Molecules of life

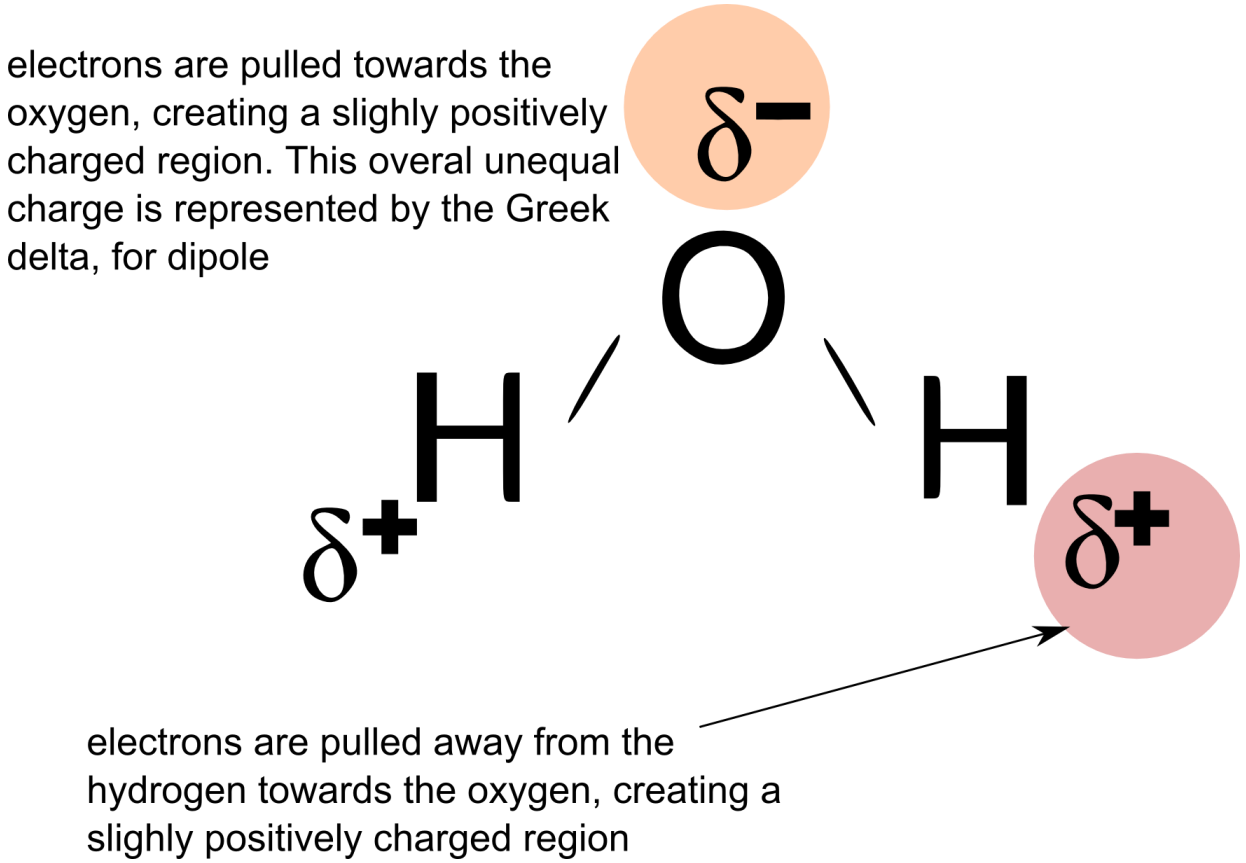
Covalent and non-covalent bonds

- A **covalent bond** is a chemical bond that involves the sharing of electron pairs between atoms. Covalent bonds create molecules.
- A **non-covalent bond** is an interaction between atoms that does not involve the sharing of electron pairs. Non-covalent interactions can occur within a single molecule or between different molecules. Many interactions of biological molecules have non-covalent character.

Water

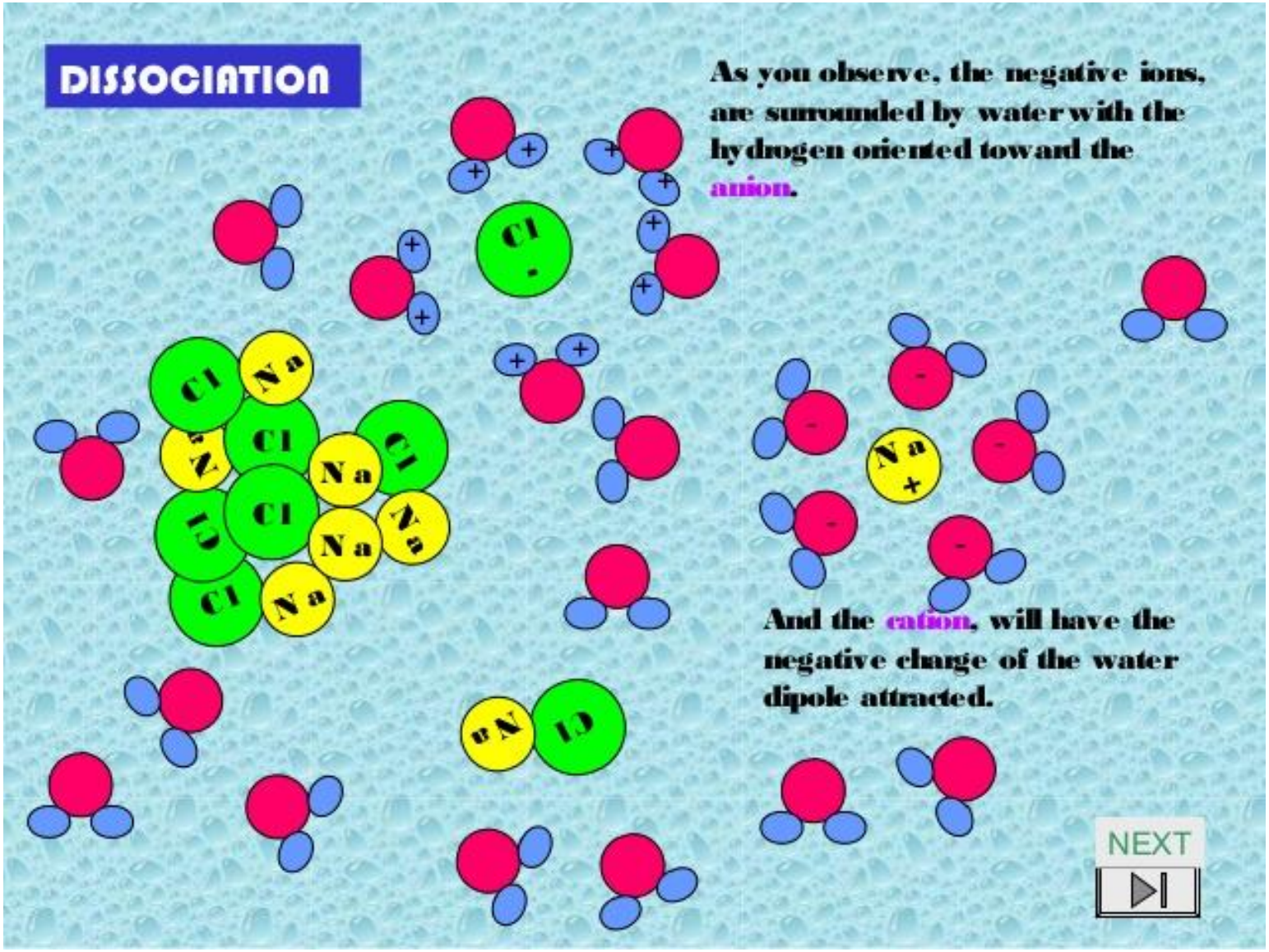
- Water is of major importance to all living things; in some organisms, up to 90% of their body weight comes from water.
- Water is an active matrix of life for cell and molecular biology
- Up to 60% of the human adult body is water.

Water molecule

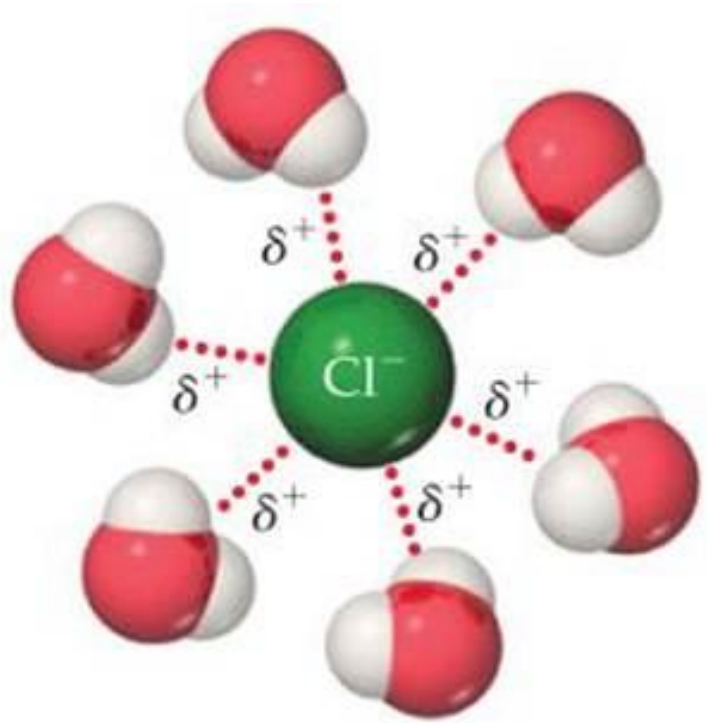


Electrolytic Dissociation

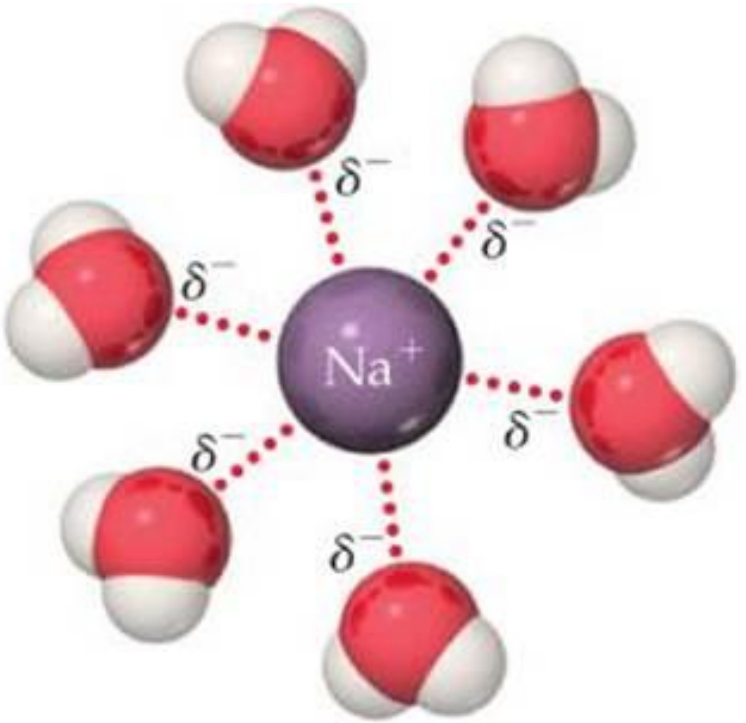
- Many substances will undergo an even called *dissociation* when dissolved in water.
- In electrolytic, or ionic, dissociation, the addition of a water causes molecules or crystals of the substance to break up into *ions* (electrically charged particles).
- The salt can be recovered by evaporation of the solvent.
- Positively charged ions are called *cations*, negatively charged – *anions*.


DISSOCIATION
As you observe, the negative ions, are surrounded by water with the hydrogen oriented toward the anion.
Cl -
Na +
And the cation, will have the negative charge of the water dipole attracted.
NEXT

Ions in water



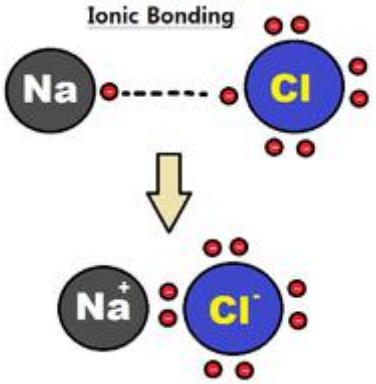
Positive ends of polar molecules are oriented toward negatively charged anion



Negative ends of polar molecules are oriented toward positively charged cation

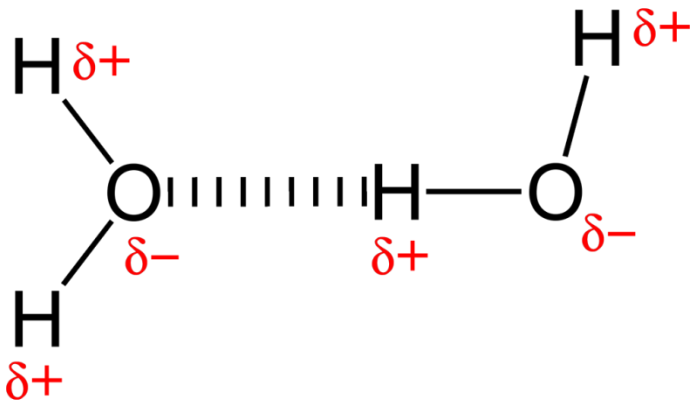
Non-covalent bonds

Ionic bonding - the electrostatic attraction between oppositely charged ions.

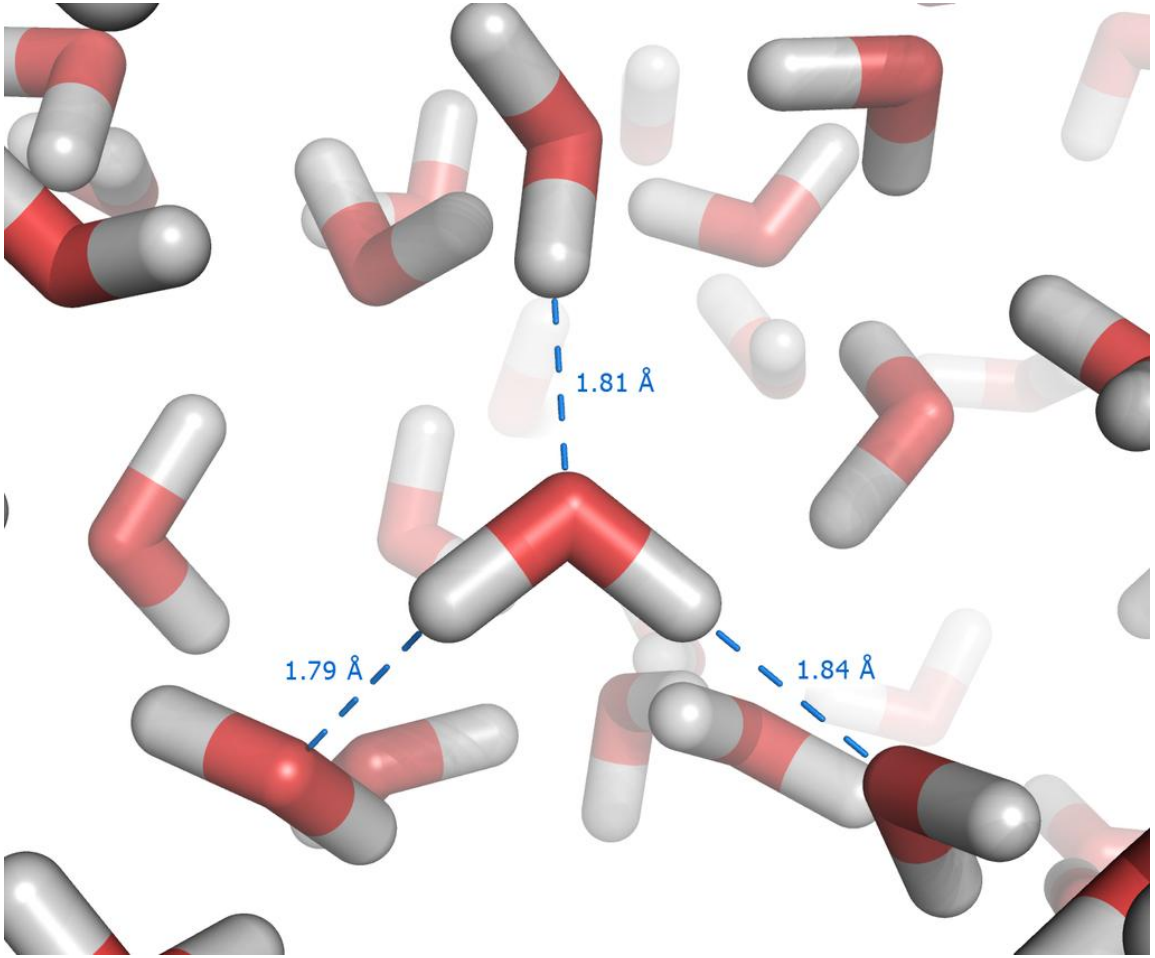


Non-covalent bonds

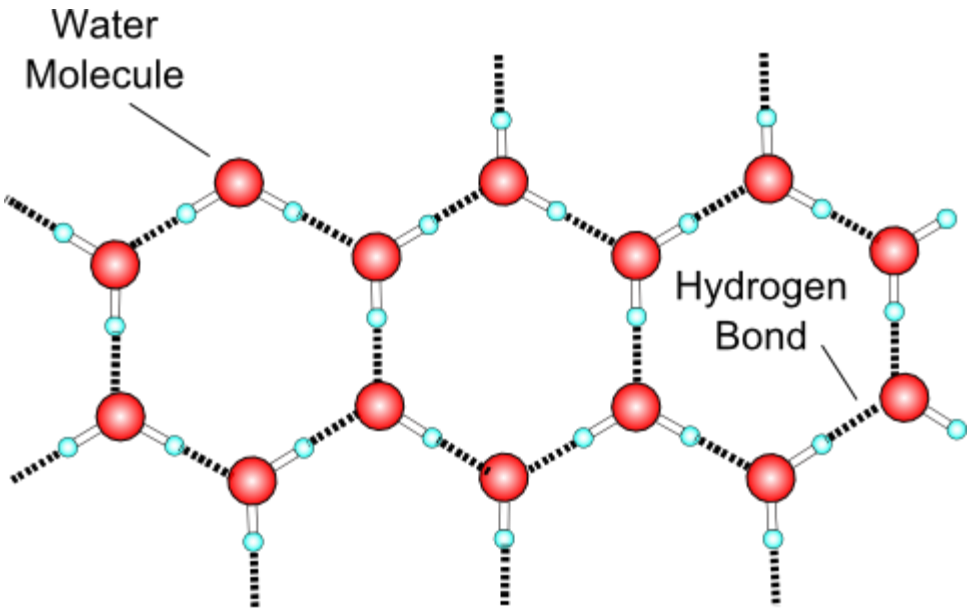
Hydrogen bond - electrostatic attraction between two polar groups. It involves hydrogen (H) atom covalently bound to a highly electronegative atom such as nitrogen (N), oxygen (O), or fluorine (F) .



Dynamic hydrogen bonds between molecules of liquid water



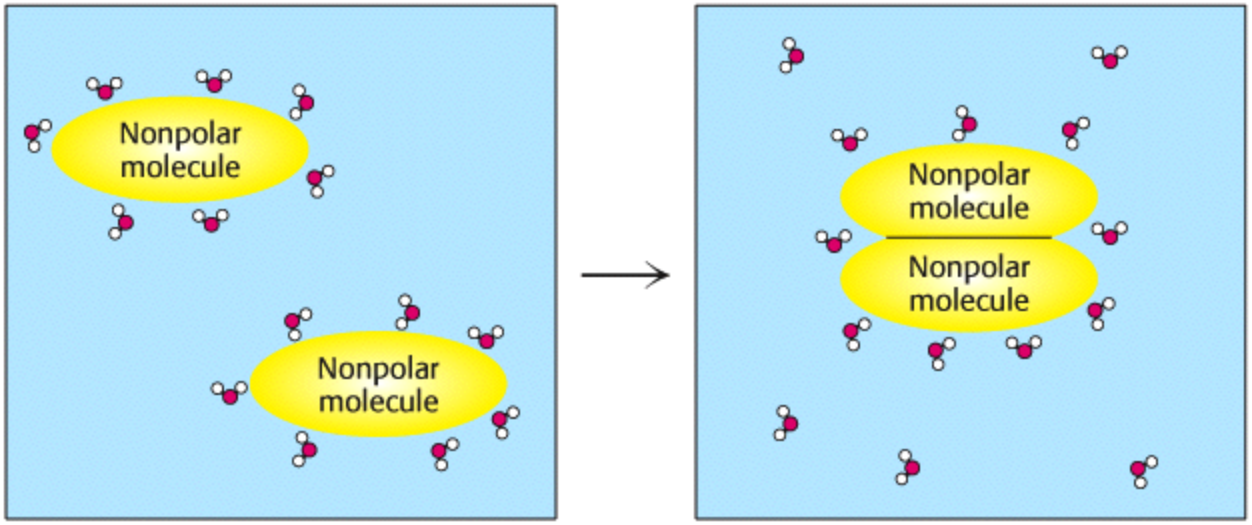
Ice



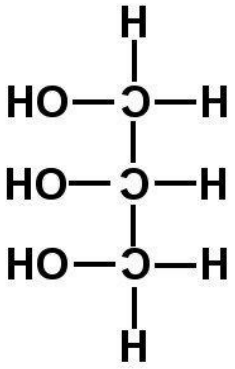
As more water molecules stick together with hydrogen bonds, they form a regular pattern, as shown here.

Hydrophobic effect

Non-polar molecules aggregate in aqueous solutions in order to separate from water.

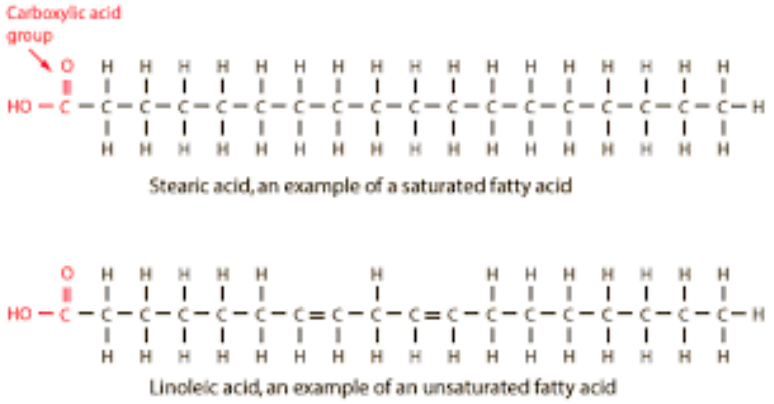


Example of a hydrophobic molecule – triglyceride (fat)



glycerol

+



Fatty acids

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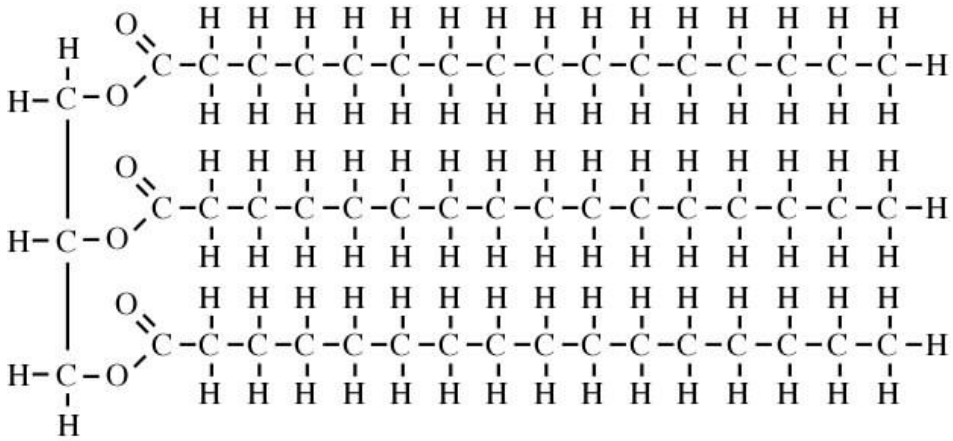
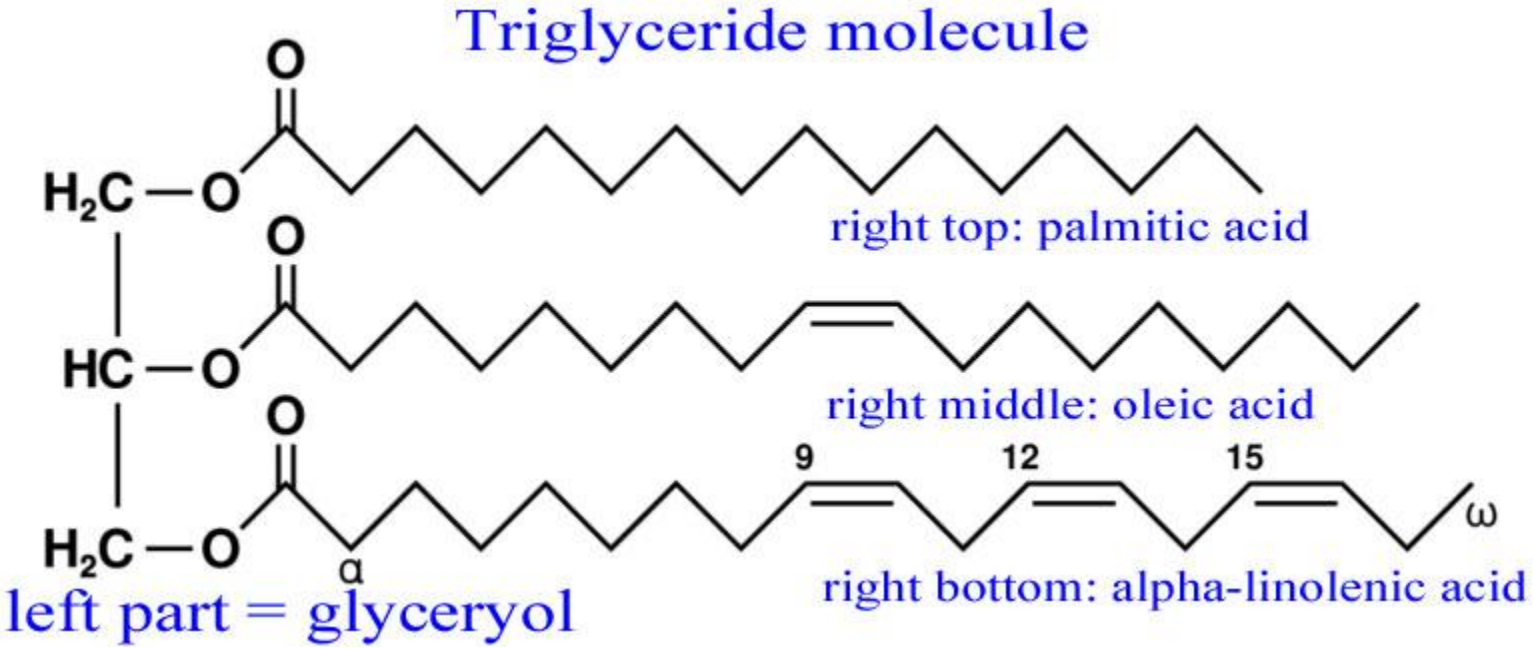


=

-triglyceride

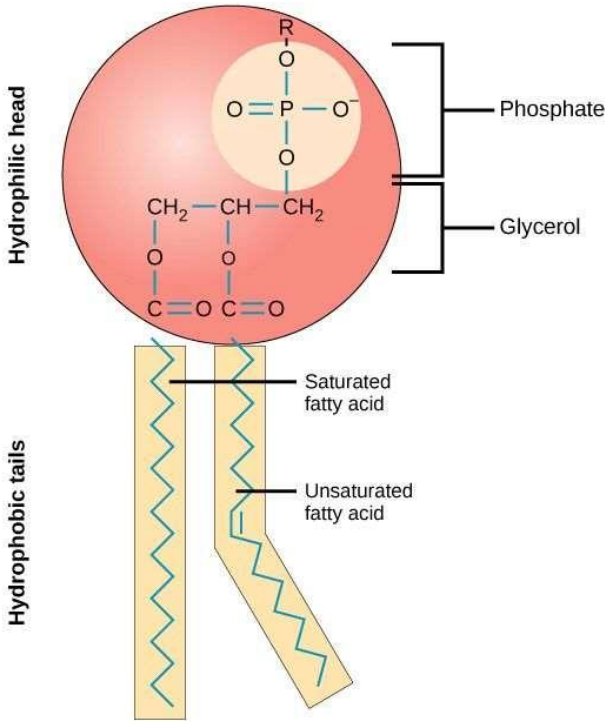
triglyceride

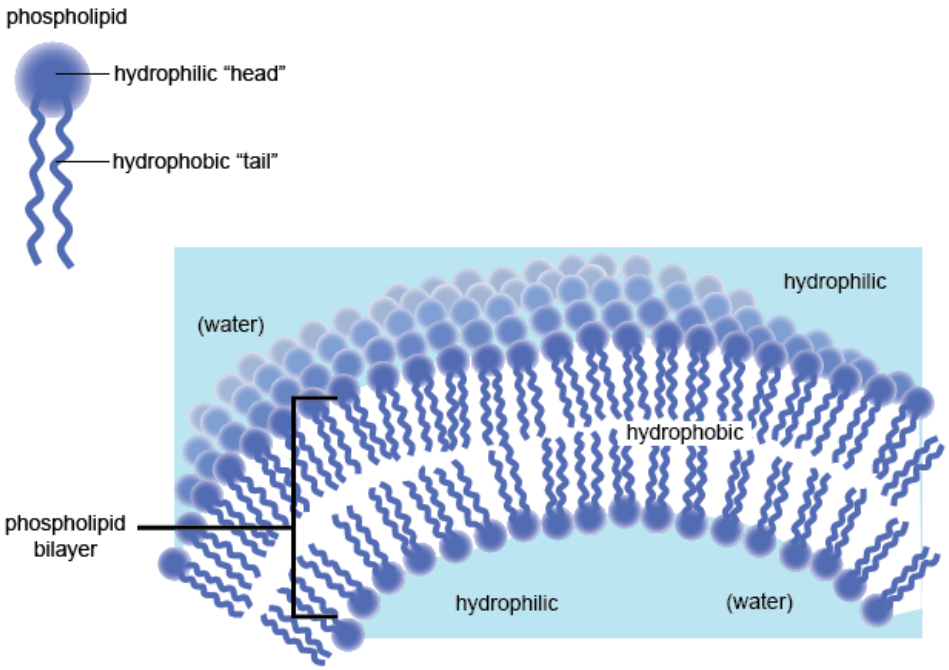


Cell membrane

- A cell is surrounded by the cell membrane that separates its interior from the outside environment (the extracellular space).
- The cell membrane is the barrier that keeps ions, proteins and other molecules where they are needed and prevents them from diffusing into areas where they should not be.
- Eucariotic cells have internal compartments separated from the rest of the cell by their own membranes

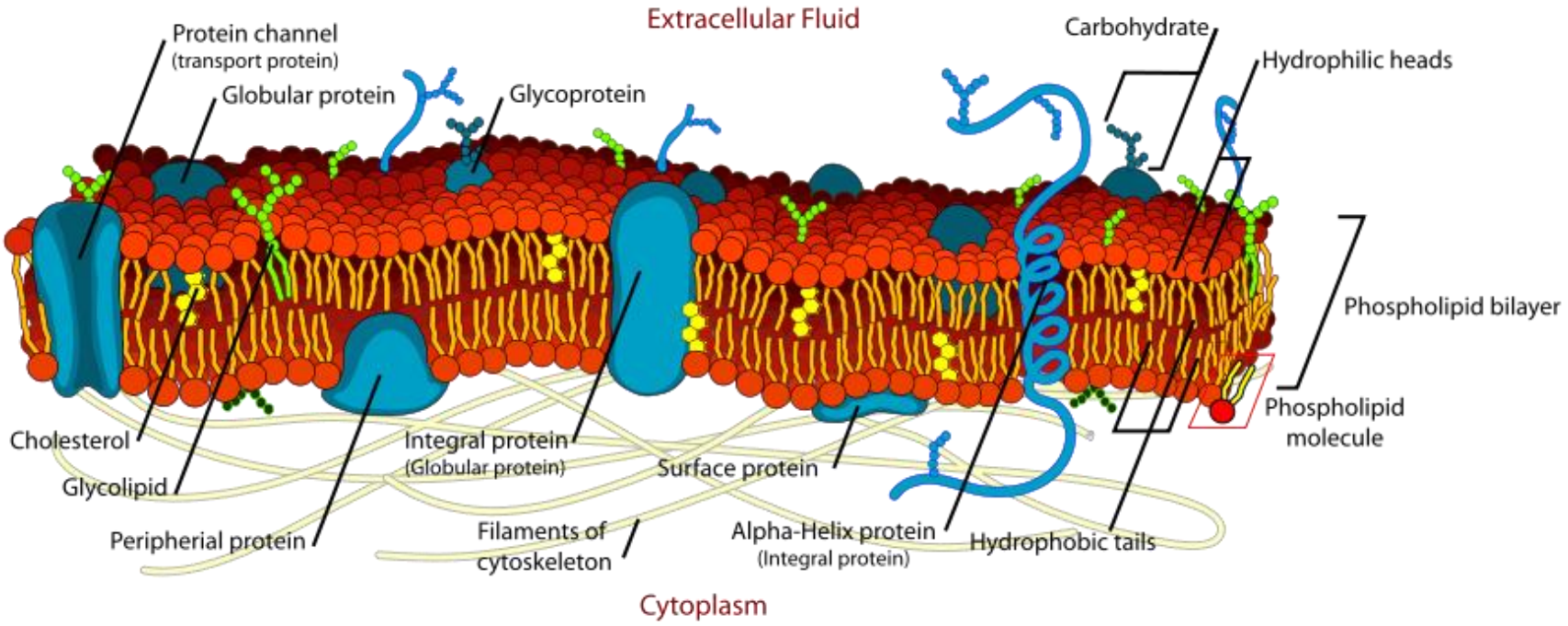
Cell membrane consists of lipid bilayer





- The cell membrane is selectively permeable and able to regulate what enters and exits the cell, thus facilitating the transport of materials needed for survival. The movement of substances across the membrane can be either "passive", occurring without the input of cellular energy, or "active", requiring the cell to expend energy in transporting it. The cell membrane thus works as a selective filter that allows only certain things to come inside or go outside the cell.

A detailed diagram of the cell membrane



PROTEINS

Functions of proteins

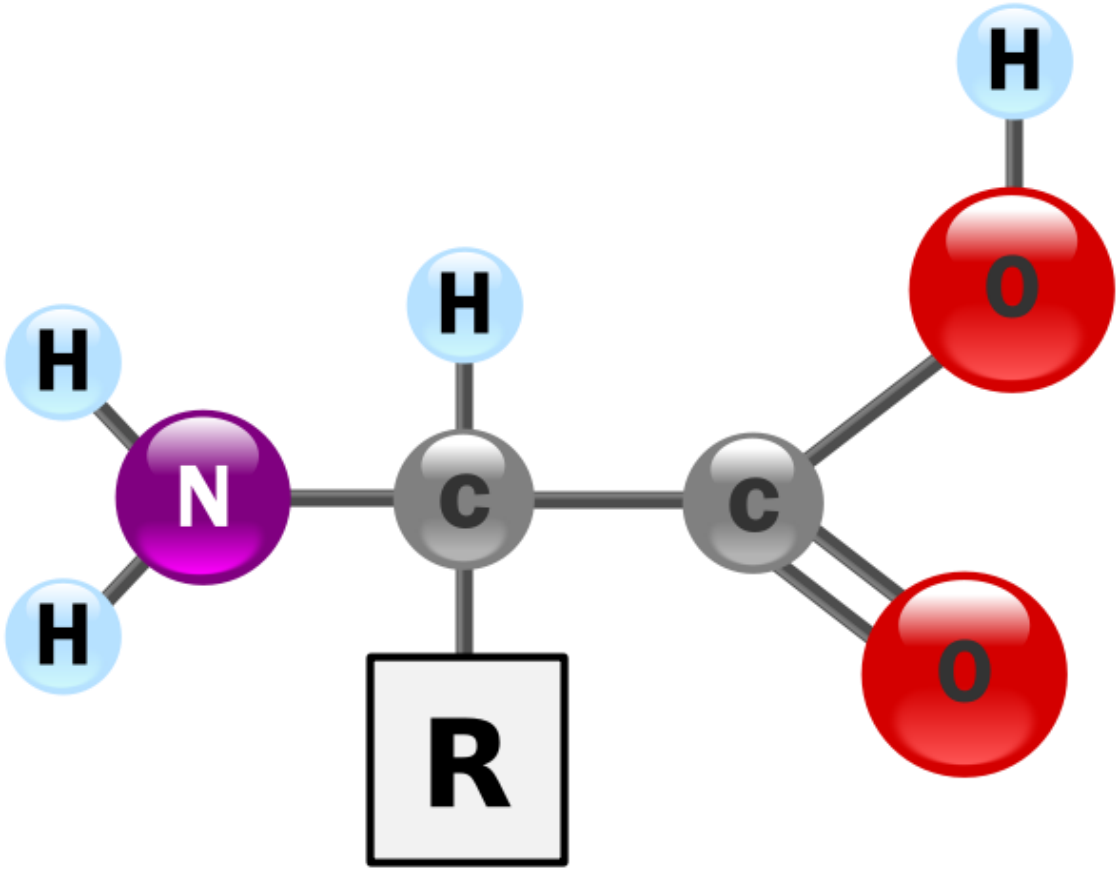
- Proteins are large, complex molecules that play many critical roles in the cell:

1. Enzymes carry out almost all of the thousands of chemical reactions that take place in cells. They also assist with the formation of new molecules by reading the genetic information stored in DNA.
2. Structural component proteins provide structure and support for cells.
3. Transport/storage proteins bind and carry atoms and small molecules within cells and throughout the body

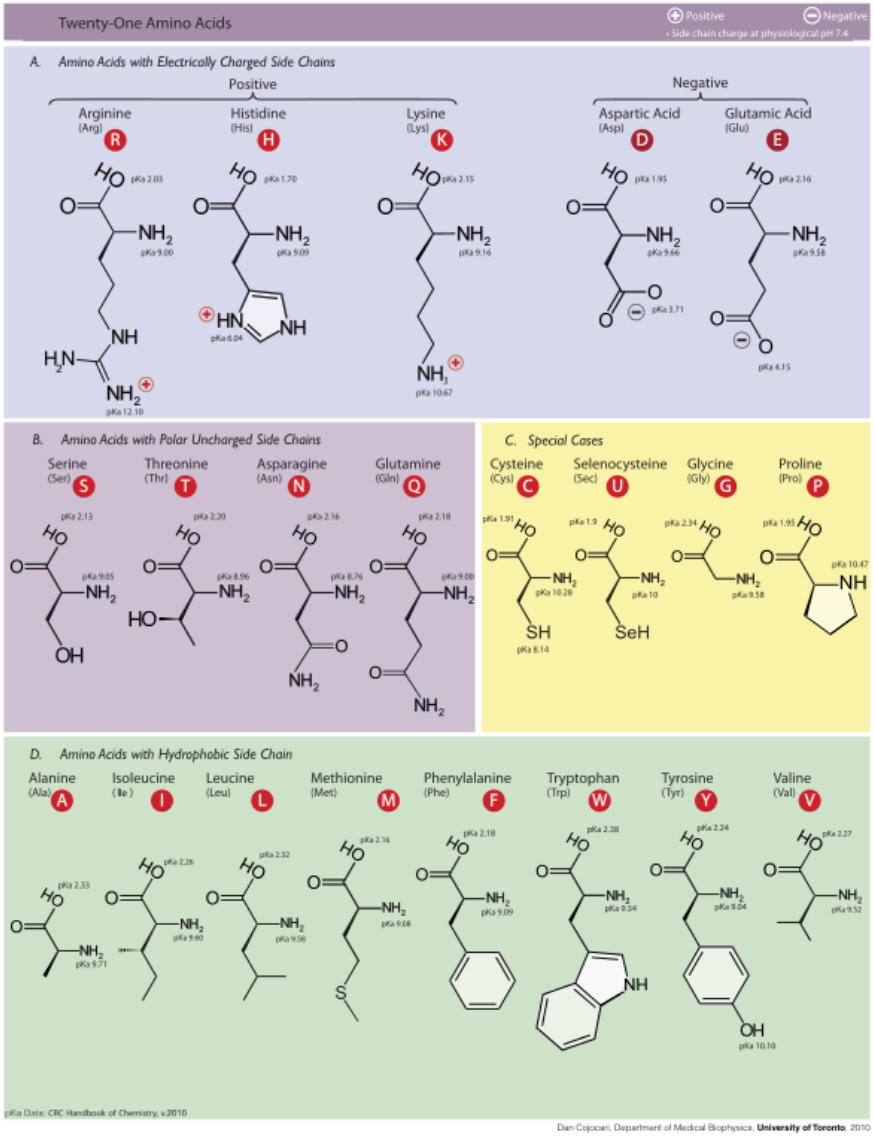
Proteins are composed of amino acids

- Proteins are made up of hundreds or thousands of smaller units called amino acids, which are attached to one another in long chains. There are 20 different types of amino acids that can be combined to make a protein.

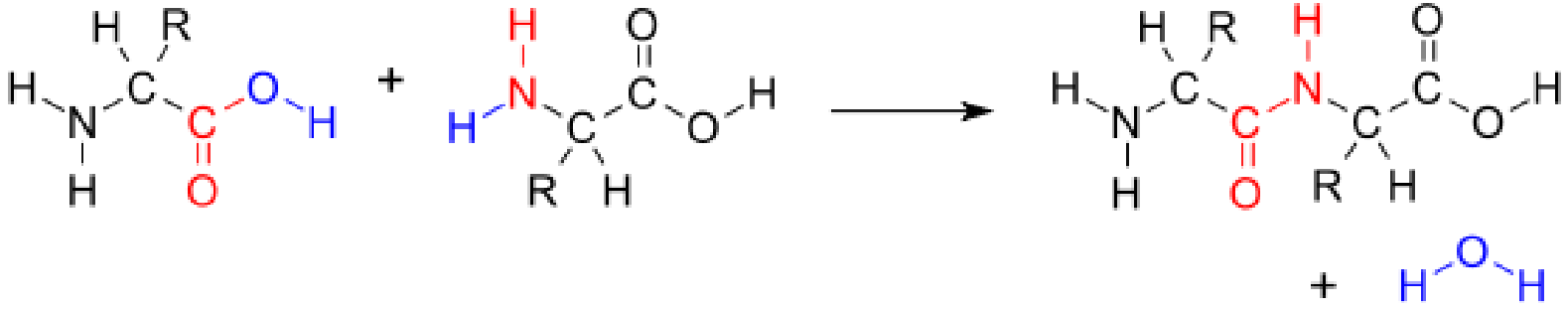
Amino acid



The 20 amino acids



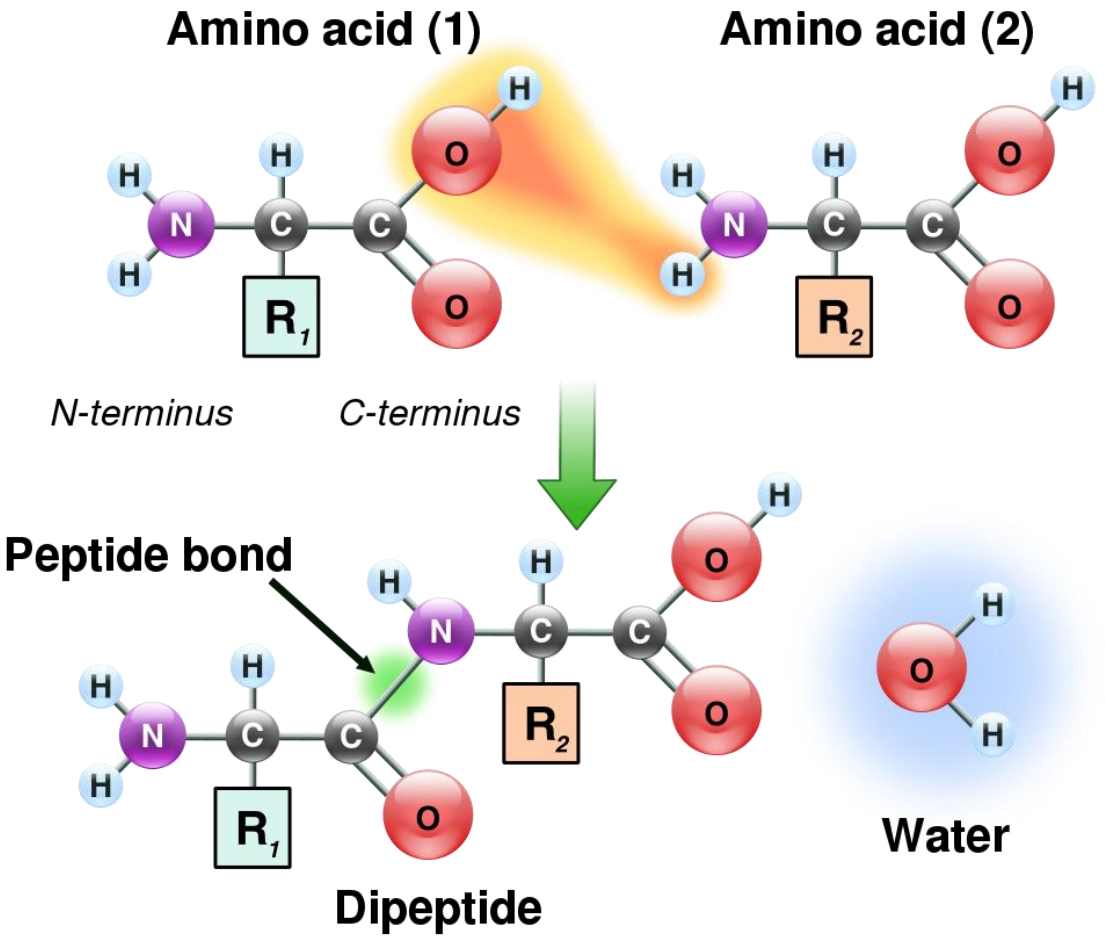
Peptide bond



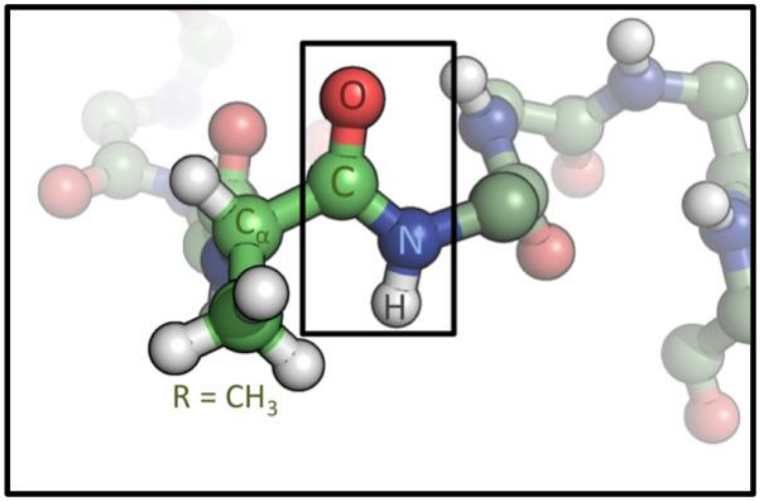
Peptides

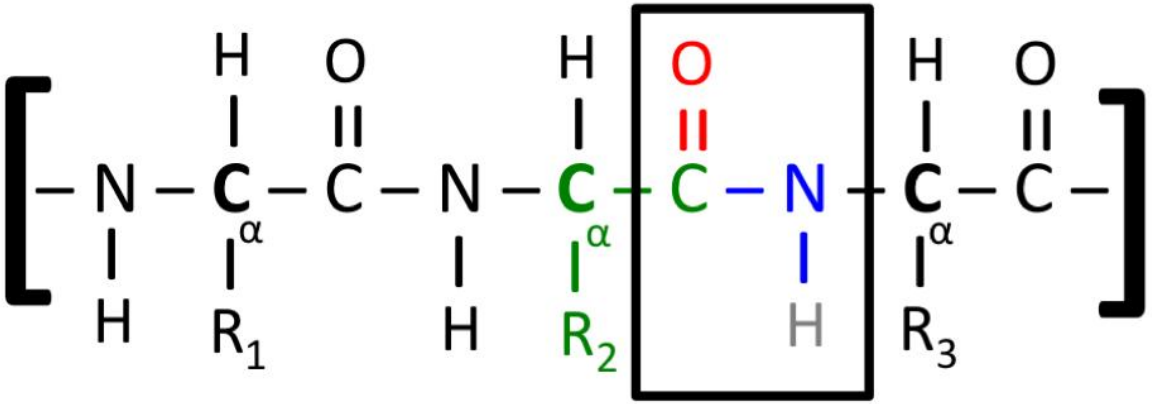
- ***Peptide*** – a molecule consisting of two or more amino acids joined together by peptide bonds.
- Peptides made up of two amino acids are called dipeptides of three amino acids – tripetides, etc.
- Peptides have N-terminus and C-terminus

Peptide bond



Proteins are polypeptides

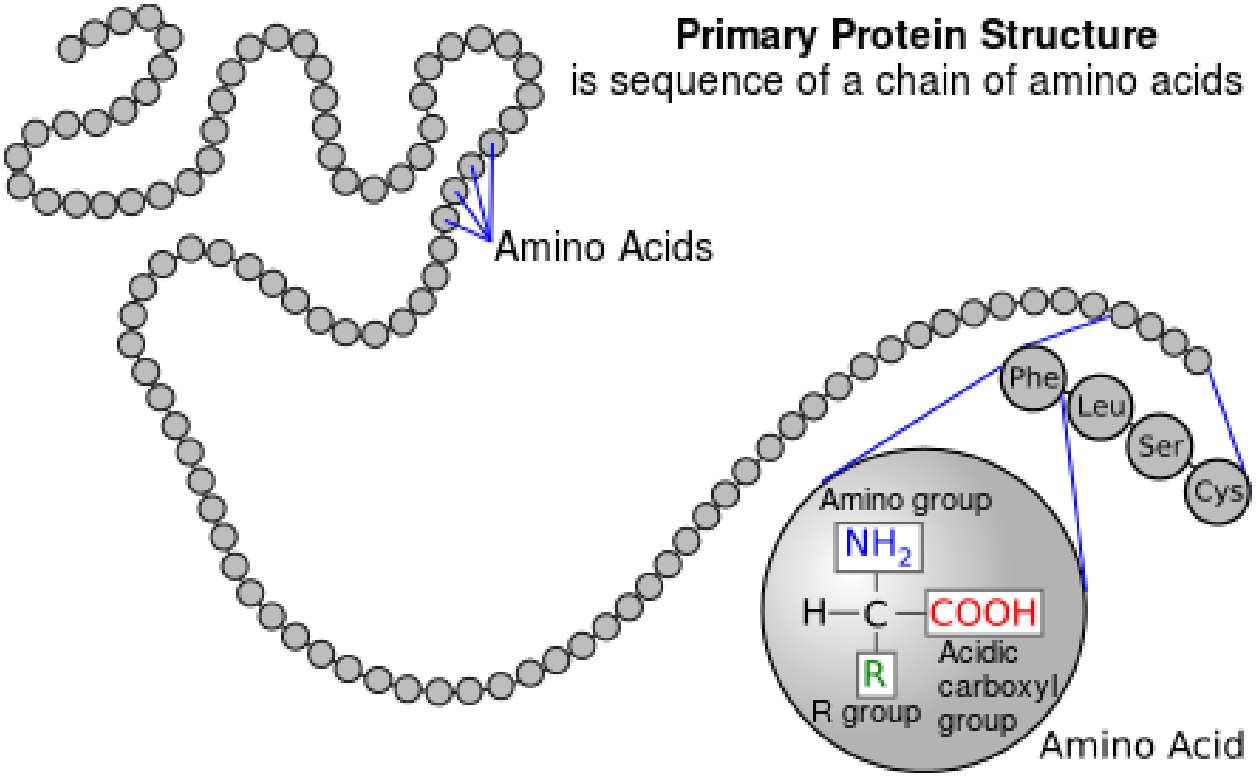




Protein primary structure

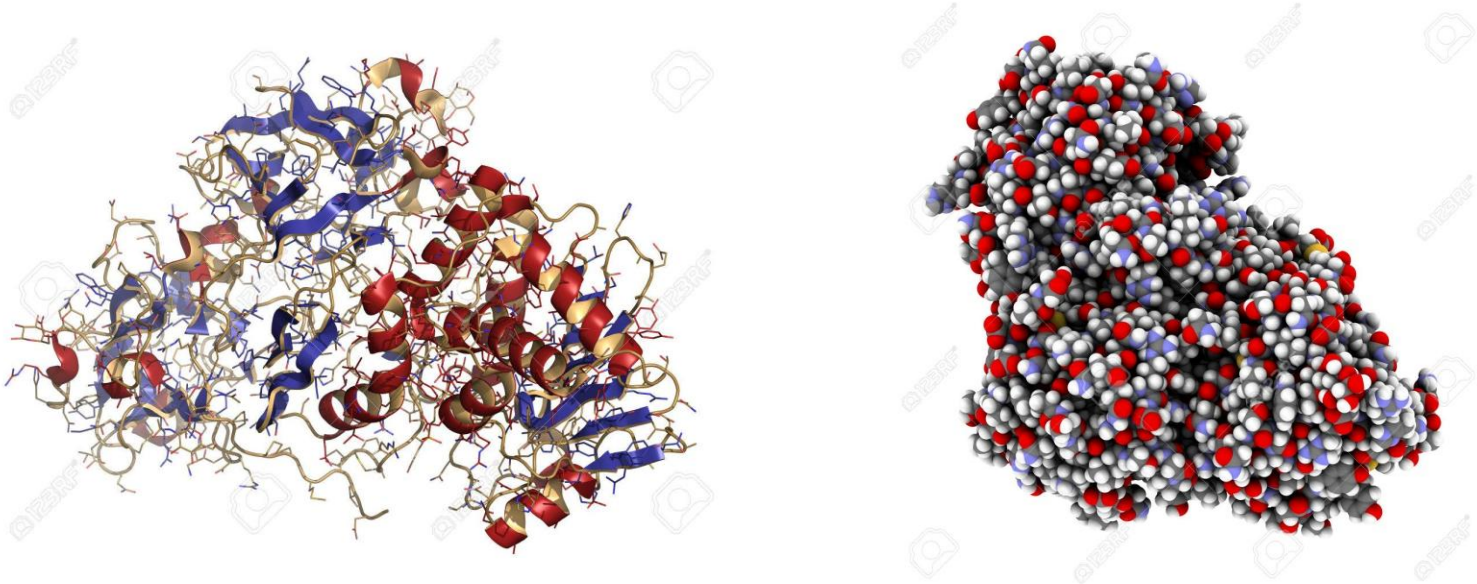
- Protein primary structure is the linear sequence of amino acids in a peptide or protein.
- The sequence of amino acids determines each protein's unique 3-dimensional structure and its specific function.

Primary protein structure



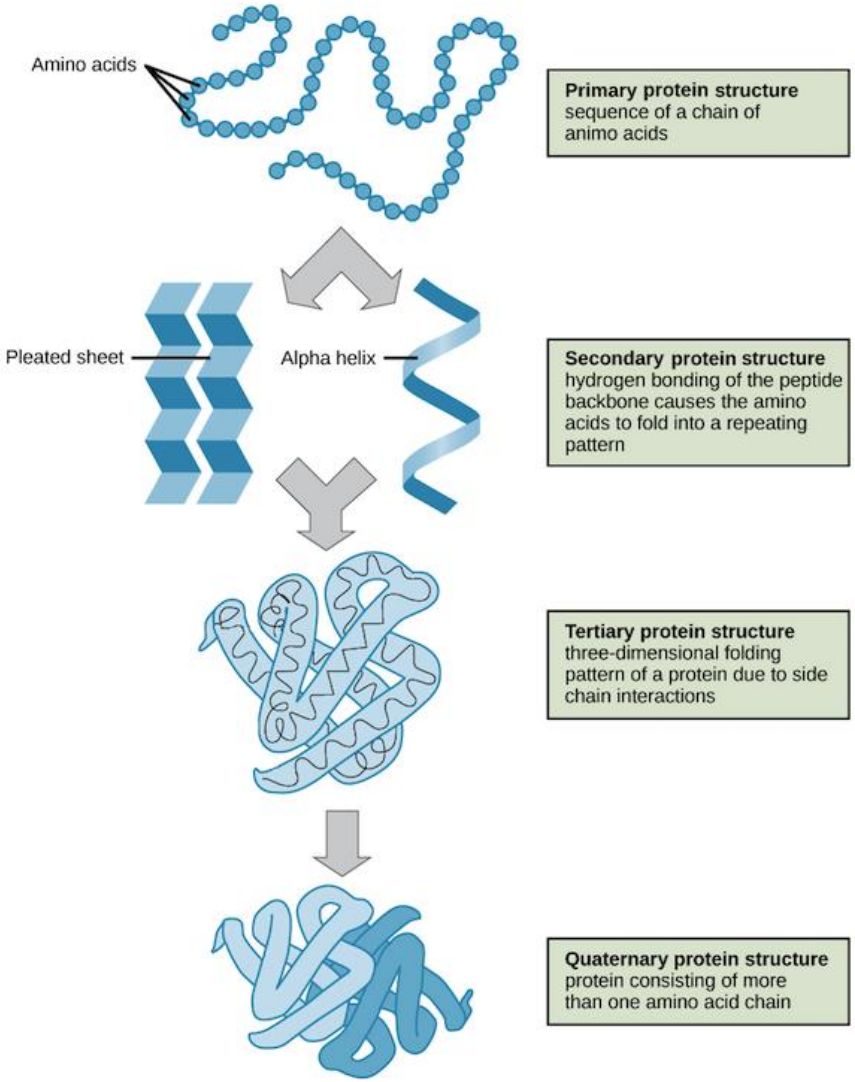
LEVELS OF PROTEIN STRUCTURE

Proteins are very large molecules with complex 3-D organization



3-D structure of ricin – poisonous protein of castor beans

Levels of protein structure



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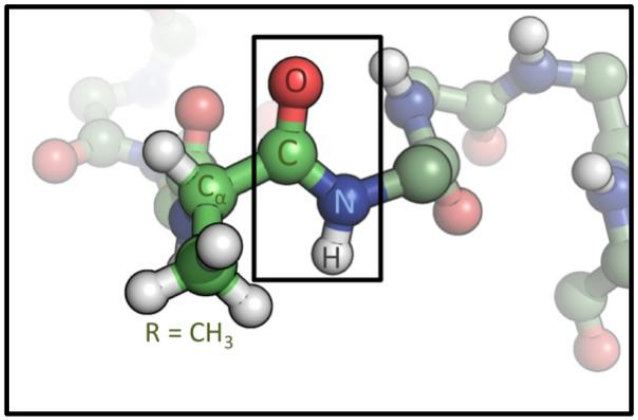
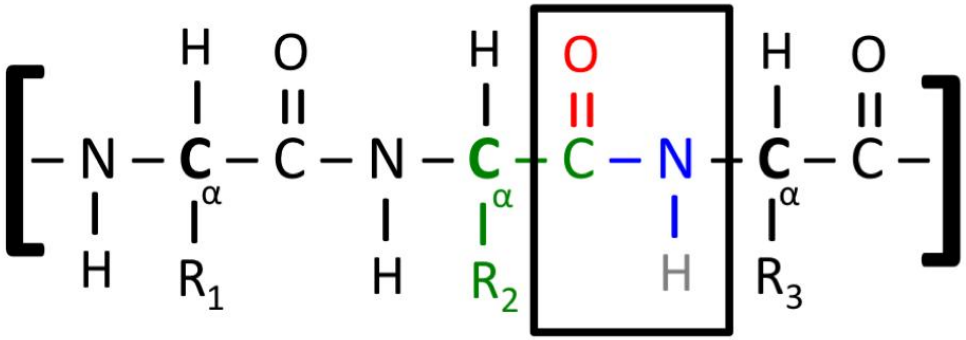
Protein secondary structure

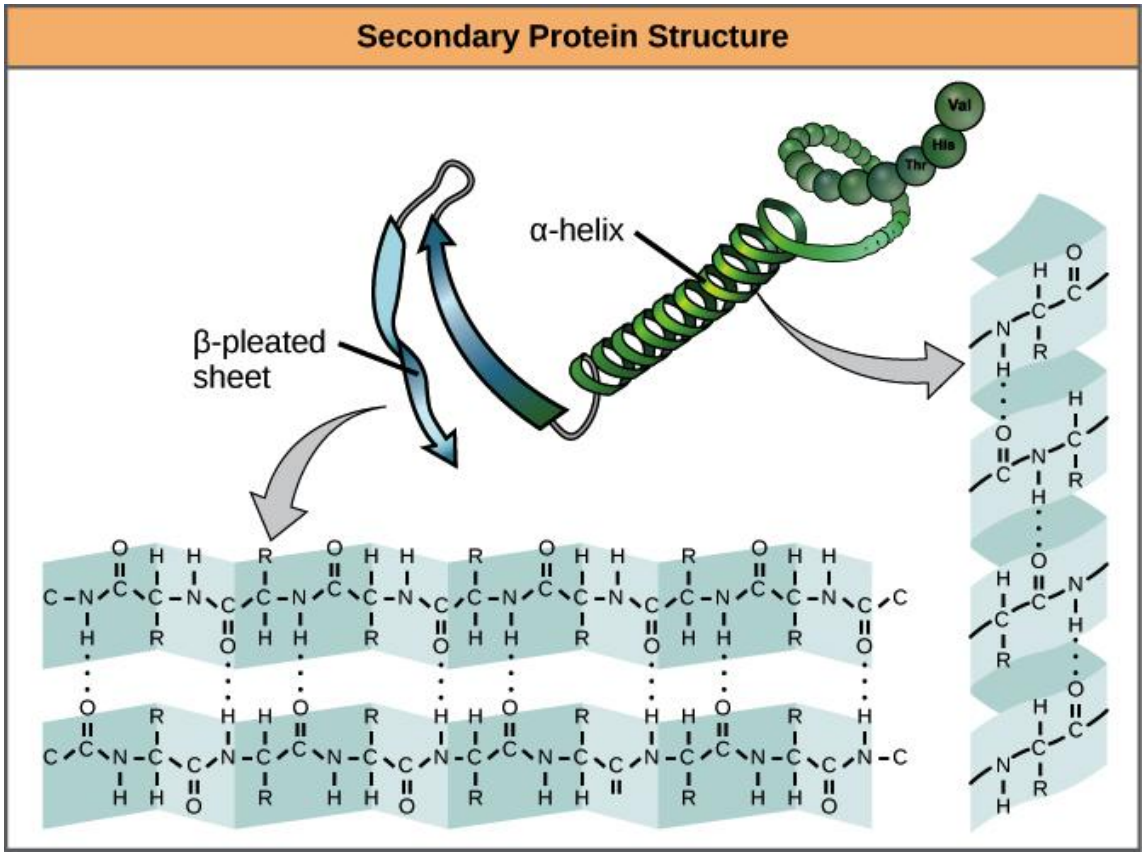
- Protein secondary structure is the three dimensional form of local segments of proteins.
- The two most common secondary structural elements are alpha helices and beta sheets.
- Secondary structure elements typically spontaneously form as an intermediate before the protein folds into its three dimensional tertiary structure.

- **Protein secondary structure forms due to <u>hydrogen bonds</u> between the amino hydrogen and carboxyl oxygen atoms in the <u>peptide backbone</u>.**

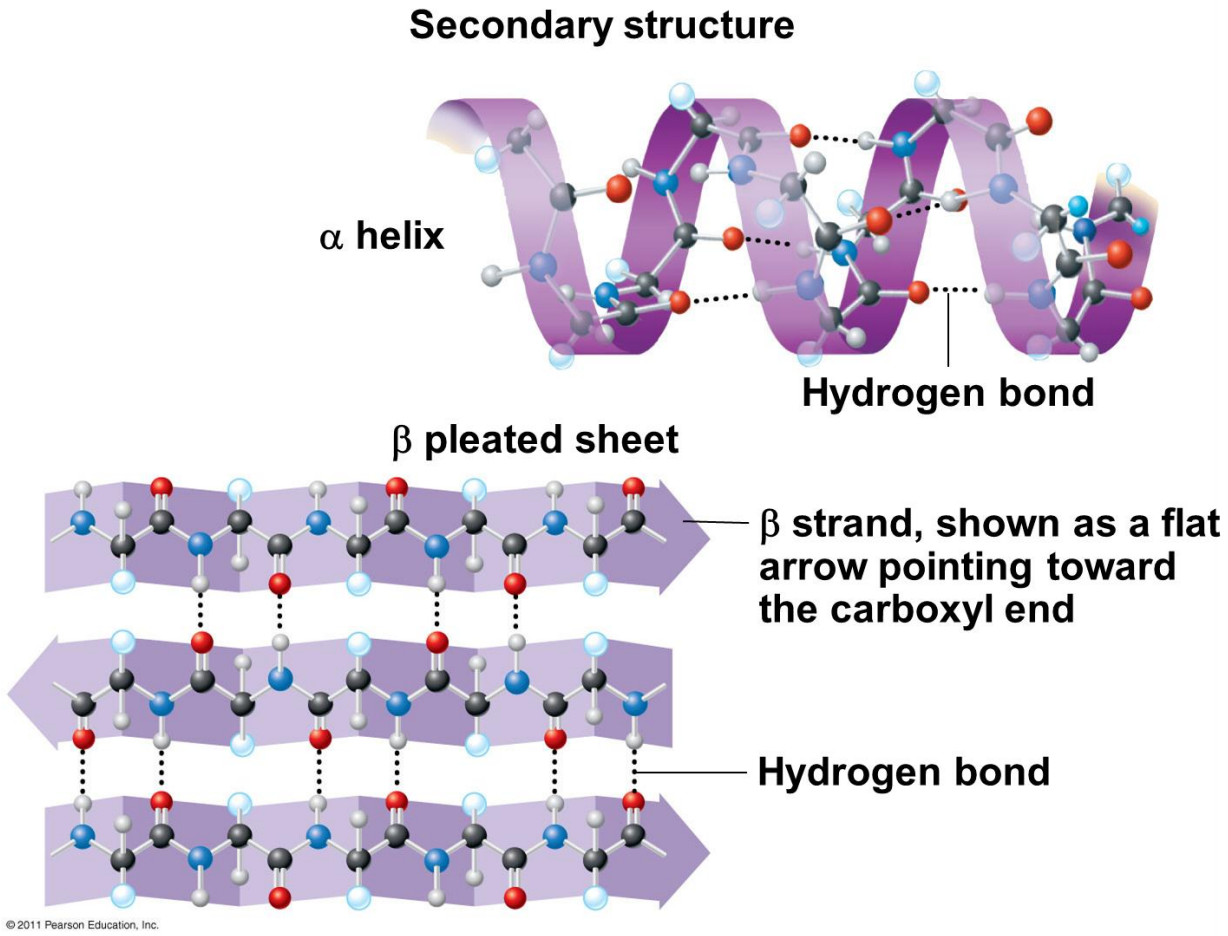




- **In alpha helices hydrogen bonds are formed within the peptide strand, in beta sheets – between peptide strands.**



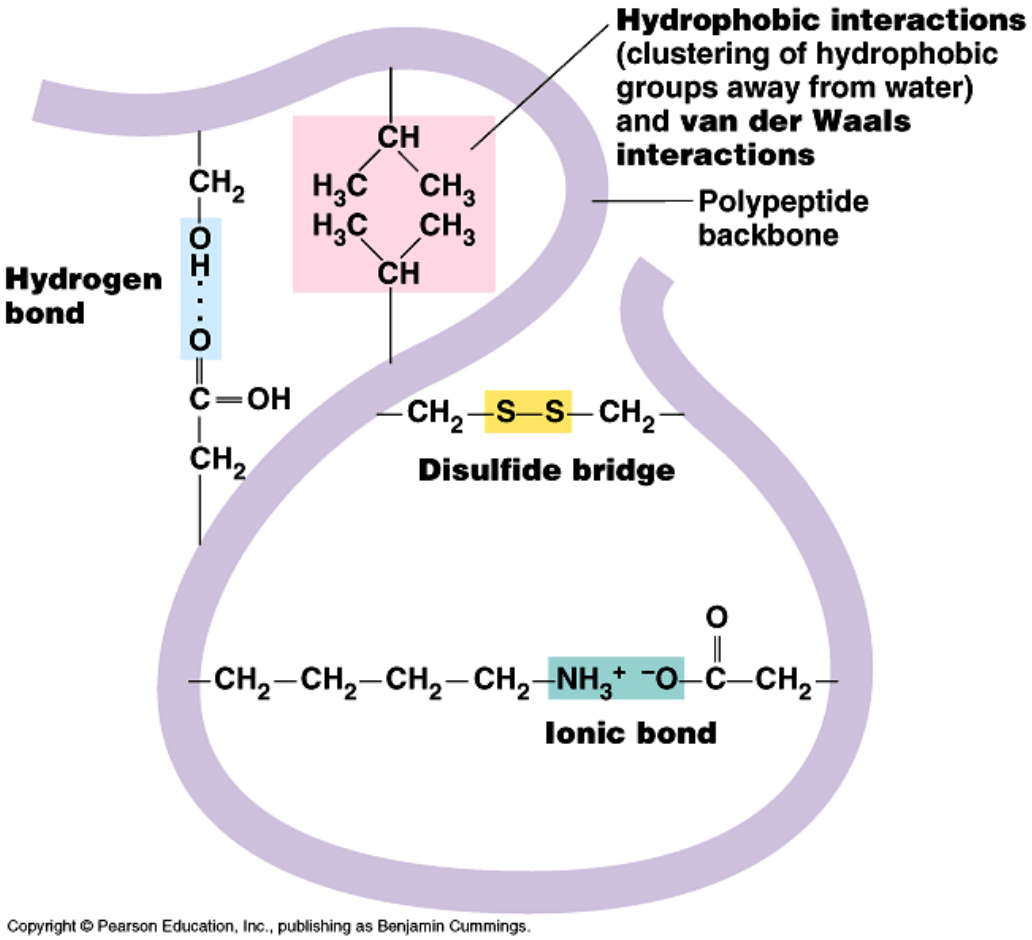
Protein secondary structure



Protein tertiary structure

- The overall three-dimensional shape of an entire protein molecule is the tertiary structure. The protein molecule will bend and twist in such a way as to achieve maximum stability. Although the three-dimensional shape of a protein may seem irregular and random, it is fashioned by many stabilizing forces due to bonding **interactions between the side-chain groups** of the amino acids.

Protein tertiary structure



Protein quaternary structure

- Many proteins are made up of **multiple polypeptide chains**, often referred to as **protein subunits**. These subunits may be the same (as in a homodimer) or different (as in a heterodimer). The quaternary structure refers to how these protein subunits interact with each other and arrange themselves to form a larger aggregate protein complex.
- The final shape of the protein complex is once again stabilized by various interactions, including hydrogen-bonding, disulfide-bridges and ionic bonds.