Biochemistry
Chemical bonds
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STABILISING FORCES IN BIOMOLECULES

- The stability of biomolecules is maintained by various types of chemical bonds. It represents attraction forces between atoms, strong enough to function as a single unit

PRIMARY BONDS

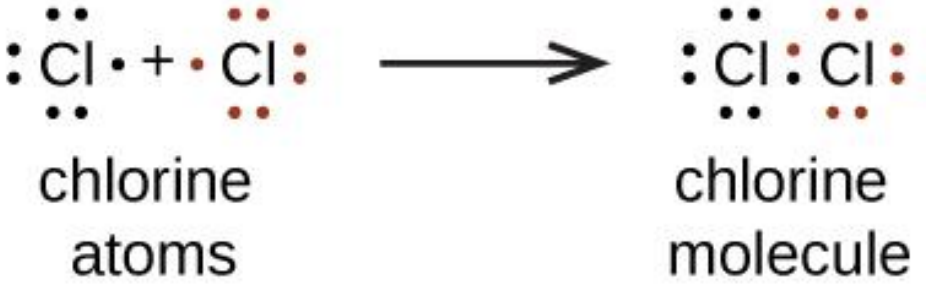
- There are mainly three types of Primary Bonds - in which atoms can group together by gaining or losing or sharing electrons, so that they can attain stable inert gas electron configurations eg: Covalent bond, Ionic bond and Metallic bonds

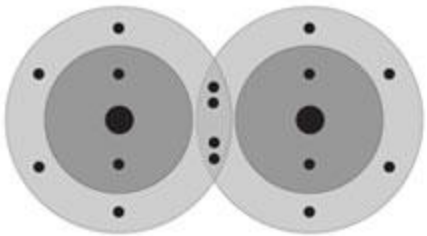
COVALENT BONDS

- Are the bonds formed by sharing of electrons between two atomic nuclei. A single covalent bond involves sharing of two electrons, double bond has four shared electrons and triple bond has 6

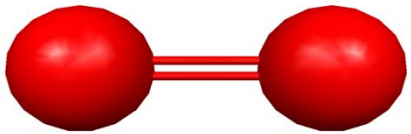
  - Single bond Cl_2
    Cl – Cl [2,8,7]
  - Double bond O_2, CO_2
    O=O [2,6]
  - Triple bond N2
    N = N [2,5]

- Covalent bonds are very strong bonds that the

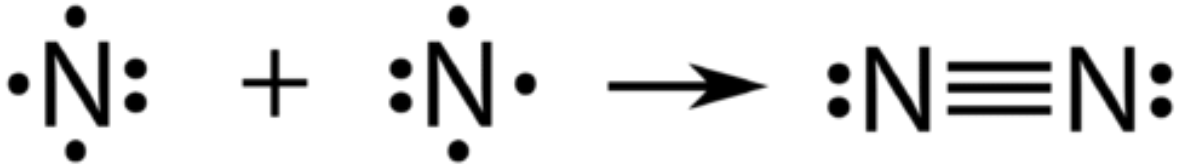


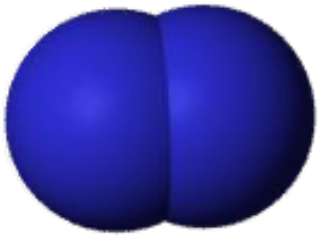


Oxygen Molecule (O_2)

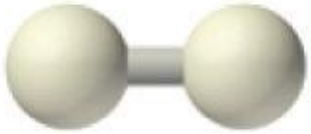


Carbon dioxide



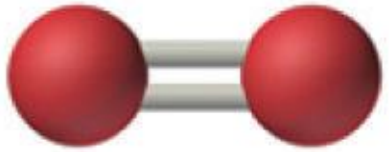


H—H



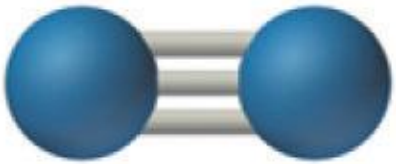
Single bond

O=O



Double bond

N≡N



Triple bond

- Covalent bonds may range from non-polar to extremely polar

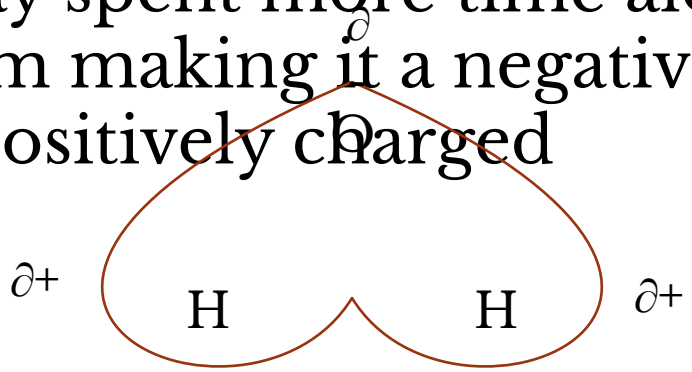
Non – polar Bonds

If the two atoms in a covalent bond have the same electronegativity, the bonding electrons are evenly shared between them. Such bonds which has no directionality or polarity are known as Non-polar bonds Eg: H_2 [H – H]

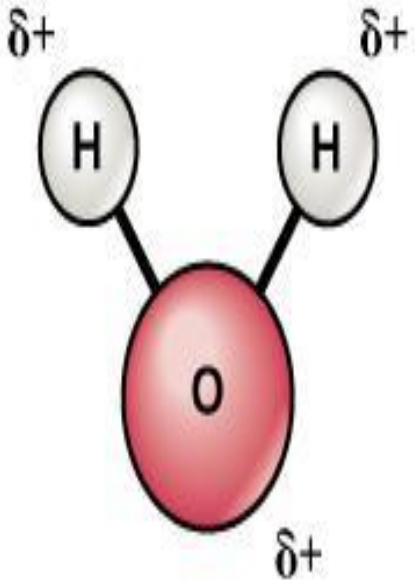
Polar Bonds

Are formed when bonding electrons are shared unevenly by the two atoms. Here the bonding electrons may spent more time along with the more negative atom making it a negatively charged, leaving the other a positively charged

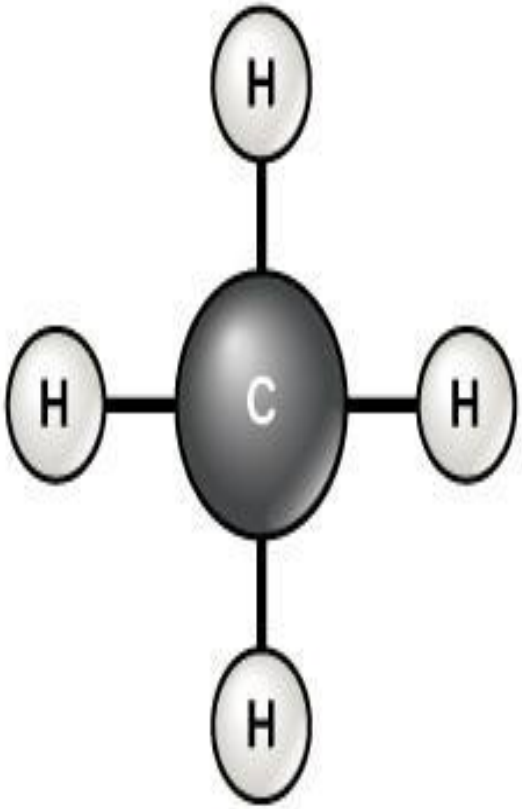
Eg: H_2O



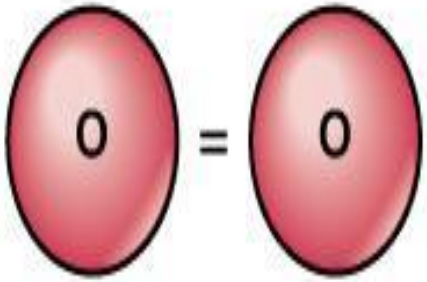
Polar covalent bond

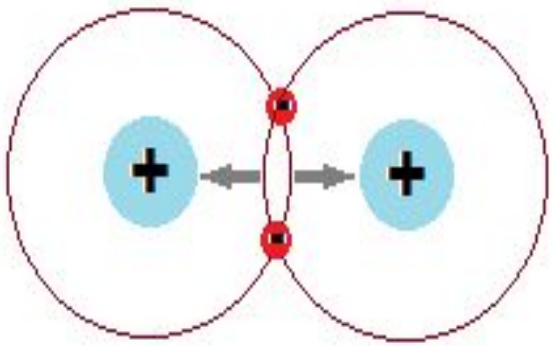


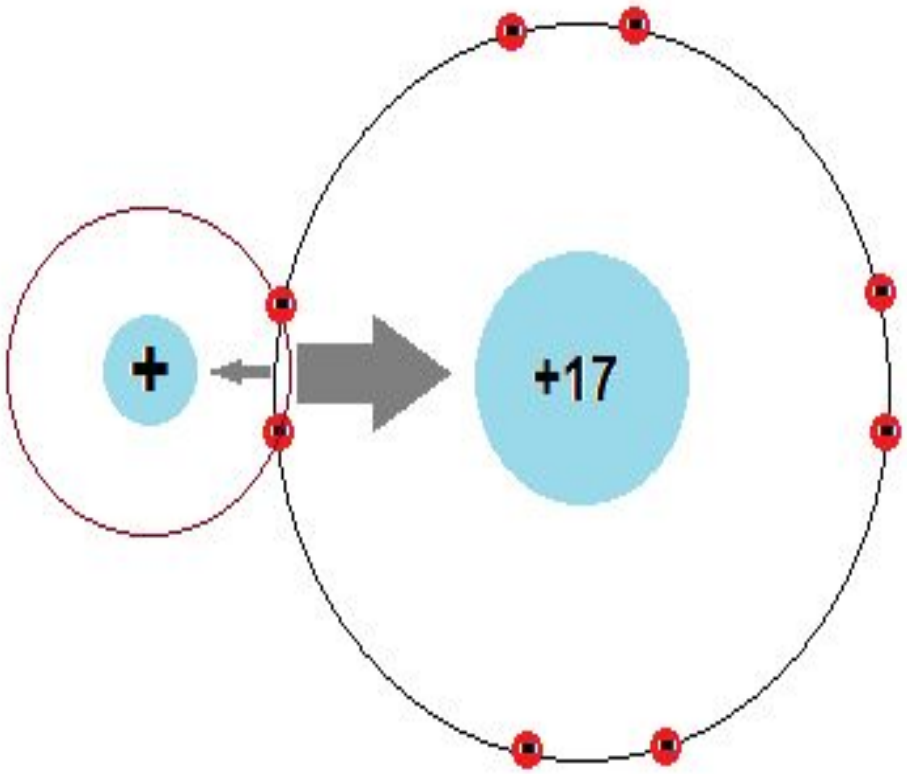
Nonpolar covalent bond



Nonpolar covalent bond







H÷H

equal sharing
non-polar bond

H÷Cl

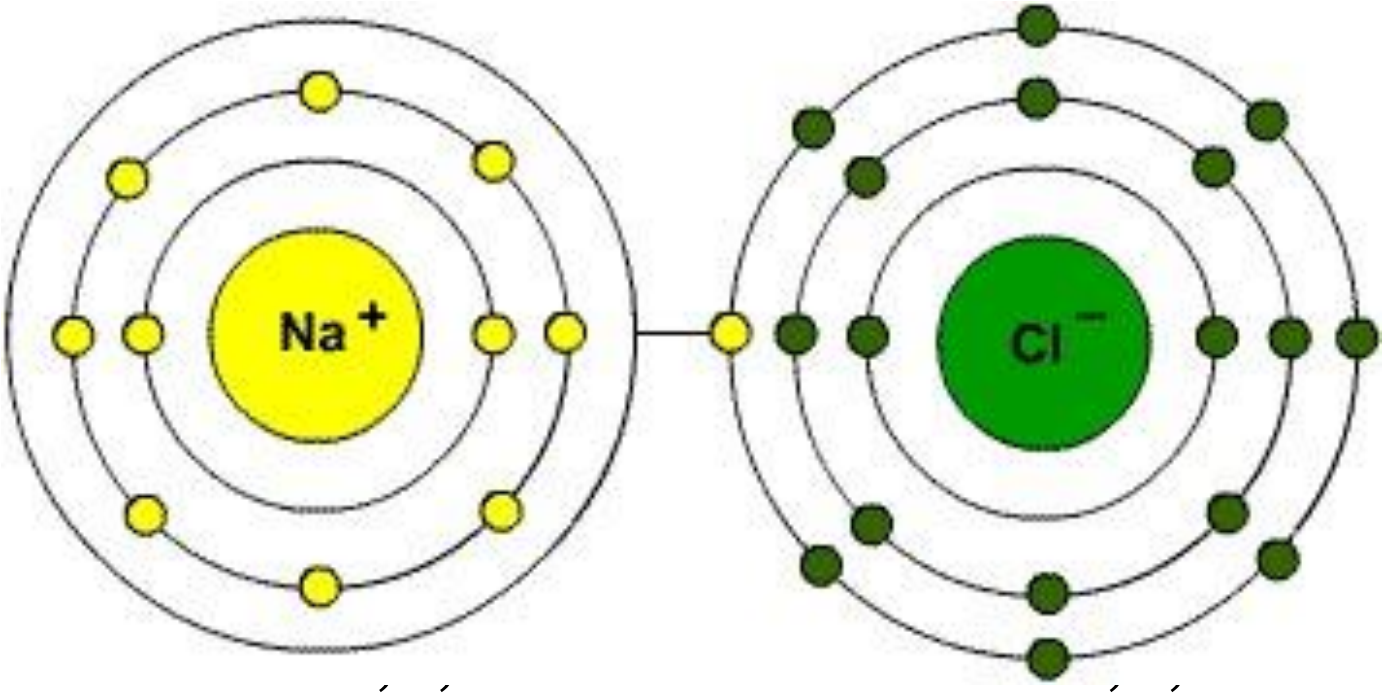
unequal sharing
polar bond

IONIC BOND/ELECTROVALENT BOND/ELECTROSTATIC BOND

- **Ionic bonding** is a type of chemical **bond** that involves the **electrostatic** attraction between oppositely charged ions

- It is formed by the complete transfer of one electron or more between the atoms

  Eg: NaCl


Na+
Cl−

- The strength of ionic bonds depends on the Dielectric constant of the medium.
- The attraction is strongest in vaccum where D=1 and the attraction is very weak in a medium of high dielectric constant such as water (D=80) where the compounds dissociate into oppositely charged ions

[Dielectric constant = a quantity measuring the ability of a substance to store electrical energy in an electric field]

- The force of an electrostatic attraction between the ions is given by Coulomb's law

$$F = \frac{q_1 q_2}{r^2 D}$$

$Q_1 q_2$ are charges of ions
r = distance between them
D = Dielectric constant of the medium

- The ionic bonds are very important in bringing about biochemical reactions such as enzymatic reactions and also in structural stabilisation of biomolecules such as DNA nucleoprotein

SECONDARY BONDS

- Secondary or weak bonds are formed when there is effectively a partial and/or momentary charge.
- They are secondary in terms of strength but not necessarily in terms of importance, as life is only made possible because of them. Eg: Hydrogen bonds, Hydrophobic or non-polar interactions, Van der Waals interactions etc.

HYDROGEN BOND

- When a H-atom is covalently linked to a highly electronegative atom having lone pairs, a partial charge separation occurs and the molecule becomes polar. ie, it become a dipole with the hydrogen end having a partial positive charge and the other end having a partial negative charge.

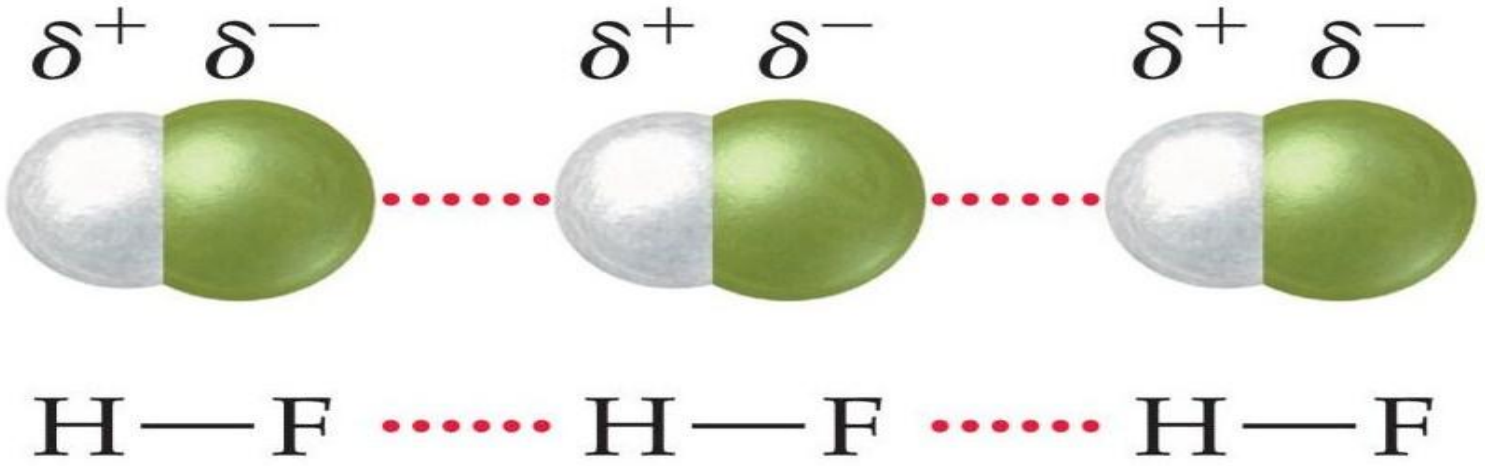
- Here the positive hydrogen end of the molecule interacts with the negative end of a neighbouring molecule forming a bridge between them. This special case of dipole-dipole attraction is called a hydrogen bond.

- Protonic Bridge : The hydrogen atom in a polar covalent bond is positively charged, it may attract an electron pair of the other molecule. This is called a Protonic Bridge

- Hydridic Bridge : The hydrogen atom in a polar covalent bond is negatively charged, it may attract the nucleus of an atom of the other molecule. This is called a Hydridic Bridge

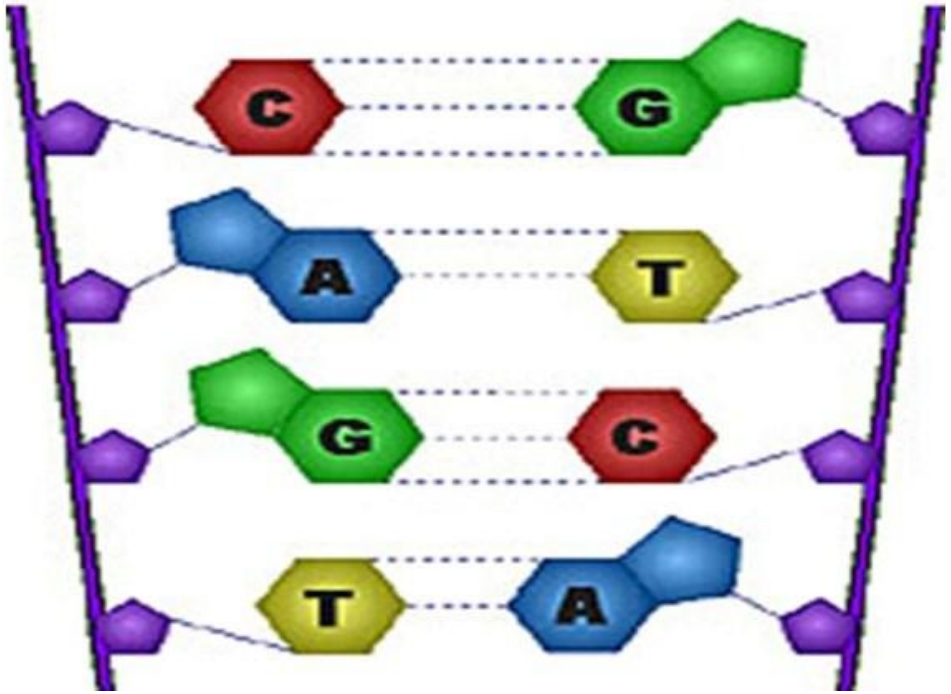
- It is comparitively a weaker bond and the energy required to break such a bond is

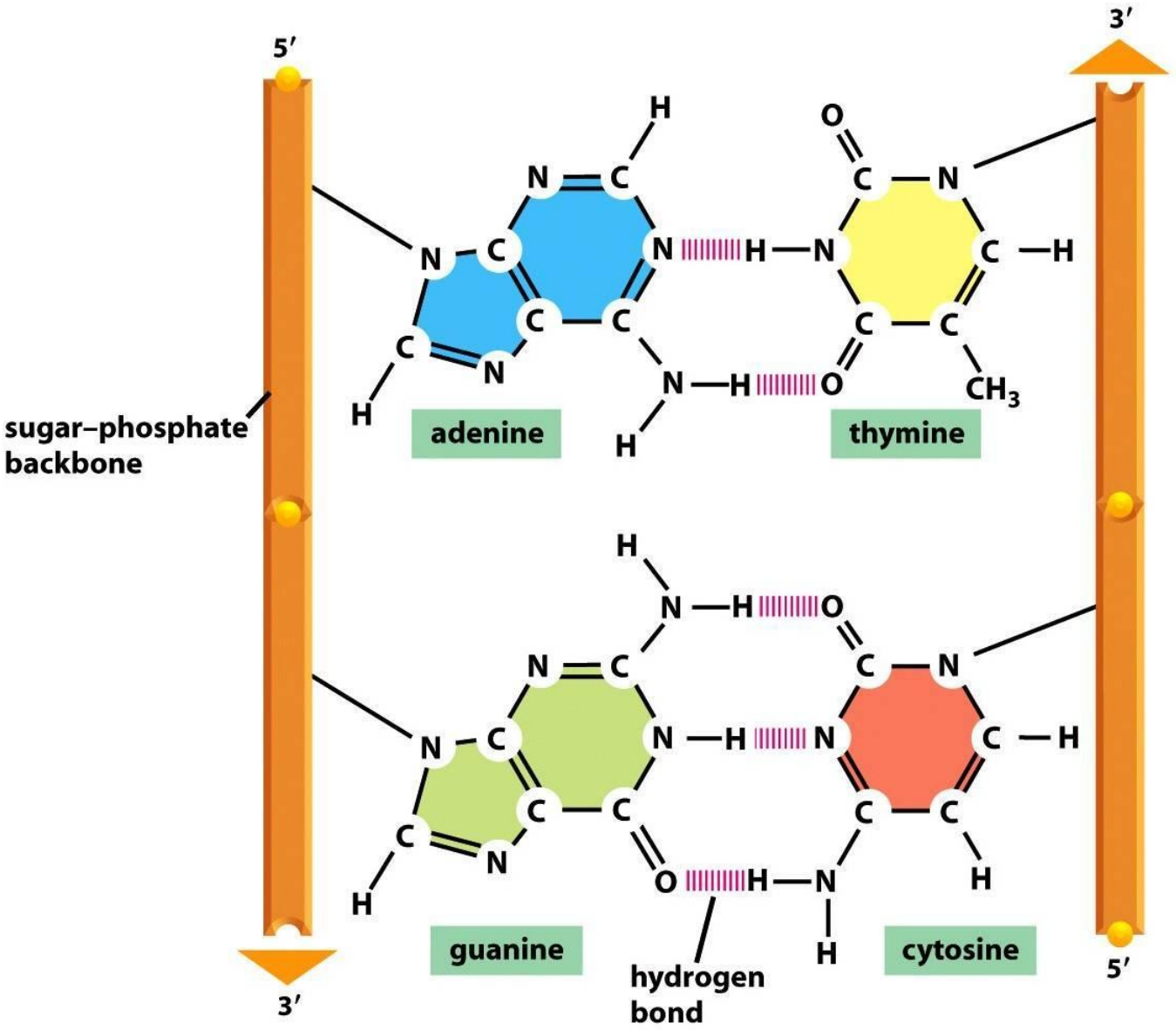
- **<u>Intermolecular Hydrogen bond</u>**: Hydrogen bonding present between different molecules of the same substance [eg: HF, H_2O] or different substance [Organic compounds containing –OH, -COOH, NH_2 etc. form hydrogen bonding with water] is called intermolecular hydrogen bonding



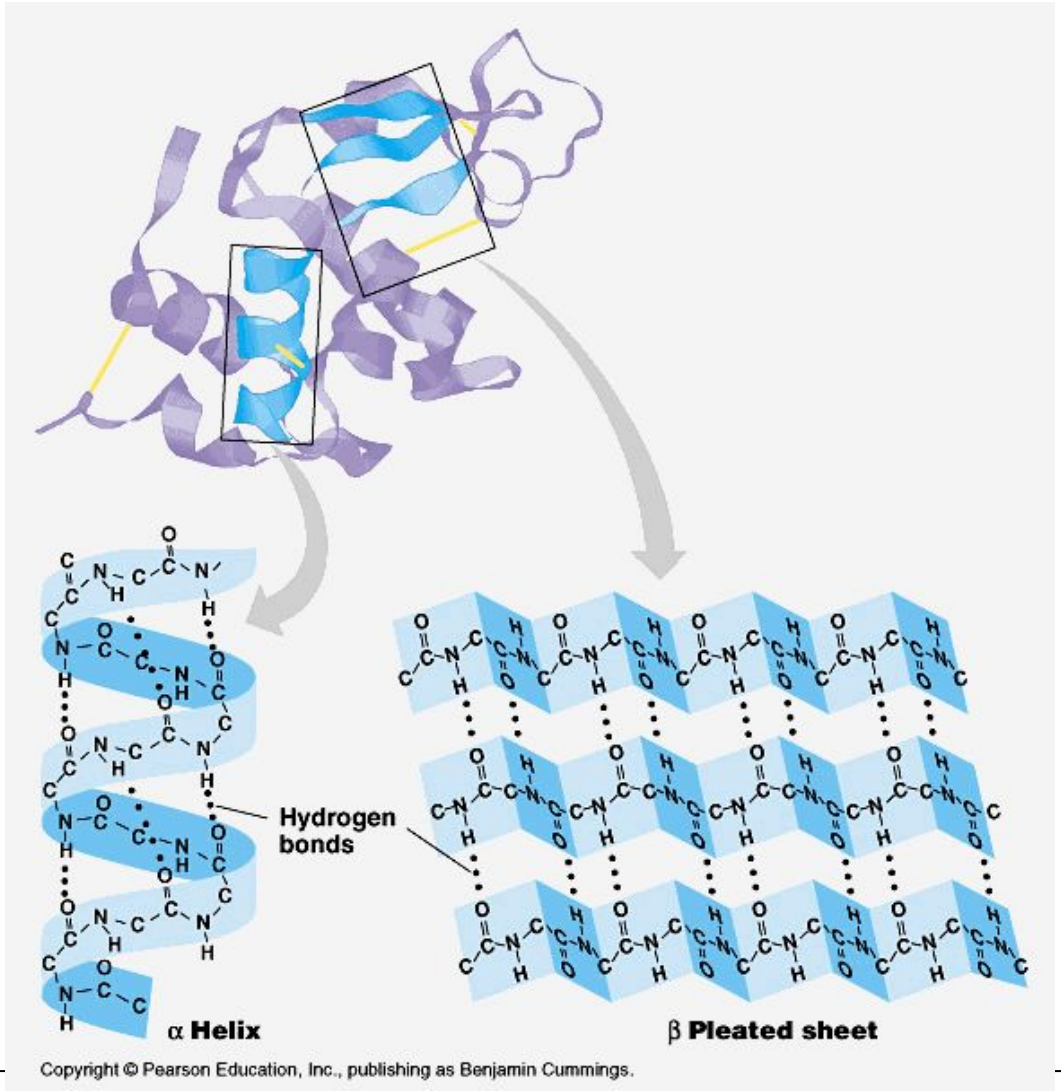
- **<u>Intramolecular Hydrogen bond</u>**: Hydrogen bonding present within same molecules is called intramolecular hydrogen bonding
- Eg: Hydrogen bonding in DNA

- Hydrogen Bonds hold the nitrogen bases together in the middle
  - Adenine pairs with Thymine
  - Cytosine pairs with Guanine




5′
3′
sugar–phosphate backbone
adenine
thymine
guanine
cytosine
hydrogen bond
3′
5′

- Helical structure of proteins derived from folding of polypeptide chains

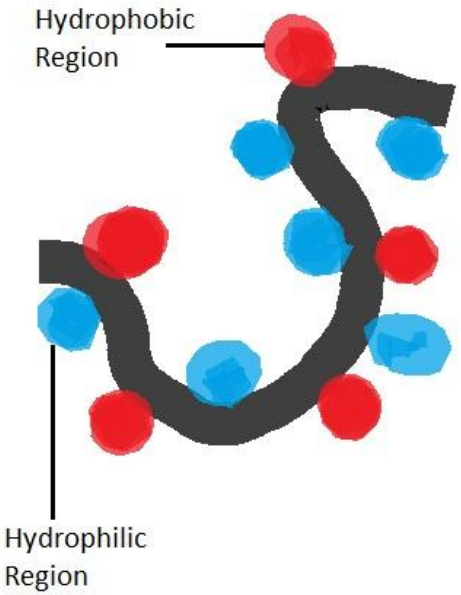


HYROPHOBIC / NONPOLAR INTERACTIONS

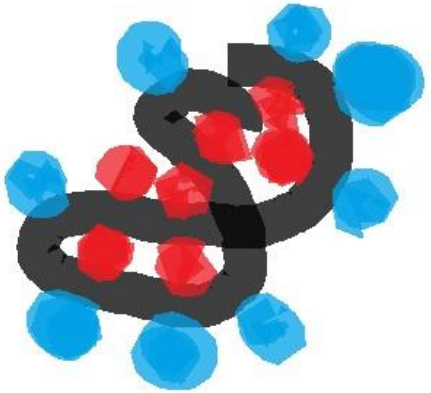
- Amphipathic compounds contain a polar part and a non-polar part in their molecule. When such a molecule is mixed with water polar hydrophilic part interact with water and non-polar hydrophobic part cluster together to form a spherical structure called Micelle

- In each micelle, the non-polar hydrophobic tail of each molecule is directed towards the centre while its polar hydrophilic head is on the

- Eg: Proteins, Lipids, Sterols, Phospholipids etc.

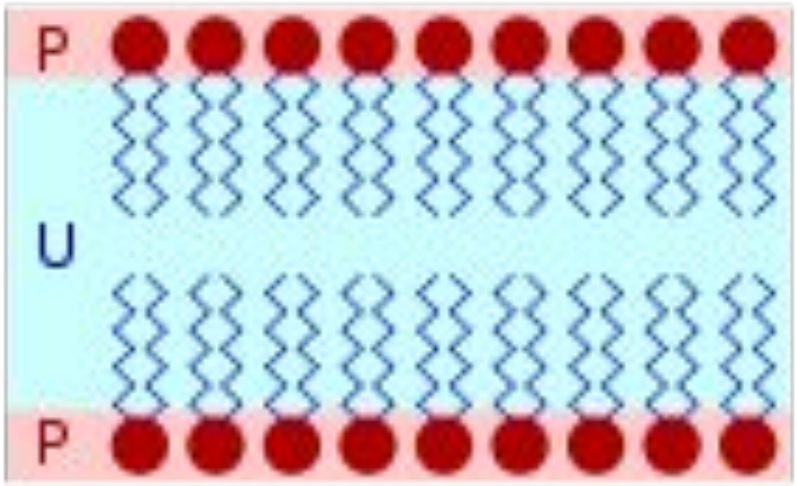


Isolated Protein

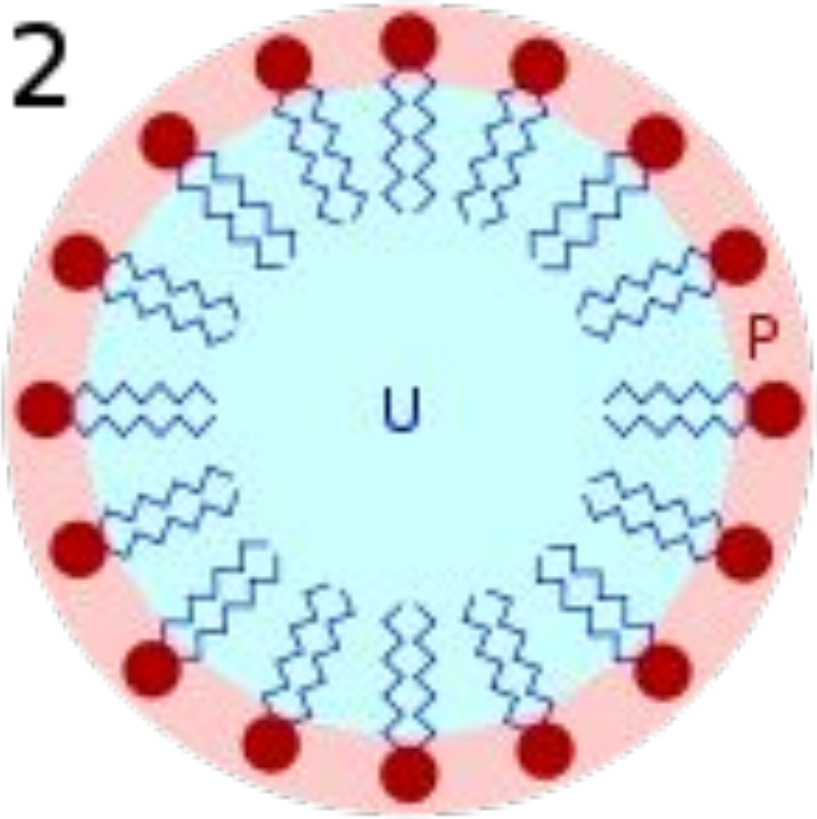


Protein in aqueous solution

1



2

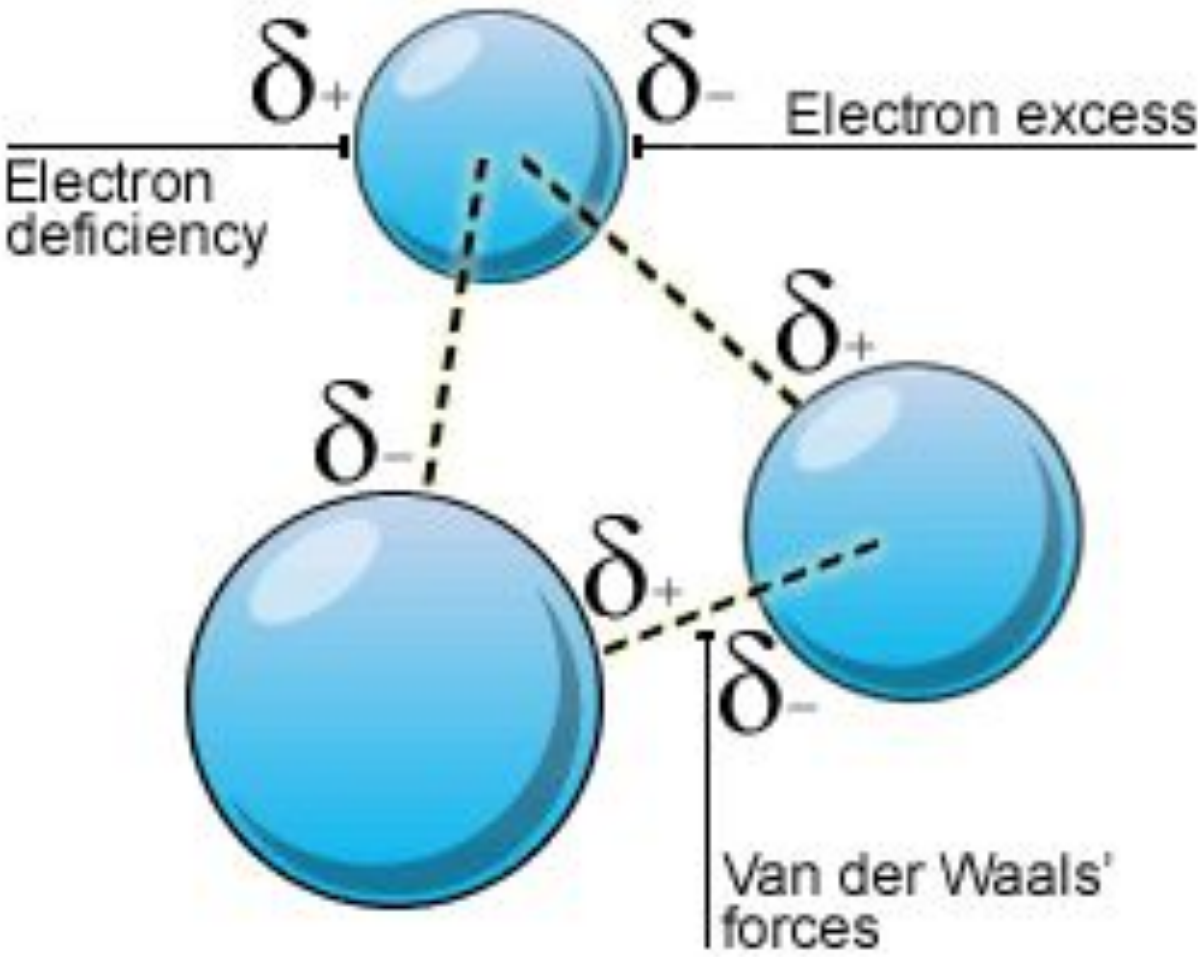


van der Waals interactions

- Are very weak intermolecular forces having energy <10kJ
- They can be of 3 types

a) Dipole – dipole forces : Weak interactions between polar molecules (weaker than hydrogen bonds) where the positive end of one dipole will attract the negative end of a neighbouring dipole

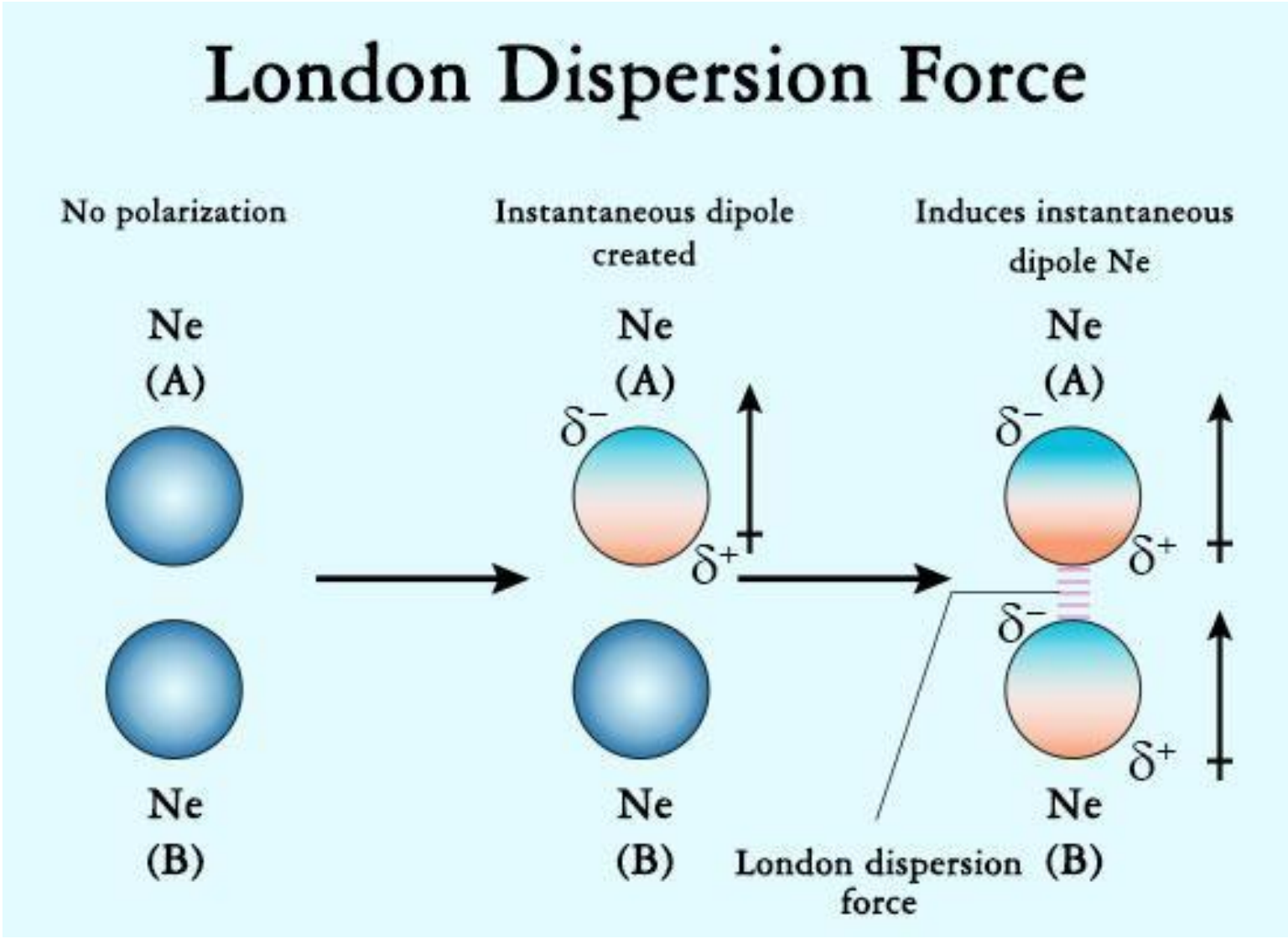
b) Dipole – induced dipole forces : Attractive interactions between the permanent dipoles in polar molecules and dipoles induced in non-polar


δ+
δ−
Electron excess
Electron deficiency
δ+
δ−
δ+
δ−
Van der Waals' forces

c) Induced dipole – induced dipole forces : Also known as Dispersion forces OR London Disperson forces

Attractive interactions between the instantaneous fluctuating dipoles (electronic clouds) induced in non-polar molecules by the proximity of other molecules or nonpolar molecules

London Dispersion Force



- The dipoles involved in Van der Waals bonding come from *fluctuations in the symmetry* of the electron distribution surrounding the nucleus of an atom. Momentary electric dipoles are set up and give rise to weak, very short-range, non-directional attractive forces between molecules or atoms. Permanent dipoles can also be involved, e.g. by inducing other temporary dipoles.