Biochemistry

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Biochemistry

Introduction:

General Biochemistry: Discusses the structure of Proteins, Carbohydrates, Lipids and Nucleic acids. This is an essential science that helps us understand how enzymes and hormones work.
Metabolic biochemistry: Study of the chemical reactions that occurr within a cell.
Molecular & Genetics

Some Objectives:

- **Description of chemical and physical properties of water**
- **The ionization, Ph, titration curve**

Text book: lehninger principles of biochemistry, 6th edition

Chapter2: Water

Water: is the major component of Cytosol where most of important chemical reaction occurs. Blood is an aqueous solvent.

Kinds of molecules according to polarity:

1. **Polar molecules** (hydrophilic): these molecules are water soluble. Has the ability to replace water-water interaction with water-solute interaction such as sodium chloride (NaCl).

2. **Non polar molecules** (hydrophobic): are water insoluble molecules. It can't attract water molecules such as oil and waxes.

Solvents can be classified by their physical properties shown in this Table

	Melting point (°C)	Boiling point (°C)	Heat of vaporization (J/g)[a]
Water	0	100	2,260
Methanol (CH_3OH)	−98	65	1,100
Ethanol (CH_3CH_2OH)	−117	78	854
Propanol ($CH_3CH_2CH_2OH$)	−127	97	687
Butanol ($CH_3(CH_2)_2CH_2OH$)	−90	117	590
Acetone (CH_3COCH_3)	−95	56	523
Hexane ($CH_3(CH_2)_4CH_3$)	−98	69	423
Benzene (C_6H_6)	6	80	394
Butane ($CH_3(CH_2)_2CH_3$)	−135	−0.5	381
Chloroform ($CHCl_3$)	−63	61	247

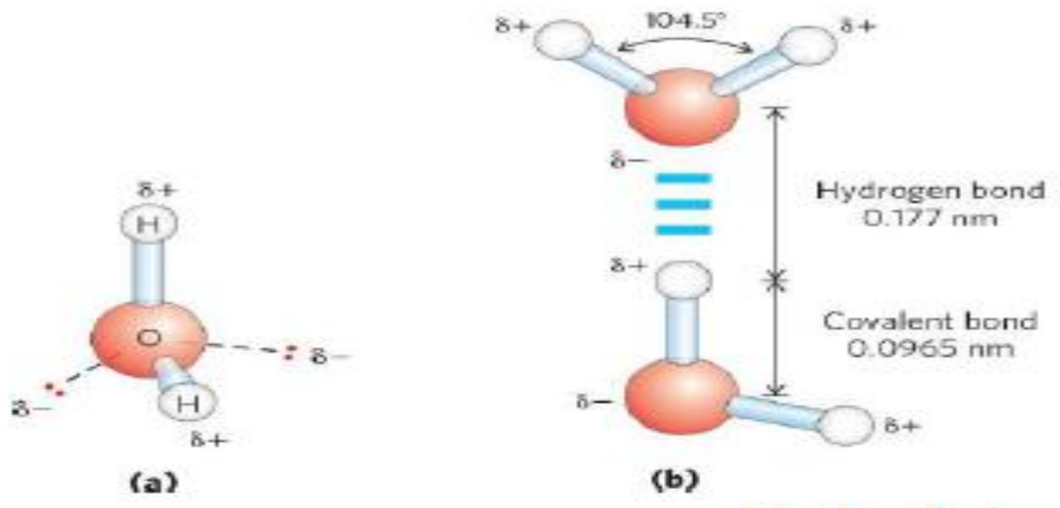
[a] The heat energy required to convert 1.0 g of a liquid at its boiling point and at atmospheric pressure into its gaseous state at the same temperature. It is a direct measure of the energy required to overcome attractive forces between molecules in the liquid phase.

*Water has a large heat of vaporization compared with other solvents that's why water is a good medium for chemical reactions.

Structure of water molecules:

*Ball and stick model: Display both the three-dimensional position of the atoms and the bonds between them. The atoms are typically represented by spheres, connected by rods which represent the bonds

*Space filling model: Display atom into consideration of its size.



1. **Dipolar nature of water**: In Water molecule O atom is partially negative due to the unshared pair of electrons. H atom is partially positive which give it its polarity. Dipolar nature of water molecule applies water attraction by making kind of intermolecular forces between O atom from the first water molecule and H atom from the second one. (That's why small water drops attract each other making big drop).

2. There is **nearly tetrahedral arrangement (rough tetrahedral)** of the outer shell due to the unshared pair of electrons which reduce the angel from 109 degrees (in perfect tetrahedral) to 104.5 degree.

Hydrogen bonding in water:

- An electrostatic attraction interaction occurs between O atom from water molecule and H atom from <u>other</u> water molecule (Donated with 3 parallel lines).

- The attraction of O and H atoms in the <u>same</u> water molecule is called covalent bond

- Two ways to detect the strength of a bond:
  1. Bond length is related to bond strength. Water covalent bond (0.0965nm) is shorter and stronger than the hydrogen bond (0.177nm) between the two water molecules.
  2. Dissociation energy (the energy required to break a bond) the dissociation energy of hydrogen bond between water molecules are relatively weak (23 kJ/mol), compared with (470 kJ/mol) for the covalent O—H bond in water or (348 kJ/mol) for a covalent C—C bond. Stronger bonds need higher dissociation energy. Covalent bonds are stronger than hydrogen bonds.

  Other weak bonds exist between molecules like: hydrophobic interaction. Although these kinds of interaction between molecules is weak, but their combination makes the structure of crystals, saccharides and other molecules.

Hydrogen bonding in water and temperature:

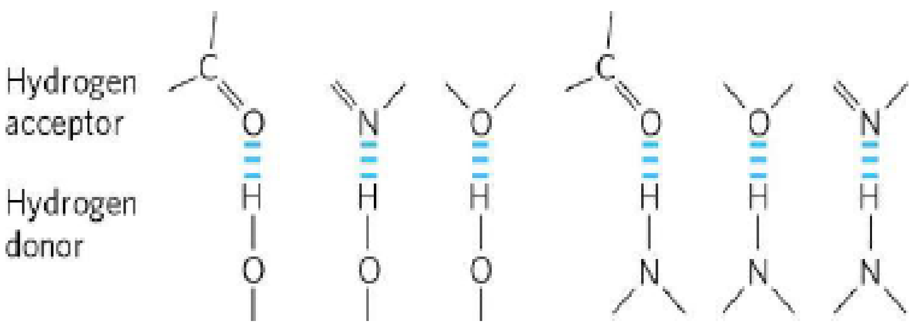
In liquid water (at room temperature), each water molecule hydrogen-bonds with an average of 3.4 with other water molecules due to its continuous movement.

In ice water molecules are fixed so each one form four hydrogen bonds which give ice solid shape.

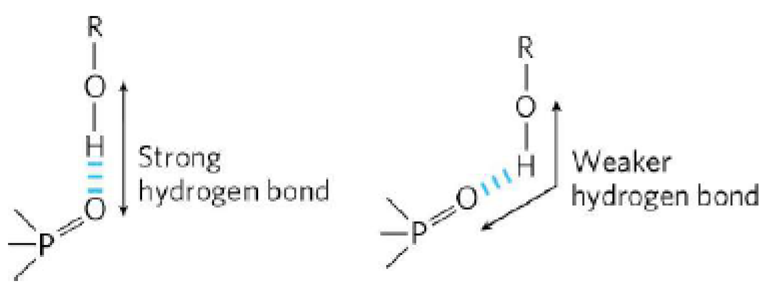
A number of hydrogen bonds for each water molecules is affected by heat.

(Increase of temperature → increase of molecule entropy → increase of molecule movement → decrease in number of hydrogen bonds).

Hydrogen bonds are not specific only for water molecules, it is also found in other molecules where a molecule has a hydrogen donor (molecule with H atom) and the other one is hydrogen acceptor (can be O or N atoms) partially negative. For example, between amino acids and nitrogen bases, water and carbohydrates, water and proteins, hydrogen donor and accepter can exist in the same compound such as in poly peptide chains that make globular proteins<enzymes>.

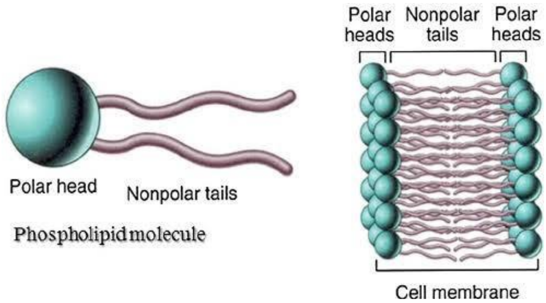


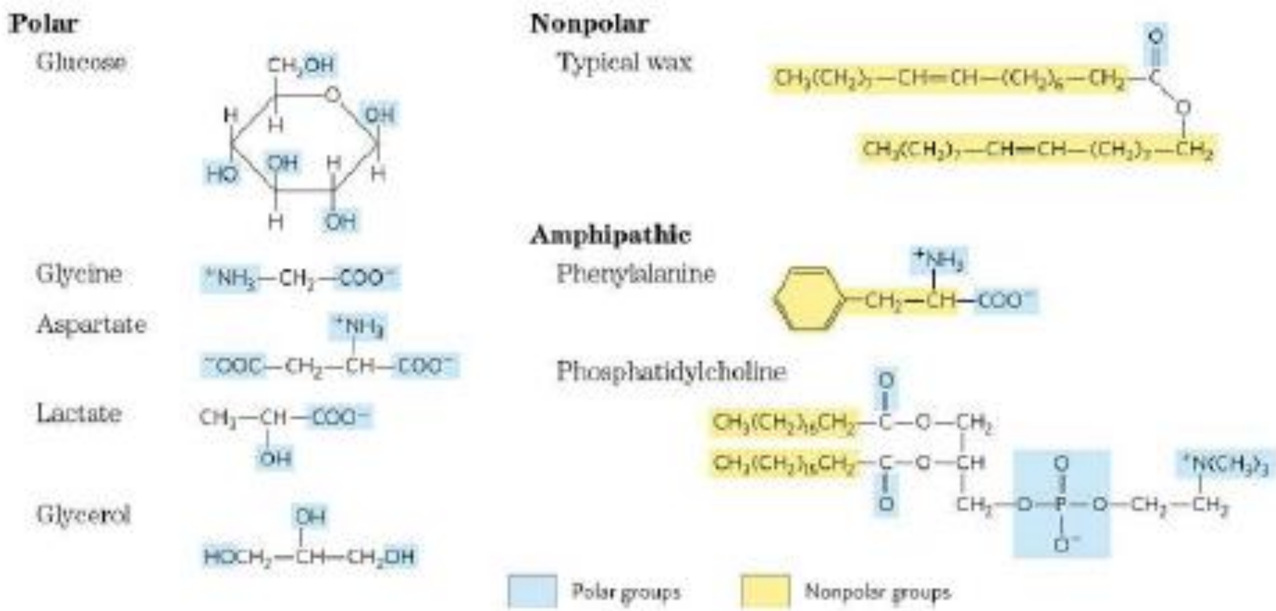
Hydrogen bond has directionality (location of hydrogen bond in the big molecule). the strongest hydrogen bond is straight without any bends because it gives the maximum electrostatic interaction (which means that the hydrogen bond is affected with the overall structure of the molecule) in some states it is difficult to get the straight state due to other repulsion powers, so the molecule keeps moving until it gets the stable shape and functional one.



As mentioned before: Molecules are polar (hydrophilic), non polar (hydrophobic).

Amphipathic molecules have two parts, one of them is polar and the other one is nonpolar such as: Phospholipids (hydrophilic head and hydrophobic tail).





How does water work as a solvent:

NaCl crystals in water: water dissolve NaCl in two steps:

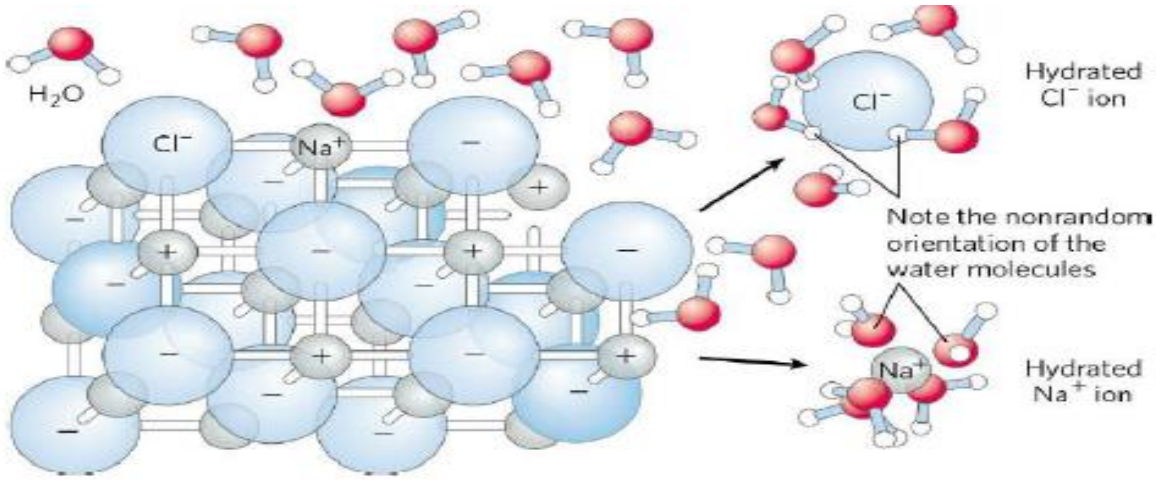
1. Hydrating crystals: water molecules surrounds the salt crystal, then they start to break down ionic bonds between Na ion And Cl cation (removing solute-solute interaction) to build (solvent-solute interaction). (Start with the surface of the crystal → inner parts →dissolving all crystals).

2. Stabilization of water molecules: arrangement of water molecules in which the negative parts of water surrounds the Na ion (positive charged). Positive charged parts of water molecules surrounds the Cl cations (most stable arrangement → lower energy).

Saturation state: when the solvent can't dissolve an extra amount of solutes.

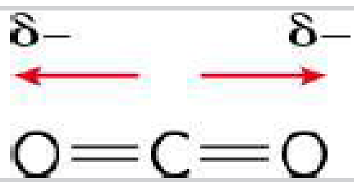
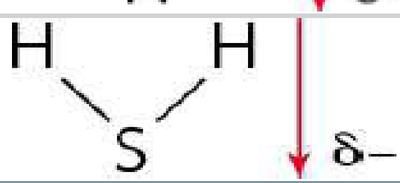
*To facilitate dissolving process, we give it more energy by stirring. Also it can be affected by high temperature.

*These two steps also work inside the cytosol. To dissolve proteins...



Nonpolar Gases Are Poorly Soluble in Water:
The molecules of the biologically important gases CO_2, O_2 and N_2 are nonpolar.

TABLE 2-3 Solubilities of Some Gases in Water

Gas	Structure[a]	Polarity	Solubility in water (g/L)[b]
Nitrogen	N≡N	Nonpolar	0.018 (40 °C)
Oxygen	O=O	Nonpolar	0.035 (50 °C)
Carbon dioxide		Nonpolar	0.97 (45 °C)
Ammonia		Polar	900 (10 °C)
Hydrogen sulfide		Polar	1,860 (40 °C)

*Solubility determine polarity
*In O2 and N2, electrons are shared equally by both atoms
*In CO2, each C=O bond is polar, but the two dipoles are oppositely directed and cancel each other
O and CO need carriers such as hemoglobin to move in the blood or any other aqueous solution

Amphipathic compounds in aqueous solution.
Compounds contain regions that are polar (or charged) and regions that are nonpolar (like fatty acids).
Changes in water after adding fatty acids or oil drops:
1. Organized water become unstable due to the increase of entropy and movement of water molecules →new arrangement of water molecules trying to isolate these drops.
2. The nonpolar regions of the Molecules cluster together to minimize the number of water molecules that interact with the droplets.
3. Amphipathic rearrangement: to become a stable structure. In which nonpolar portions arranged in the interior and the polar portions at the exterior surface, exposed to water. This arrangement called **micelle**.
HDL/ LDL: cholesterol in blood