Lecture :.16 (lec 1 after mid)

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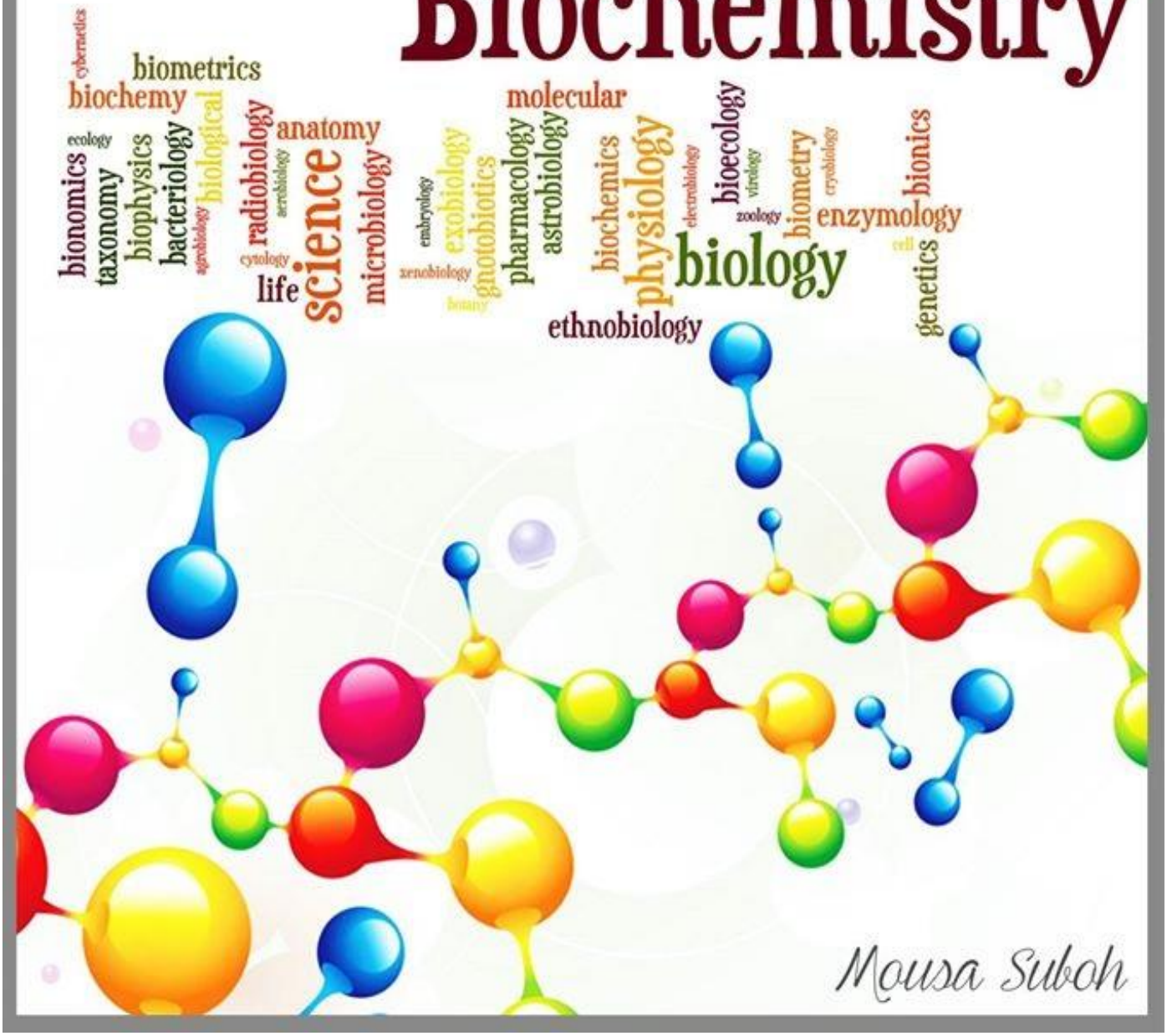
☐ Slide ■ Sheet

Medical Committee
The University of Jordan

Biochemistry



Enzymes 1

- This is the first lecture about enzymes, we have taken most of the information about this subject before, hopefully it is an easy lecture.

references of this lecture is" Marks' Basic Medical Biochemistry". slides from (1-7)

We are going to talk about general introduction of enzyme in the coming 2 weeks, we are concerned with the mechanisms, kinetic energy, regulation, general role, and lastly with the biochemistry and the techniques of dealing with enzyme.

in the beginning before we start, two definitions are needed to be familiar with;

 # A ligand :any material that binds to enzyme

 # affinity&Specificity:.

- Affinity: measures attraction, the strength of binding between a protein and other molecules

- Specificity: the ability of a protein to bind one molecule in presence of other molecules, how much this enzyme is specific to this material. <there are enzymes which combine one material only, and others that can bind with more than one ligand>.

Most of the time specificity and affinity are linked together the more the specificity, the more the affinity is.

What are enzymes?

Enzymes: are large biological molecules which are responsible for thousands of metabolic processes that sustain life. They are highly selective catalysts , greatly accelerating both the rate and specificity of metabolic reactions.

Note: for a certain reaction to occur, enzymes are needed in a small amount mainly, because they are not consumed after all, so they are being used over and over again.

Are enzymes consumed DURING THE REACTION?

Yes, they are being used during the reaction, they go through a big change like their shapes and their amino acids modification but by the end of the reaction they return back to their original state.

Most enzymes are proteins, although some catalytic RNA molecules have been identified ,they are called **ribozymes**.

#There are other catalysts in chemistry however the catalyst within the cell are called enzymes and they are the most efficient type of catalysts, they are the fastest.

Their range of speeding up the reaction is $10^{(6)}$ to 10^14 time and they may reach up $10^{\wedge 20}$.

Non-enzymatic catalysts rate is ($10^2$to 10^4).

What does " Enzyme efficiency " mean?

How much you can turn the reaction per unit of time

what an enzyme simply does? it provides a place to arrange a meeting for these substances to react , this place is called the **active site**.

a common example about enzymes,

Catalase is an enzyme tha breaks hydrogen peroxide "a toxin material" to water and oxygen <hydrogen peroxide is a product in O2 metabolism> as follow

$2H_2O_2 = 2H_2O + O_2$

when this reaction occurs on platinum surface -which is a chemical catalysis- it is 10000 time faster than without a catalyst. However, catalase increases the speed up yo 10^8 times.

Note: catalase is present in all cells of the human body.

An experiment you can do alone in your house, just drop a piece of fresh meat in a hydrogen peroxide, the enzymes in the meat cells will catalyze this reaction, you can notice the reaction by recording O2 bubbles from the test tube.

first low of thermodynamic

$\Delta G = \Delta H - T\Delta S$

Δ*H*: changes in enthalpy, (the energy within the present covalent bonds)

Δ*S*: changes in entropy <the degree of disorder or randomness in the system. most of the universal systems tend to prefer randomness, for example you don't need any effort to make your room messy while doing your room up takes the whole day :D (lots of efforts). *(Delta S also explains how the molecules are arranged around eachother)* For water, the molecules in the solid state are well arranged and less random compared to the gaseous state.

T:tempreture in(Kelvin)

So **ΔG**: *describes the whole energy within the covalent bonds considering another term* ***which is delta S***

This law describes chemical reactions, Whether it was spontaneous or nonspontaneous, exorgonic or endorgonic. The sign of Δ*G* depends on the signs of the changes in enthalpy (Δ*H*) and entropy (Δ*S*), as well as on the absolute temperature (*T*, in kelvin).

**When Δ*G* is negative, a process or chemical reaction proceeds spontaneously, and it is exergonic (more favorable).

**When Δ*G* is positive, the process proceeds nonspontaneously, and it is endergonic (unfavorable).

**When Δ*G* is zero, the process is already in equilibrium, with no net change taking place over time.

Again:

when we look at water as an example, the energy within bonds is Δ*H* , Δ*G describes the whole energy of the system, PLUS the orientation of the molecule -the entropy-*

Ice melting is an endothermic and *EXERGONIC reaction at the same time

Endothermic : it absorbs heat from the SURROUNDING* and this is why the weather gets colder during ice melting

Exothermic : heat is released to the surrounding when a bond forms

* Bond BREAKING : ENDOthermic

Bond MAKING : EXOthermic*

Endergonic: absorbing heat from the sys

Note:

Negative delta H does not mean negative delta G because still we depend on the value of delta S.

Now after understanding the definition of this law, WHAT does it measure again ?

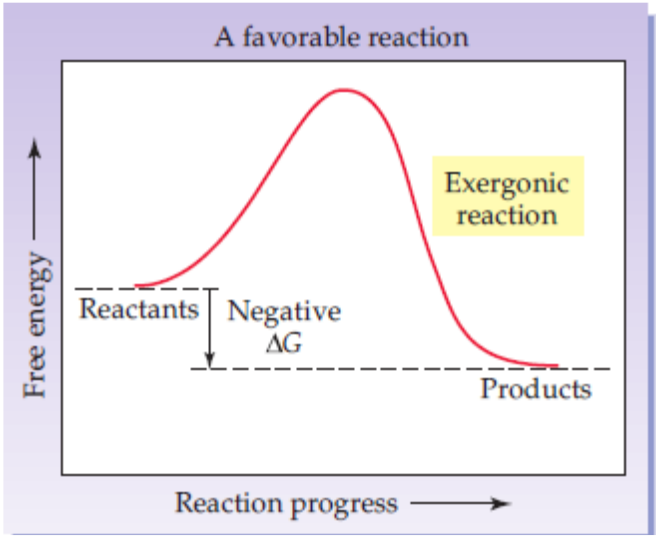
It is used when we are asked about thermodynamic question and kinetic energy

Thermodinamics VS kinetic energy

Thermodynamic: the science which measures the potential within the material to convert from A-B.

kinetic : measure the actual conversion of energy

There is a difference between potential and actual potential conversion, that is the thermodynamic tells us whether the reaction is going to happen spontaneously or non spontaneous, if we have a curve we really only care about the difference between reactant to product only no matter how the curve is shaped (it's about prediction).



Kinetic theory considers the transfer of energy itself so it looks at the pathways of the reaction.

So thermodynamic theory considers the start and the end of a reaction while kinetic energy considers what is between them

< kinetics energy cannot say if the reaction is favorable or not>

if the reaction was favorable, does that mean the rate is fast? NO!

ΔG could be very negative and the reaction can still be slow and vice versa <there is no relationship>

SO the rate of the reaction has nothing to do with delta G,H or S the rate is something different.

why do reactions occur !?

In order to reach more stability- for substances -, reactions can do that because substances always tend to reach highest stability state as possible -lower energy-

we have a theory which is called "collision theory" which indicates that all substances moves randomly and when two or more collide by chance -> reaction happens, the collision must be strong enough to provide such energy to do so,

the high energy in the substances and molecules is the one which makes the reaction, that's why we have spontaneous and nonspontaneous reactions.

What enzymes actually do is they lower the activation energy by providing the place required for the reaction to occur,thus, orients the reaction so the energy required for it to occur will be minimum .

#now let's look at the reactants that join in the reaction, are they stable or not ? they are stable, in fact there are no unstable radical present in nature, they do occur in the intermediate state during reaction but they never stay at such condition. They simply react to reach higher rate of stability.

if that is true how come reactants are present as products , they should react all the time to reach higher stability !! but; we have energy barrier which must be reached in order to continue the reaction.

---unrelated to the subject.**

***in order to detect free radicals <the intermediate> very specialized techniques should be applied to do so, it took the doctor 2 years to prove that.*

Are **enzymes** important commercially ? **yes**

if we look at crushed tea leafs in the slide, they are black - obviously- but before, they were green!! in order to prepare this product green leaves should be dried, crushed and oxidized. crushing it will open the cell walls, polyphenols is present within it, an enzyme called polyphenoloxidase breaks up polyphenols into tannins which impart the darker color and characteristic flavor,, as a result the color, taste and smell will change.

snacks and chocolate when making them we add materials and enzymes which gives the taste and viscosity. for example, the chocolate which is soft inside and has a harsh surface, it is prepared by putting enzymes in the core of the chocolate, inside there is Sucrose and its enzyme sucarase. which breaks sucrose into its two smaller sugar, which increases the

solubility of it and makes the fluidic form of the core, outside on the surface there are no such enzyme so it is kept hard.

Amoxicillin is an antibiotics which is made by an enzymatic reaction, it is a common drug here and people in Jordan tend to abuse using it, eventually it made a resistance to some of them so it become useless.

corn syrup is also a product made enzymatically.

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how to express an enzymatic reaction

In enzymatic reactions, reactants are known as substrates

We can simply express an enzymatic reaction using this formula

$$E + S \leftrightarrows ES \leftrightarrows EP \leftrightarrows E + P$$

Or

$$E + S \leftrightarrows ES \leftrightarrows E + P$$

where E is the free enzyme; S is the free substrate, ES is the enzyme-substrate.

complex: P is the product of the reaction, and EP is the enzyme-product.

then the product will be separated from the enzyme and the enzyme will retain its original structure.

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active sites of enzymes <this topic is mentioned in the next lecture>

now as we know enzymes are protein , proteins are formed by the combination of polypeptide which could be in the 3° or the 4° structure.

now in order for the enzyme to catalyze and do its work here there is a specific place where the reaction occurs this place is called the **active site.**

so the active site is a specific three-dimensional shape which includes a region where the biochemical reaction takes place.

a way to see it, if we imagine this whole building to be enzyme the active site is only this room, then why the whole building is needed here?, to maintain the shape of the active site so it will be more like a pocket in the enzyme you need a bigger structure to keep this pocket in this specific shape with all the *Any non-covalent bond ex: hydrogen bonds which interact in the whole structure. another reason that, it has another binding site for inhibitors, regulators competitive and uncompetitive so on.
to sum it up, the big structure

#1help to stabilized the whole structure.

#2change the shape of the active site to fit the substrate as the induced theory indicates.

#3it can provide a place for other material to combine and regulate enzymes activity.

< all enzymes work within regulator processes >

inside the active sites there are two areas one of them is the binding site and the other is catalytic sites

Binding site: binds substrate through ionic, H-bonding or other electrostatic forces in the right orientation

Catalytic site: contains the catalytic groups that is responsible for the specific reaction the enzyme perform (basic,acidic,polar).

in most enzymes the binding and the catalytic site is the same.

Here are Some related links that may help you:

Enthalpy,delta s and the free energy:

http://www.chem.uwec.edu/Chem150_S07/elaborations/unit3/unit3-b-energy.html

A video about entropy and enthalpy (great :D):

http://www.youtube.com/watch?v=2L2w63uz04Q

How do enzymes function to lower the activation energy:

http://education-portal.com/academy/lesson/function-of-enzymes-substrate-active-site-activation-energy.html#lesson

Done by:

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I did my best in writing this, I hope you like it, enjoy.