❖ Reversible reactions and chemical equilibrium

Reversible reaction: a reaction which can go on both ways; forward direction (from reactants to products) and backward direction (form products to reactions). And it can show equilibrium.

- **Equilibrium**:
  [P] remains constant and [R] remains constant (constant and not necessarily equalized), and the rate of reactants' formation equal the rate of products' formation.
  K_{eq}: Equilibrium constant.
  [P]: Concentration of products.
  [R]: Concentration of reactants.

$$K_{eq} = [P] / [R]$$

-If **K_{eq} = 1** that means that at the equilibrium point [P] =[R].

-If **K_{eq} > 1 up to 10^3** that means that at the equilibrium [P]>[R].

-If **K_{eq} < 1 down to 10^{-3}** that means that at the equilibrium [P] <[R].

-If **K_{eq} > 10^3** that means that at the equilibrium point [P]>> [R] and the reaction is going to completion.

-If **K_{eq} < 10^{-3}** that means that at the equilibrium point [P] << [R] and the reaction is hardly going.

❖ The effect of changing conditions on equilibrium

When a stress is applied to a system at equilibrium, the equilibrium shifts to relieve the stress.

- **Effect of changes in Concentration**
  if you are increasing [P] then you are shifting the equilibrium towards the reactants' formation.

  If you are increasing [R] then you are shifting the equilibrium towards the products' formation.

ΔG is controlled by [P]/[R] if you play with these concentrations you are playing with the thermodynamics of the system.

The concentration of products and the concentration of reactants affects any system because the ratio [P]/[R] controls the equilibrium constant **K_{eq}**, affect the system's thermodynamics.

If you are decreasing the [P] you increase that products formation, Glucose and how it does enter the cells and the glycolysis process goes through follows that system because the product you are forming, continuously you are removing it, so you are shifting the equilibrium always towards breaking glucose in cells.

- **Effect of changes in Temperature**

The equilibrium is affected according to the reaction type;
if you are applying heat – expressed into temperature- to an **exothermic** reaction, you are shifting the equilibrium towards the reactants' formation (backward).

If you are applying heat to an **endothermic** reaction, you are shifting the equilibrium toward the products' formation (forward).

- **Effect of a Catalyst**

It has **no effect**; because the system is already at the equilibrium point and the catalyst will accelerate both ways of the reaction; increase the rate of products' formations and the reactants' formations in the same amount and both of them will neglect each other.

- **<u>ΔG and K_{eq}</u>**

$\Delta G = \Delta G^{o\prime} + RT \ln ([P]/[R])$

*ΔG determines the spontaneity of the reaction, whether it's favorable or not and toward which direction the reaction will go.
The reaction which can reach the equilibrium, at the equilibrium point **ΔG = ZERO** because the thermodynamics of the system cancel each other.

In this case: **$\Delta G^{o\prime} = -RT \ln ([P]/[R])$** **R:** gas constant

<u>Can a reaction has a $+\Delta G^{o\prime}$ and still be favorable (has a $-\Delta G$)?</u>

If [R]>> [P] at equilibrium, this ratio will be a fraction "less than one" and ln of any fraction is a negative value. So if this negative value (RT ln ([P]/[R])) is higher than the positive value of $\Delta G^{o\prime}$, the total ΔG of that system will be negative.
→ Yes, the reaction with $+\Delta G^{o\prime}$ still can be favorable if [R]>> [P] at equilibrium.

Metabolic Processes inside body in some biochemical reactions remove the products continuously, to keep this ratio low, then its **ln** is more negative which will overcome the positive Δ **G°'** of the reactions.

- ❖ **Metabolism**

- What is the main source of all energy?
Sun; which gives the energy to plants then it's transformed to animals.

Why energy is needed?

1- Generating heat.
2- The performance of mechanical work in muscle contraction and cellular movements.
3- The synthesis of macromolecules and other biomolecules from simple precursors (formation of bonds).
4- The active transport of molecules and ions.

Metabolism in general is composed of two main processes either Anabolism or Catabolism.
Anabolism: the process of building up.
Catabolism: the process of degradation.
Once you are building up macromolecules then you are anabolising them, and when you are degrading them into small ones then you are catabolisng these molecules.
The metabolism is a link series of metabolic pathways which are interconnected to each other.

- How do we store energy for long-term purposes?

As bonds in macromolecules, and once you need energy you'll start degrading these bonds to get the energy you need.

- ❖ **Cellular metabolism:**
  It's the sum of total biochemical activities of all cells.

The pathways inside body are either **anabolic** (Need energy, endergoinic because you are making bonds) or **catabolic** (Give energy, exergonic because you are degrading

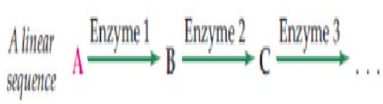
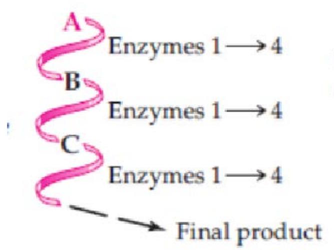
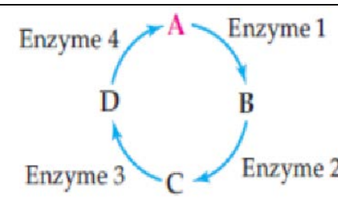
bonds).
We have a third system **Amphibolic pathways**; those systems which can go either directions, they can form energy or consume it, depending of the state of the body and state of energy; you can either generate bigger macromolecules or degrade macromolecules to get energy.

❖ <u>Biochemical pathways</u>

- They are **interdependent**, related to each other. Why? To save energy.
- Metabolic pathways are subjected to thermodynamics laws, they apply to them.
- Their activity is coordinated by sensitive means of communication.
- **Allosteric** enzymes are the predominant regulators of the metabolic pathways. Why?
  *allosteric enzymes are enzymes composed of more than subunit can work in a cooperative way, that have allosteric sites -other than the active site-can bind different materials and once you are working with different biochemical pathways, so a lot of materials can bind to that enzyme and affect its work.
  *Simple enzymes are controlled by competitive or non-competitive inhibition through one site.

  So, Allosteric enzymes offer having multiple sites which can regulate the enzyme work through binding different materials. E.g. the product of lipid metabolism can bind an enzyme of a carbohydrates metabolism and affect its work.

  Biosynthetic & degradative pathways are almost always distinct. Why?
  It offers you a better regulation.

Metabolic pathways:		
Linear	**Spiral**	**Cyclic**
Series of biochemical reactions where	Series of biochemical reactions where	Series of biochemical reactions where
Each step is regulated by different enzyme or group of enzymes.	Each step is controlled by the same enzyme or same group of enzyme	Each step is controlled by different enzyme or group of enzyme.
Has an End point.	Has an End point.	Doesn't have and End point, but you will regenerate the material that you've started with the reaction.
		

❖ **<u>The energy machinery of the cell</u>**

The energy machinery inside Eukaryotic cells is Mitochondria
In Prokaryotic cells in the cell membrane which composed of outer and inner membranes, on the inner membrane there are multiple proteins which generate energy.
Mitochondria are responsible for generating 90% of the body's energy.
Number of mitochondria varies inside the human body according to the tissue; depending on the function and the activities that the tissue performs, if it has high activity there will be a high amount of mitochondria.

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