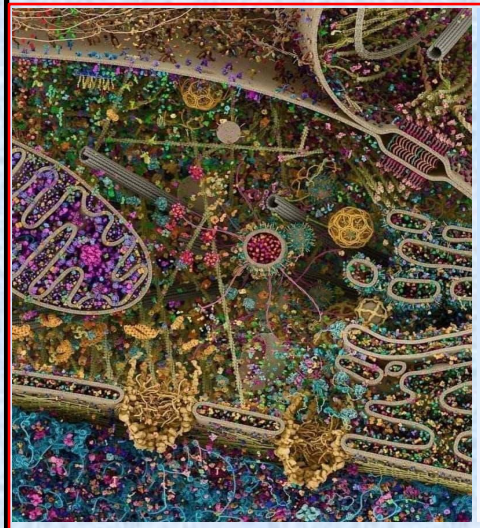
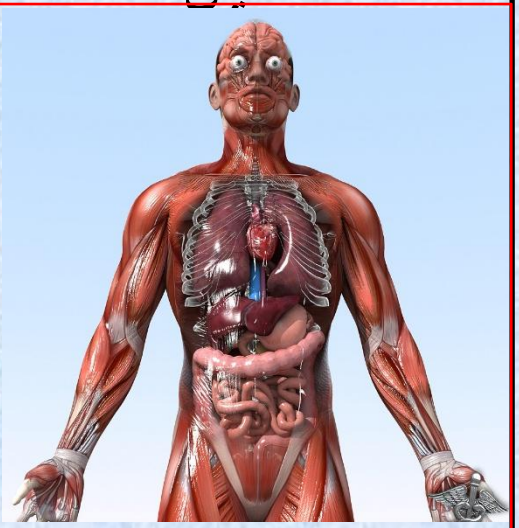
General Animal Biology

ZOO-109 علم الأحياء -109 حين





For Pre-Medical Students - المسار الصحي

Common First Year السنة الأولى المشتركة

1447-H - 2026

Reference: *Campbell, N. A. and Reece, J. B. (2014). Biology (10th edition). Pearson Education. Inc. USA.*

عمادة التعليم الإلكتروني والتعلم عن بعد
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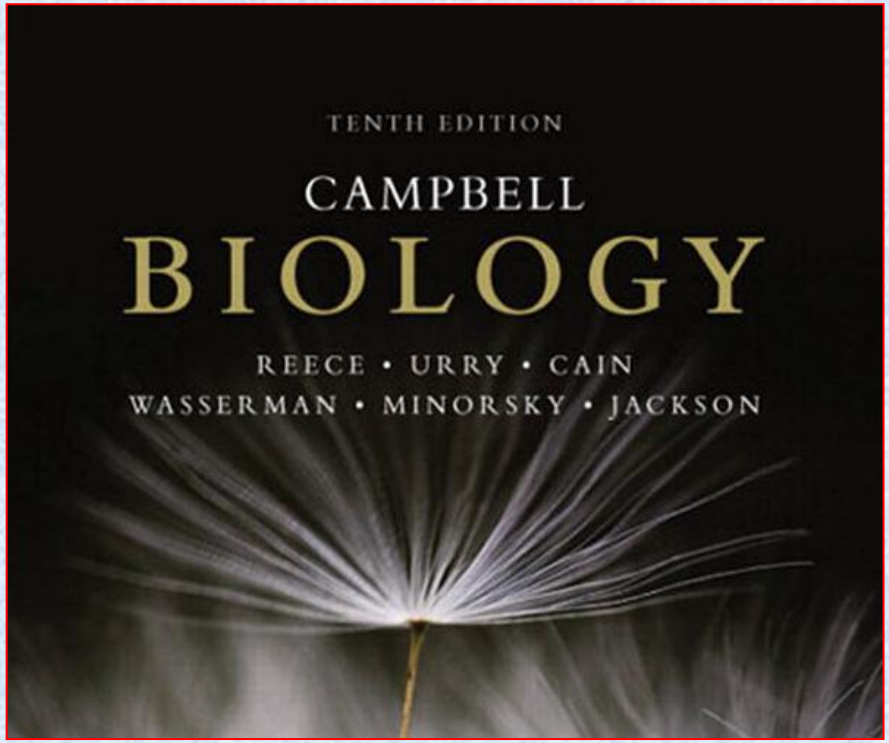
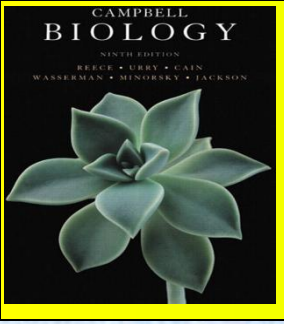


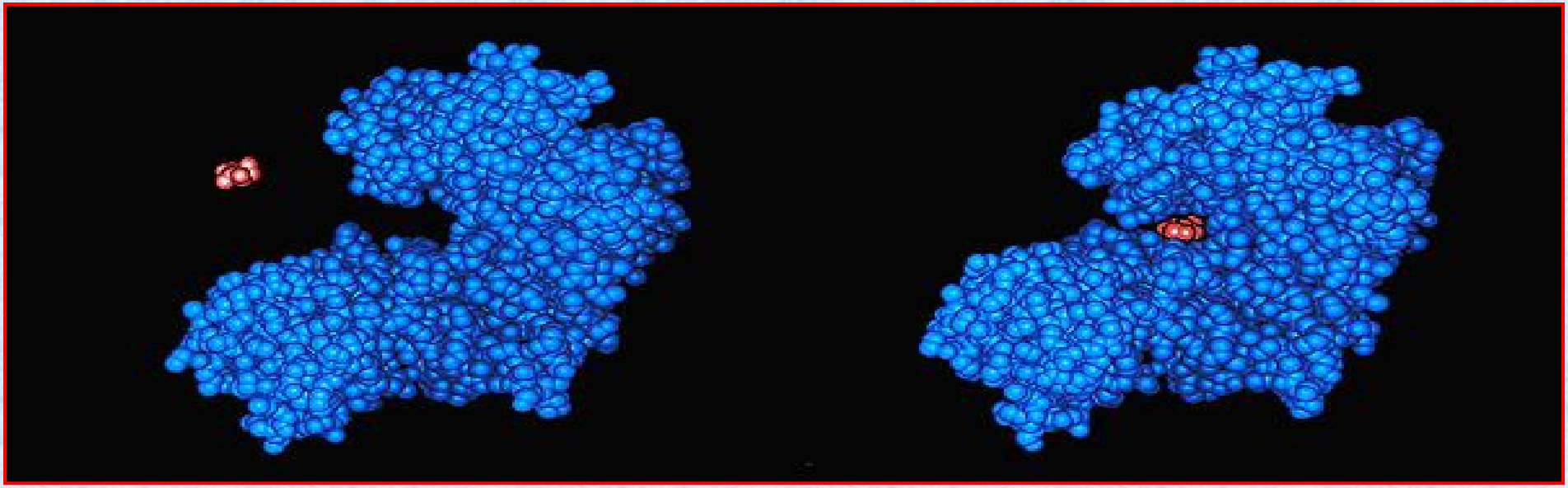


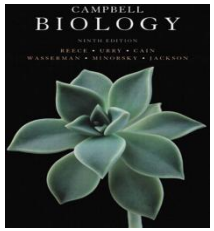
AN INTRODUCTION TO METABOLISM

AN INTRODUCTION TO METABOLISM

Enzymes

Protein molecules with catalytic properties due to their power of specific activation



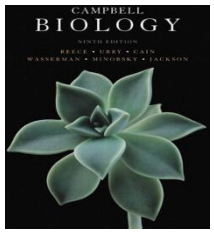


Objectives

- **Enzymes speed up metabolic reactions by *lowering energy barriers*.**
  - Enzymes and Activation Energy (E_A).
  - Enzymes are **substrate specific**.
  - **The active site:** is the enzyme's catalytic center.
  - Catalytic Cycle of Enzyme.

- **Cellular factors affecting enzyme activity:**
  - Temperature.
  - pH.
  - Cofactors.

- **Types of enzyme inhibition**
  - Competitive inhibition.
  - Non-competitive inhibition.
  - Some benefits of enzyme inhibition



1)- Enzymes speed up metabolic reactions by lowering energy barriers حواجز الطاقة

Hydrolysis of sucrose (table sugar)

Glucose + Fructose —(Dehydration)→ Sucrose

Sucrose —(Hydration (H_2O); Sucrase)→ Glucose + Fructose

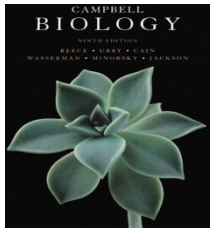
Hydrolysis of sucrose in the presence of Sucrase results in its two monosaccharide components.

This process include:

1- Breaking the bond between Glucose and Fructose;

2- Then, forming new bonds with H^+ and OH^- to from water.

This process consumes تستهلك energy (Activation Energy; E_A)



Enzymes and Activation Energy

Activation Energy:

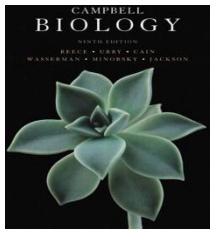
It is the amount of energy needed for the reaction (between enzyme & substrate**) to complete (**to break the bonds**).**

Raising the temperature for these reactions to complete will either denature the compounds or kill the cell.

Thus, organisms must therefore use a catalyst عامل محفز.

A catalyst: is a chemical agent that accelerates the reaction without being consumed by the reaction.

Enzyme is a catalytic protein بروتين مساعد/محفز

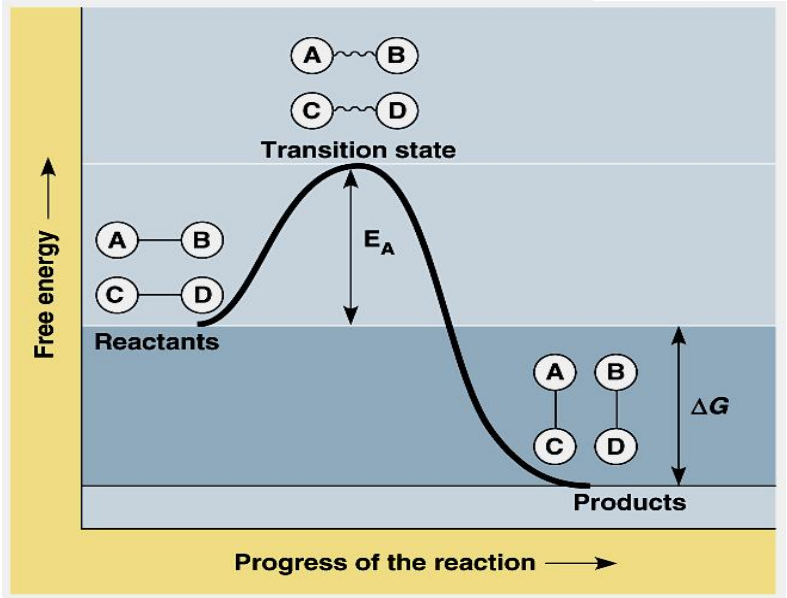


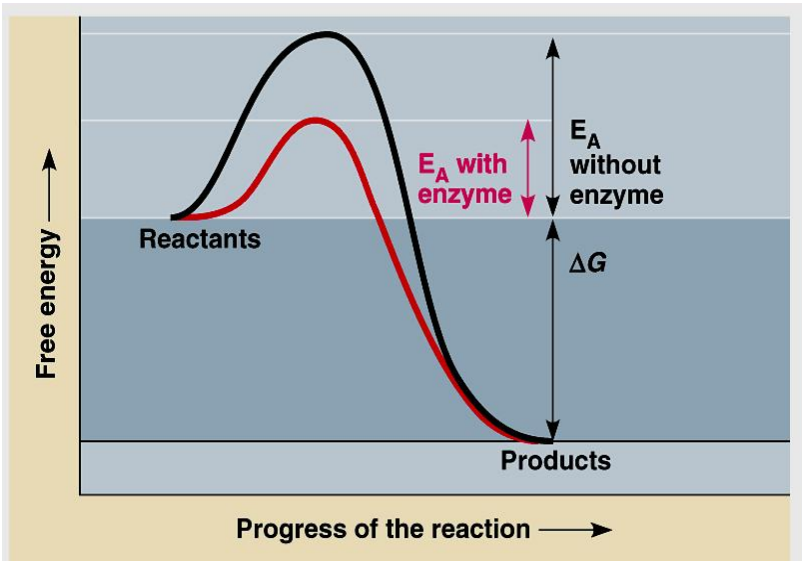
Activation energy

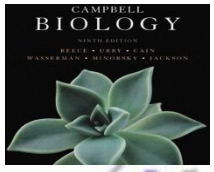
Activation energy: is the amount of energy necessary to push the reactants over an energy barrier.

- At the transition state, the molecules are at an unstable point.
- The difference between free energy of the products and the free energy of the reactants is the delta G.
- Enzyme can increase the rate of reactions by lowering E_A.
- The transition state can then be reached even at moderate temperatures.

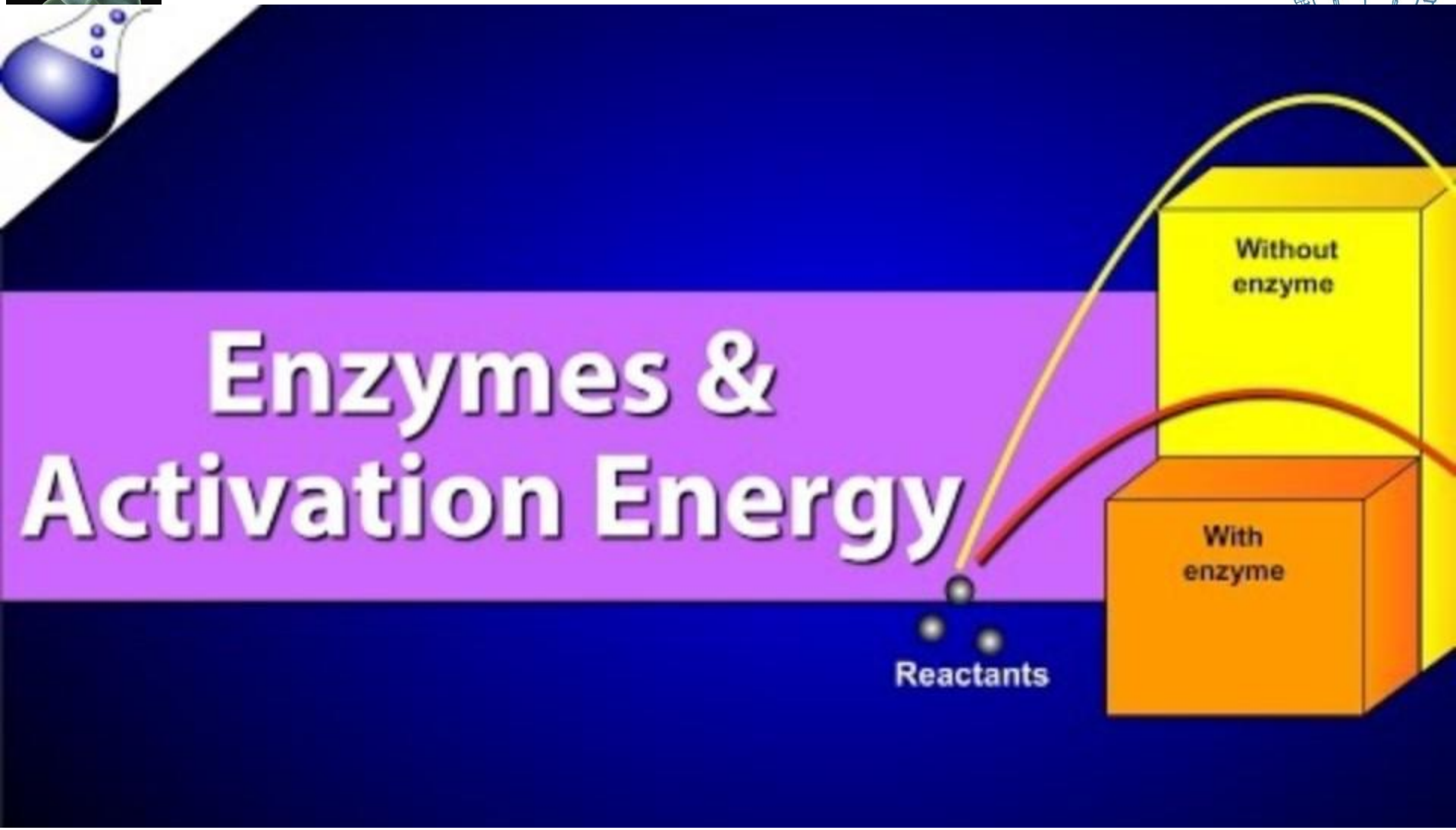
Enzymes speed up metabolic reactions by lowering the activation energy

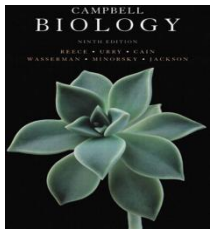






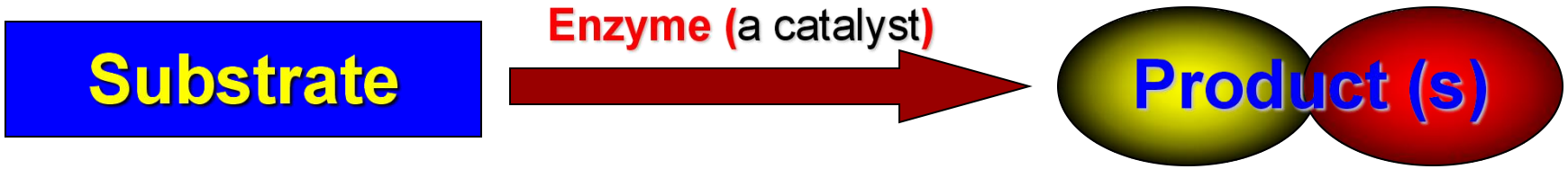
Activation energy

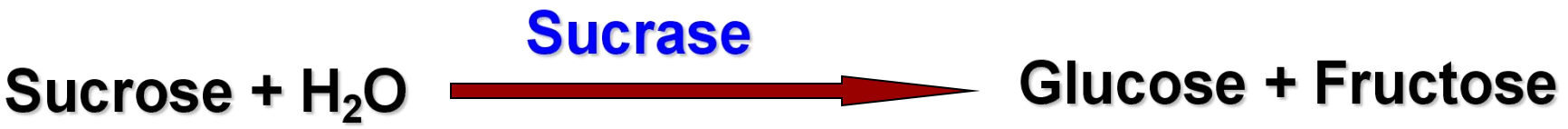




Enzymes are substrate specific

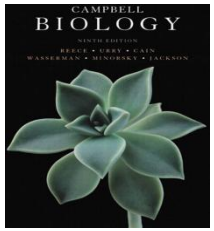
- The **substrate** المادة المطلوب تكسيرها: **is a reactant which binds to an enzyme.**
- **When a substrate binds to an enzyme, the enzyme catalyzes** يسهل **the conversion** تحويل **of the substrate to the product** مكوناتها البنائية.
  - **Sucrase** (catalyst) **is an enzyme that binds to sucrose** (substrate) **and breaks the disaccharide into fructose and glucose** (products).





Enzyme specificity: an enzyme is specific متخصص **catalyst for specific reactants in the cell** (e.g. Sucrase for only Sucrose).

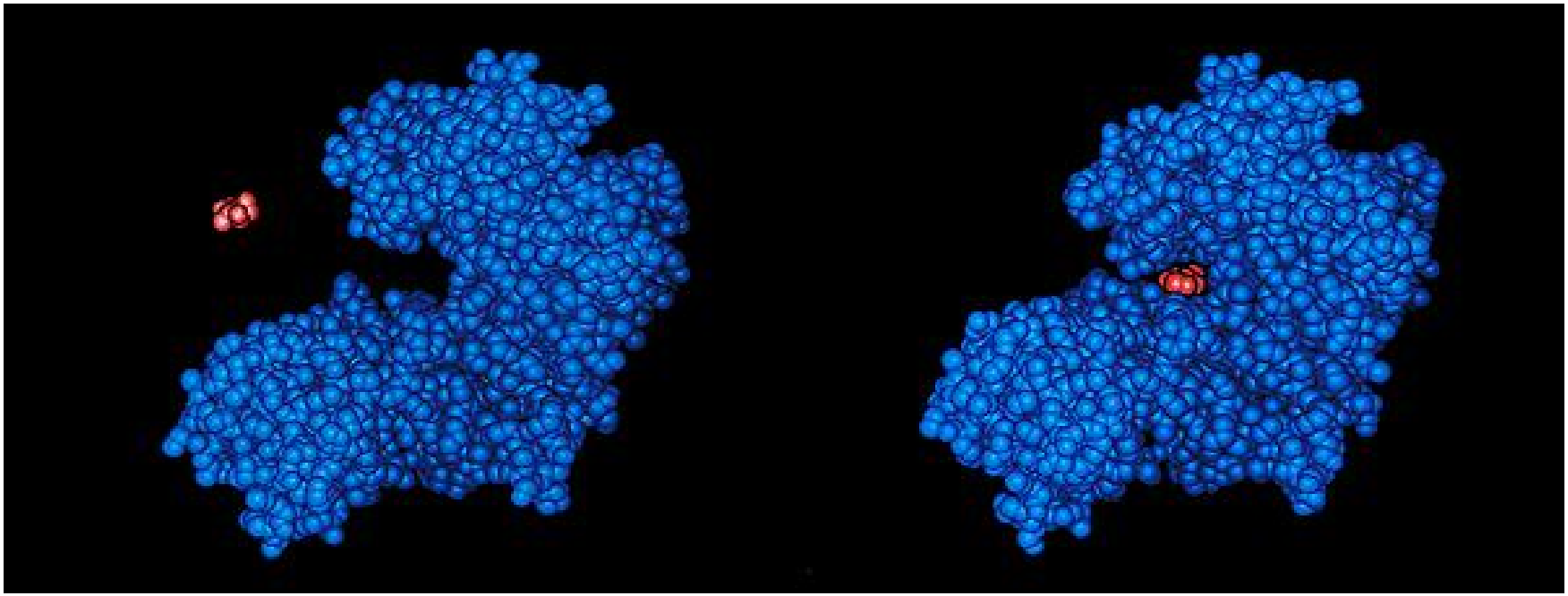
- **This specificity of an enzyme** تخصصية الإنزيم **refers to the shape of its Active Site** المركز النشط **into which fits** يناسب **the surface of the substrate.**

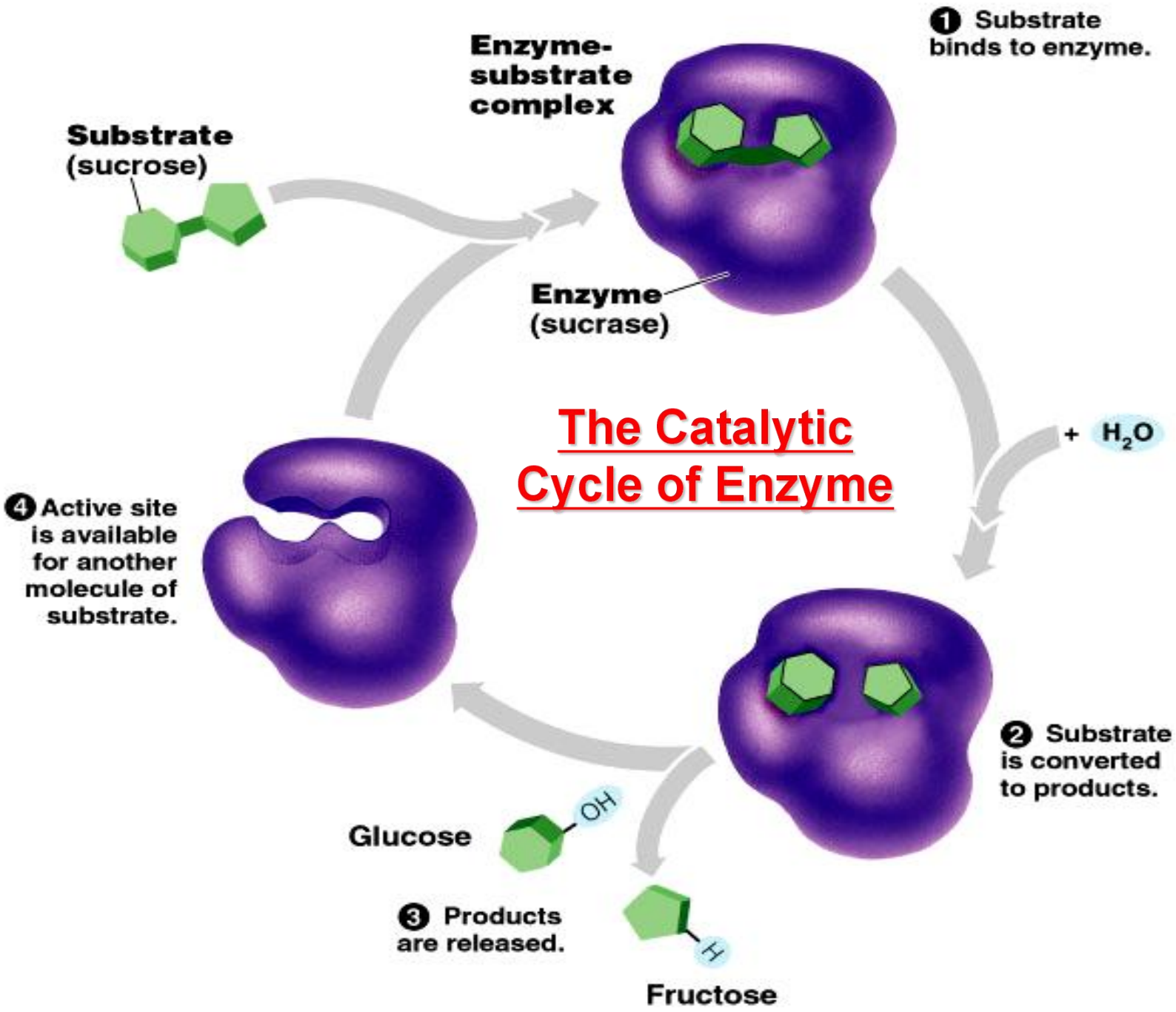


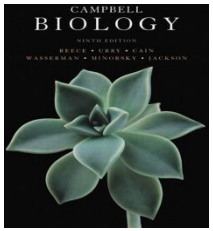
The active site is an enzyme's catalytic center

- The **active site** المكان النشط **of an enzymes*:***

  is the groove الجيب ***on the surface of the enzyme into which the substrate fits*****.**
- **Thus, specificity of an enzyme is due to the fit between** التناسب بين **the active site and the substrate.**
- **As the substrate binds, the enzyme changes shape to fit the substrate, bringing chemical groups in position to catalyze the reaction.**

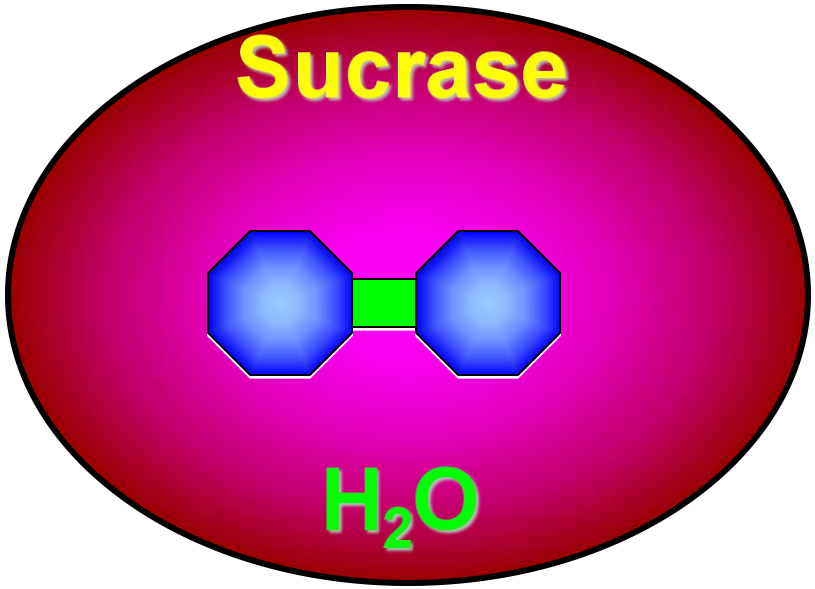


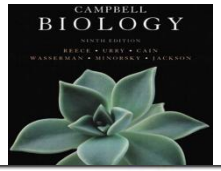

1 Substrate binds to enzyme.
Enzyme-substrate complex
Substrate (sucrose)
Enzyme (sucrase)
The Catalytic Cycle of Enzyme
+ H_2O
4 Active site is available for another molecule of substrate.
2 Substrate is converted to products.
Glucose
OH
3 Products are released.
H
Fructose



Summary:

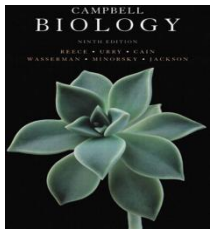
Active site of enzyme and Catalytic Cycle





Summary:

Active site of enzyme and Catalytic Cycle



Summary:

Active site of enzyme and Catalytic Cycle

1- The substrate binds to the active site of enzyme.

2- This forms an Enzyme-Substrate complex (*via* weak hydrogen bonds).

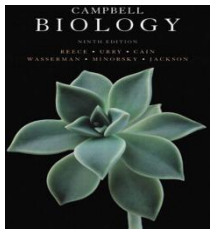
3- The active site catalyzes the conversion of the substrate to final products (*to its original components*) by breaking bonds.

4- The resulting products release from the enzyme.

5- The enzyme starts another reaction over and over again.

6- Thus, the enzyme can have a huge metabolic effect in the catalytic cycle.

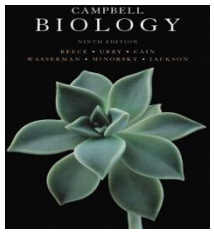
7- An enzymes has catalytic properties due to its power of hydrolytic activities



Summary:

Some characters of enzyme

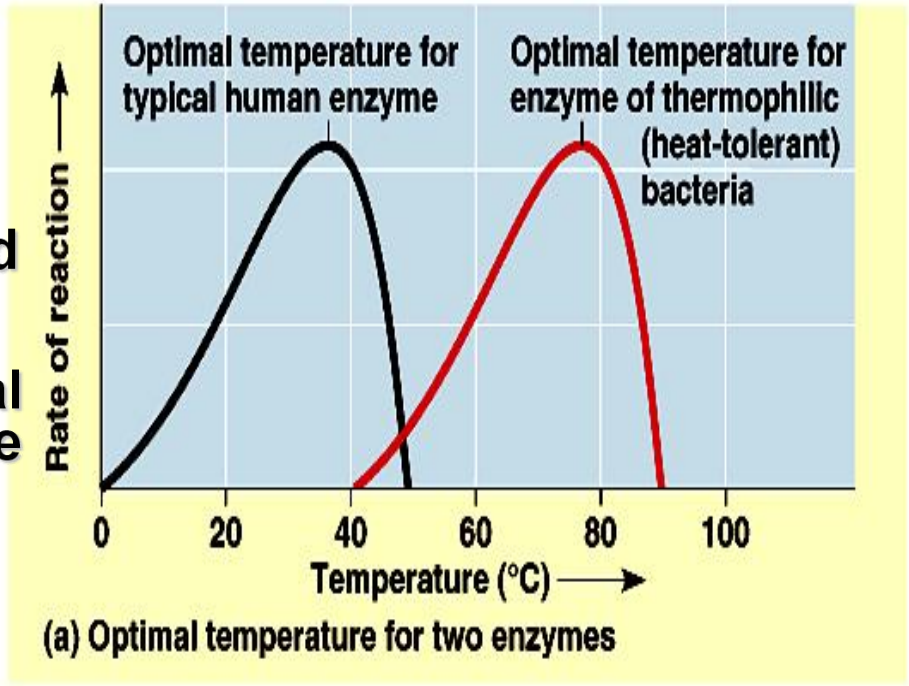
- A single enzyme molecule can catalyze thousands or more reactions a second.
- Enzymes are un-affected by the reaction and are reusable يُعاد استخدامها.
- Most metabolic enzymes الإنزيمات الأيضية can catalyze a reaction in both the ***forward*** and ***reverse*** directions.
  - The actual direction depends on the relative concentrations of products and reactants.
  - Enzymes catalyze reactions in the direction of equilibrium التعادل.
- The enzyme lowers the activation energy and speed up the reaction.
- The rate that a specific number of enzymes converts substrates to products depends, in part, on substrate concentrations.
- At some substrate concentrations, the active sites of all enzymes are engaged مشغولة, called enzyme saturation التشبع الإنزيمي.



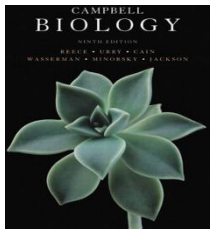
2)- Cellular factors affecting enzyme activity

- **Some conditions lead to the most active conformation and lead to optimal rate of reaction. These factors are:**

1. **Temperature: has a major impact on the reaction rate.**
   - ❖ **As temperature increases, reaction between substrate and active sites occur faster.**
   - ❖ **However, at some point thermal increase begins to denature the enzyme.**
   - ❖ **Each enzyme has an optimal temperature** درجة حرارة مُثلى .



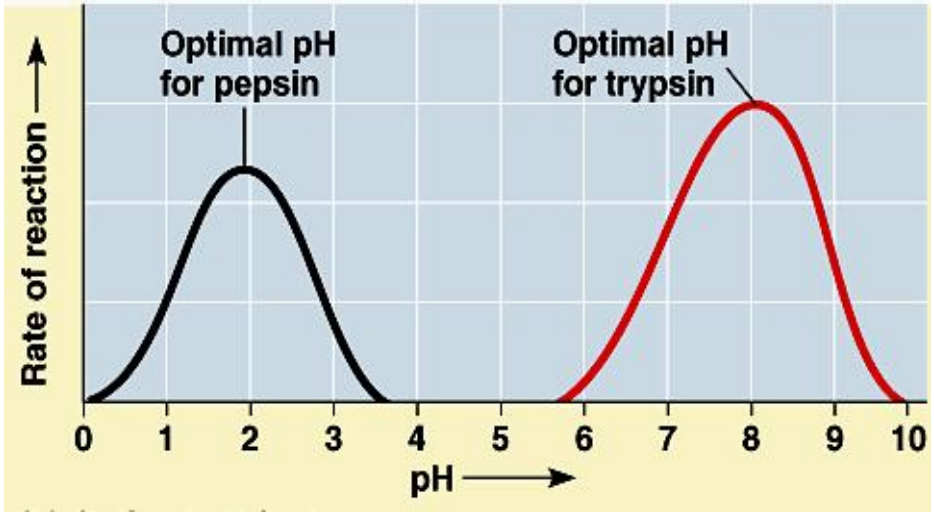
(a) Optimal temperature for two enzymes



2)- Cellular factors affecting enzyme activity

2. pH: also influences the reaction rate, each enzyme has an optimal pH falls between pH 6 - 8 for most enzymes.

- However, digestive enzymes in the stomach are designed to work best at pH 2 while those in the intestine are optimal at pH 8, both matching their working environments.

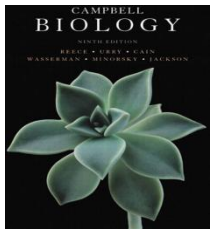


3. Cofactors: العوامل المساعدة

A non-protein helpers for catalytic activity of enzymes. They bind permanently دائما to the enzyme and include two types:-

a)- Inorganic cofactors, include zinc, iron, and copper.

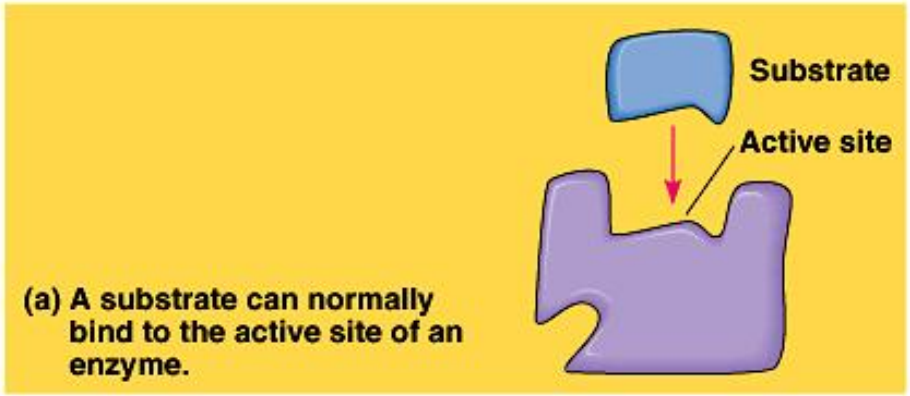
b)- Organic cofactors, include vitamins or molecules derived from vitamins called (coenzymes)

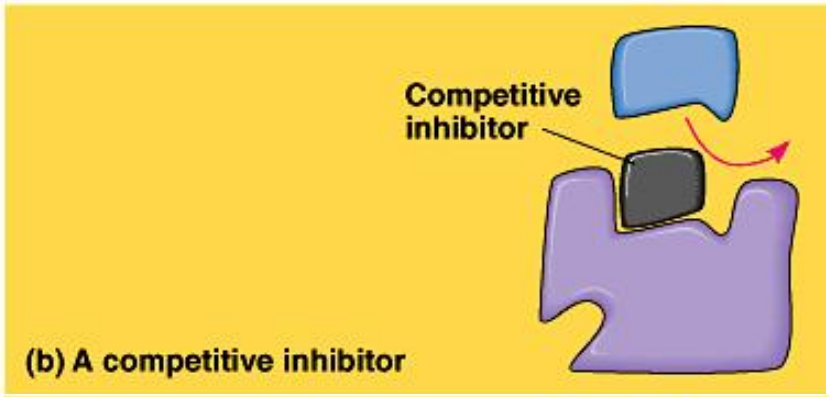


3)- Enzyme inhibitors: مُثبِّطات الإنزيمات

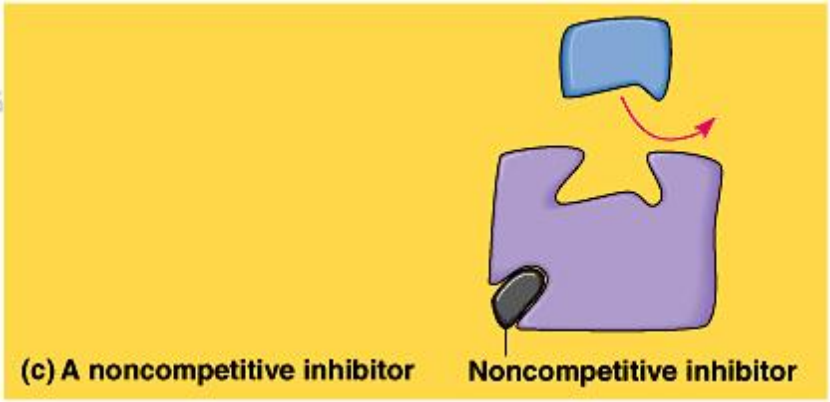
- **Inhibitors: are chemicals that reduce the rate of enzymatic reactions.**
  - **They are usually specific and work at low concentrations.**
  - **They block the enzyme but do not usually destroy it.**
  - **Many drugs and poisons are inhibitors of enzymes in the nervous system.**

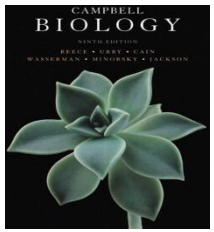
- **A)- Competitive inhibition تثبيط تنافسي : the inhibitor binds to the same site as the substrate, thus prevents the enzymatic reactions.**





- **B)- Non-competitive inhibition: تثبيط لا تنافسي the inhibitor binds somewhere other than the active site, resulting in changing enzyme shape. Finally, deactivates يُخمد the active site**





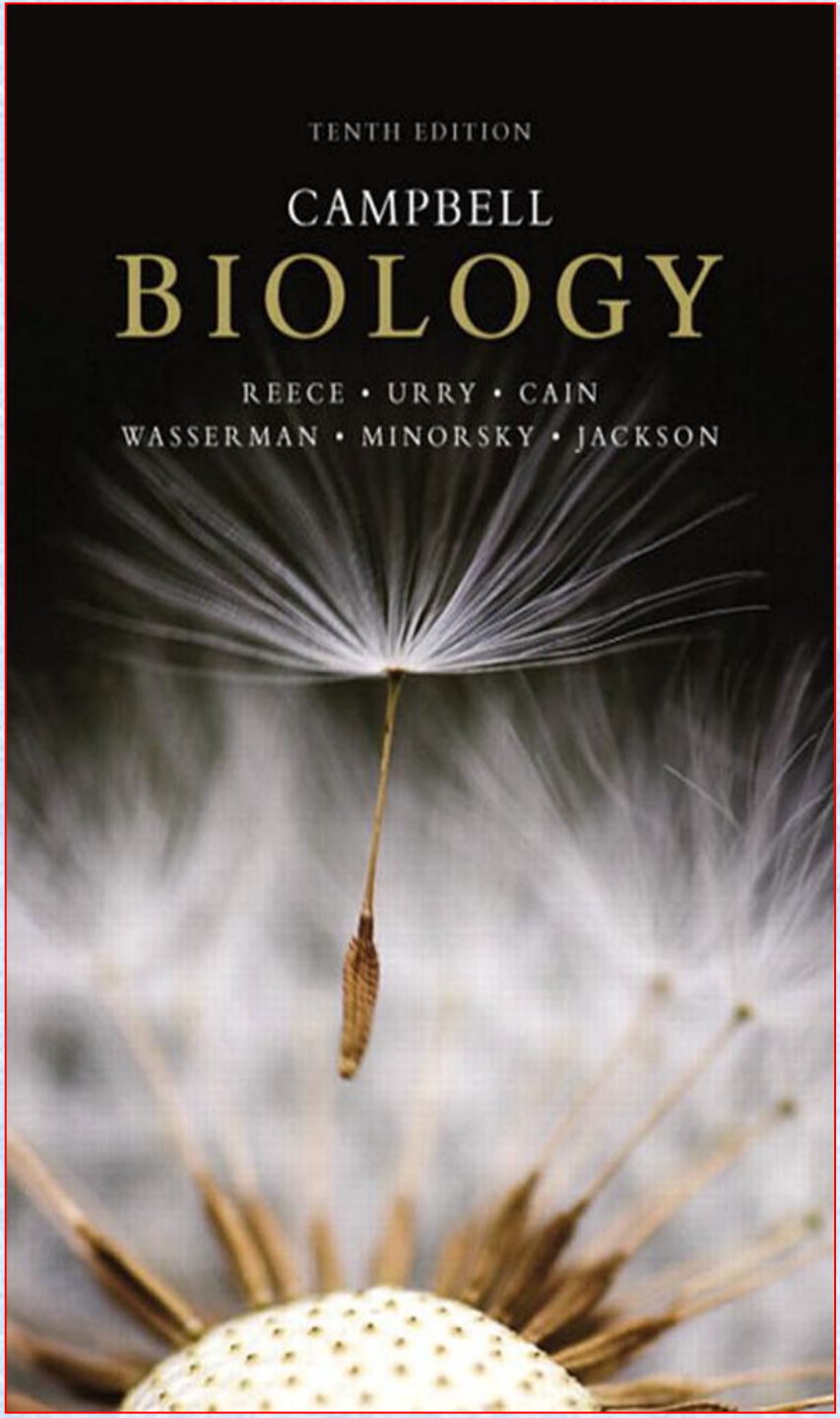
Some benefits of enzyme inhibitors

The insecticide DDT is an inhibitor for key enzymes of nervous system in insects results in death.

Many antibiotics (e.g. Penicillin) inhibits enzymes that help bacteria to make their cell walls.

In the next lecture we will explain that:

Activation and inhibition of enzymes are essential for metabolic control



عمادة التعليم الإلكتروني والتعلم عن بعد
E-learning Deanship

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جامعة الملك سعود

College of Science,
Zoology Department

General Animal Biology

(Zoo-109)

جامعة الملك سعود
King Saud University

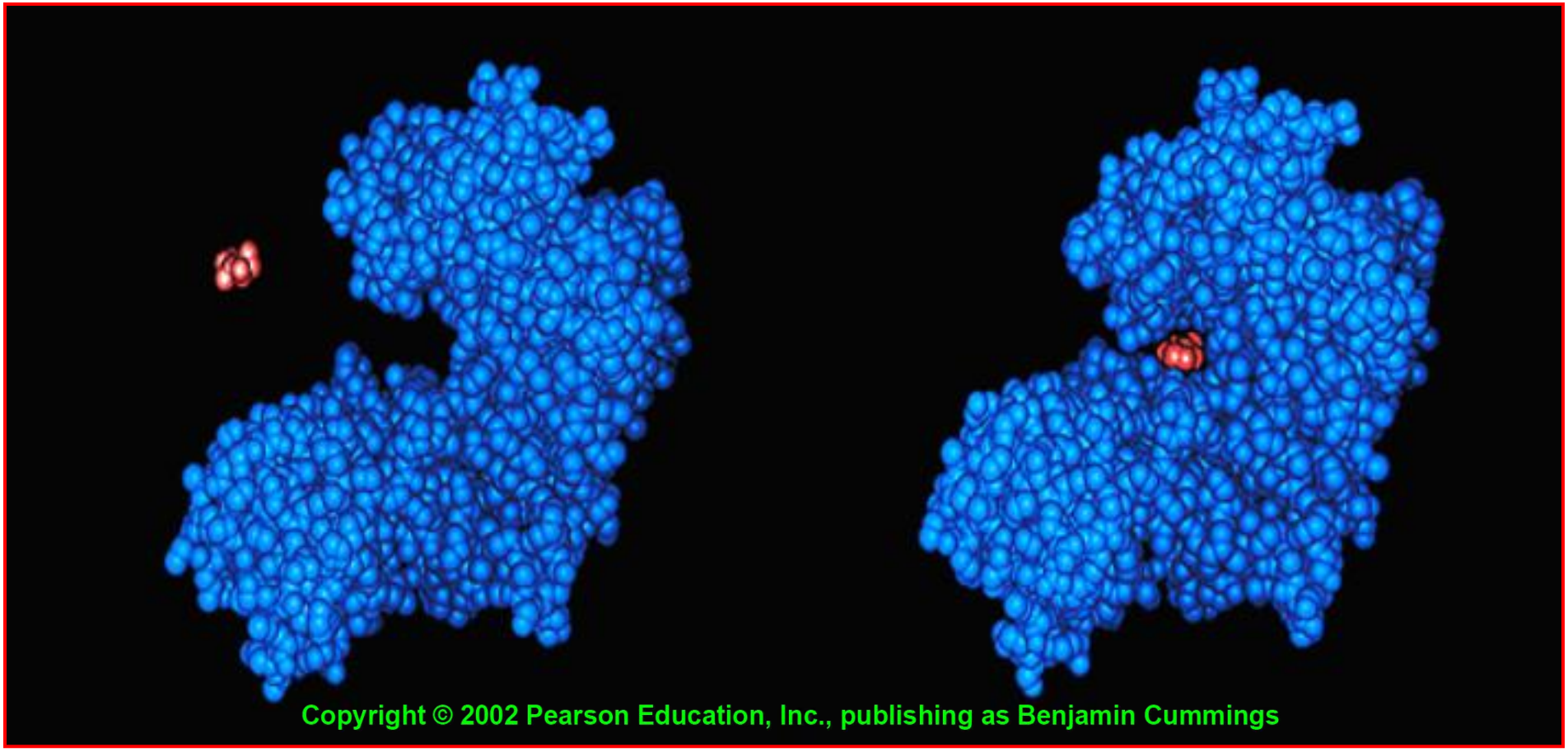
Thank you very much

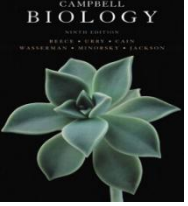
شكرا جزيلا

Zoology Department

بسم الله الرحمن الرحيم

AN INTRODUCTION TO METABOLISM





Objectives

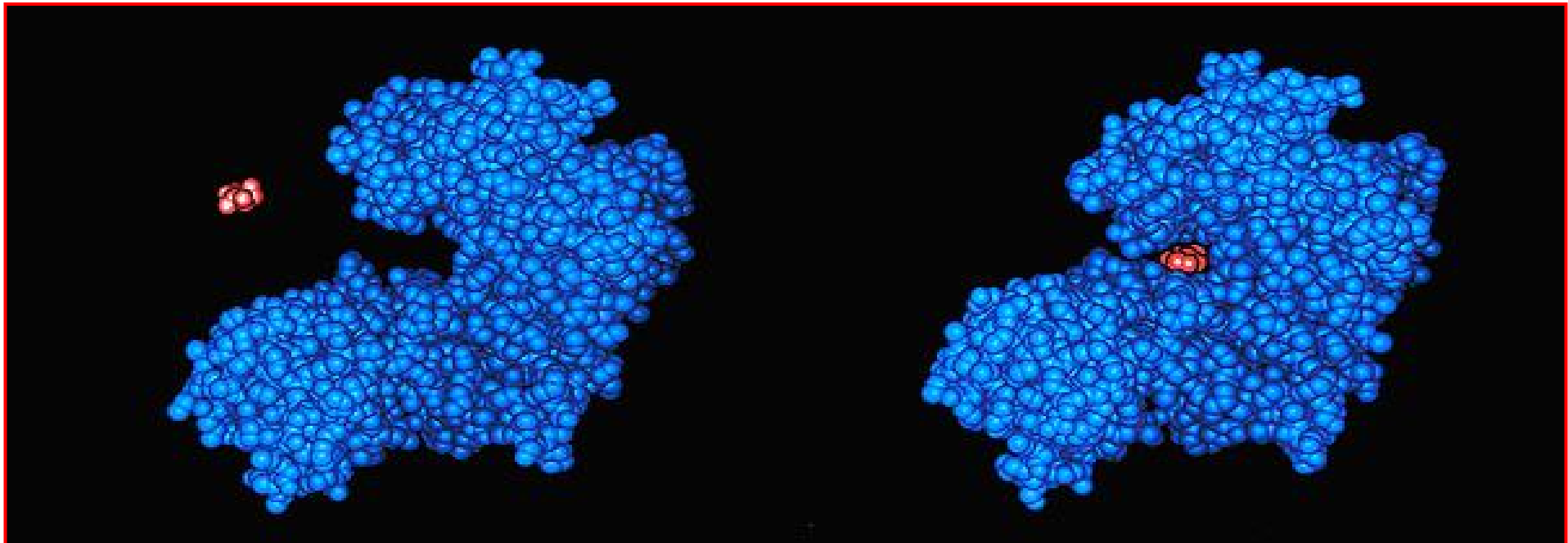
The Control of Metabolism via regulation of enzymes

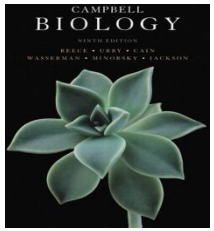
A. Allosteric Regulation of Enzymes

- Allosteric Activation
- Allosteric Inhibition
- Feedback Inhibition

B. Cooperativity regulation.

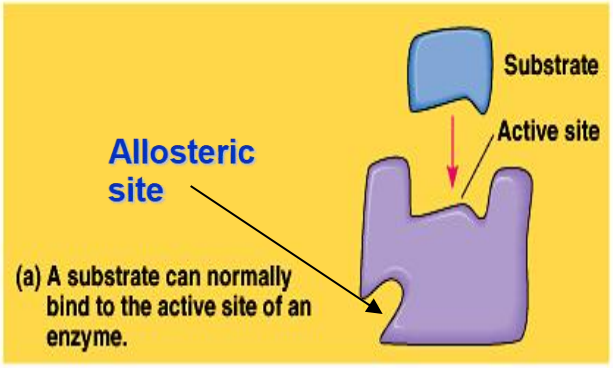
التحكم في الإنزيم





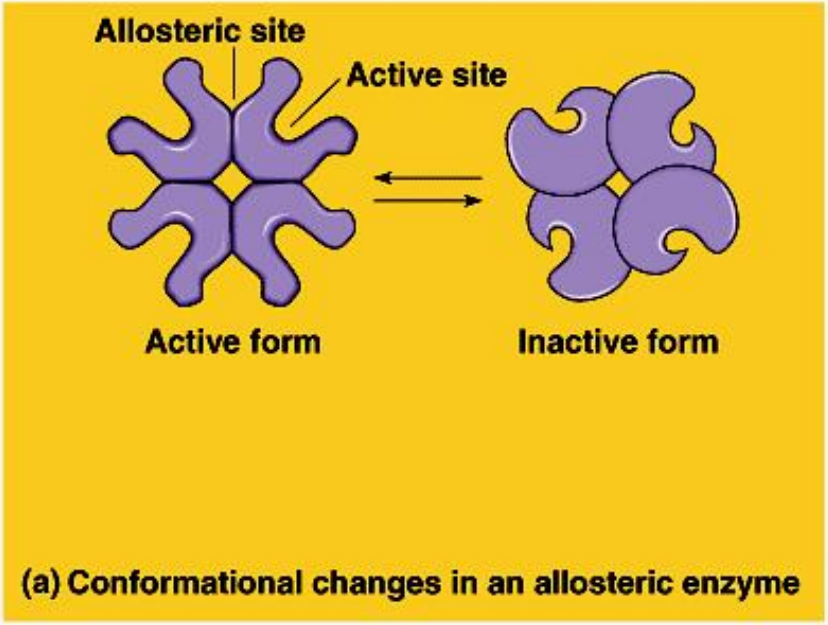
The Control of Metabolism

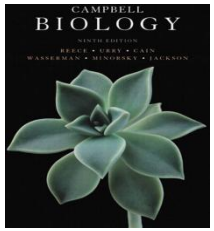
- In many cases, the molecules that naturally regulate enzyme activity behave like reversible noncompetitive inhibitors.
- These molecules often bind weakly to an allosteric site which is a specific receptor on the enzyme that is not the active site.
- These molecules can either inhibit or stimulate enzyme activity.



A)- Allosteric Regulation: التنظيم الألوستيري

- Most allosterically regulated enzymes are constructed of two or more polypeptide chains.
- Each subunit has its own active site. The allosteric sites are often located where subunits are joined.
- The whole protein exists in two conformational shapes, The active form, and the inactive form.





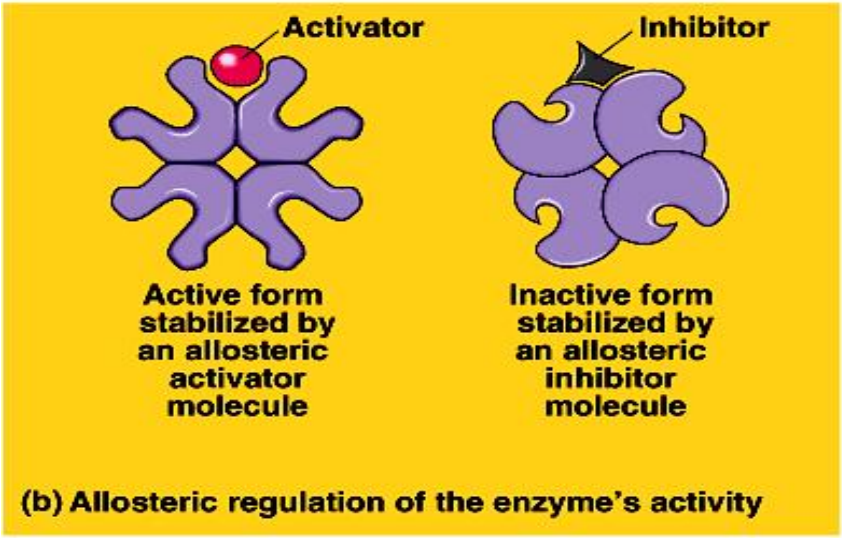
The Control of Metabolism

a)- Allosteric activators منشطات:

It stabilizes the conformation that has a functional active site.

b)- Allosteric inhibitors مثبطات:

It stabilizes the conformation that lacks an active site.



- **In many cases, both inhibitors and activators are similar enough in shape that they compete for the same allosteric sites.**
- **These molecules may be products and substrates of a metabolic pathway.**

c)- Feedback inhibition

التثبيط بالأثر الراجعي:

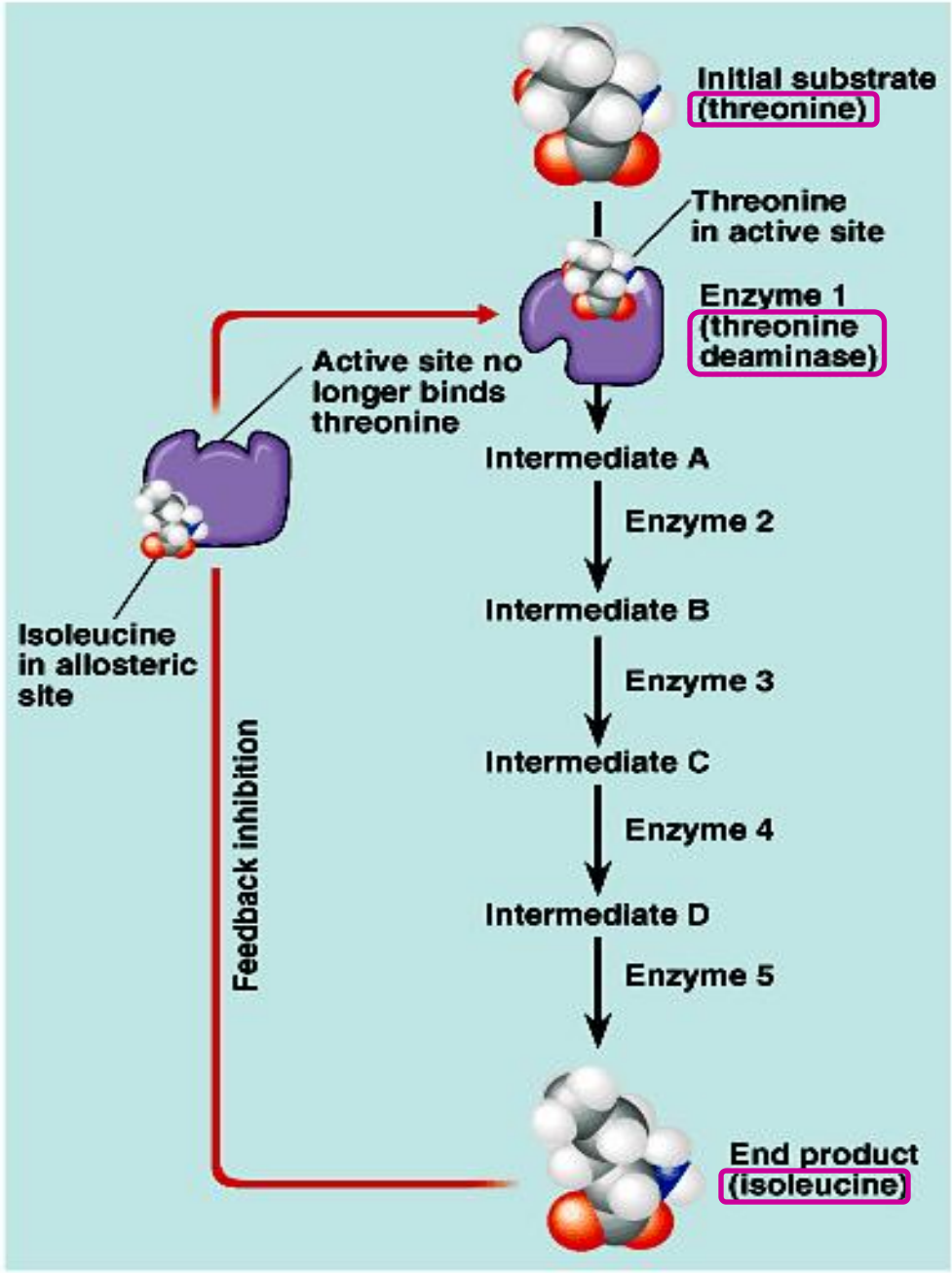
It is one of the common methods of metabolic control in which a metabolic pathway is turned off يتوقف by its end product الناتج النهائي.

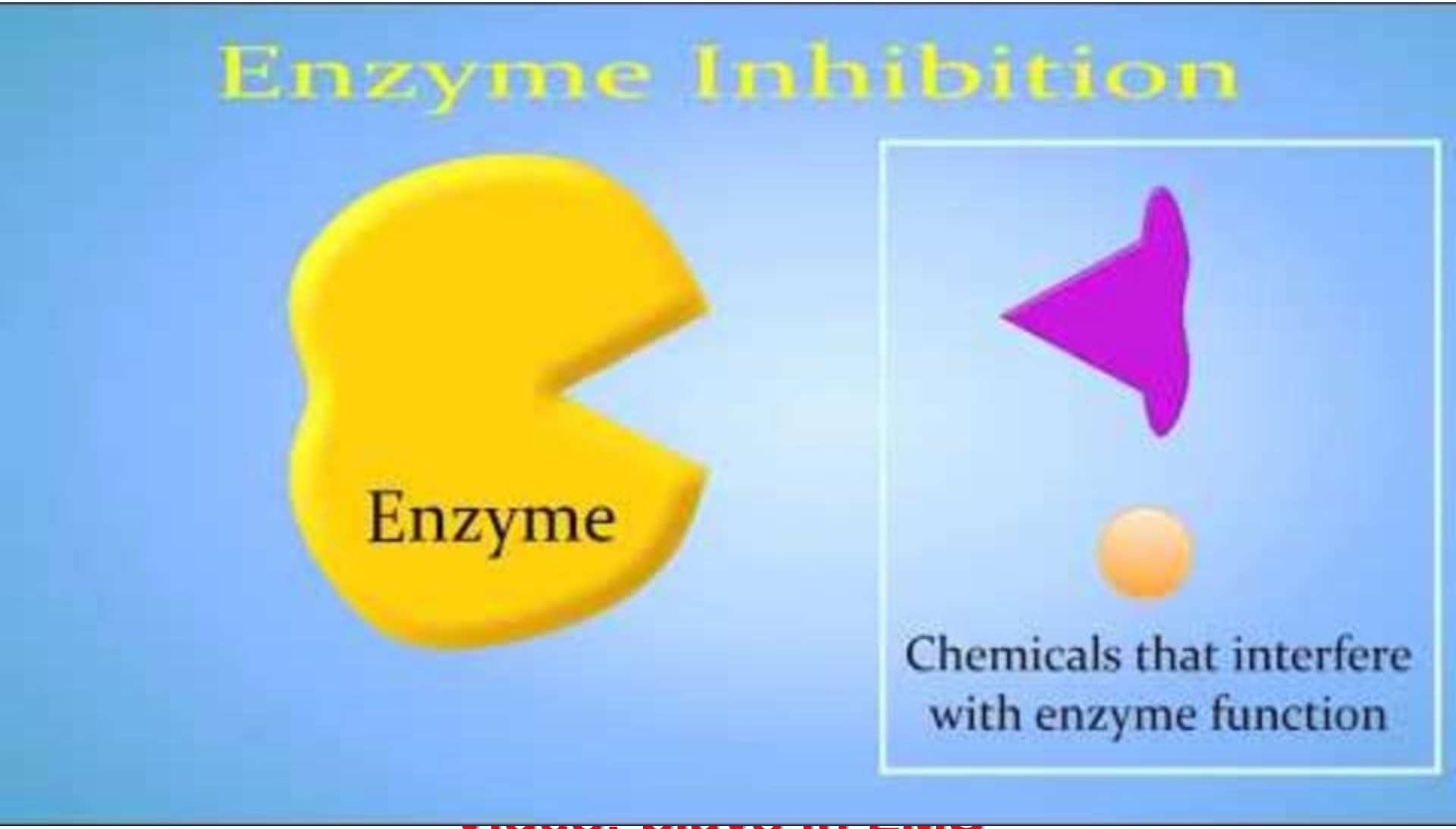
- **Example:**

  The production of Isoleucine from Thereonine by Thereonine deaminase:-

- The end product acts as an inhibitor of an enzyme in the pathway.

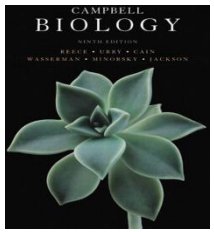
- When the product is abundant متوفر, the pathway is turned off, when rare قليل the pathway is active.





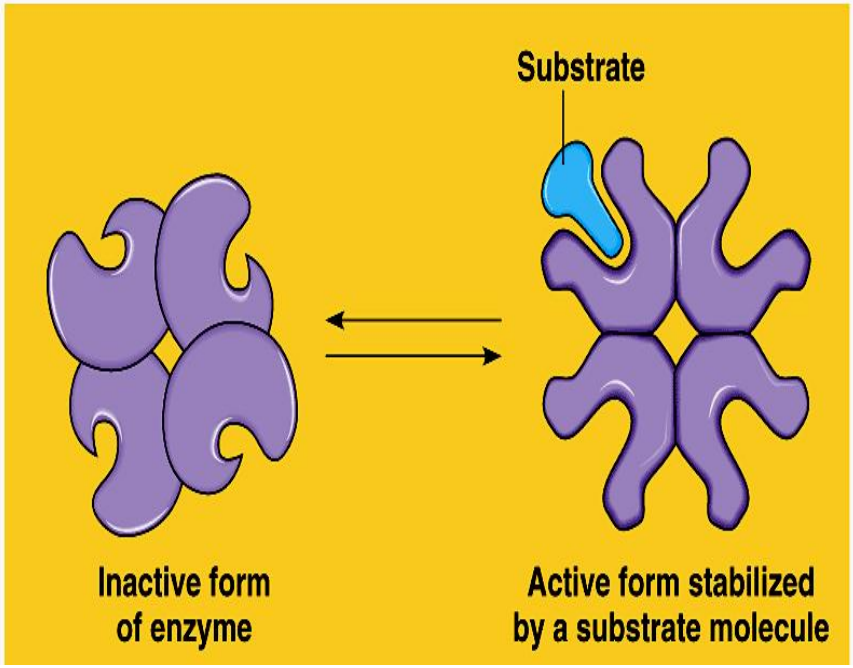
Video plays in LMS

Source: http://highered.mcgraw-hill.com/sites/dl/free/0072437316/120060/ravenanimation.html

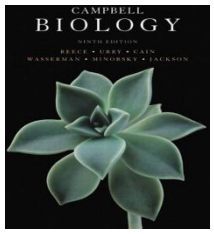


B)- Cooperativity regulation التنظيم التضامني

- It occurs in enzymes with multiple catalytic subunits. binding a substrate to one active site stabilizes favorable conformational changes at all other subunits, a process called cooperativity التضامنية.



- This mechanism amplifies يزيد the response استجابة of enzymes to substrates, making the enzymes accept additional إضافي substrates.



Summary of metabolic control

The cell is controlling its metabolism by regulating enzyme activity:

1)- Allosteric Regulation:

Regulatory molecules that bind weakly to an Alosteric site of the enzyme (Allosteric Enzymes) in order to inhibit or stimulate the enzyme activity

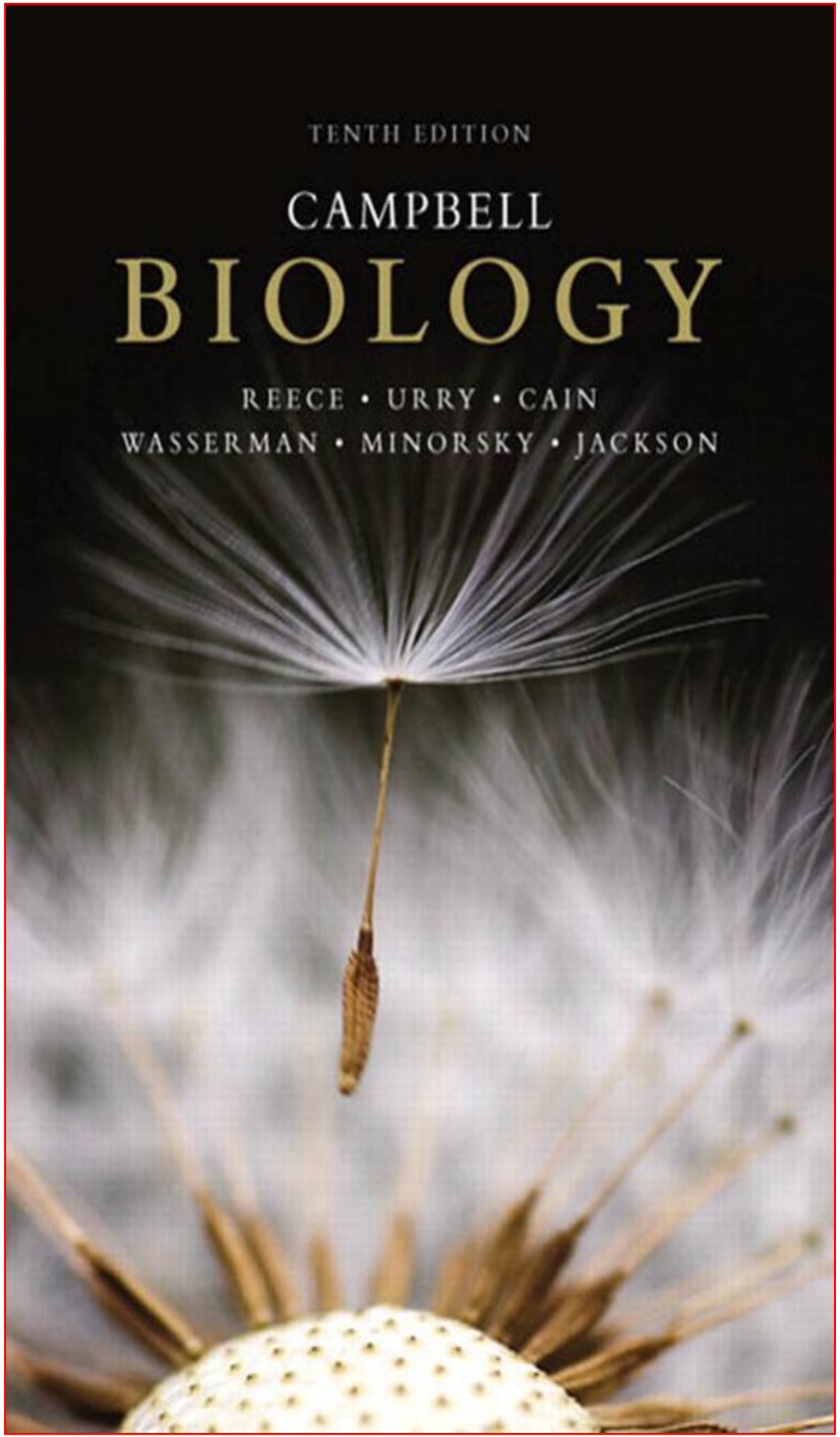
A)- Allosteric activation.

B)- Allosteric inhibition

C)- Feedback inhibition.

2- Cooperativity.

Stabilizes favorable conformational changes at all other subunits to make the enzyme more efficient.



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General Animal Biology

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Thank you very much

شكرا جزيلا

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