Biochemistry Team 435

جامعة الملك سعود
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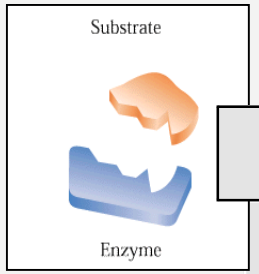
ENZYMES AND COENZYMES I

"THE STRUGGLE YOU'RE IN TODAY IS DEVELOPING THE STRENGTH YOU NEED FOR TOMORROW"

435 Biochemistry Team

OBJECTIVES:

- What are Enzymes ?
- Properties of Enzymes.
- Enzymes-substrate binding.
- Classification of Enzymes
- Enzymes nomenclature.
- Holoenzymes,Cofactors&Coenzymes,Ribozymes,Isoenzy-mes & zymogens.
- Enzymes decrease activation energy of a reaction.
- The effect of a catalyst on the transition state diagram of a reaction.
- Enzyme Activity or Velocity.
- Factors that affect enzyme activity.
- Enzyme kinetics.
- Michaelis Menten Equation.
- Lineweaver-Burk plot.



Substrates

Converted by Enzymes to → Product(s)

Substance upon which the enzymes act.

Enzymes

In nature are → Proteins

In nature are not

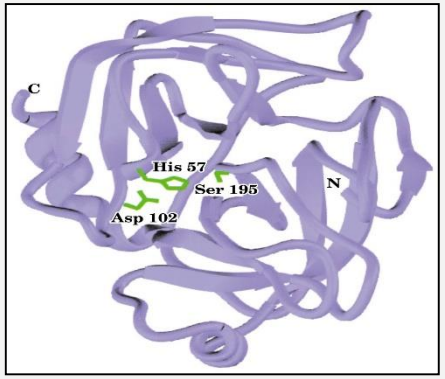
- Biological catalysts.
- Speed up the rate of a reaction without being changed in the reaction.

Properties:

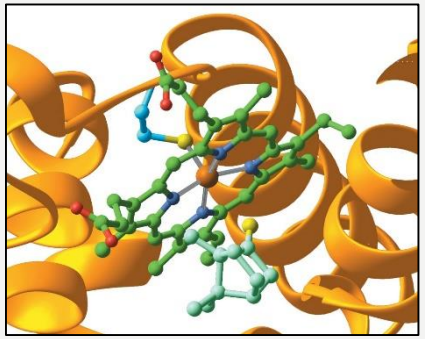
- **Active site-**
  - The region of enzyme that binds with the substrate and where catalysis occurs
  - All enzymes have one or more active sites
- **Specificity-**
  - Enzymes bind to their specific substrates in the active site to convert them to product(s)
- **Regulation-**
  - Enzymes can be activated or inhibited so that the rate of product formation responds to the need of the cell

Specificity:

- Enzymes are highly specific
- Interact with only one or a few of the substrates
- Catalyze only one type of reaction



Structure of trypsin enzyme

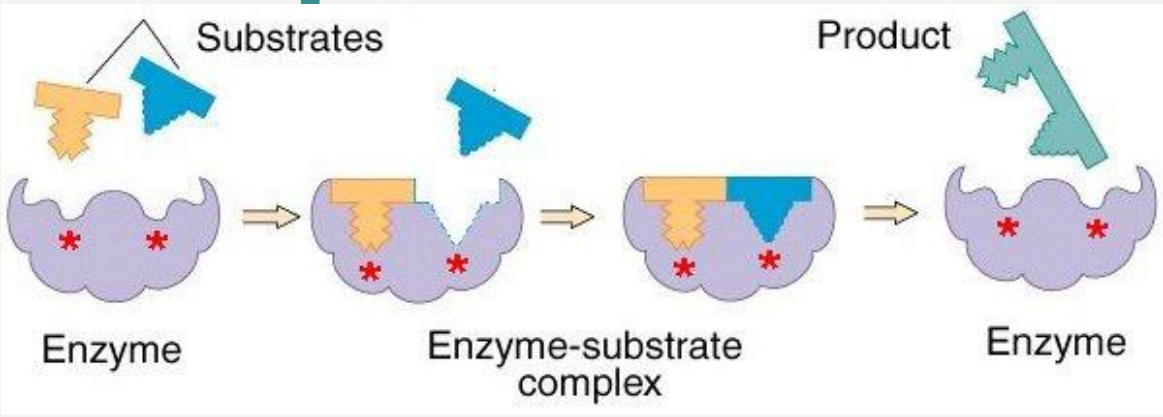


An enzyme with its active site

Enzymes substrate binding

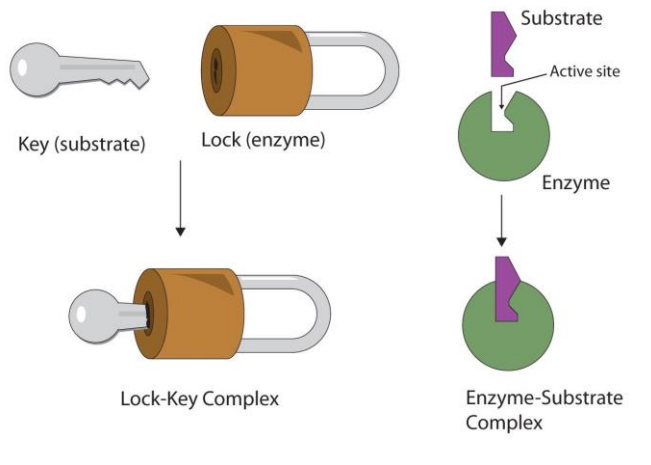
Induced fit binding

After the binding of substrate, the enzyme changes its shape to fit more perfectly with substrate.



Lock and key binding

The enzyme has an active site that fit the exact dimensions of of the substrate.



Classification of enzymes

Enzymes are Classified into six types according to the reaction catalyzed

1. **Oxidoreductases** — Oxidation-Reduction Reaction (أكسدة و اختزال)
2. **Transferases** — Transfer of functional group
3. **Hydrolases** — Hydrolysis Reaction (تفكك مائي)
4. **Lyases** — Group elimination to form double bonds
5. **Isomerases** — Isomerization
6. **Ligases** — Bond formation coupled with ATP Hydrolysis

*Oversea Travelers Had Lychee In London

Enzyme nomenclature (Naming)

Enzymes nomenclature is based on rules given by IUBMB (International Union of Biochemistry and Molecular Biology).We use Enzyme Commission number(EC number) :

EC 3.4.17.1 → Enzyme number

- 3 → class
- 4 → subclass
- 17 → Sub-subclass
- 1 → Enzyme number

*It is very Important to memorize all the six types of classification of enzymes

Some **enzymes** require **non-protein** groups to become active, theses enzymes have 2 forms:

Holoenzymes

The active form of these enzymes

Apoenzymes

The inactive form of these enzymes

The non-protein part can be:

Cofactors

If the nonprotein part is a metal ion Such as Cu^{2+}, Fe^{3+}, Zn^{2+}, etc

Coenzymes

If the nonprotein part is small organic molecule

Prosthetic

Coenzymes that are permanently associated with an enzyme eg. FAD

Cosubstrates

Coenzymes that only temporarily associate with an enzyme eg. NAD

Apoenzyme (inactive) + Cofactor/coenzyme =Holoenzyme (active)

Another types of enzymes

Riboenzymes : are RNAs with enzyme activities

Isoenzymes : are enzymes that catalyze the same chemical reaction but they have slightly different structures

Zymogenes: are inactive enzyme precursors that require a biochemical change to become active e.g. cleavage of a peptide blocking the active site

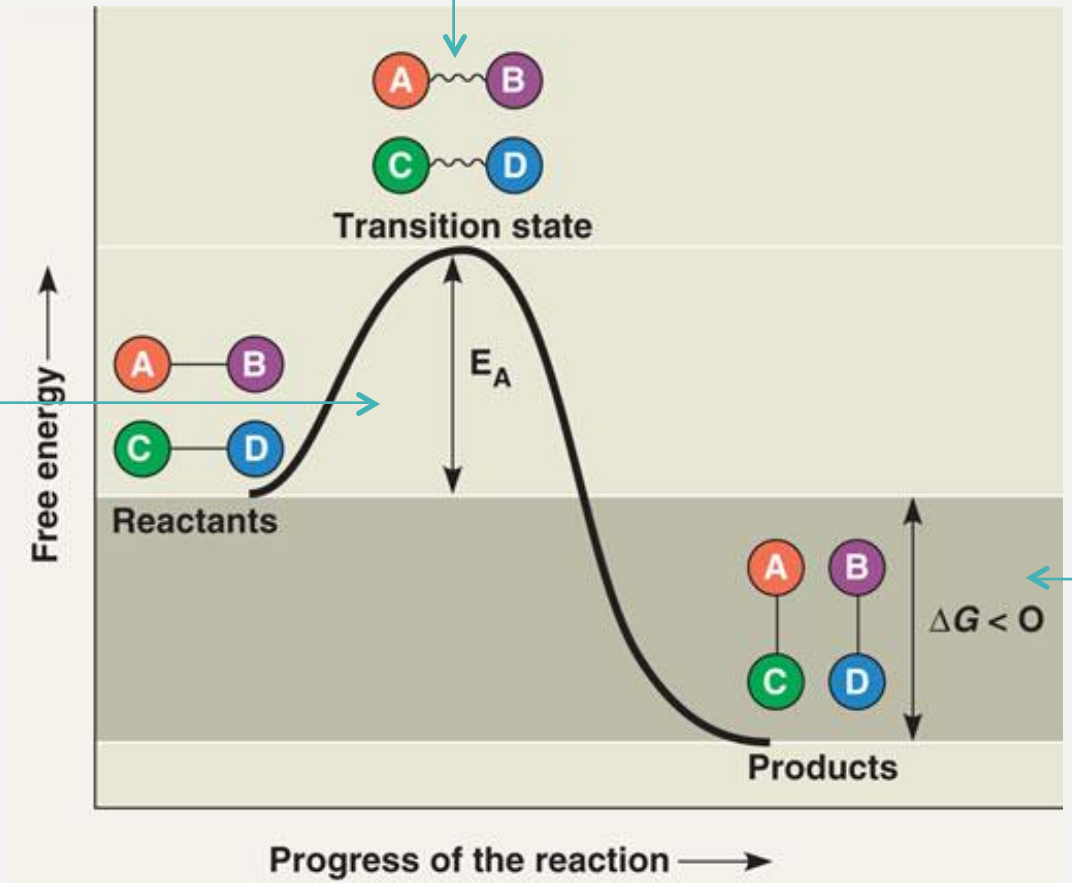
الفكرة العامة للتفاعلات :
المواد المتفاعلة تحتاج تمتص كمية معينة من الطاقة (activation energy) حتى تصل لـ (transition state) ومن ثم تكون الناتج المطلوب
- If the activation energy is available then the reaction can proceed forming products.

transition state:
the reactants pass through a transition state
- It has greater energy than that of the reactants or products alone

- طاقة الترانسيشون ستايت تكون أعلى من طاقة المتفاعلات وطاقة النواتج.

Activation energy(Ea):
What is it ?
- the minimum energy required to start a chemical reaction
- The difference in energy between the reactants and the transition state

- أقل قيمة من الطاقة يحتاجها التفاعل حتى يبدأ.
- تساوي الفرق بين طاقة المتفاعلات وطاقة الترانسيشون ستايت



- دلتا جي تساوي الفرق بين طاقة المتفاعلات وطاقة النواتج .
- لا تتأثر عندما يعمل الأنزايم ، بل تبقى ثابته ولا تتغير.

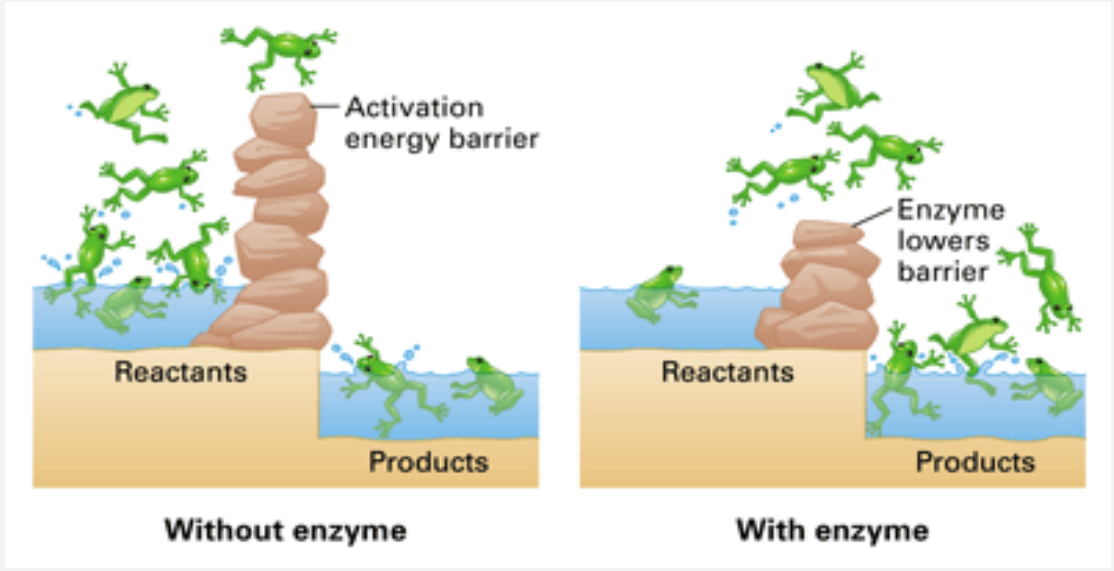
The effect of a catalyst on the transition state diagram of a reaction:

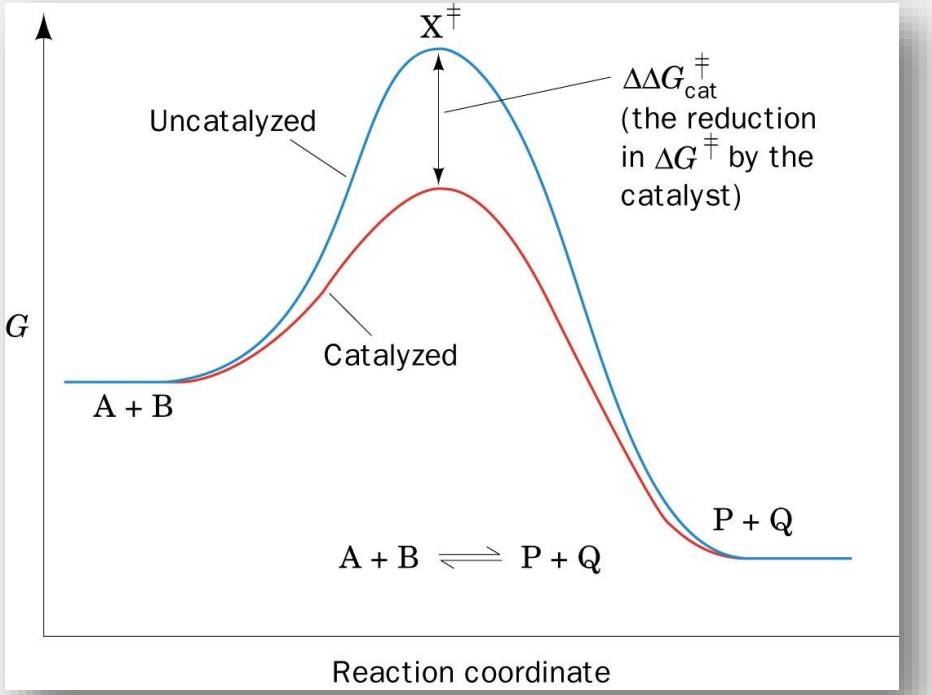
- When enzymes work on a reaction they :

1- Speed up the reaction by :
Decreasing the activation energy (E_a)

(this decreasing results from providing an alternative transition state of lower energy(enzyme-substrate complex)

2- Don't change the free energy (ΔG)





- عندما يعمل الأنزايم فإن التراسيشن ستايت راح تقل طاقتها وعليه :
١- طاقة التنشيط ستقل (لأنها الفرق بين طاقة المتفاعلات وطاقة الترانسيشن ستايت ،وطاقة الترانسيشن ستايت قلت!)
٢-لن يحدث أي تغيير في دلتا جي (لأنها الفرق بين طاقة المتفاعلات وطاقة النواتج ولم يحدث أي تغيير فيهم)

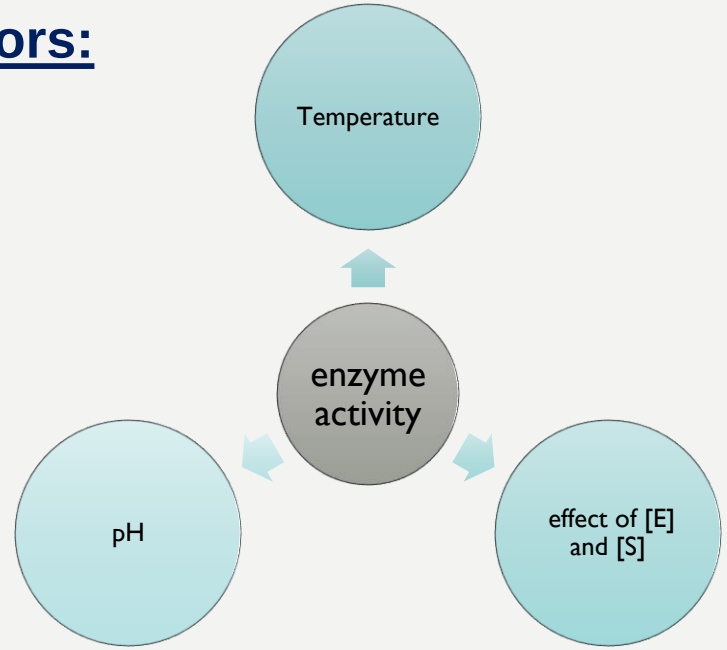
Enzyme velocity and activity

Enzyme velocity and activity are considered some of the many enzyme assays used in biochemistry lab.

Enzyme velocity:
number of reactions catalyzed by the enzyme per unit time (the rate of the reaction).

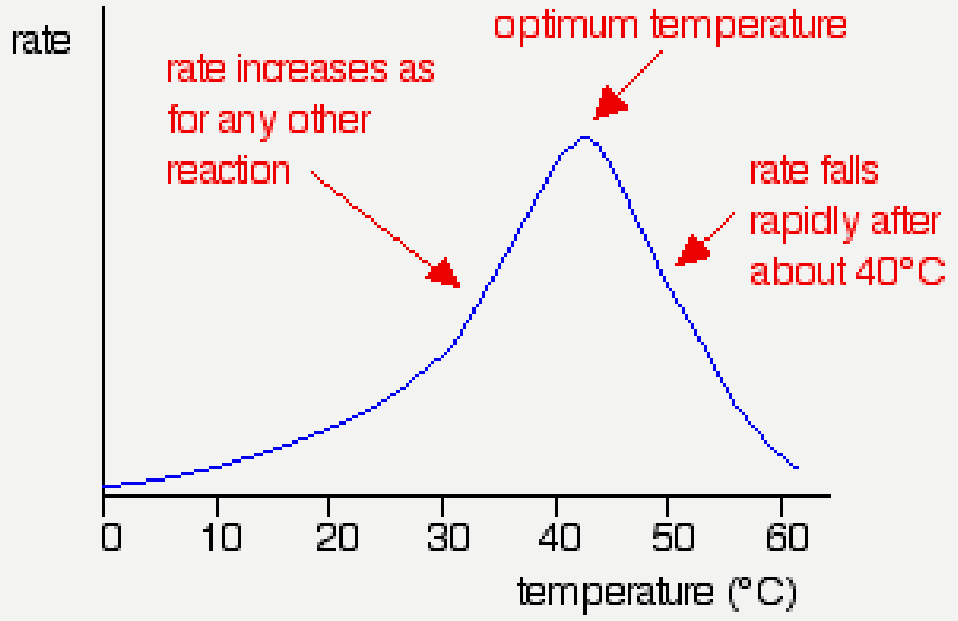
Enzyme activity:
µmoles of the product per min over mg of the enzyme.

Enzyme activity or velocity are affected by factors:



#Temprature:

- Every enzyme has an optimal temperature for catalyzing a reaction.
- The rate of an enzyme reaction will be increased with higher temperatures, until it reaches a specific temperature that is considered too high for the enzyme to work because it denatures it (becomes inactive).
- In humans most enzyme have an optimal temperature of 37°C.



More Explanation:

-The rise of temperature → increases the rate of the reaction.

- When it reaches a high temperature → Enzyme will denature

- Example : Enzymes in Human Body have an optimal temperature between 35°C and 40°C . the rate of reaction at 38oC is greater than the rate of reaction at 35°C , and above 40oC the enzyme will start to denature

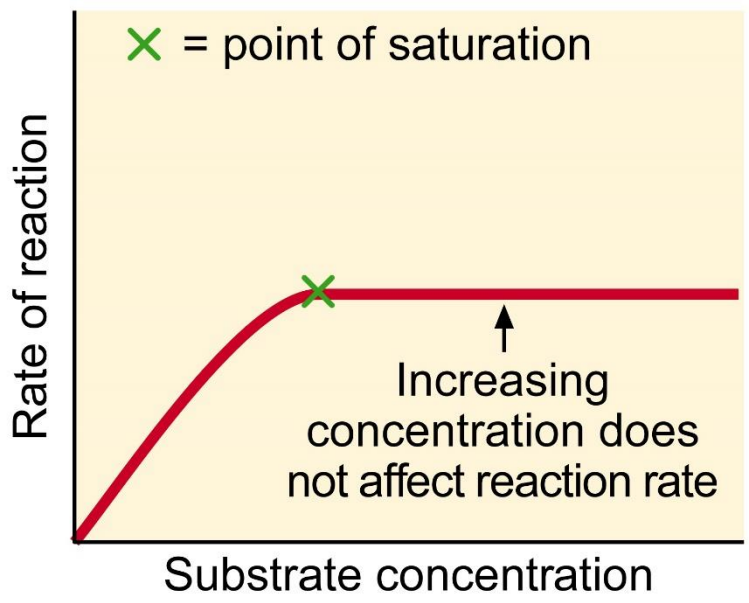
-درجات الحرارة هنا فقط للتوضيح ونحن مطالبين فقط بالـ٣٧ درجة المذكورة بالسلايدز.

#Effect of [E] and [s]:

[s] = substrate concentration.

[E] = enzyme concentration.

- The reaction velocity increases initially → with increasing [S].
- excess substrate will cause the reaction velocity to be constant (because enzyme is saturated). *Further addition of substrate has no effect on enzyme velocity*.
- if [s] > enzyme → rate of enzyme reaction is <u>proportional</u> to the conc. Of enzyme.



Note:

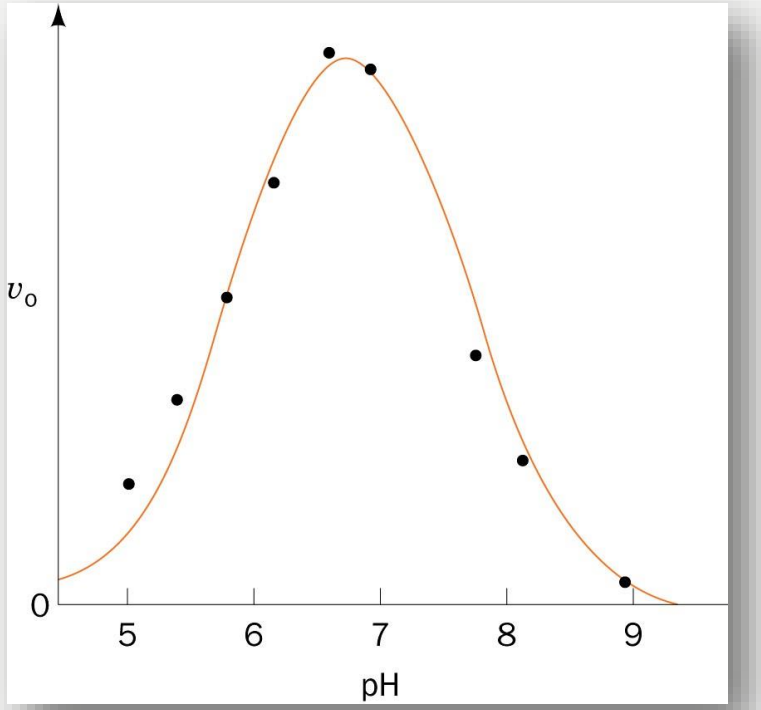
Unlimited substrate > velocity will depend on concentration of the enzyme.

Unlimited enzyme > velocity will depend on concentration of the substrate.

Click here for a Link that might help you to understand the factors that affect the enzyme activity

#Effect of PH:

- Every enzyme has an optimal pH for catalyzing a reaction.
- Effect on PH is going to be on the ionizable groups of the side chains of amino acids in the active site of enzymes or in the substrate and in both cases it's going to effect the catalysis.
- Most enzymes have highest activity between **pH 6** and **pH 8.**
- Pepsin (digestive enzyme in the stomach) has highest activity at **pH 2.**



The bell shaped curve
Shows the effect of pH on initial velocity catalyzed by most enzymes

More Explanation:

- Catalytic processes usually require that the substrate or the enzyme have a specific chemical groups either ionizable or non-ionizable in order to interact.

- Example:

catalytic activity may require that the amino group of an enzyme may be in protonated, from (NH2) to (NH3+).
If the pH is high (alkaline solution) → this group will be deprotonated
Therefore, the rate of the reaction will decline!

Enzyme Kinetics:

-The model of enzyme kinetics was first proposed by Michaelis and Menten in 1913 and later modified by Briggs and Haldane

*Initial rate of enzyme reaction (v_0):

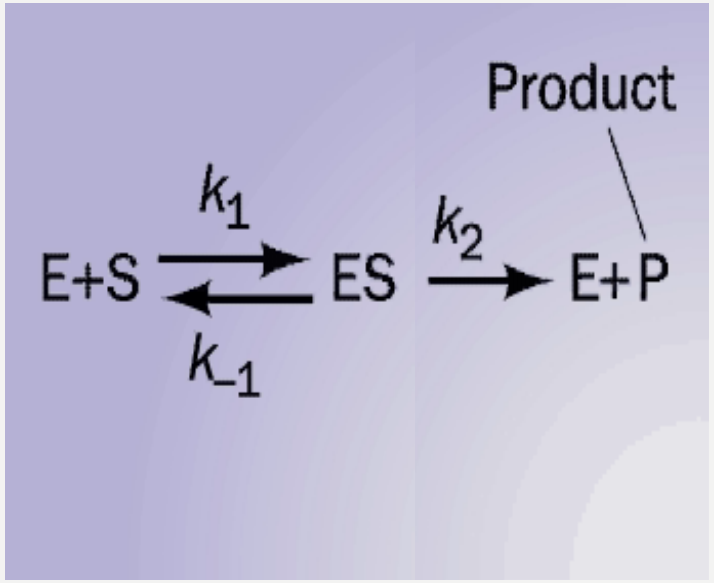
Pre-steady state kinetics

- When an enzyme is mixed with high concentration of substrate.
there is an initial short period of time where no products are produced (a few hundred microseconds) during which intermediates leading to the formation of product gradually build up

Steady state kinetics

- After initial state, the reaction rate and the concentration of intermediates change **slowly** with time called steady state reaction

- An intermediate is said to be **steady state** when its rate of synthesis is equal to its rate of degradation



s = the substrate
E = enzyme
ES = Enzyme-Substrate complex
P= product
K_1,K_{-1},K_2 = Rate constant

*Video that might help you

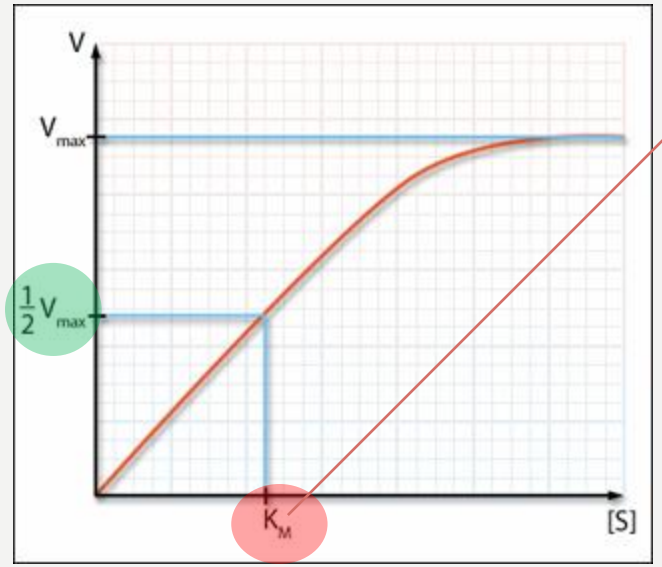
Michaelis Menten Equation:

$$v_o = \frac{V_{max}[S]}{K_m + [S]}$$

[S] = substrate concentration
Vmax = maximum velocity
Km = Michaelis constant

-The Michaelis Menten equation describes the relationship of initial rate of an enzyme reaction to the [S].
-It measures the initial velocity of an enzyme's reaction.

Km (Michaelis Constant):



K_m :

- it is the substrate concentration at which **the initial rate** is one-half of the maximum rate (½ V_{max}).
- *So It is the (S) required to saturate half of all of the active sites of an enzyme*.

The K_m value of a substrate depends on **its affinity** with the enzyme

High K_m
low affinity with enzyme (**more substrate** needed to saturate the enzyme)

Low Km
high affinity with enzyme (**less substrate** needed to saturate the enzyme)

Lineweaver-Burk plot

❖ **Anouther name:**

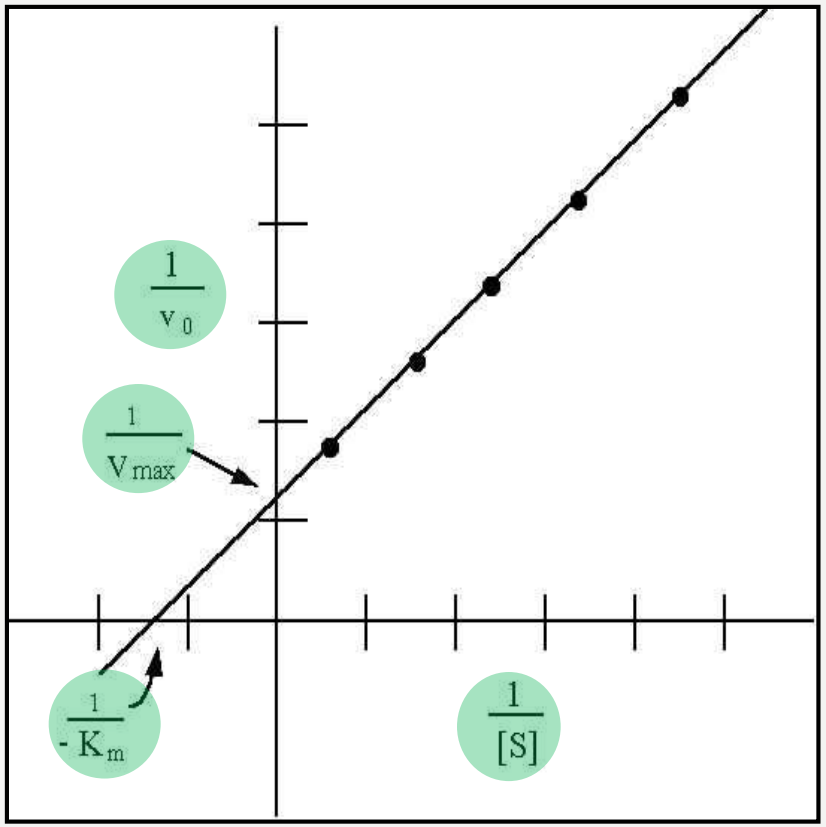
double-reciprocal plot

❖ **It's obtained by :**

taking reciprocals of the Michaelis Menten equation.

❖ **It is plotted to :**

-calculate the Km and Vmax values
- to determine the mechanism of action of enzyme inhibitors.



MCQs

1-Class 4 of enzyme is:
A. Ligases B. Isomerases C. Lyases

2-Transferases is:
A. Class 2 Enzyme B. Class 3 enzyme C. Class 6 enzyme

3-The enzyme that catalyze the reaction of transferring groups within molecules to yield isomeric forms is :
A. Transferases B. Ligases C. Isomerases

4-The molecule that binds to the active site and is acted upon by the enzyme is a :
A. Product B. Substrate C. Coenzyme

5-The energy required to reach the transition state before the system goes on to product is :
A. Activation energy B. Free energy (ΔG) C. Inhibition energy

6-The rate of a reaction reflects this activation energy; a higher activation energy corresponds to a _____ reaction, while a lower activation energy corresponds to a _____ reaction.
A. Faster-slower B. Slower-faster C. Slower-slower

1-C
2-A
3-C
4-B
5-A
6-B

7-C
8-A
9-B
10-C
11-A
12-C

7-The enzyme activity is affected by :
(A) PH (B)Temperature (C) Both

8-Lock and key binding is :
(A)Type of enzymes substrate binding (B) Enzyme (C)Type of induced fit binding

9-In the Induced fit binding , the enzyme changes its shape …….. Binding of substrate
(A) Before (B)After (C)Between

10-less substrate needed to saturate the enzyme is the meaning of:

(a) Km (b) High Km (c) low Km

11- in the lock and key model,The Lock is the ____ and the key is the ____.
A. Enzyme-substrate B. Substrate-enzyme C. Enzyme-product

12-High Km means:

(a) high affinity (b) equal affinity (c) low affinity

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13-B
14-A
15-C
16-B
17-C

13-Michaelis Menten Equation measures the ..... of an enzyme reaction.

(a) maximum velocity (b) initial velocity (c) substrate concentration

14-Km is the substrate concentration at which the initial rate is .....

(a) one-half of the maximum rate (b) double of the maximum rate (c) equal to the maximum rate

15-The optimal temperature for human enzymes is:

(A)35 ° C (B)36 ° C (C)37 ° C

16-Most enzymes have higher activity between:

(A)pH 4-6 (B)pH 6-8 (C)pH 8-10

17-Classification of EC has :

A. 6 different categories depending on the enzyme's structure

B. 7 different categories depending on the type of reaction catalyzed by the enzyme

C. 6 different categories depending on the type of reaction catalyzed by the particular enzyme

Videos

- ✓ https://www.youtube.com/watch?v=XTUm-75-PL4
- ✓ https://www.youtube.com/watch?v=7u2MkbsE_dw

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- علا النهير.
- أفنان المالكي.
- فاطمه الدين.
- جوهره المالكي.
- خوله العريني.
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