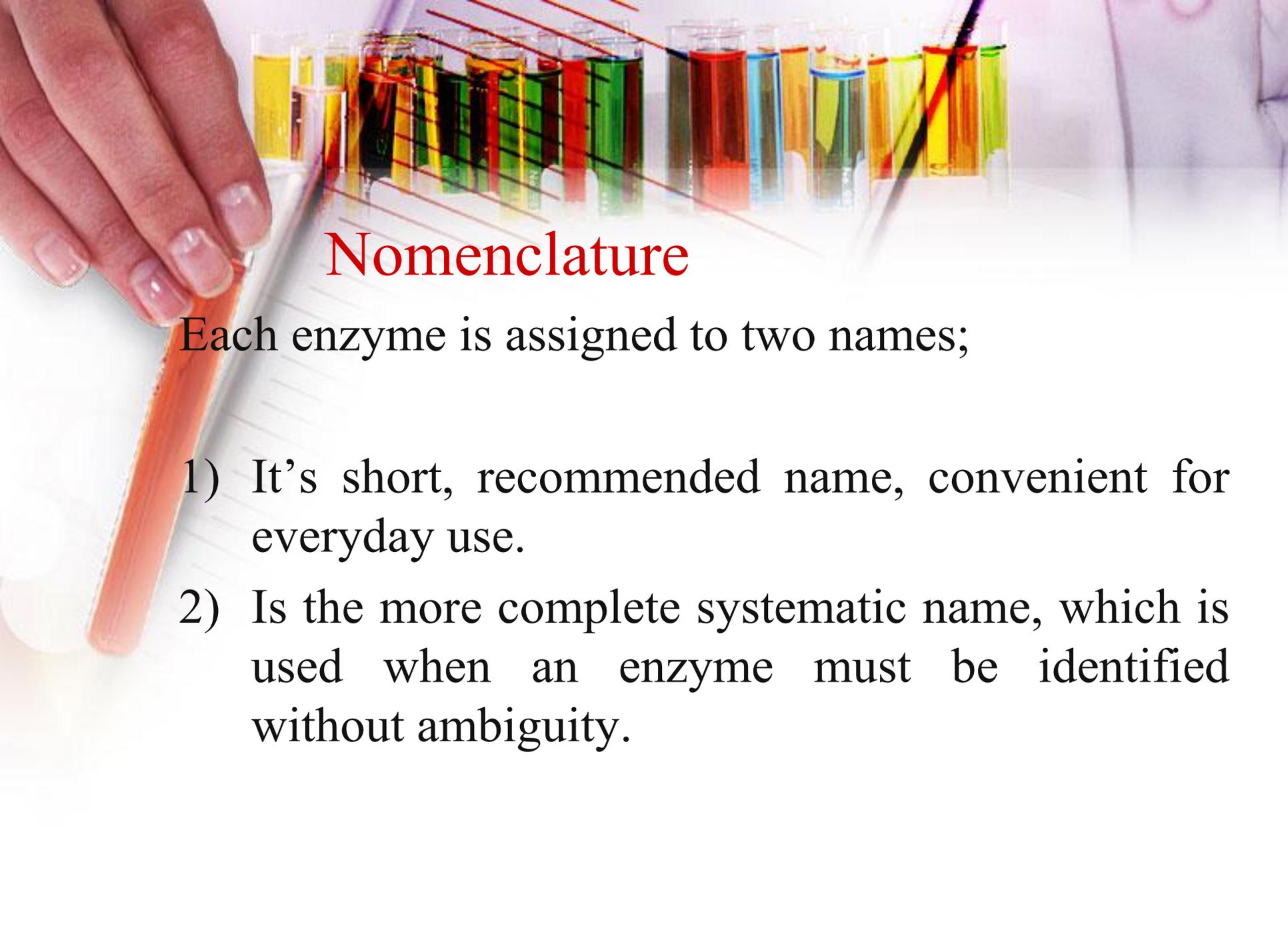
Overview

- All reactions in the body are mediated by *enzymes*, which are protein catalysts that increase the rate of reactions without being changed in the overall process.
- Among the many biologic reactions that are energetically possible, enzymes selectively channel reactants called Substrates into useful pathways.
- Thus, enzymes direct all metabolic events.



What is an Enzyme?

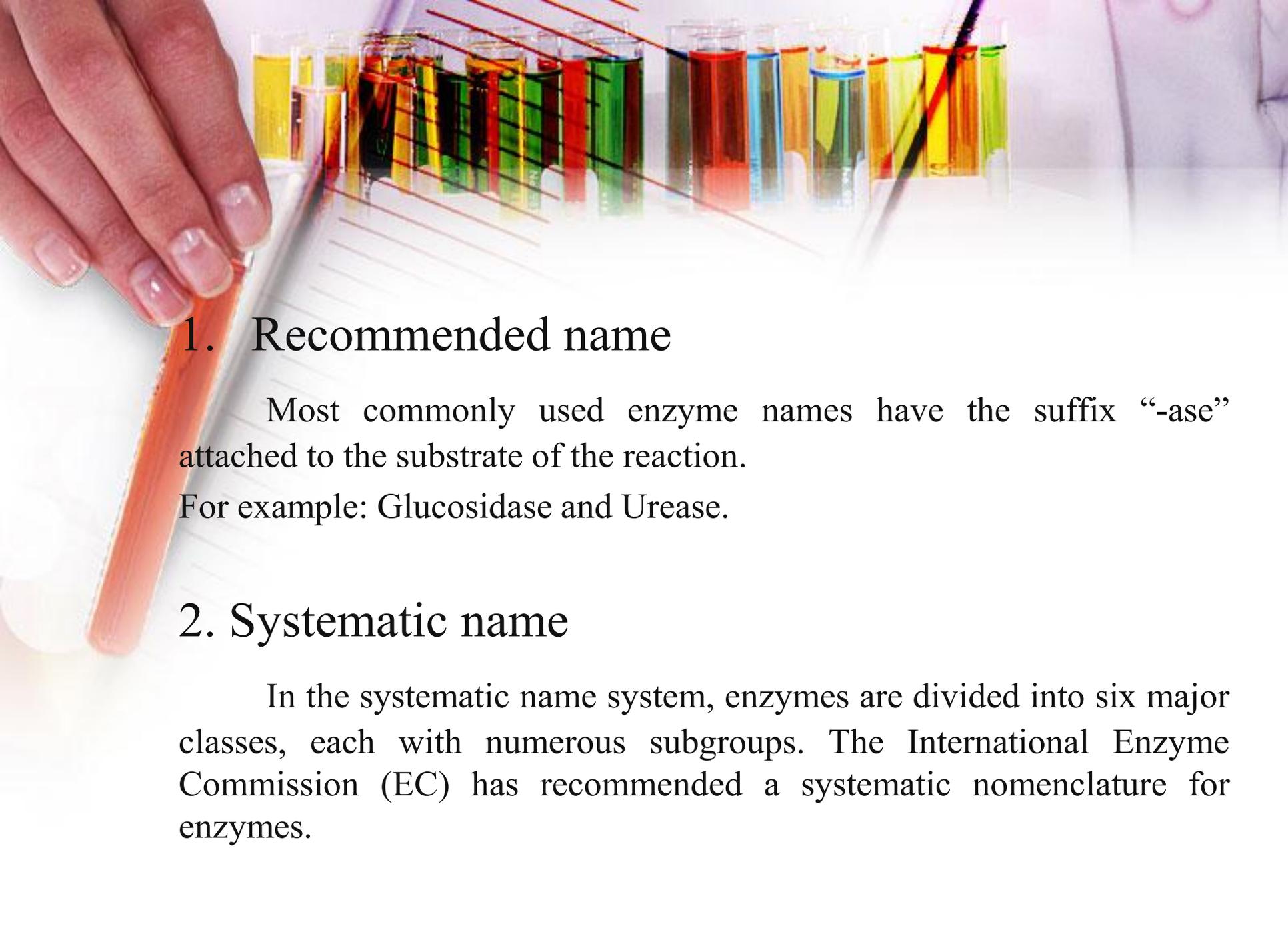
- Are the most remarkable and highly specialized protein.
- Catalyze hundreds of stepwise reactions in biological systems.
- Regulate many different metabolic activities necessary to sustain life.



Nomenclature

Each enzyme is assigned to two names;

- 1) It's short, recommended name, convenient for everyday use.
- 2) Is the more complete systematic name, which is used when an enzyme must be identified without ambiguity.

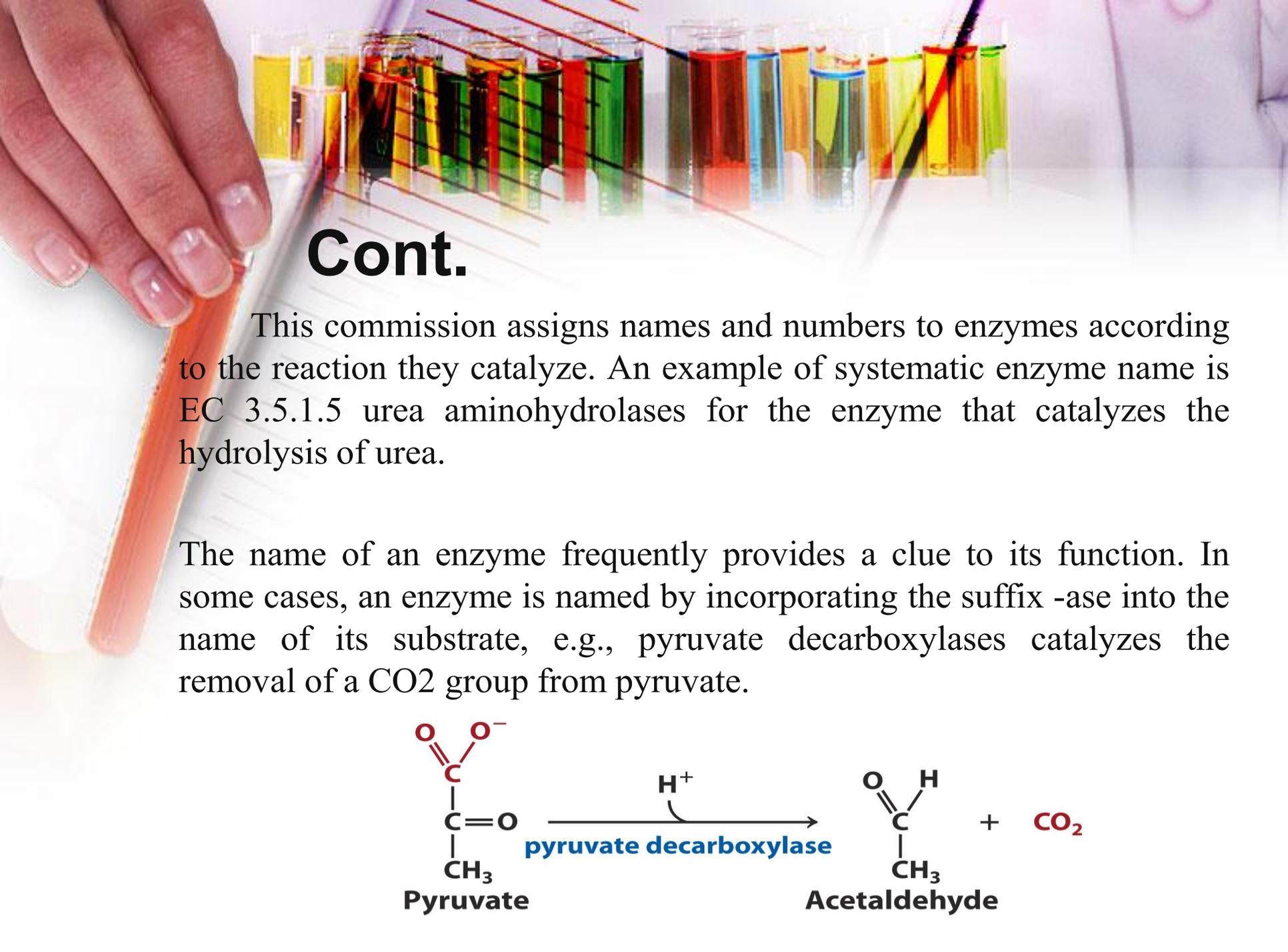


1. Recommended name

Most commonly used enzyme names have the suffix “-ase” attached to the substrate of the reaction.
For example: Glucosidase and Urease.

2. Systematic name

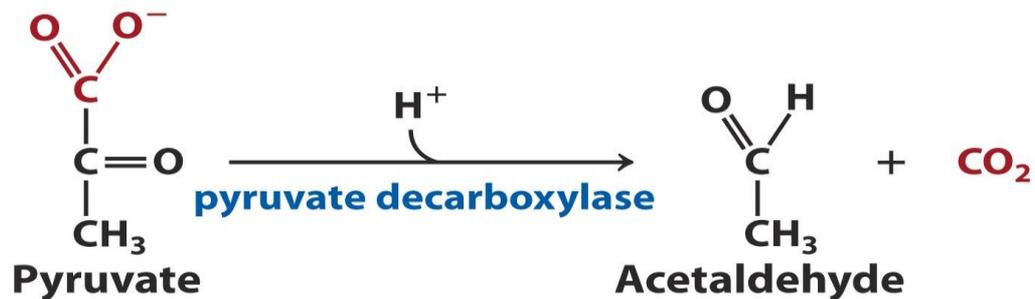
In the systematic name system, enzymes are divided into six major classes, each with numerous subgroups. The International Enzyme Commission (EC) has recommended a systematic nomenclature for enzymes.

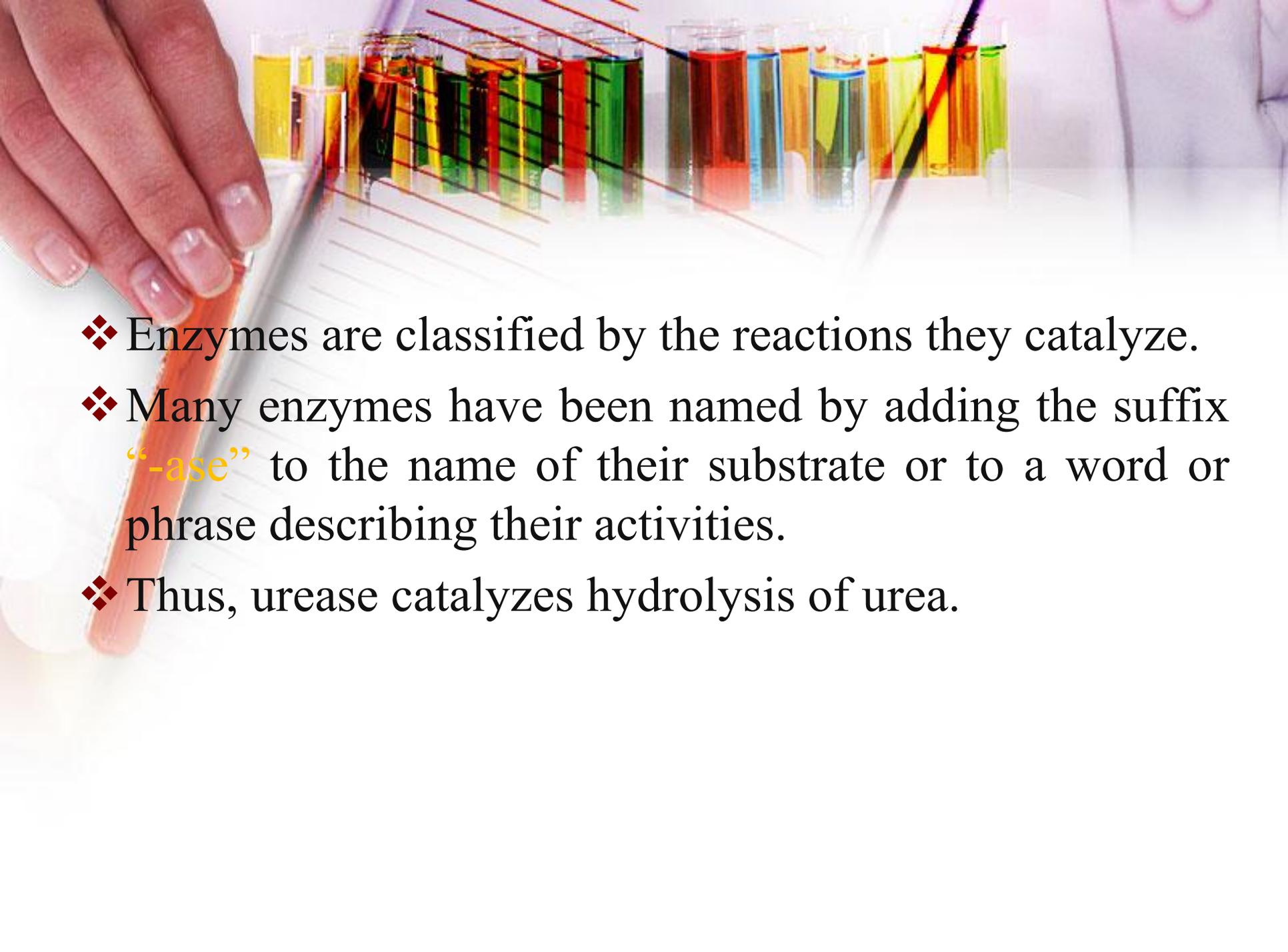


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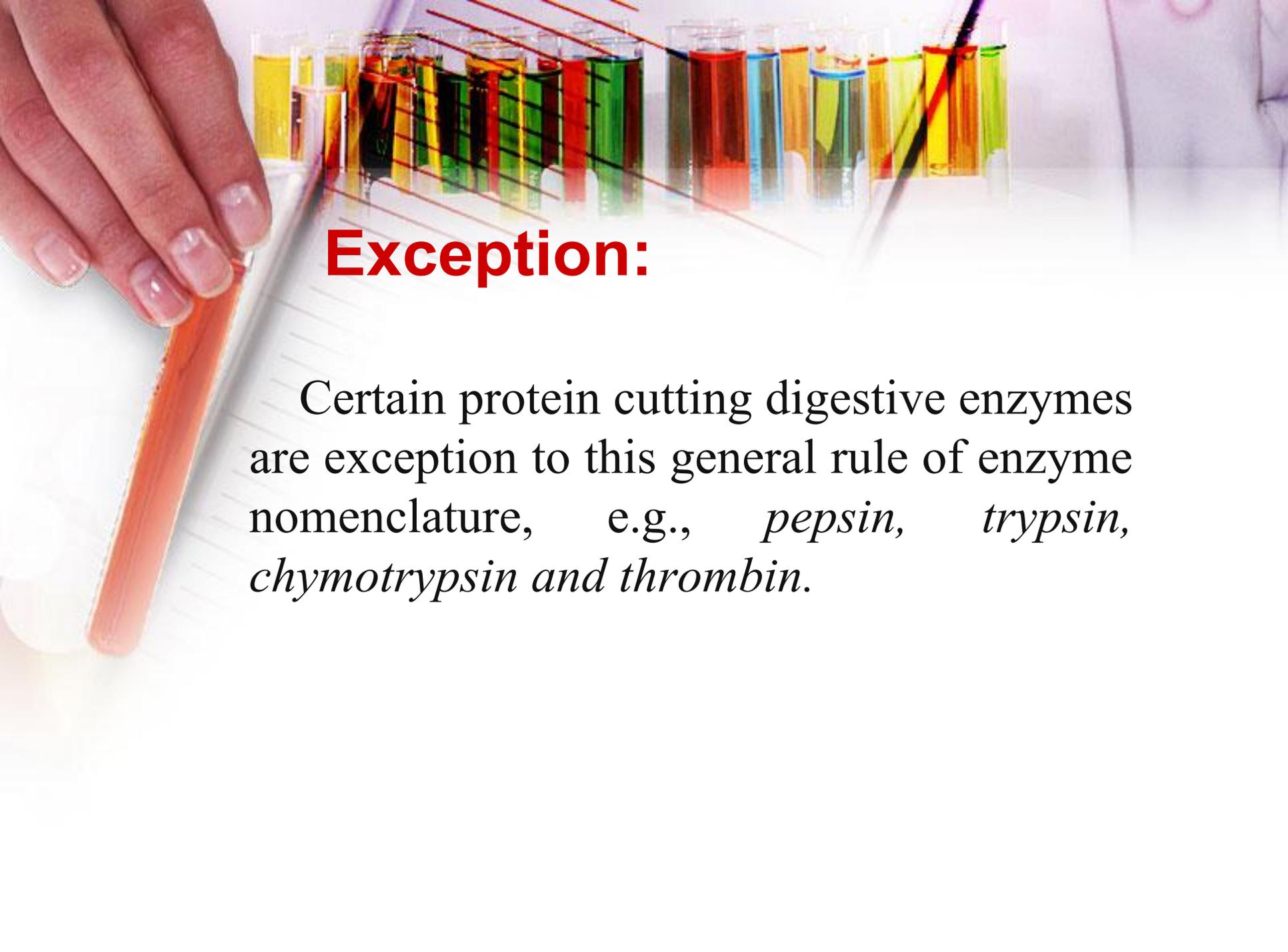
This commission assigns names and numbers to enzymes according to the reaction they catalyze. An example of systematic enzyme name is EC 3.5.1.5 urea aminohydrolases for the enzyme that catalyzes the hydrolysis of urea.

The name of an enzyme frequently provides a clue to its function. In some cases, an enzyme is named by incorporating the suffix -ase into the name of its substrate, e.g., pyruvate decarboxylases catalyzes the removal of a CO₂ group from pyruvate.



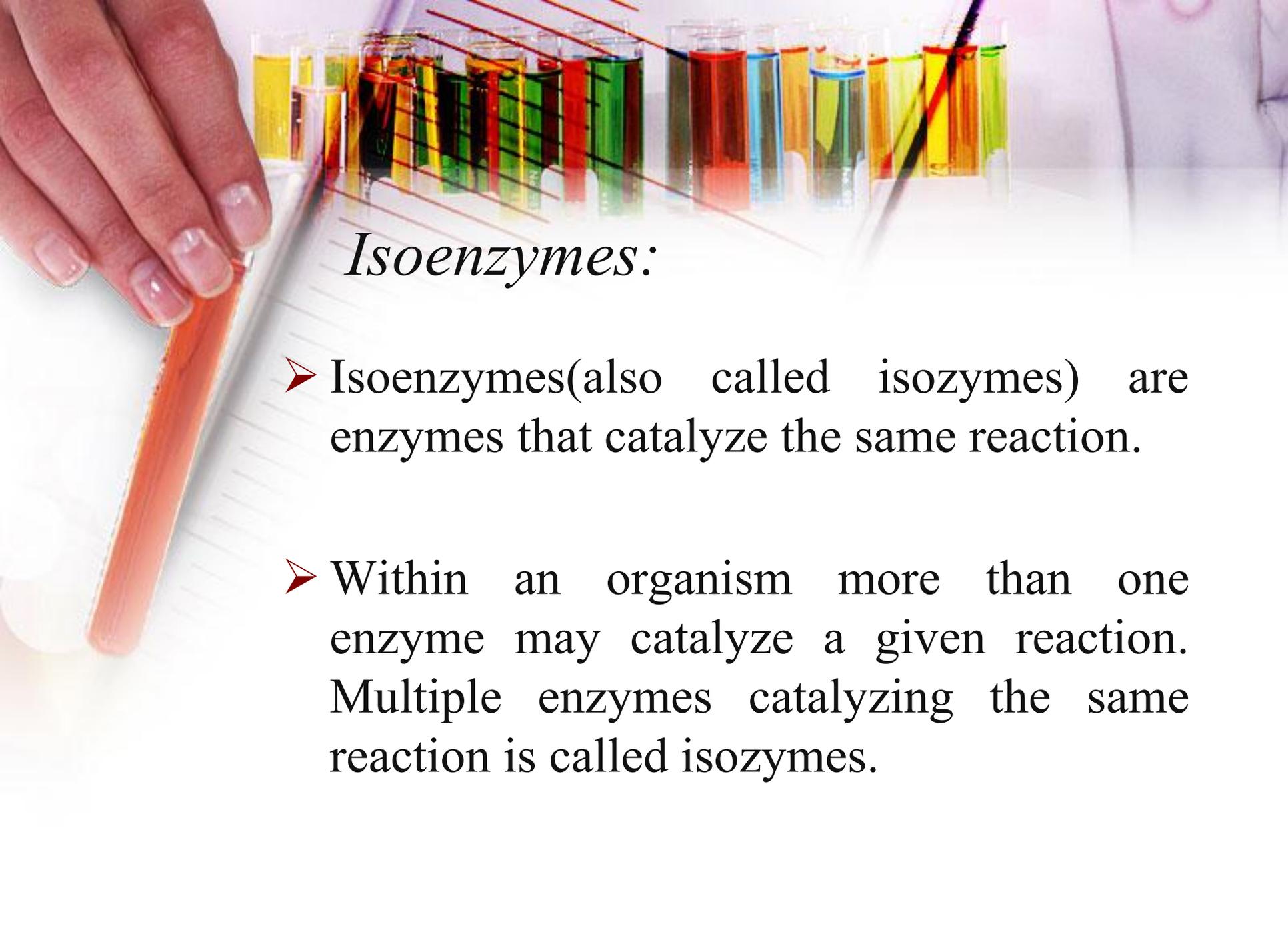


- ❖ Enzymes are classified by the reactions they catalyze.
- ❖ Many enzymes have been named by adding the suffix “-ase” to the name of their substrate or to a word or phrase describing their activities.
- ❖ Thus, urease catalyzes hydrolysis of urea.



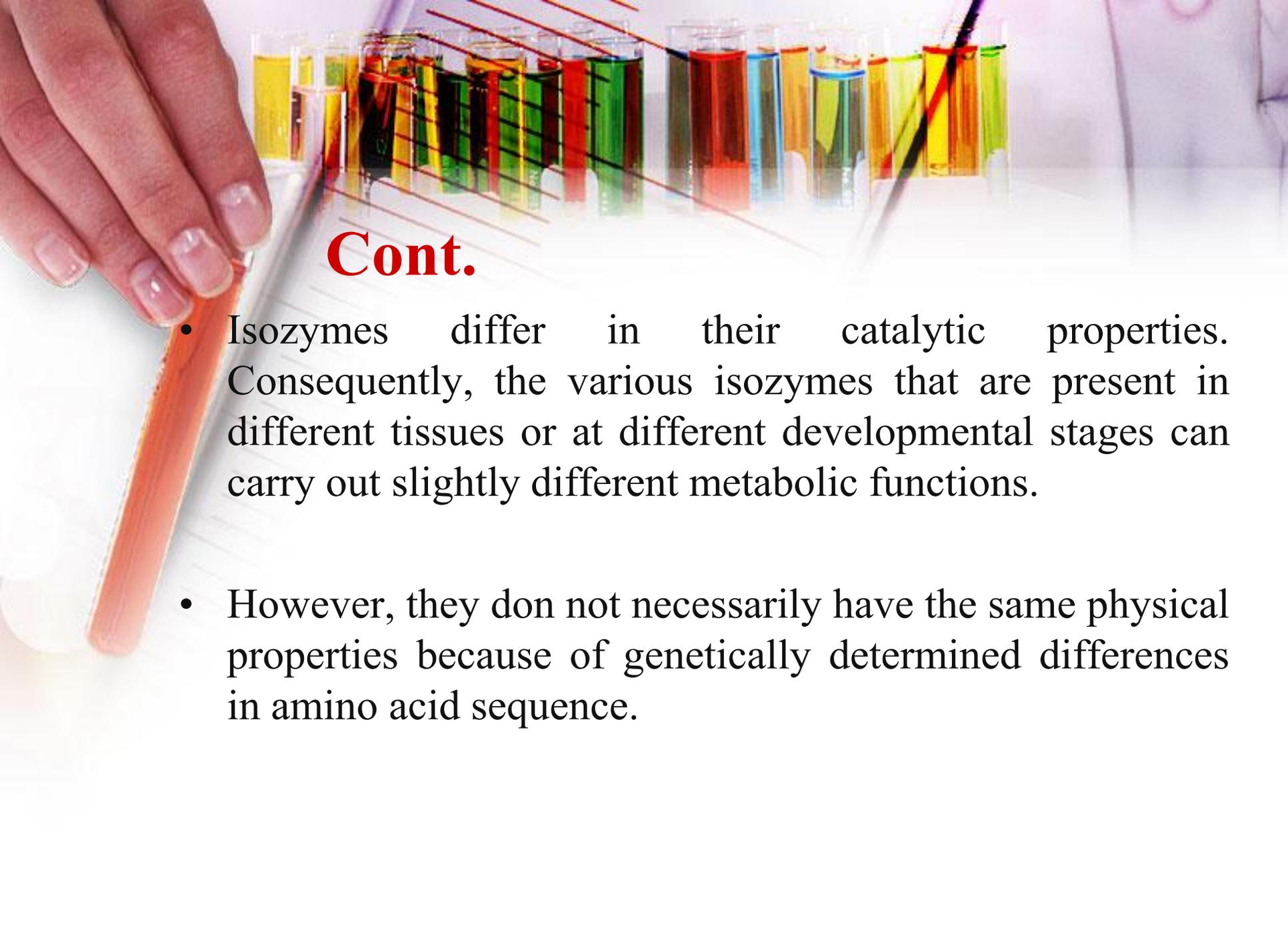
Exception:

Certain protein cutting digestive enzymes are exception to this general rule of enzyme nomenclature, e.g., *pepsin*, *trypsin*, *chymotrypsin* and *thrombin*.



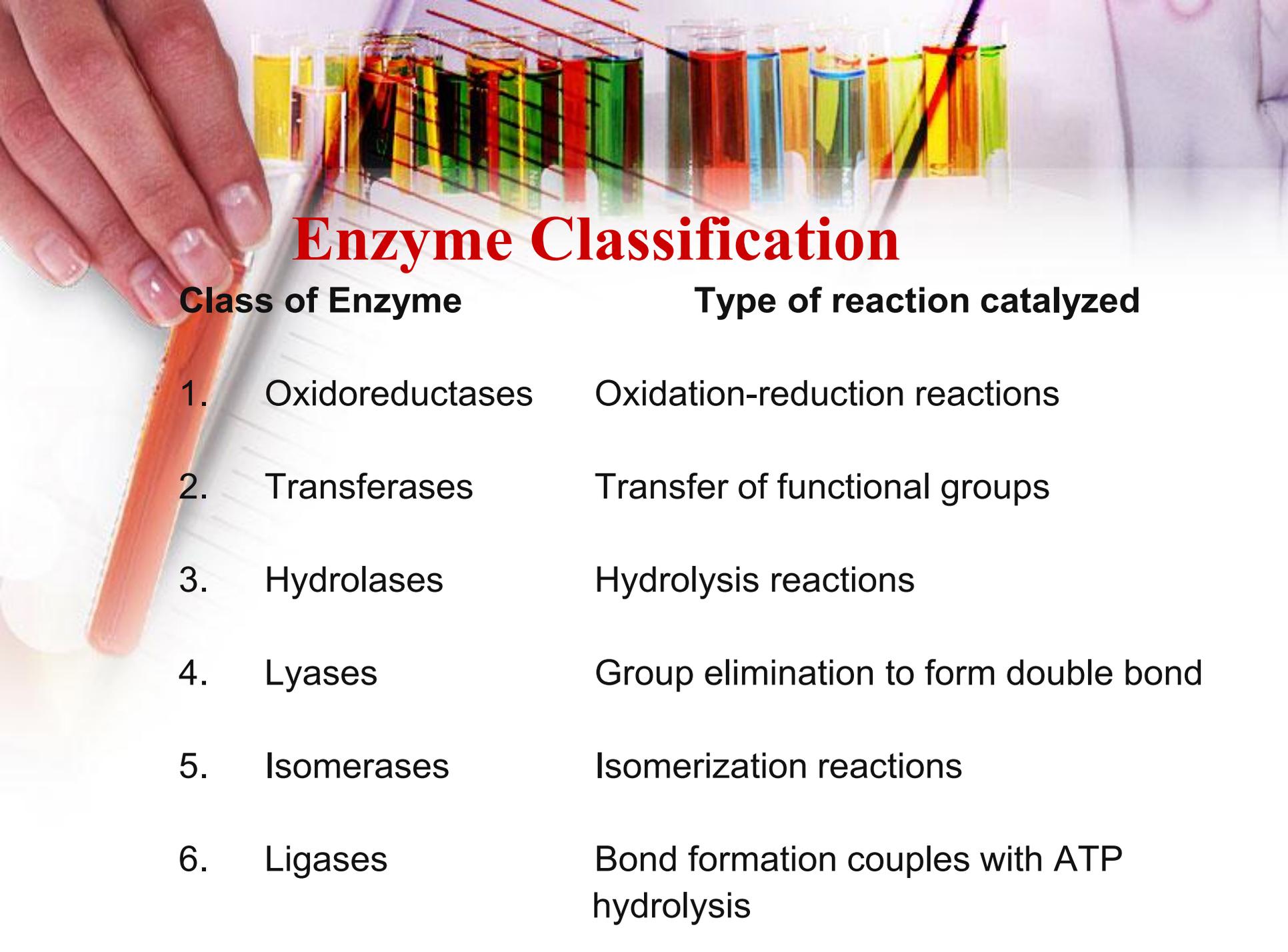
Isoenzymes:

- Isoenzymes(also called isozymes) are enzymes that catalyze the same reaction.
- Within an organism more than one enzyme may catalyze a given reaction. Multiple enzymes catalyzing the same reaction is called isozymes.



Cont.

- Isozymes differ in their catalytic properties. Consequently, the various isozymes that are present in different tissues or at different developmental stages can carry out slightly different metabolic functions.
- However, they do not necessarily have the same physical properties because of genetically determined differences in amino acid sequence.



Enzyme Classification

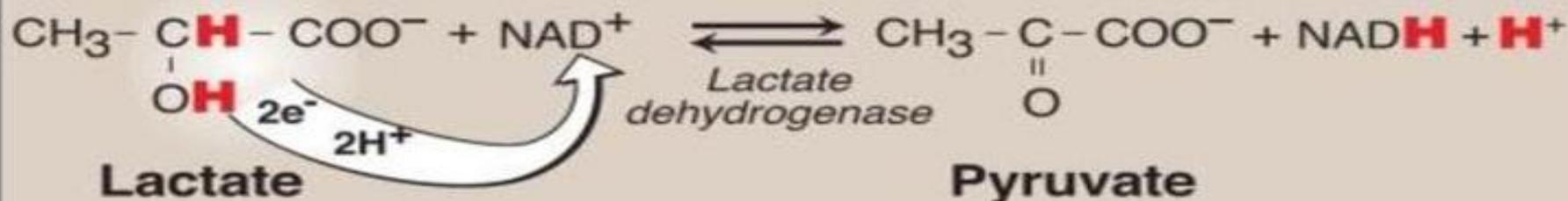
Class of Enzyme

Type of reaction catalyzed

1. Oxidoreductases Oxidation-reduction reactions
2. Transferases Transfer of functional groups
3. Hydrolases Hydrolysis reactions
4. Lyases Group elimination to form double bond
5. Isomerases Isomerization reactions
6. Ligases Bond formation couples with ATP hydrolysis

1. Oxidoreductases

Catalyze oxidation-reduction reactions, such as:



2. Transferases

Catalyze transfer of C-, N-, or P-containing groups, such as:



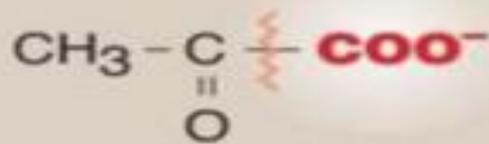
3. Hydrolases

Catalyze cleavage of bonds by addition of water, such as:

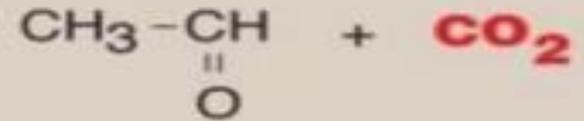


4. Lyases

Catalyze cleavage of C-C, C-S, and certain C-N bonds, such as:



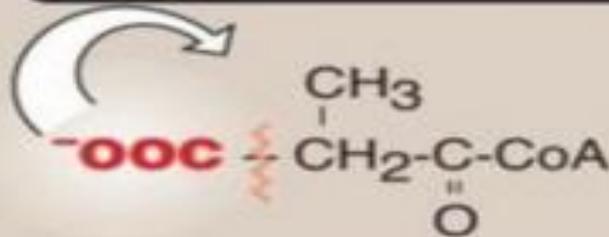
Pyruvate



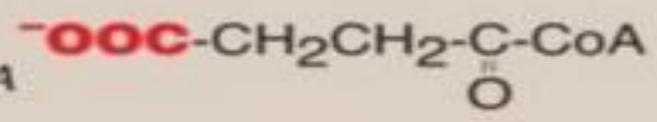
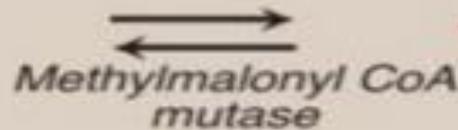
Acetaldehyde

5. Isomerases

Catalyze racemization of optical or geometric isomers, such as:



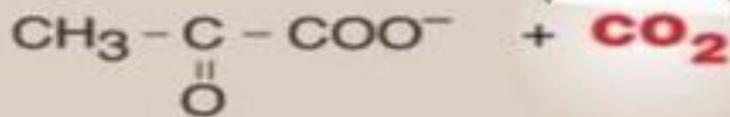
Methylmalonyl CoA



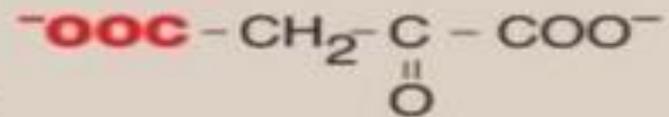
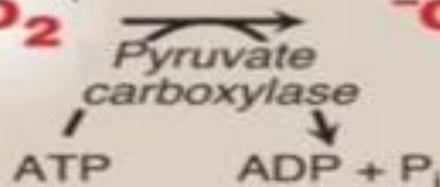
Succinyl CoA

6. Ligases

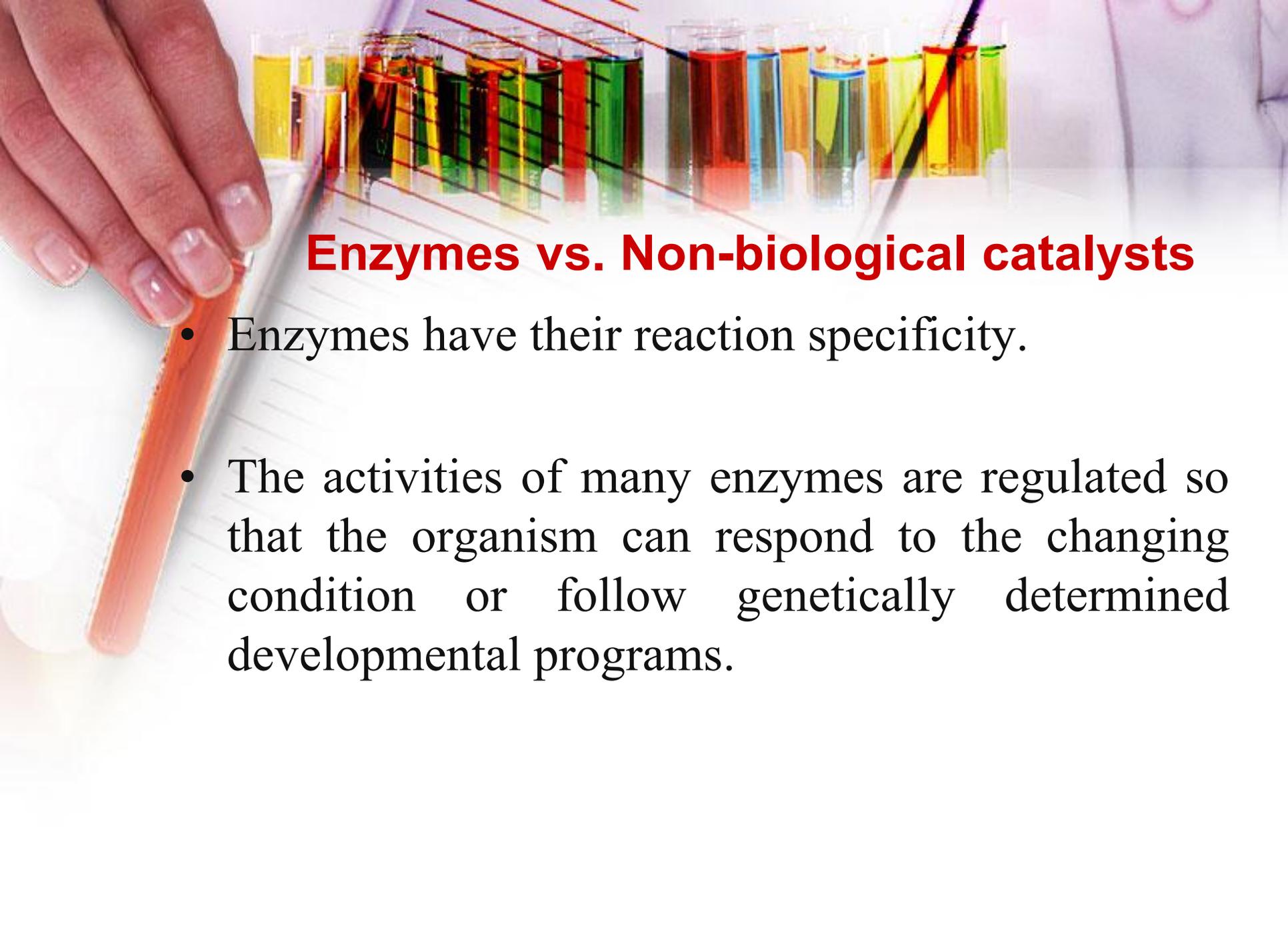
Catalyze formation of bonds between carbon and O, S, and N coupled to hydrolysis of high-energy phosphates, such as:



Pyruvate

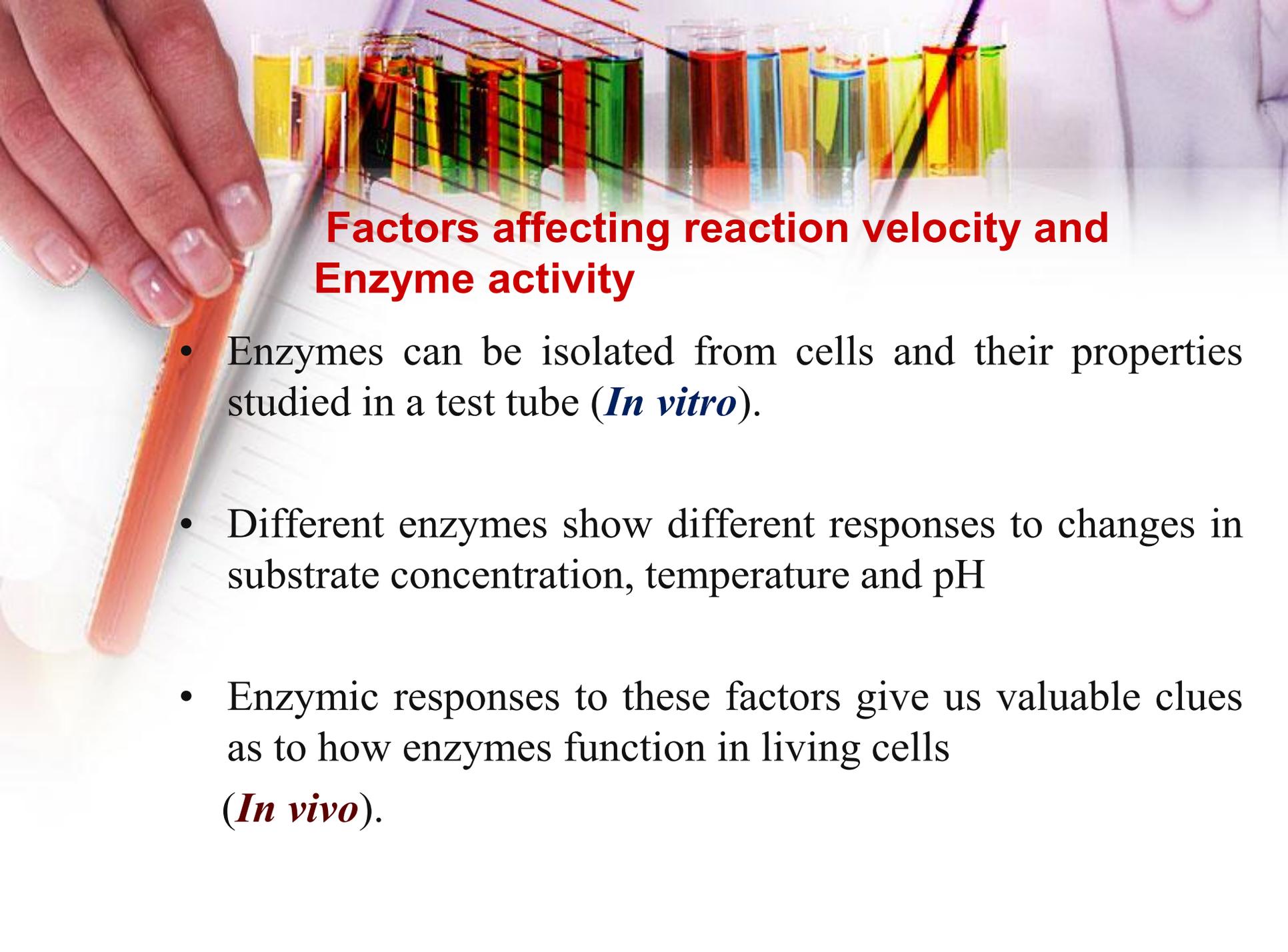


Oxaloacetate



Enzymes vs. Non-biological catalysts

- Enzymes have their reaction specificity.
- The activities of many enzymes are regulated so that the organism can respond to the changing condition or follow genetically determined developmental programs.



Factors affecting reaction velocity and Enzyme activity

- Enzymes can be isolated from cells and their properties studied in a test tube (*In vitro*).
- Different enzymes show different responses to changes in substrate concentration, temperature and pH
- Enzymic responses to these factors give us valuable clues as to how enzymes function in living cells (*In vivo*).

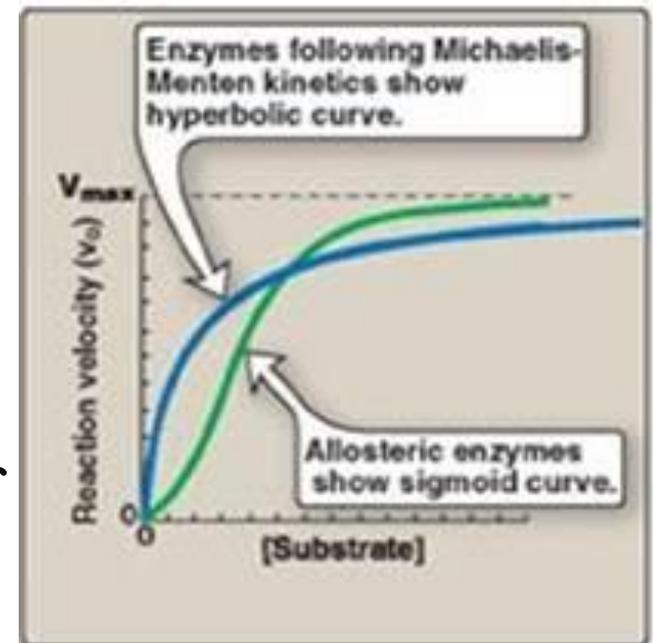


Factors:

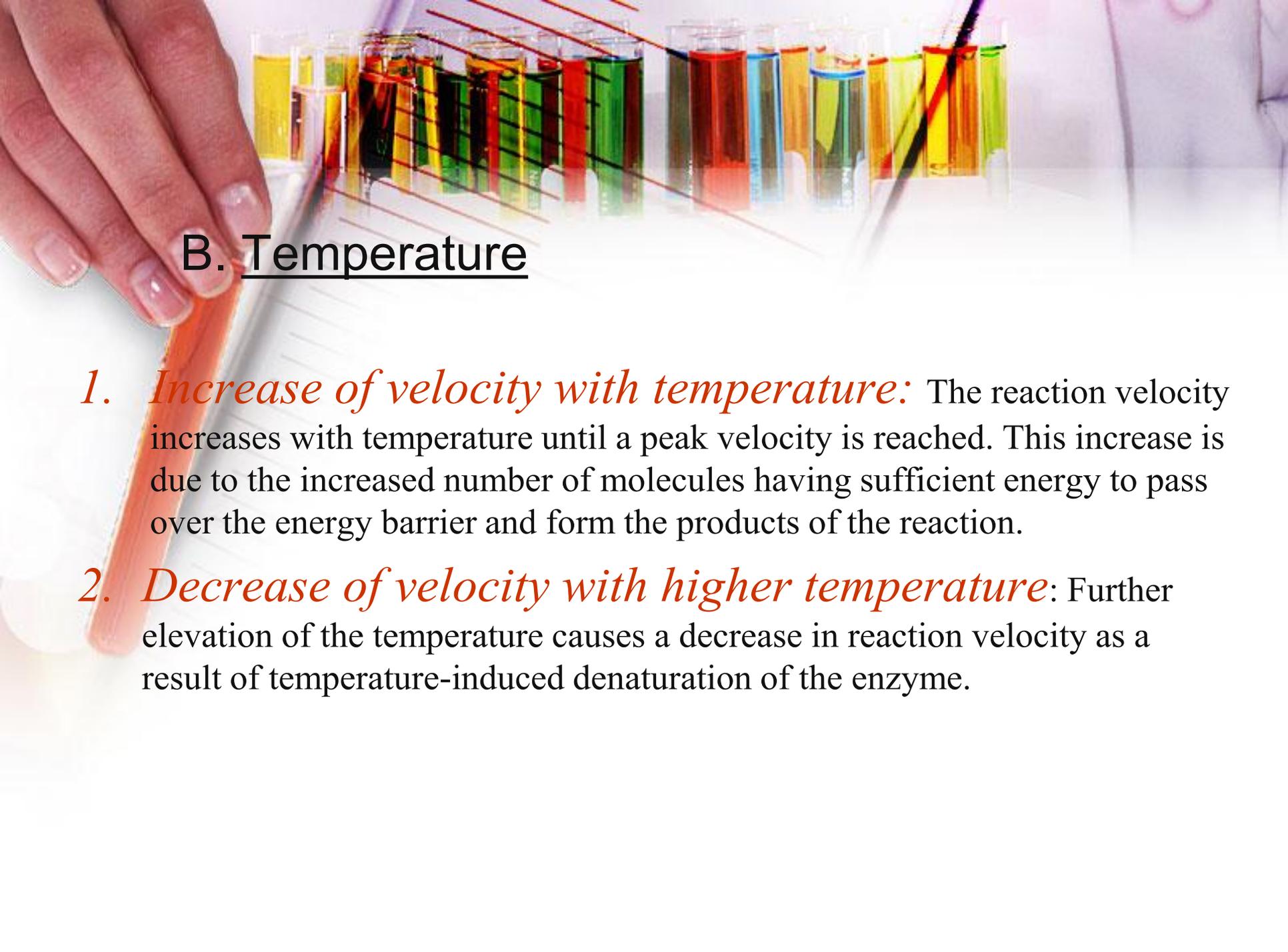
A. Substrate concentration:

The rate of an enzyme catalyzed reaction increases with substrate conc. Until a maximal velocity (V_{max}) is reached.

Further increase in the substrate conc. Does not increase rate of reaction.



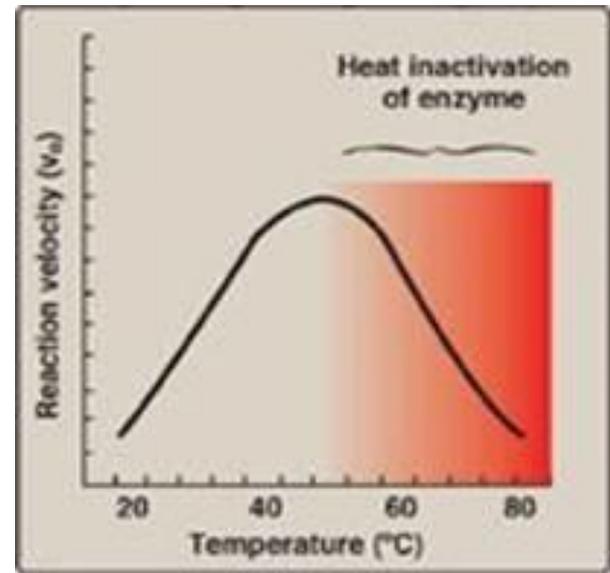
Effect of substrate concentration on reaction velocity.



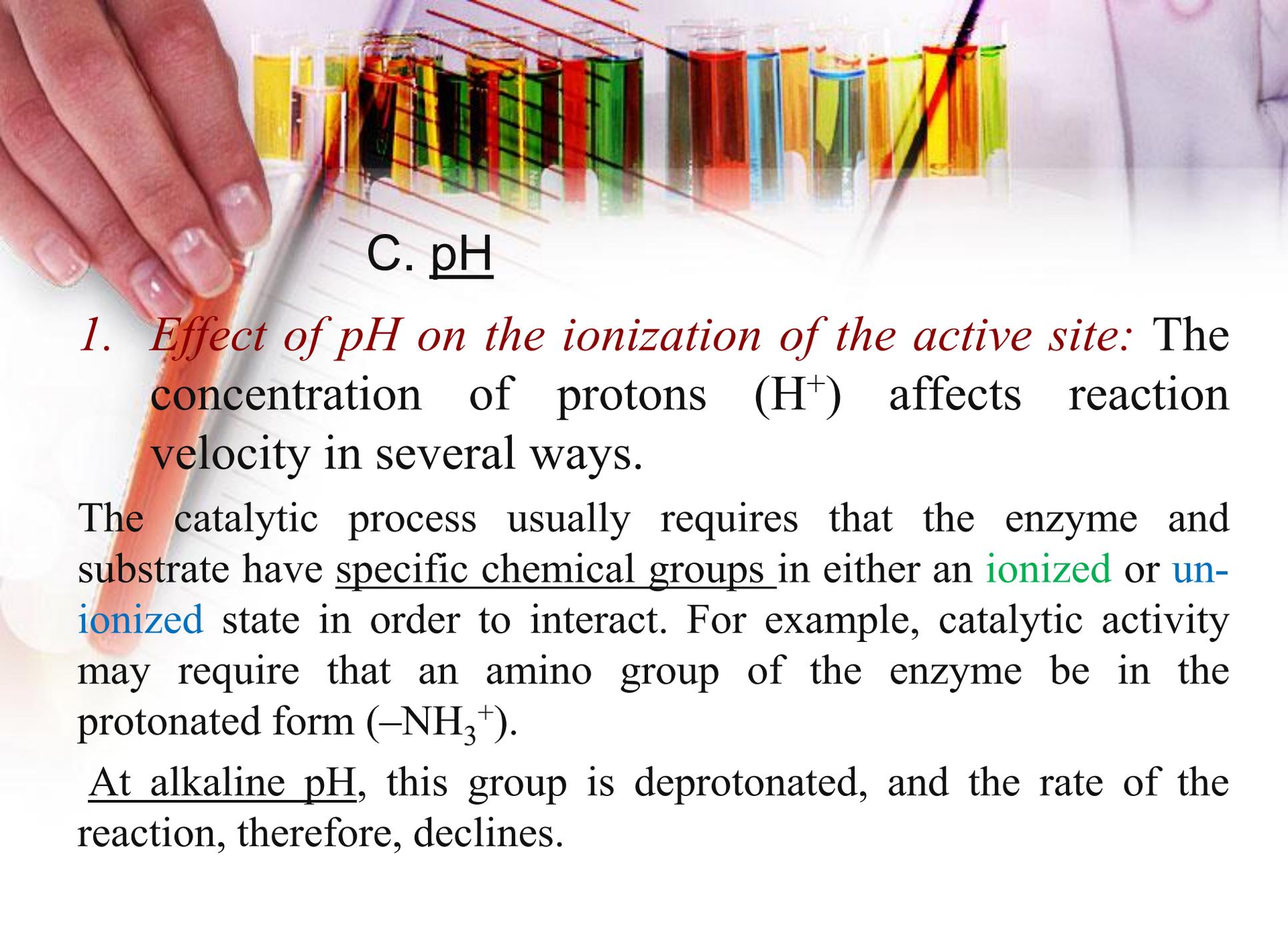
B. Temperature

- 1. Increase of velocity with temperature:* The reaction velocity increases with temperature until a peak velocity is reached. This increase is due to the increased number of molecules having sufficient energy to pass over the energy barrier and form the products of the reaction.
- 2. Decrease of velocity with higher temperature:* Further elevation of the temperature causes a decrease in reaction velocity as a result of temperature-induced denaturation of the enzyme.

✓ The optimum temperature for most human enzymes is between 35°C and 40°C . Human enzymes start to denature at temperatures above 40°C , but thermophilic bacteria found in the hot springs have optimum temperatures of 70°C .



Effect of temperature on an enzyme catalyzed reaction.

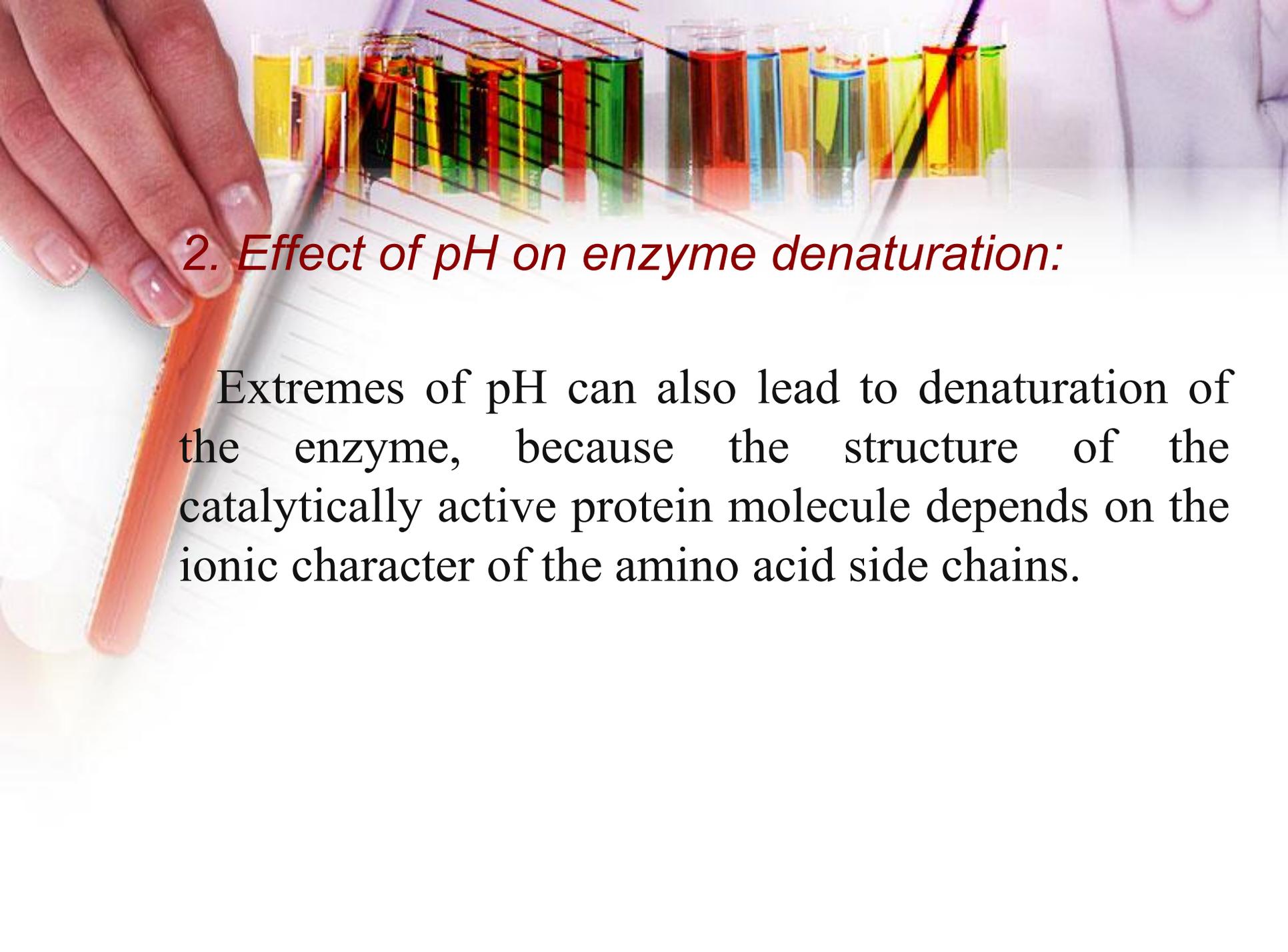


C. pH

1. *Effect of pH on the ionization of the active site:* The concentration of protons (H^+) affects reaction velocity in several ways.

The catalytic process usually requires that the enzyme and substrate have specific chemical groups in either an **ionized** or **un-ionized** state in order to interact. For example, catalytic activity may require that an amino group of the enzyme be in the protonated form ($-NH_3^+$).

At alkaline pH, this group is deprotonated, and the rate of the reaction, therefore, declines.

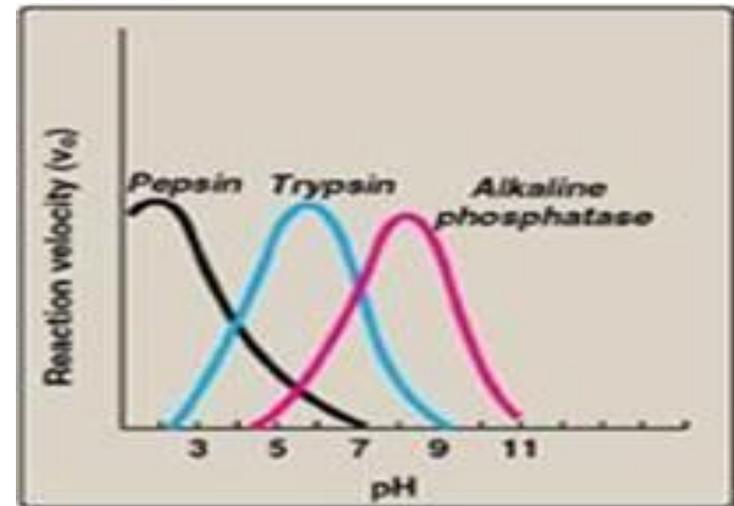
A hand is holding a test tube containing an orange liquid. In the background, there is a rack of test tubes containing various colored liquids (yellow, green, red, blue, orange, yellow, green).

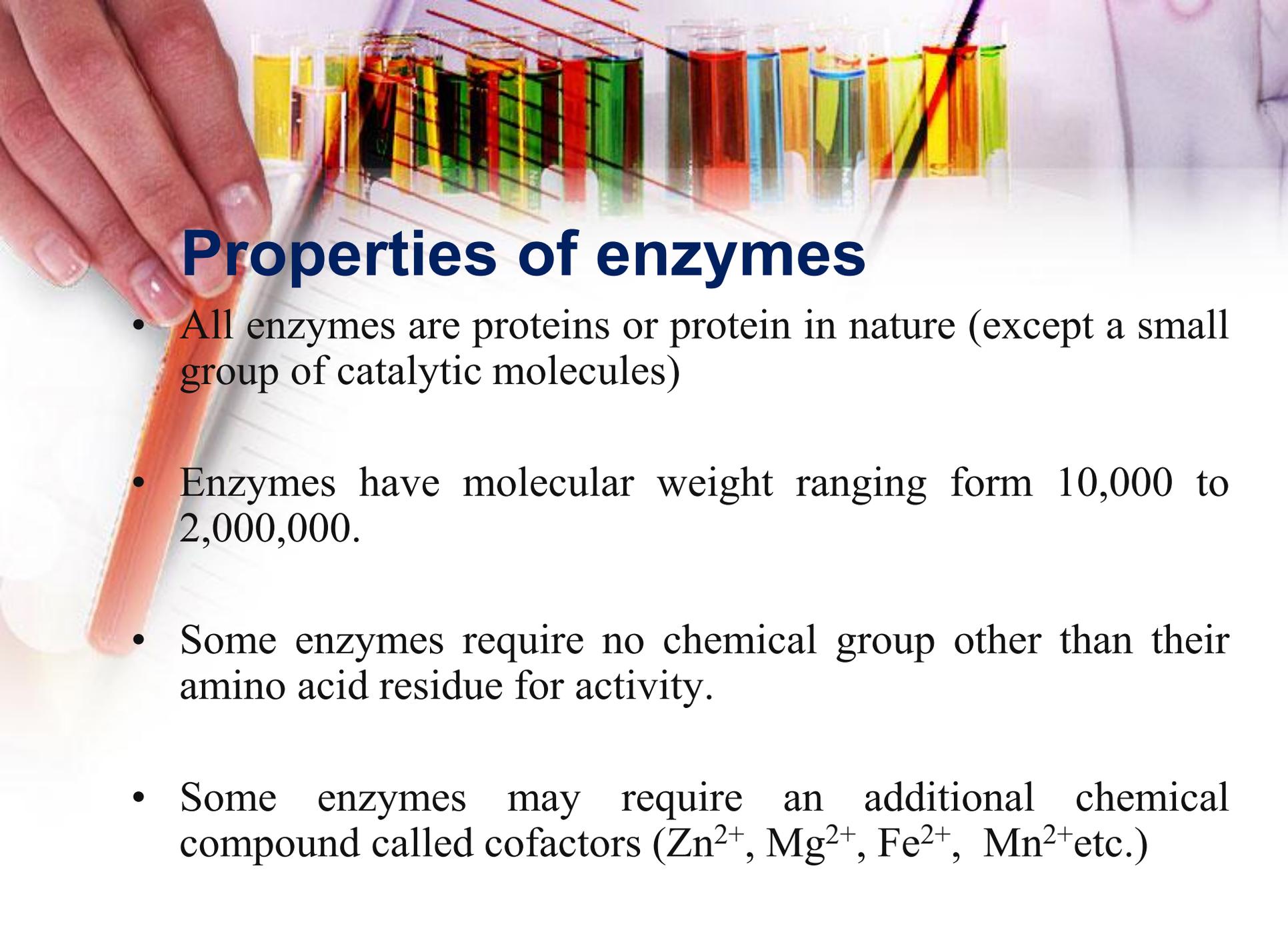
2. Effect of pH on enzyme denaturation:

Extremes of pH can also lead to denaturation of the enzyme, because the structure of the catalytically active protein molecule depends on the ionic character of the amino acid side chains.

3. Variable pH optimum

The pH at which maximal enzyme activity is achieved is different for different enzymes and often reflects the $[H^+]$ at which the enzyme functions in the body.





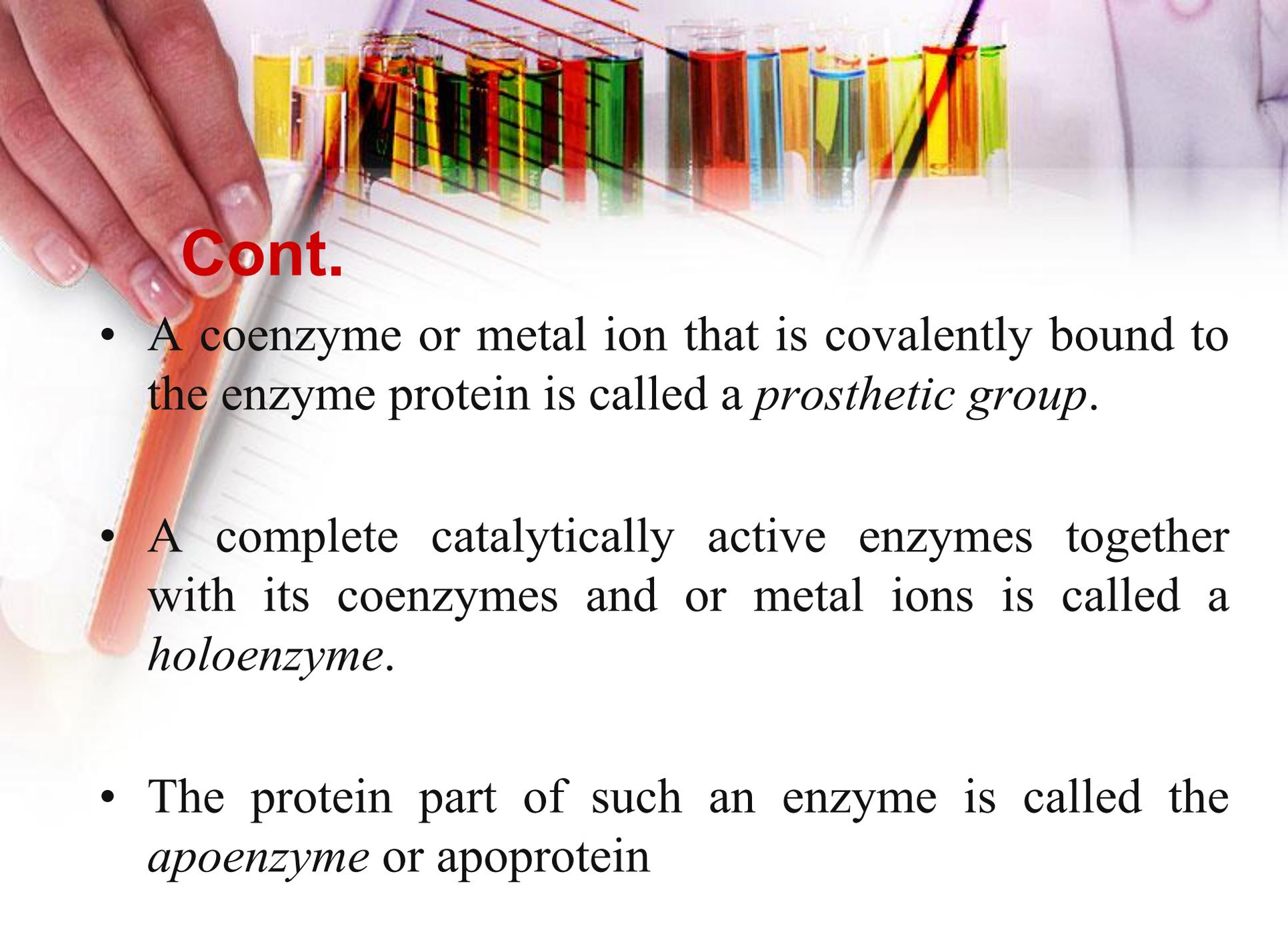
Properties of enzymes

- All enzymes are proteins or protein in nature (except a small group of catalytic molecules)
- Enzymes have molecular weight ranging from 10,000 to 2,000,000.
- Some enzymes require no chemical group other than their amino acid residue for activity.
- Some enzymes may require an additional chemical compound called cofactors (Zn^{2+} , Mg^{2+} , Fe^{2+} , Mn^{2+} etc.)



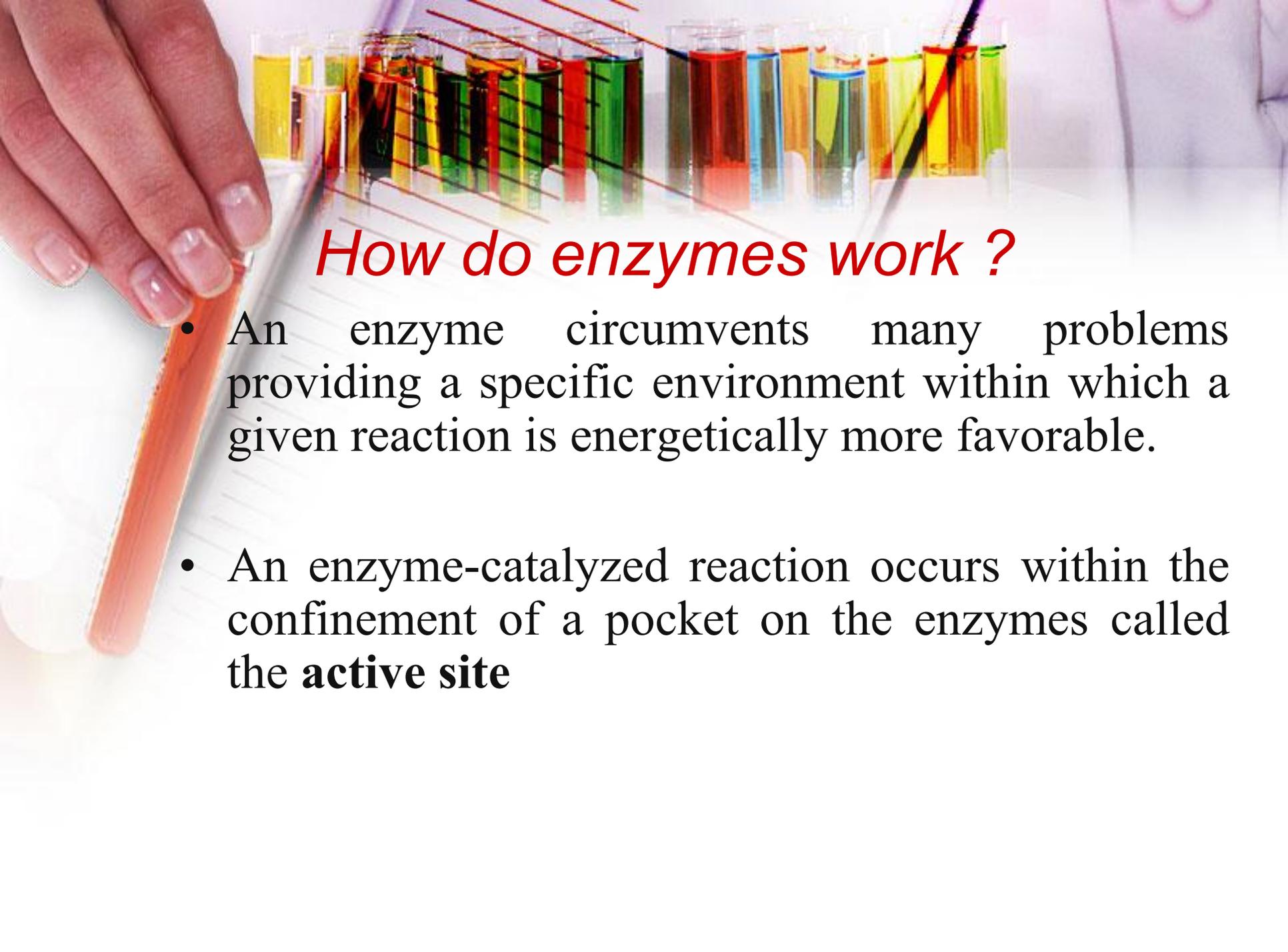
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- Some enzymes may require a complex organic or metallorganic molecule called **coenzymes**
- Sometimes they need both **cofactors** and **coenzymes**



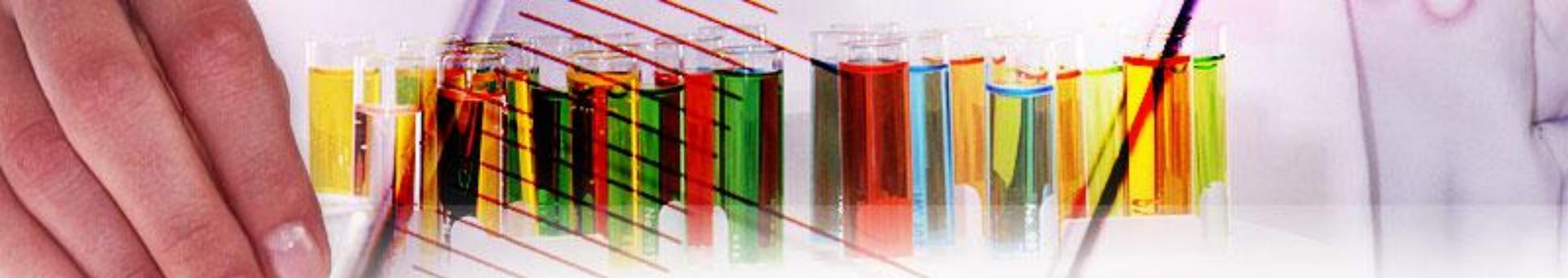
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- A coenzyme or metal ion that is covalently bound to the enzyme protein is called a *prosthetic group*.
- A complete catalytically active enzymes together with its coenzymes and or metal ions is called a *holoenzyme*.
- The protein part of such an enzyme is called the *apoenzyme* or apoprotein



How do enzymes work ?

- An enzyme circumvents many problems providing a specific environment within which a given reaction is energetically more favorable.
- An enzyme-catalyzed reaction occurs within the confinement of a pocket on the enzymes called the **active site**



The molecule that is bound by the active site and acted upon by the enzyme is called the **substrate**

The enzyme-substrate complex is central to the action of enzymes.

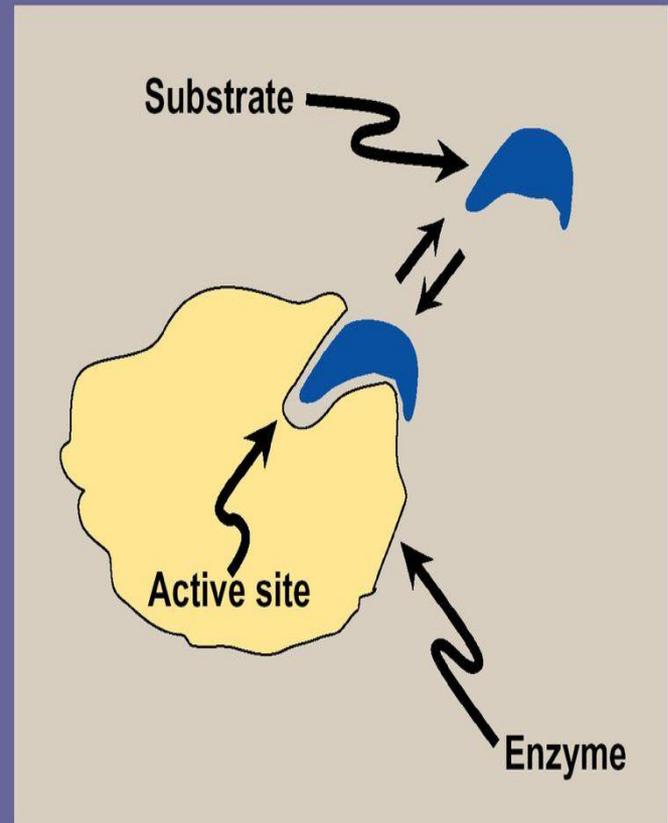
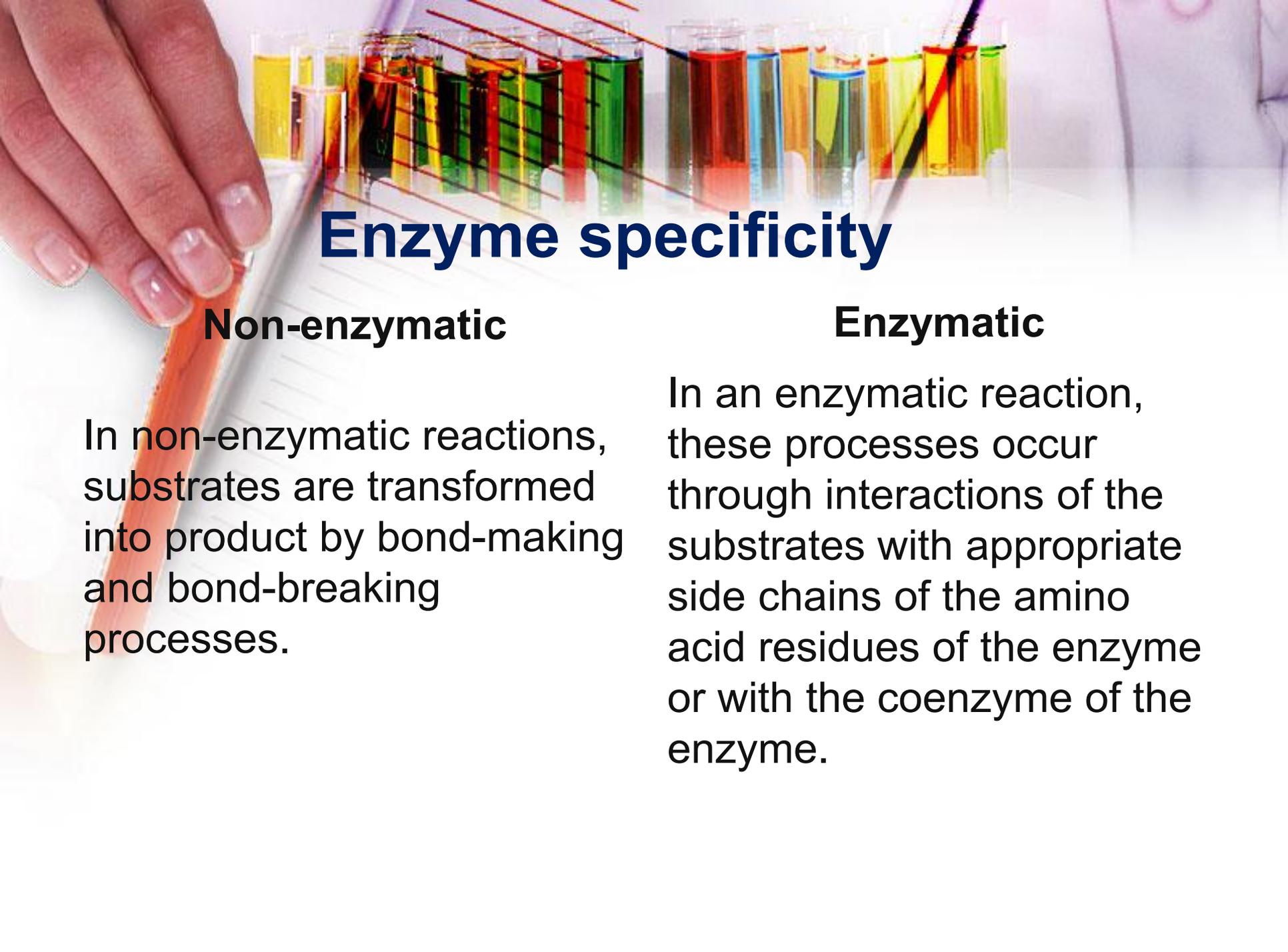


Figure 5.2. Schematic representation of an enzyme with one active site binding a substrate molecule.

A hand is holding a rack of test tubes containing various colored liquids (yellow, green, red, blue, orange). The background is a white lab coat.

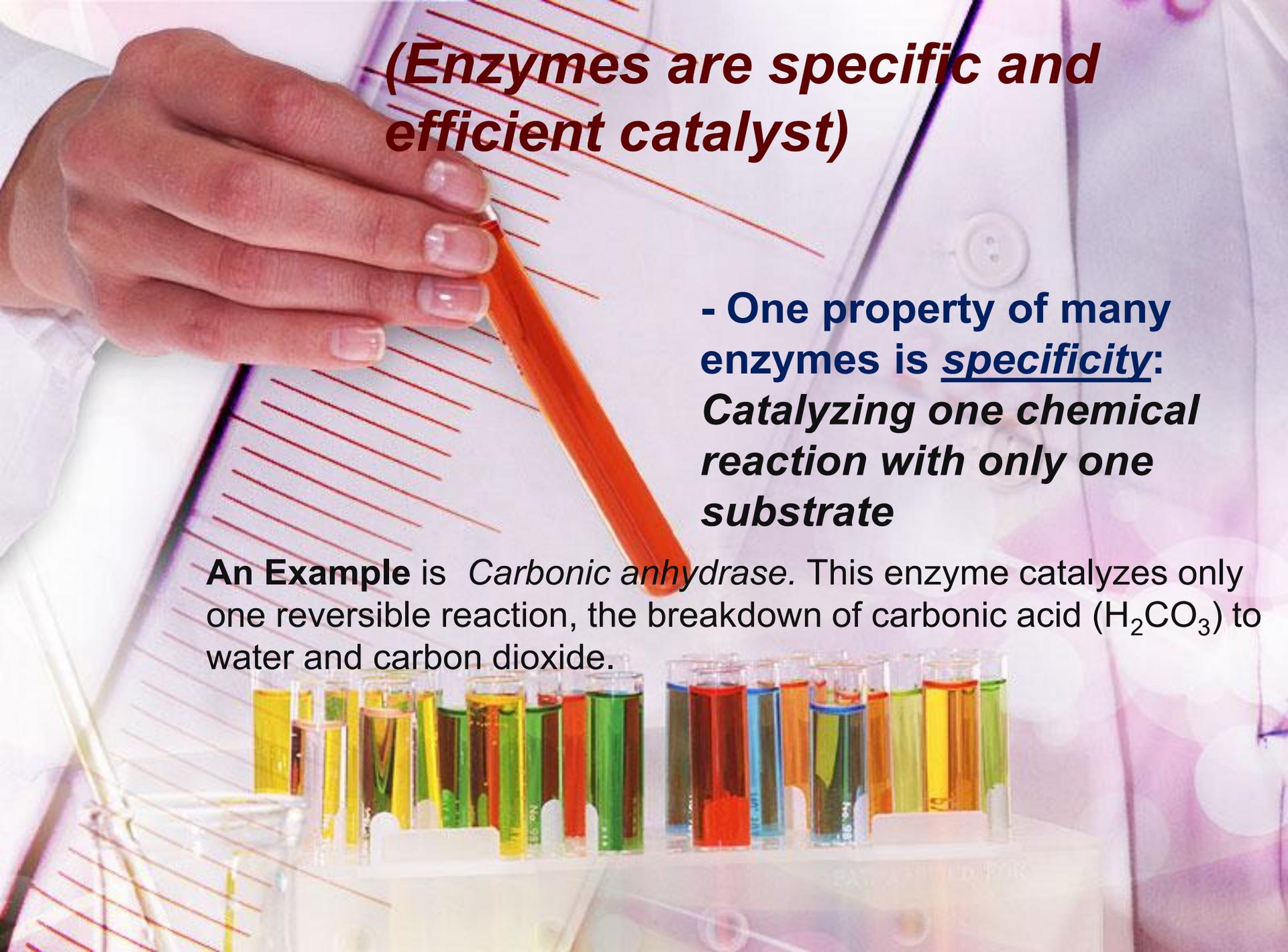
Enzyme specificity

Non-enzymatic

In non-enzymatic reactions, substrates are transformed into product by bond-making and bond-breaking processes.

Enzymatic

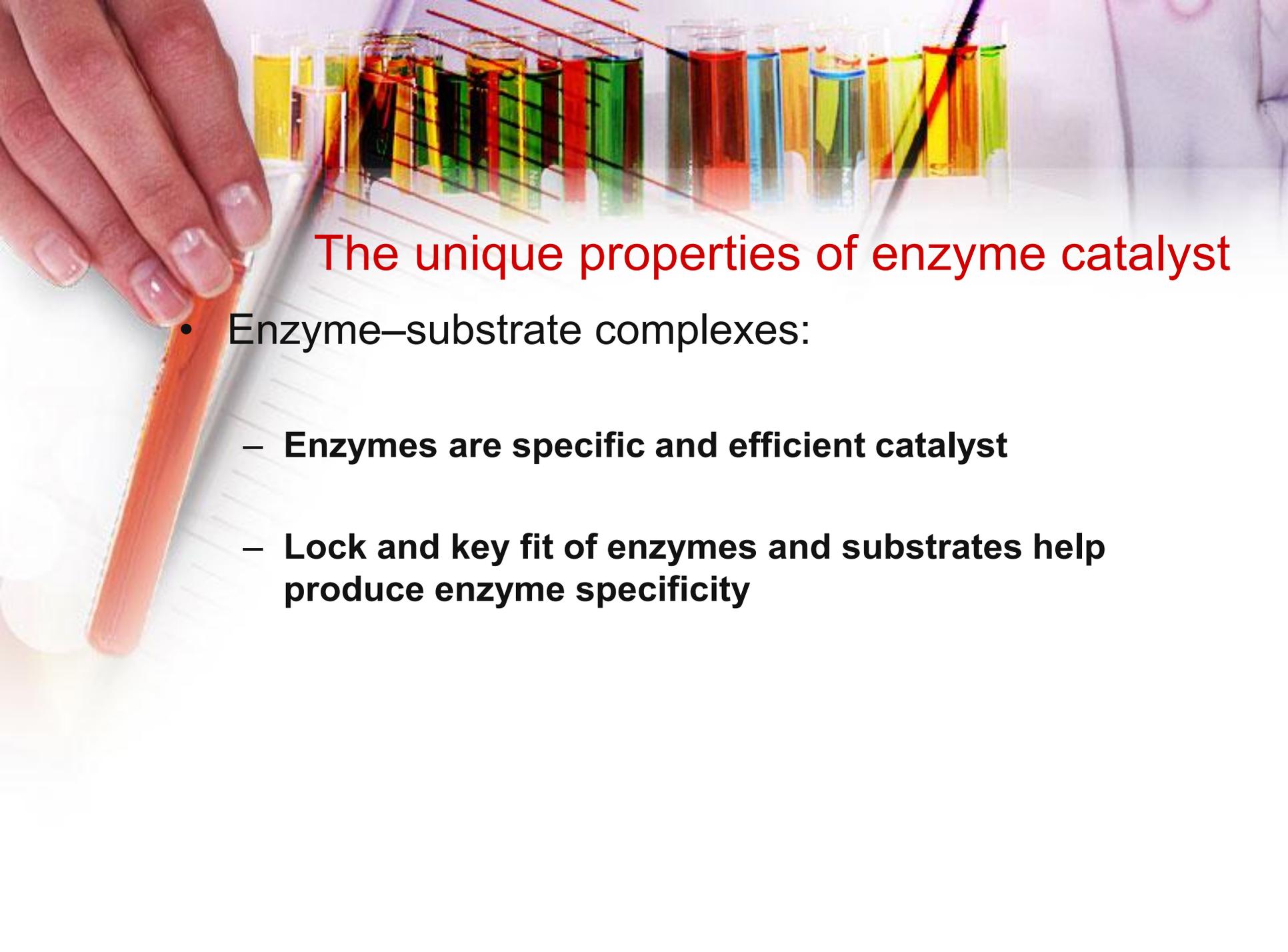
In an enzymatic reaction, these processes occur through interactions of the substrates with appropriate side chains of the amino acid residues of the enzyme or with the coenzyme of the enzyme.



(Enzymes are specific and efficient catalyst)

- One property of many enzymes is specificity: Catalyzing one chemical reaction with only one substrate

An Example is *Carbonic anhydrase*. This enzyme catalyzes only one reversible reaction, the breakdown of carbonic acid (H_2CO_3) to water and carbon dioxide.

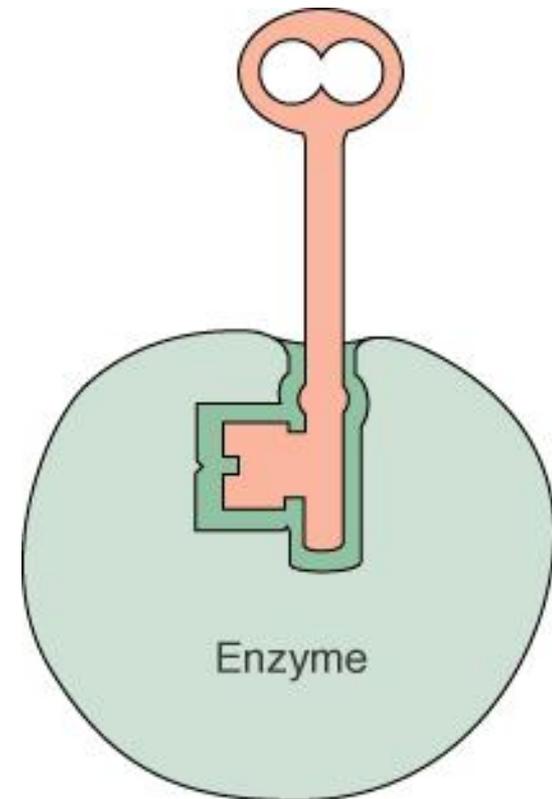


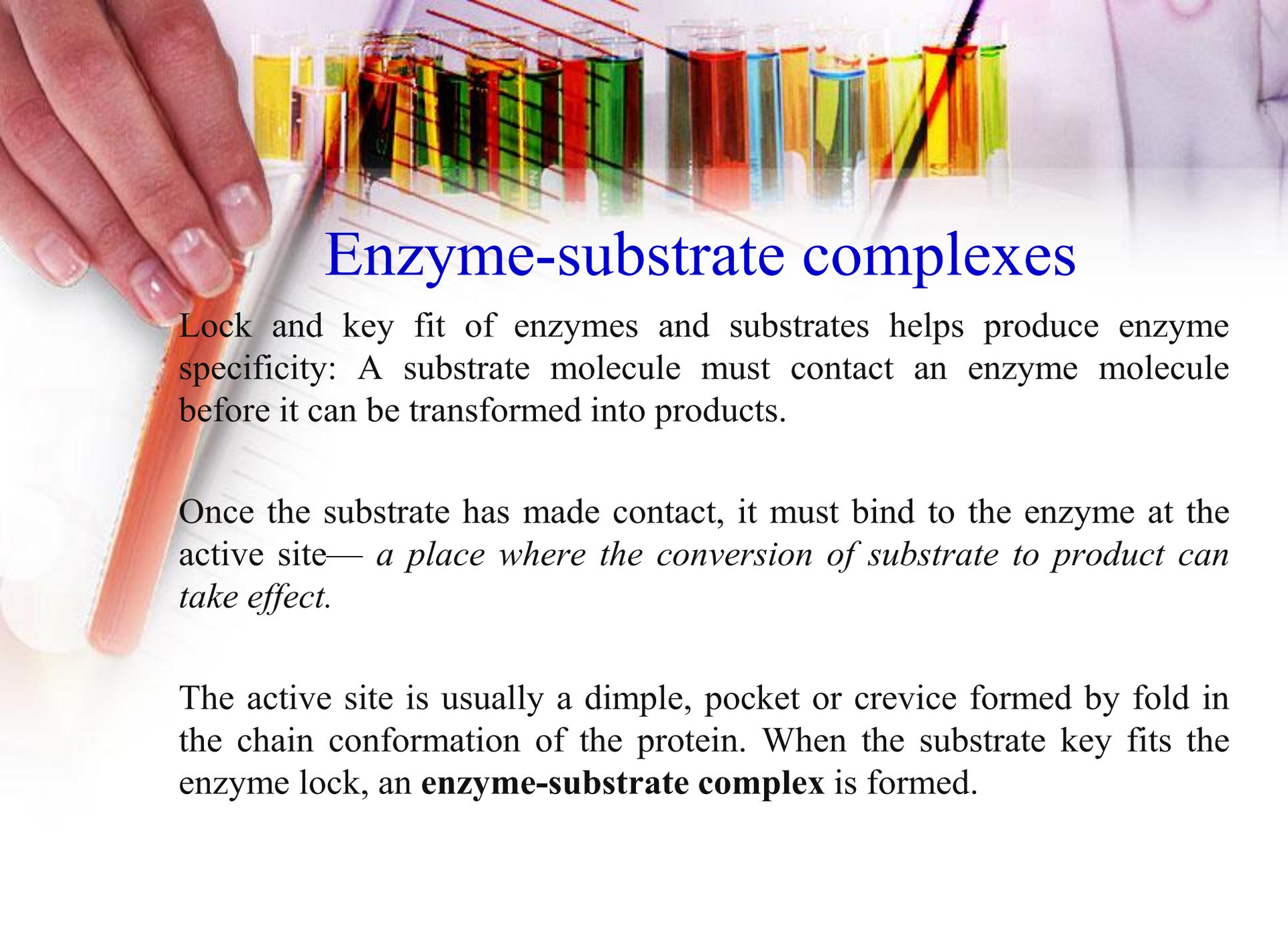
The unique properties of enzyme catalyst

- Enzyme–substrate complexes:
 - Enzymes are specific and efficient catalyst
 - Lock and key fit of enzymes and substrates help produce enzyme specificity

Lock-and-key model of enzyme action

In this early model, the substrate (key) was believed to bind tightly to a site on the enzyme (lock) that was exactly complementary to it in its size, shape and charge.





Enzyme-substrate complexes

Lock and key fit of enzymes and substrates helps produce enzyme specificity: A substrate molecule must contact an enzyme molecule before it can be transformed into products.

Once the substrate has made contact, it must bind to the enzyme at the active site— *a place where the conversion of substrate to product can take effect.*

The active site is usually a dimple, pocket or crevice formed by fold in the chain conformation of the protein. When the substrate key fits the enzyme lock, an **enzyme-substrate complex** is formed.



Next Lecture

- Inhibition of Enzyme Activity
- Regulation of Enzyme Activity
- Enzymes in Clinical Diagnosis