YTOLOGY

Premed 2018 - JU

◉ Sheet ○ Slides

Number

1

Done by:

Rama Abbady

Corrected by:

Zina Smadi

Doctor

Diala Abu-Hassan

(00:00) – (10:00)

Types of Molecules in the Cell

1. Water Molecules: a large portion of the cell mass is water (70% of total cell mass).
2. Organic molecules (carbon containing): Proteins, carbohydrates, nucleic acids and lipids. (80-90% of dry cell mass)
3. Inorganic molecules: mostly metal ions (Na^+, K^+, Mg^{+2}, Ca^{+2}), Cl^-, HCO_3^-, PO_4^{-3}. (less than 1% of total cell mass)

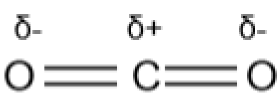
Polarity

-Polarity is due to difference in electronegativity (ability to attract electrons) between two atoms.

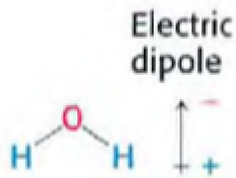
-One atom is more electronegative than the other atom, the more electronegative atom doesn’t completely gain the electrons, the shared electrons spend more time around it and that’s why it gains a partial negative charge ($\delta-$) while the other (less electronegative) atom gains a partial positive charge ($\delta+$).

-There’s a difference between a polar bond and a polar molecule, a polar molecule has polar bonds, but if a molecule has polar bonds it’s not necessarily polar, some molecules have polar bonds but are non-polar.

- Example 1: CO_2
- ✓ There’s a difference in electronegativity between the Carbon atom and the Oxygen atom, C has 4 valence electrons and they’re all shared (bonding electrons), it doesn’t have any unshared pair of electrons so the bonds are distributed around it in a linear way, furthest away from each other so that repulsions between them are minimum.
- ✓ The electronegativity difference between C and O is ≈1 which makes the bond polar.



- ✓ The two polar bonds are at 180 degrees to each other so the dipoles cancel out. (there’s no dipole moment **<u>(net dipole = 0)</u>**)
- ✓ CO_2 is non-polar even though it contains polar bonds.
- Example 2: H_2O
- ✓ A water molecule has two pairs of unshared electrons.



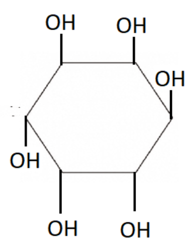
- ✓ In order for the molecule to remain stable, the repulsions between electrons should be minimum. That’s why H_2O has a bent shape.
- ✓ The net dipole isn’t zero, H_2O is a polar molecule.

➢ Based on polarity, molecules are divided into three types:

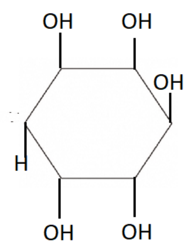
1) Polar (Hydrophilic):

What indicates that a molecule is polar?

- ✓ The presence of certain polar bonds such as (OH, C=O).
- ✓ Presence of charged atoms/groups such as (NH_3^+, COO^-, O^-).
- ✓ We also have to consider the geometry of the molecule. For example, if a molecule is hexagon (six-sided) and 3 (OH^-) groups are up and 3 are down, they cancel out so we consider it to be nonpolar, but if there were 3 (OH^-) up and 2 down then it's polar (hydrophilic).



nonpolar



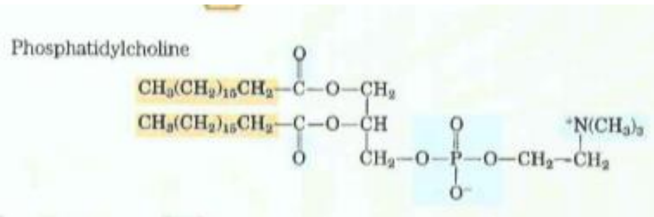
polar

2) Non-polar (Hydrophobic):

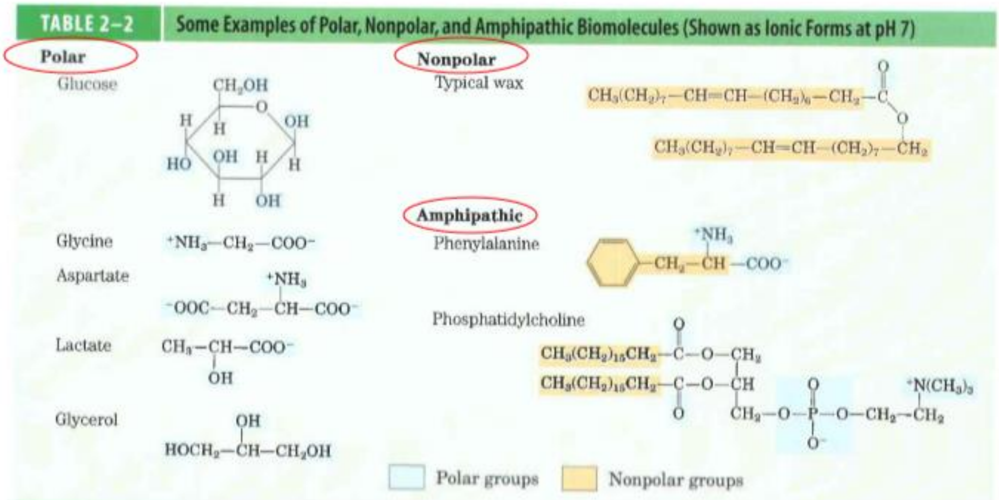
- Hydrophobic molecules are mainly hydrocarbons because there's a small difference in electronegativity between (C and H) and the electrons are almost shared equally between them. (neither C nor H gains a partial negative charge or a partial positive charge).

3) Amphipathic:

- Has both polar (hydrophilic) regions and non-polar (hydrophobic) regions.



- Note that in this example the negative charge of the O and the positive charge of the N(CH_3H)$_3$ don't cancel out each other.



➢ Noncovalent Interactions:

- Noncovalent interactions could occur between molecules in a certain space but these interactions don't produce new compounds (there's no reaction).
- They form and break all the time.
- The probability of a noncovalent interaction between two molecules increases as the distance between them decreases.

(10:00-20:00)

❖ Four types of noncovalent interactions:

1) **Electrostatic or Ionic interactions (Salt bridges):** Interactions between oppositely charged groups.

- ✓ Electrostatic interactions are one of the strongest noncovalent interactions. About (20-30) KJ/mole are needed to break them down.
- ✓ Based on Coulomb's Law, the electrostatic force of attraction and repulsion is directly proportional to the magnitude of charges and inversely proportional to the squared distance between them. Therefore, the electrostatic force between (+1, -1) is stronger than the electrostatic force between (+1/2, -1/2).
- ✓ Electrostatic interactions could happen between fully charged atoms (Na^+, Cl-), partially charged atoms (dipoles, ex.: the O in H_2O), or between a fully charged atom and a partially charged atom (dipole).

2) **Vander Waals Force:** Attractions between transient dipoles generated by the rapid movement of electrons of all neutral atoms.

- ✓ One of the weakest noncovalent interactions, only (1-5) KJ/mole are needed to break them down.

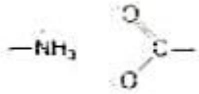
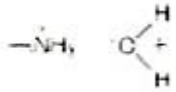
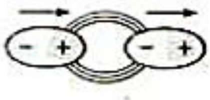
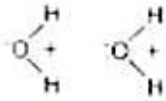
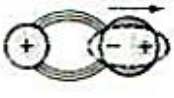
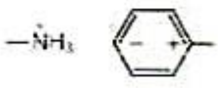
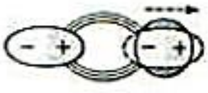
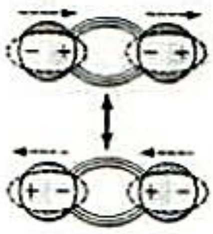
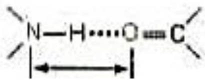
- ✓ At any point, electrons are moving 'randomly' in orbitals around atoms, so at any one point, more electrons may be on one side of the atom than the other, forming a small instantaneous electron dipole where one side of the atom is negative and the other side is more positive.
  This forms a temporary bond with other atoms which also have small instantaneous electron dipoles.
- ✓ Thus, the more electrons a molecule has, the stronger the Van der Waals forces can be said to be as there is a greater probability of these small dipoles forming, and they will likely be more polar with more electrons being present.

3) **Hydrophobic interactions:** forces that isolate hydrophobic molecules from hydrophilic environment.
   - Self-association of nonpolar compounds in an aqueous environment.
   - Minimize unfavorable interactions between nonpolar groups and water.
   - For example: when we add oil (gradually) to a cup of water, in small amount of time the small droplets of oil will group together forming one big droplet due to hydrophobic interactions between oil molecules.
   - They're relatively weak but stronger than Vander Waals interactions.
   - 5-30 KJ/mole are needed to break them down.

4) **Hydrogen bonds:** could be considered a special case of ionic interactions.
   - Between the two strands of the DNA helix.
   - 10-30 KJ/mole are needed to break them down.

❖ Types of ionic interactions:

a) **Charged-charged:** $Na^+ + Cl^-$ (NaCl).
b) **Charged-dipole (partially charged).**
c) **Dipole-dipole:** between the partial positive charge of one molecule and the partial negative charge of another molecule.
d) **Charged-Induced dipole.**
   - Dipole: difference in electronegativity is constant, one side is always partially positive and the other side is always partially negative.
   - Induced dipole: The difference in electronegativity isn't constant due to the movement of electrons, such as in benzene rings, so a temporary dipole occurs called induced dipole.
e) **Dipole-induced dipole.**
f) **Dispersion:** benzene rings stack together to increase the mechanical strength of a molecule.
g) **Hydrogen bonds.**

TYPE OF INTERACTION	MODEL	EXAMPLE	DEPENDENCE OF ENERGY ON DISTANCE	COMMENT
(a) Charge–charge			$1/r$	Longest-range force; nondirectional
(b) Charge–dipole			$1/r^2$	Depends on orientation of dipole
(c) Dipole–dipole			$1/r^3$	Depends on *mutual* orientation of dipoles
(d) Charge–induced dipole			$1/r^4$	Depends on polarizability of molecule in which dipole is induced
(e) Dipole–induced dipole			$1/r^5$	Depends on polarizability of molecule in which dipole is induced
(f) Dispersion			$1/r^6$	Involves mutual synchronization of fluctuating charges
(g) Hydrogen bond	DONOR—H···· ACCEPTOR		Length of bond fixed	Depends on donor–acceptor pair