

Chapter 6

Enzymes

Very Specific

مواقع نشطة
active site

Biological Catalysts

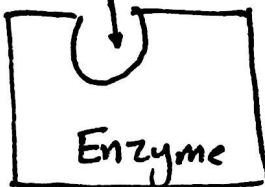
محفزات حيوية

تسرع التفاعلات الكيميائية

داخل الخلية In Vivo



Substrate
المادة المتفاعلة



The Most Efficient Catalysts

المحفزات عالية فعالية

Enzymes

↑ Reaction rate
↑ سرعة التفاعل
can increase UP to 10^{20}

Non-enzymatic Catalysts

محفزات غير انزيمية

Pb^{+2} , Fe^{+2} ..

↑ Reaction rate $10^2 - 10^4$

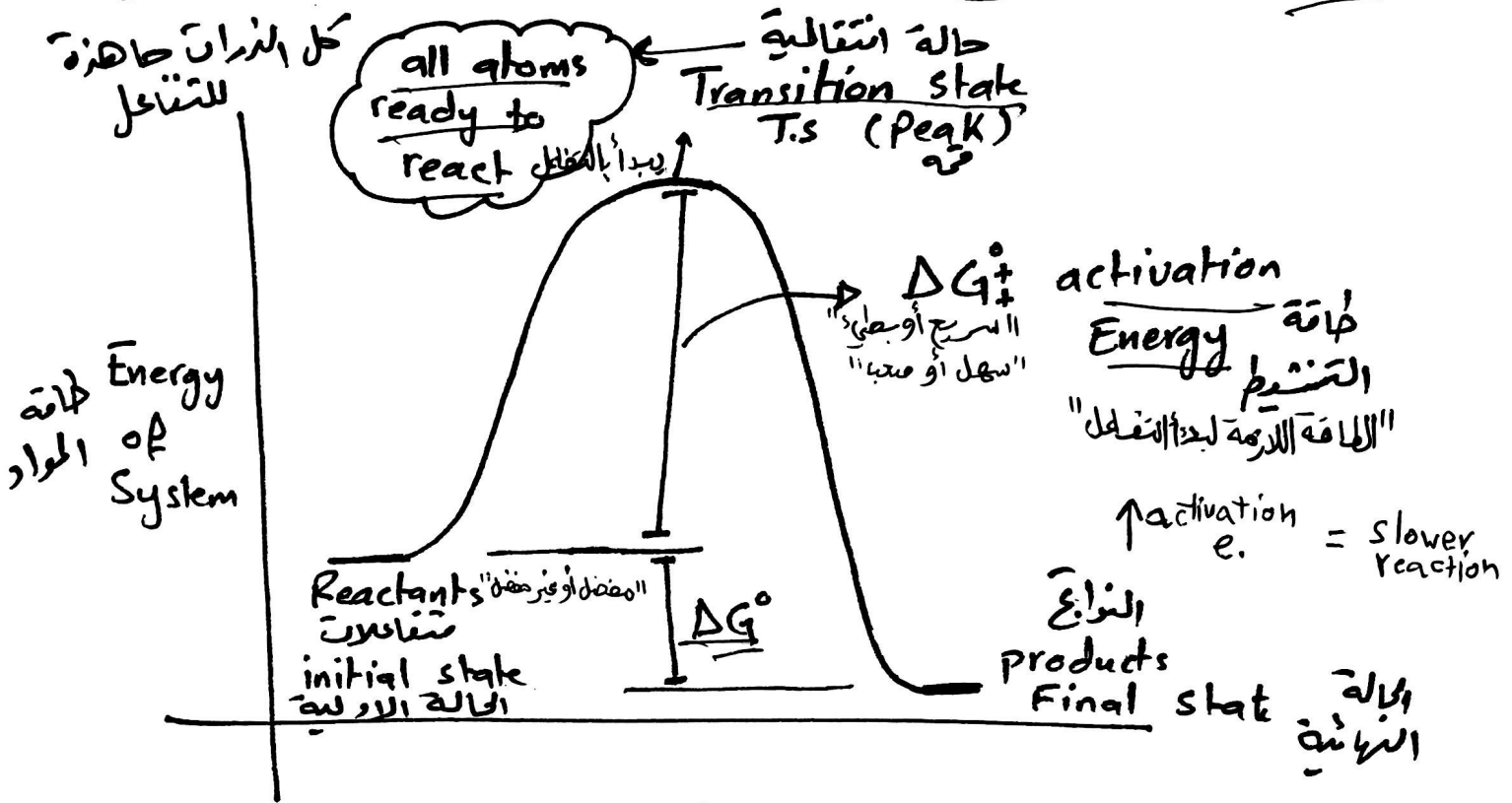
* All Enzymes are Globular proteins

Except Ribozyme → RNA

all Enzymes are proteins True False

Kinetics: Study Reaction Rate دراسة سرعة التفاعل

Thermodynamics: Study Energy changes دراسة تغيرات الطاقة أثناء التفاعل



ΔG° : Standard Free energy change (Gibbs free energy)

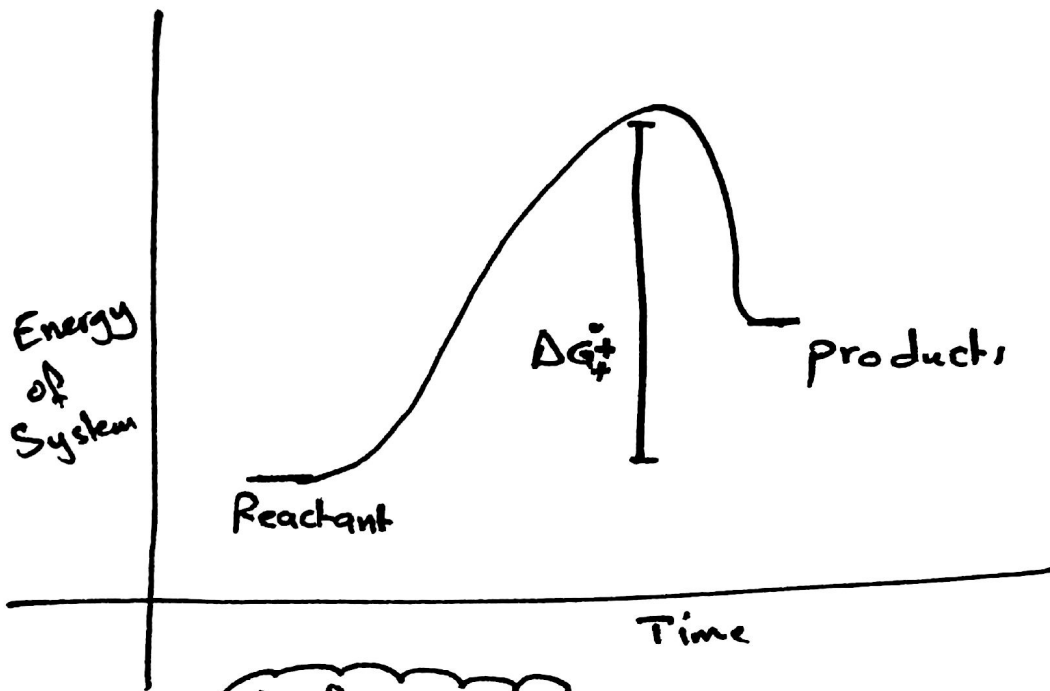
فرق الطاقة الحرة

$$\Delta G^\circ = \text{products Energy} - \text{Reactant Energy}$$

النوع المتفاعلات

$\Delta G = -ve$ → طاقة النوع أقل من طاقة المتفاعلات → النوع more Stable أكثر استقراراً

Favavarable منفضل
 Spontaneous تلقائي
 Excergonics منبع طاقة



$\Delta G^\circ = +ve$

- ▶ Not favorable غير مفضل
- ▶ Non-spontaneous غير تلقائي
- ▶ Endergonic متطلب للطاقة

طاقة التوازن اقل
less stable
اقل استقرار

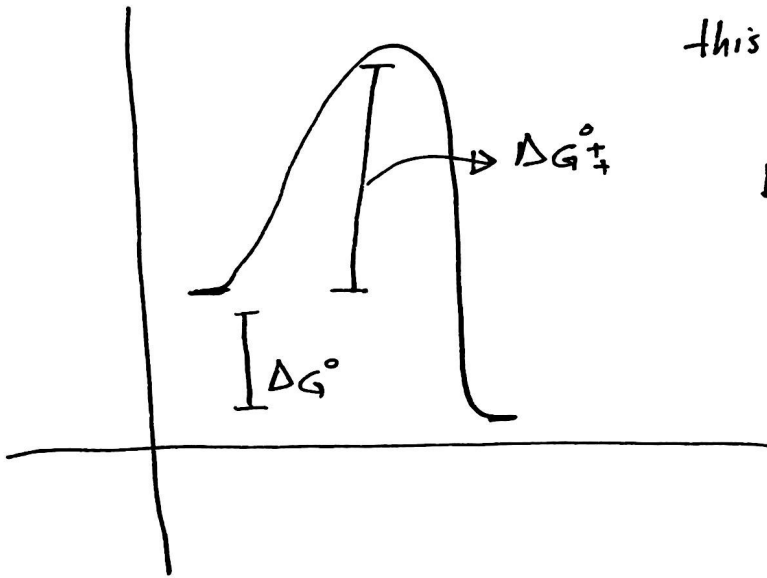
↑ ΔG^\ddagger
activation Energy
الطاقة التنشيطية

↓ Reaction rate

the species that has the highest Energy in the reaction process is Transition state

تلقائي - كين لعمده
Spontaneous \neq instantaneous

Spontaneous means that ΔG is negative so that it releases energy



this reaction is spontaneous
 ΔG° -ve
but it needs ΔG^\ddagger
to happen
not instantaneous

Q: which of the following is Not true?

- a. In thermodynamics, spontaneous does not mean instantaneous or even fast
- b. If the reaction is spontaneous then it has -ve ΔG
- c. Speed of reaction is a kinetic parameter, not a thermodynamic one
- d. A reaction with positive ΔG° can never happen.

Q The amount ΔG of energy released during the reaction tells nothing about the rate.

True

False

Q: Thermodynamically favorable reactions all release energy

True

False

Enzymes : \uparrow Reaction Rate

تزيد سرعة التفاعلات

How??

$\downarrow \Delta G^\ddagger$

activation Energy

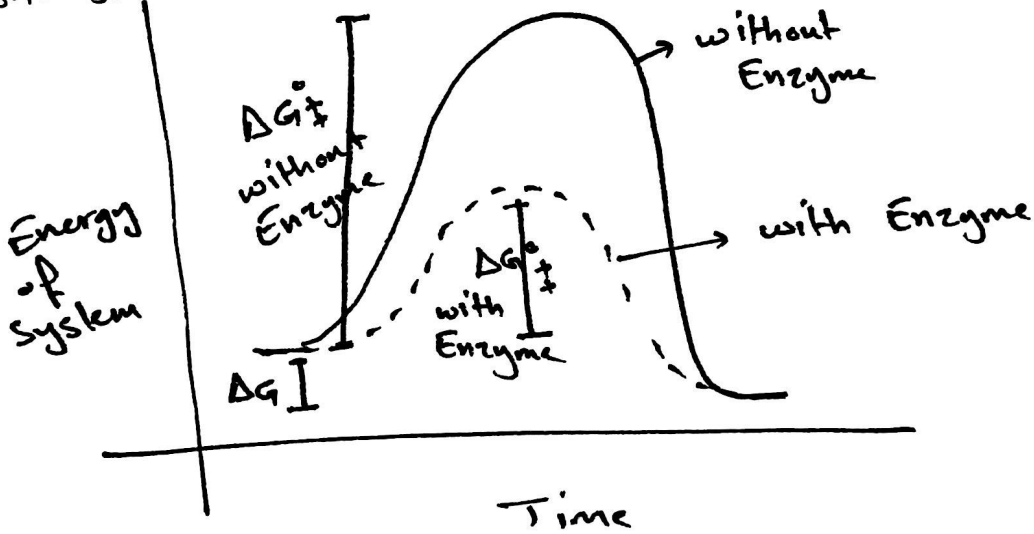
طاقة التنشيط

\uparrow Reaction rate

سرعة التفاعل

Enzymes will only affect the ~~reaction rate~~ activation energy or transition state

\downarrow Transition state Energy



ΔG° do NOT change

الإنزيمات والخمائر لا تؤثر إلا على طاقة التنشيط

$\downarrow \Delta G^\ddagger$
activation Energy

Q: All catalysts work by lowering the activation energy for the reaction

True

False

العلاقة
Relation between

Enzyme - Catalyzed reactions Vs Temperature

تفاعلان بواسطة انزيمان

↑ Temperature → ↑ Reaction rate
سرعة التفاعل

Why?

↑ Temperature → ↑ Energy

مستويات أكثر
more reactants reach to Transition state
الحالة الانتقالية

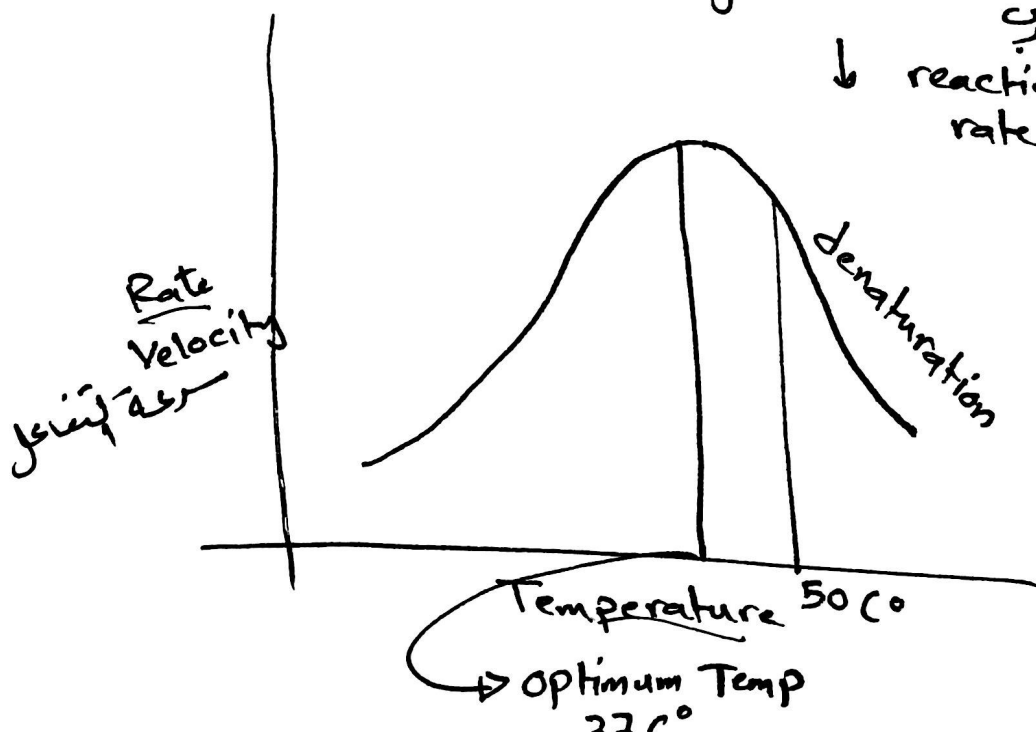
↑ Reaction rate

To limit طبعين

after certain temperature

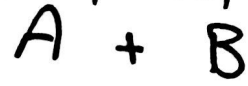
Enzymes denature

↓ reaction rate



Kinetics of Reaction

disappear
تختفي



Reactants
متفاعلات



rate
constant
ثابت
السرعة

appear
يظهر

products
نواتج

سرعة التفاعل

$$\frac{\Delta []}{\Delta t}$$

التغير في
التركيز
الزمن

غير مهم فقط لفهم الطريقة
فقط لفهم الطريقة

$$\text{Rate } V = k [A]^{\textcircled{1}} [B]^{\textcircled{2}}$$

ثابت سرعة

Exponents
الأسس

$$-\frac{\Delta [A]}{\Delta t}, -\frac{\Delta [B]}{\Delta t}, \frac{\Delta [P]}{\Delta t}$$

* determined Experimentally
تحدد عملياً

Rate of disappearance
سرعة الاختفاء

rate of appearance
سرعة الظهور

* whole #
0, 1, 2, 3...

Order of reaction
رتبة التفاعل

= الأسس

الرتبة الكلية للتفاعل

Overall order of the reaction

Ex. 1+1 = 2nd order

$$= \sum \text{الأسس}$$

مجموع



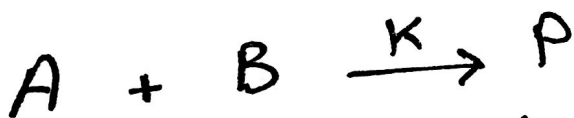
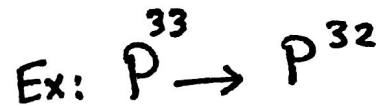
$$\text{rate} = k [A]^1$$

* the reaction is first order with respect to A
بالنسبة

↑ [A] ↑ Rate
reaction depend on rate
[التفاعل]

* Overall order = مجموع الرتبة الكلية = 1 First order

Ex: decay of radioactive atoms
التفكك المشع



$$\text{Rate} = k [A]^1 [B]^1$$

* First order with respect to A

$$\uparrow [A] \uparrow \text{Rate}$$

* First order with respect to B

$$\uparrow [B] \uparrow \text{Rate}$$

Overall order = 1 + 1 = 2 Second order
الرتبة الكلية



$$\text{Rate} = k [A]^0$$

5
10
15

* Rate is Constant
لا تتغير

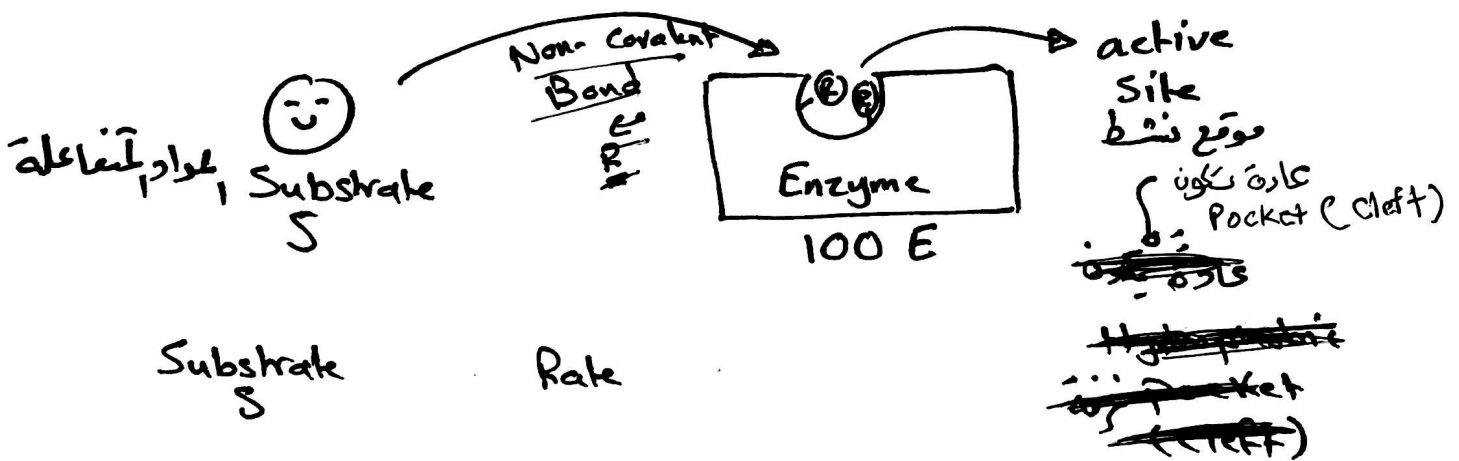
* Rate do NOT depend
(Independent)
لا تعتمد

Overall order = 0 Zero order
الترتيب الكلي = 0

on [Reactants]
المواد المتفاعلة

Example

Enzyme - Catalyzed reactions
تفاعلات بواسطة انزيمات



Substrate S

Rate

First order

20
50
70
100

20/sec

50/sec

70/sec

100/sec

→ saturation حد الإشباع

Zero order

120
200
1000

100/sec

100/sec

100/sec

V_{max} السرعة القصوى عند الإشباع

rate of reaction do NOT depend on [S]
depend on [E]

Q: A rate constant is

- a. the rate of a reaction at standard temp and pressure
- b. the rate of a reaction at equilibrium
- c. a proportionality constant that relate the rate of a reaction to the concentrations of reactants.
- d. a kind of transition state

Q: The kinetic order of a reaction :- ^(cat)

- a. Can be determined by inspection from the coefficients of the balanced equation
- b. must be determined experimentally
- c. always depends on the concentration of enzyme
- d. never depends on the concentration of reactant

Q: The rate of a reaction is always dependent on the concentration of reactant

True False

Q:- Given the rate law: $\text{rate} = k [A] [B]$
the overall reaction order is 2nd order

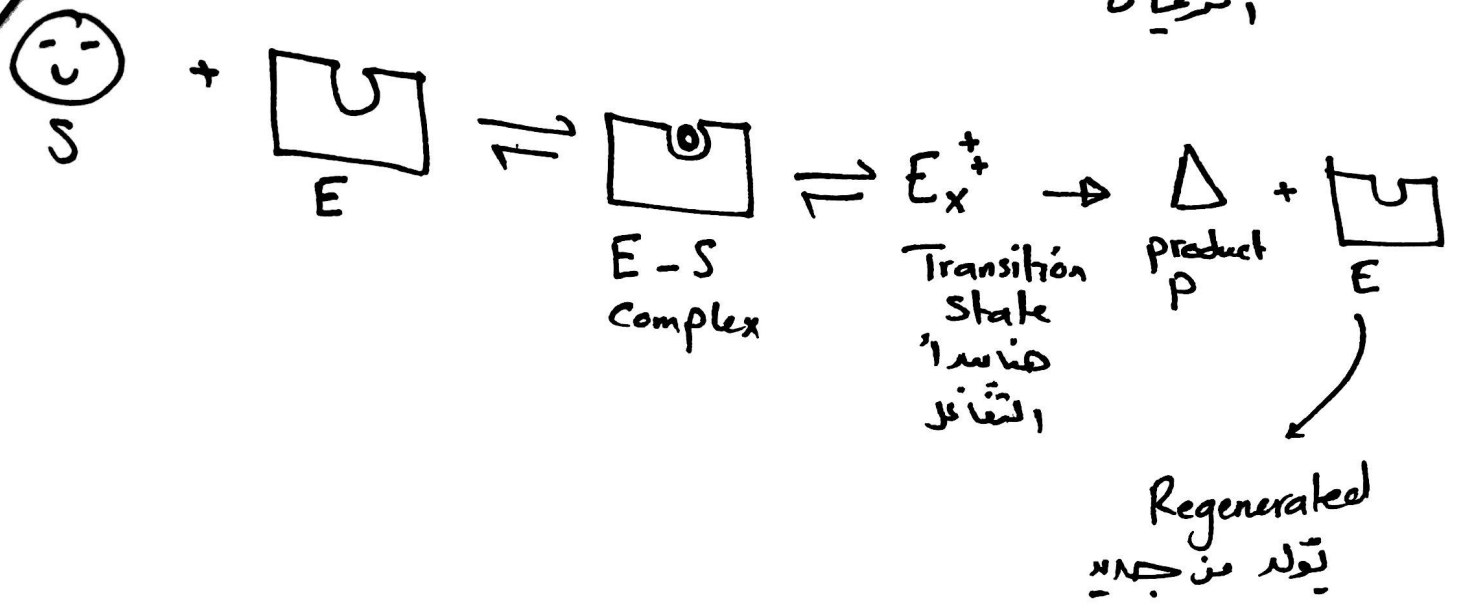
Q: The order of a reaction can be determined from the balanced equation for the reaction

True

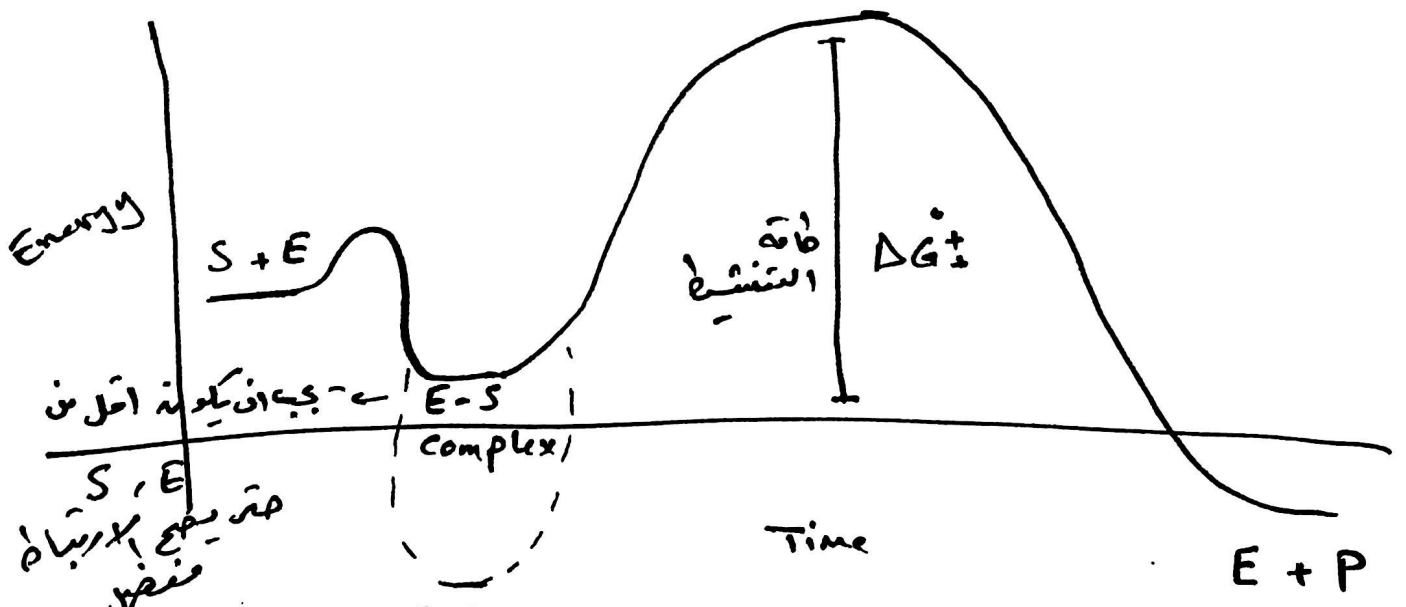
False

Enzyme - Catalyzed reaction

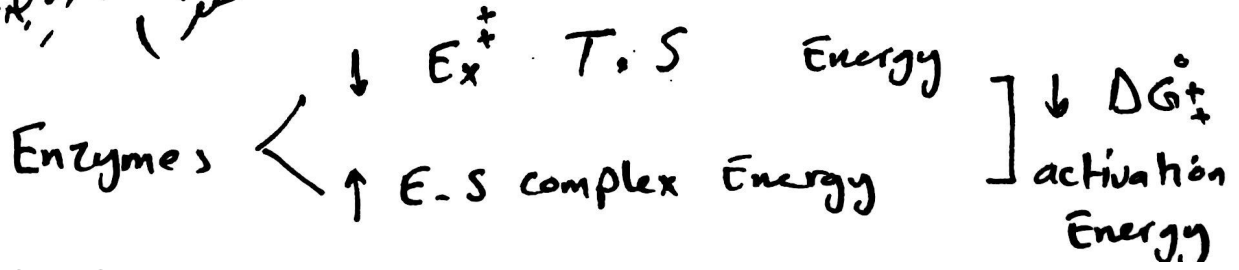
تفاعلات بوساطة
الإنزيمات



E_x^{\ddagger} حالة الانتقال، Transition State



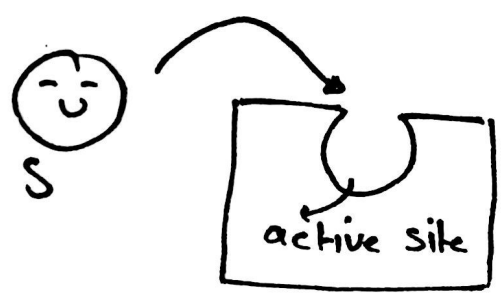
- يجب ان يكونه اقل من
 S, E
 عند بدء التفاعل
 (مستقر)
 لانه لا يتسبب في
 انهيار الإنزيم



طرق مختلفة
Models

for Substrate Binding to Enzyme

1 Lock and Key model قفل ومفتاح



Substrate is Complementary to active site

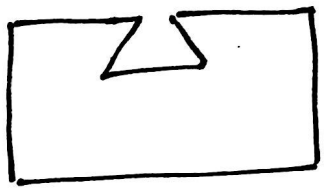
Perfect Fit تلائم مثالي

History أغلب المواد لا ترتبط بجزء إلكتروني مع الآخر

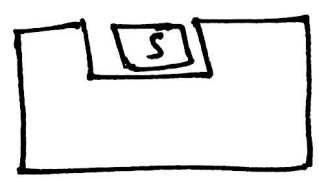
* الموقع ليس له شكل واحد

2 Induced - fit model تلائم محفز

S



Before Binding



after Binding

* الموقع ليس له شكلين

-this model Explain 3D Flexibility for active Site. المرونة

Q: The E-S complex often shows a slight depression in the energy profile for the reaction

True

False

Q: The active site of an enzyme:-

- a. is frequently located in a cleft in the enzyme
- b. is the portion of the enzyme to which the (S) bind
- c. contain the reactive groups that catalyze the reaction
- d. all of these

Q: The substrate will only bind to the enzyme when the shapes fit together rigidly

True

False