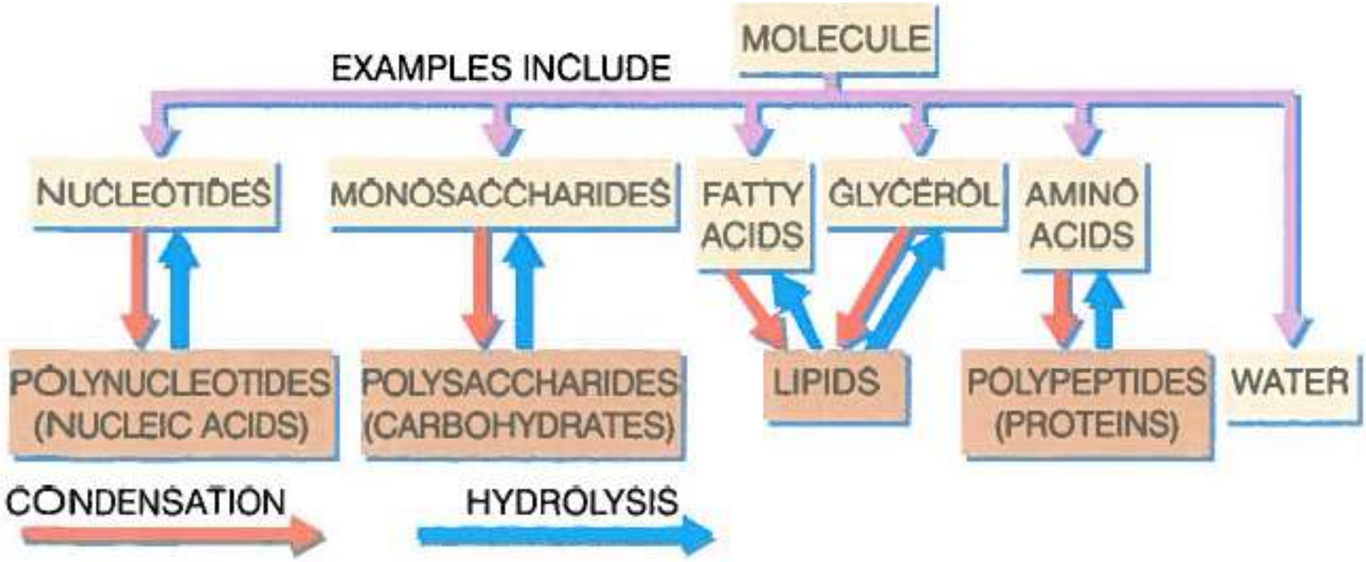
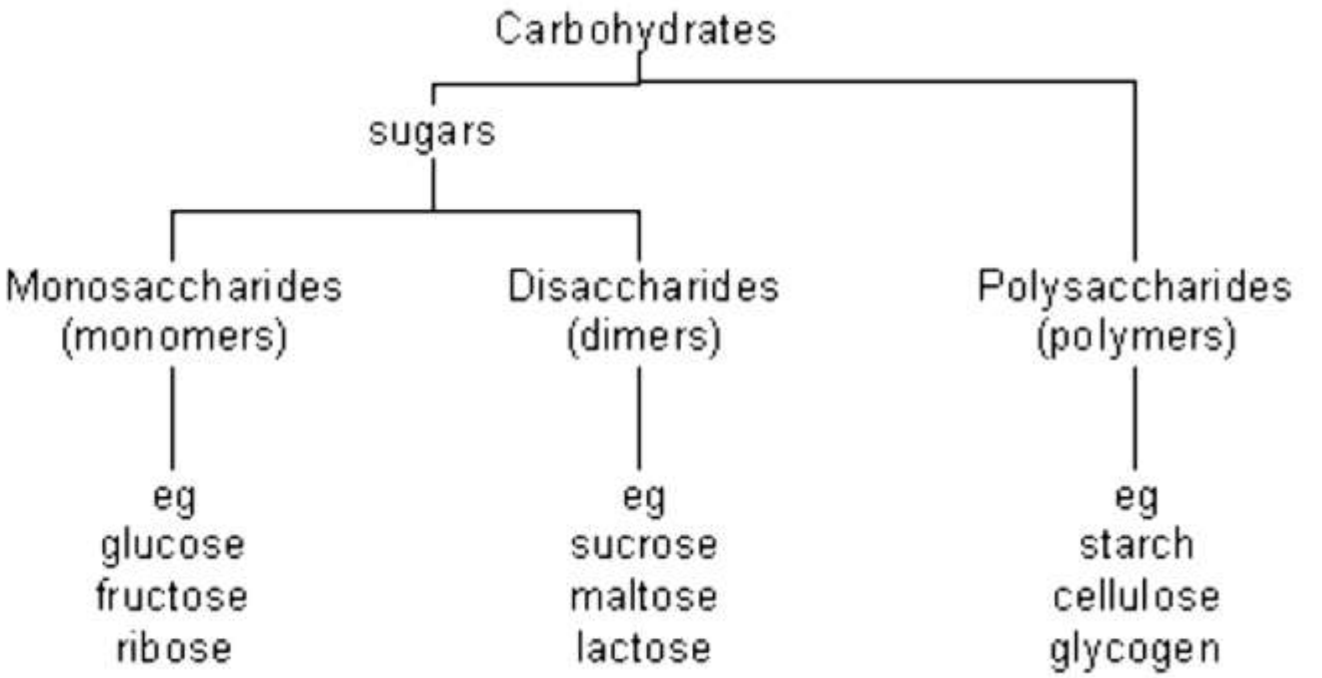
An Outline of the Biological Molecules



Carbohydrates

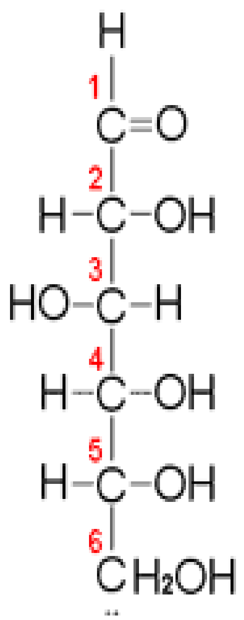


- Compounds of C,H, and O
- H to O ratio is the same as that of H_2O
- Polyhydroxy aldehydes and ketones

Define a carbohydrate

Monosaccharides
➢ The simplest carbohydrates
➢ These are sugars.
➢ general formula is $C_nH_{2n}O_n$.
➢ Soluble in water
➢ Sweet in taste
➢ Examples
○ Trioses -3C-, glyceraldehyde
○ Tetroses-4C, xylose
○ Pentoses-5C, ribose, ribulose
○ Hexoses-6C,Glucose, fructose and galactose.
Structure of Glucose

Monosaccharide molecules are often in the form of a ring made up of carbon atoms and one oxygen atom.
Glucose molecules can take up two different forms, called α – glucose and β – glucose
Straight chain structure of glucose



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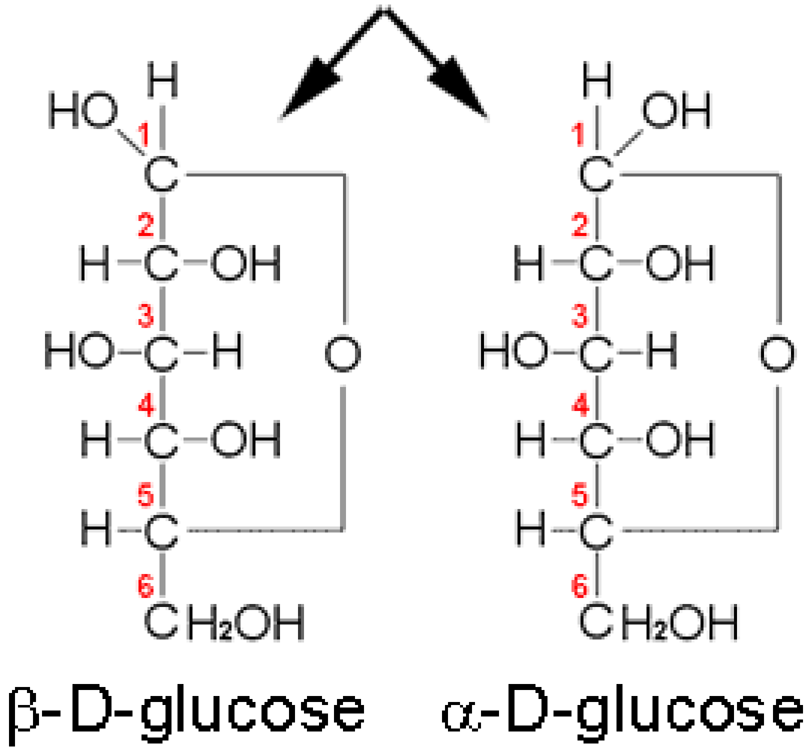
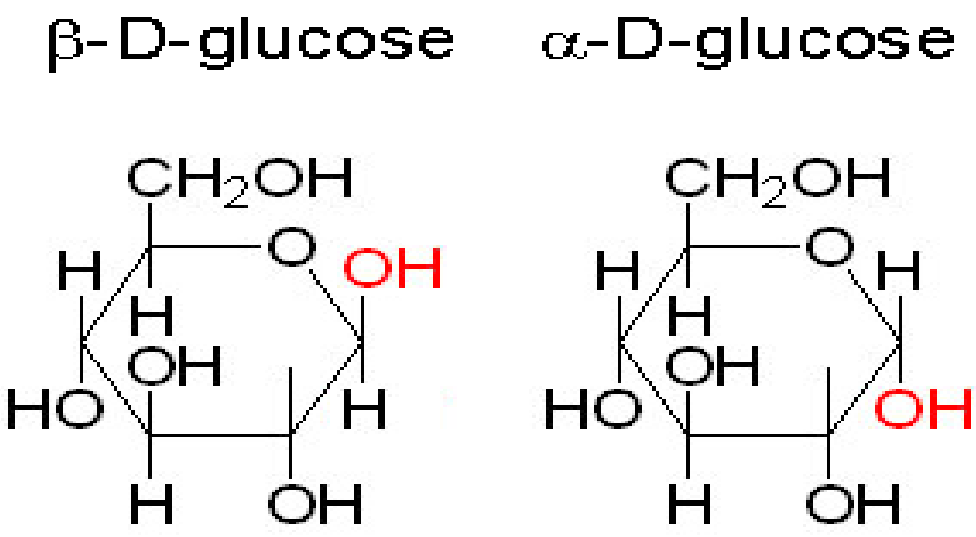


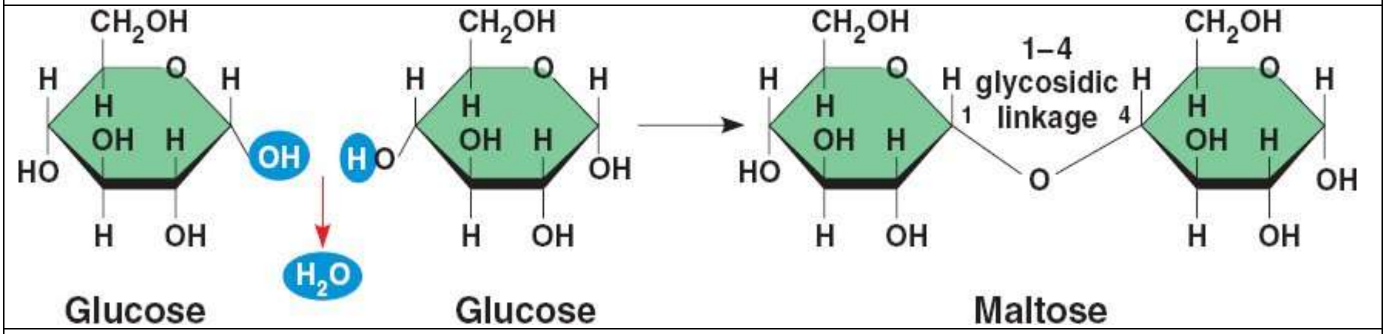
Ring Structure of glucose

Describe a difference in alpha and beta glucose

Draw structure of both alpha and beta glucose here below in the space

Disaccharides

- Two sugar units joined together by **glycosidic bond**
- For example, two glucose molecules can link to produce **maltose.**
- As the two monosaccharides react and the glycosidic bond forms, a molecule of water is released. This type of reaction is known as a **condensation reaction.**
- Upon hydrolysis a disaccharide splits into two monosaccharides
- **Hydrolysis**
- Disaccharides can be split apart into two monosaccharides by breaking the glycosidic bond. To do this, a molecule of water is added. This is called a**hydrolysis reaction.**

Structure of Maltose

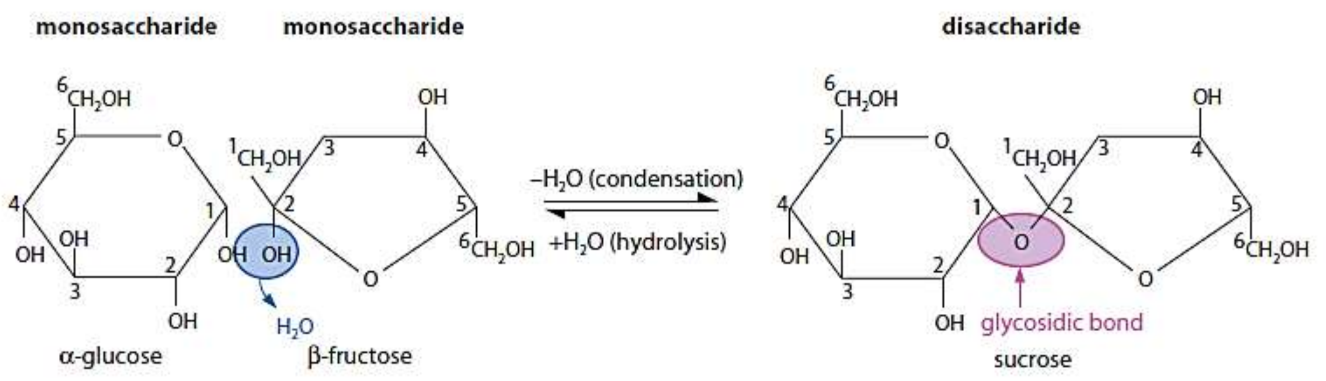


Show formation of Maltose by condensation

Show formation of alpha 1-4, glycosidic linkage formation

Show hydrolysis of maltose below

Describe a difference in hydrolysis and condensation

Structure of Sucrose

Draw structure of beta fructose
Show formation of sucrose by condensation

Importance of monosaccharides and disaccharides
➢ good sources of energy .
➢ transported in form of sucrose as it is water soluble.
➢ Ribose makes component of RNA and Deoxyribose makes part of DNA.

Polysaccharides

- contain hundreds or thousands of monosaccharides linked together into long chains.
- insoluble in water.
- reserve energy (starch and glycogen) or for forms cell structures (cellulose).

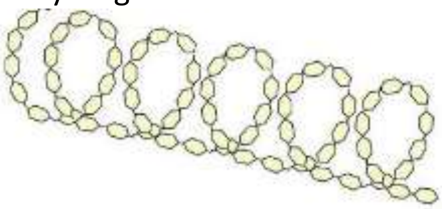
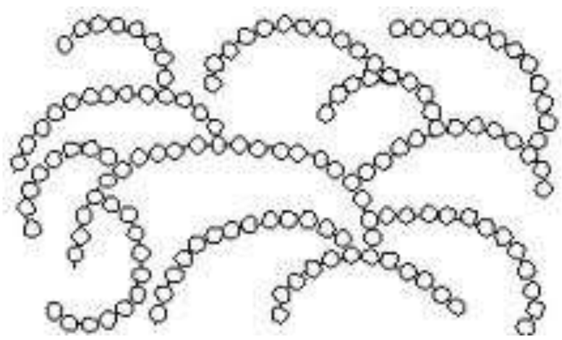
There are two types of polysaccharides

- Storage polysaccharides
- Structural polysaccharides

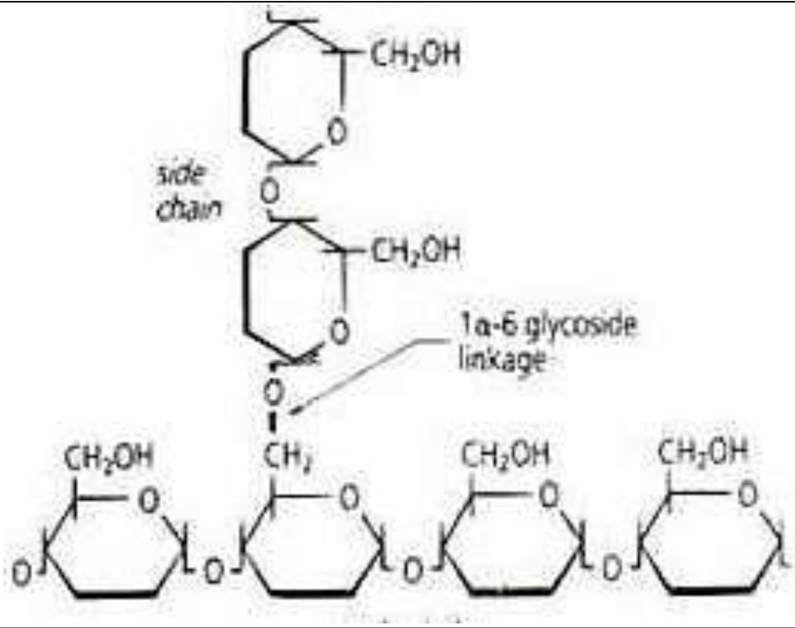
Storage polysaccharides

Starch

- storage polysaccharide in plants.
- mixture of two substances, **amylose** and **amylopectin**.

	Amylose	Amylopectin
	• An amylose molecule is a very long unbranched chain of • α – glucose molecules with 1 – 4 links. • coils up into a spiral, making it very compact. • The spiral is held in shape by hydrogen bonds 	• made of α – glucose molecules linked together • by glycosidic bonds. • More α,1-4 glycosidic linkages • Less α,1-6 glycosidic linkages 

The figure below shows a part of amylopectin showing a branched chain with alpha 1-6 glycosidic linkage



Describe differences between amylose and amylopectin

feature	Amylose	Amylopectin
Chain		
Glucose unit		
Bonds		
Branching		

glycogen
➢ the storage polysaccharide In animals and fungi.
➢ made of α – glucose molecules linked together
➢ by glycosidic bonds.
➢ More α,1-4 glycosidic linkages
➢ Less α,1-6 glycosidic linkages

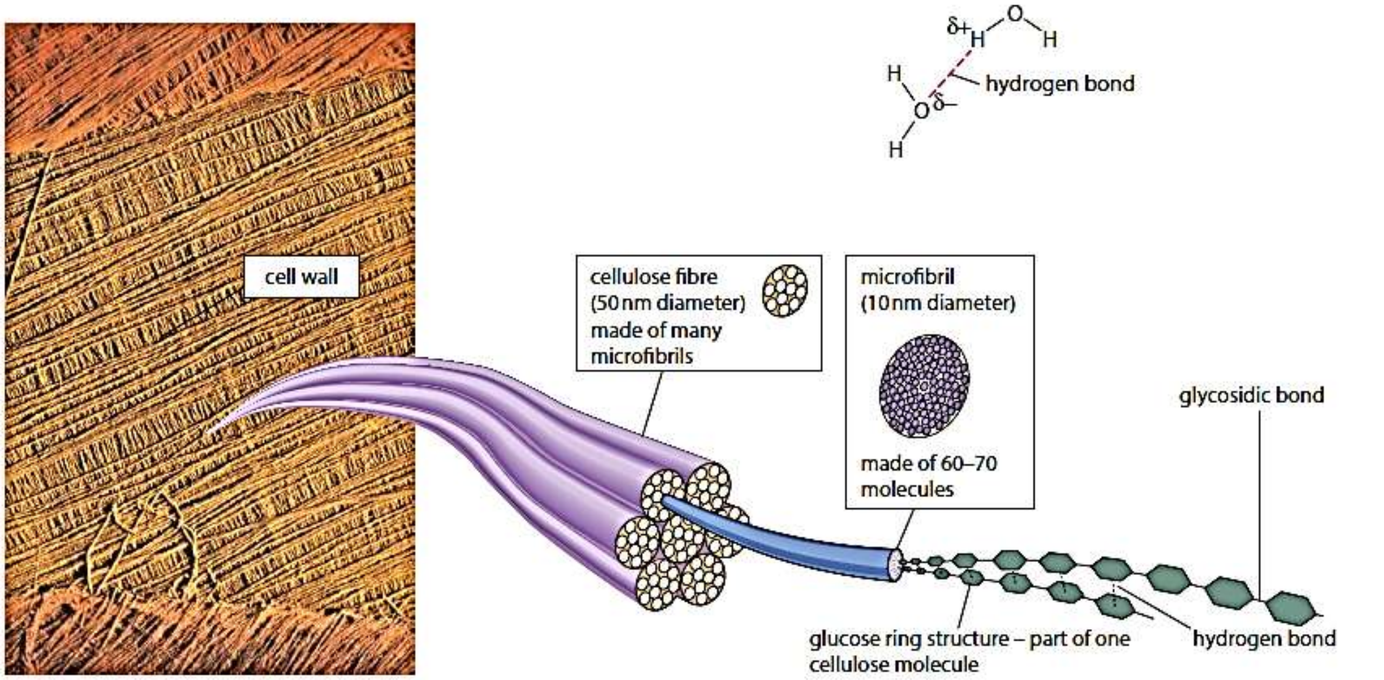
Differences between Amylopectin and Glycogen

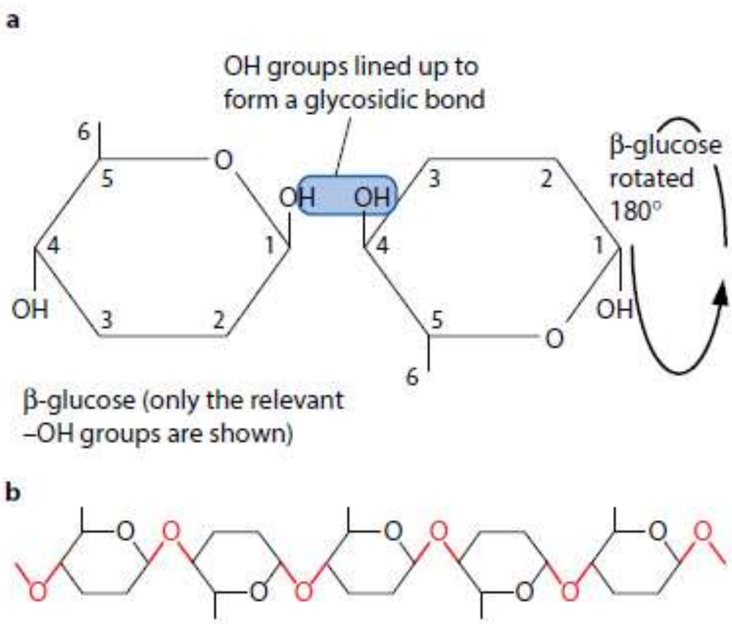
Glycogen	**Amylopectin**
More branching	Less branching
More compact	Less compact
Short branches	Long branches

Structural polysaccharides

Cellulose

- Plant cell walls contain the polysaccharide **cellulose**.
- A molecule of starch consists of a straight chain of thousands β-glucose units joined together by β,1-4, glycosidic linkage
- Every alternative β-glucose in the chain is rotated by 180° to bring the –OH group on C1 and C4 in the same plane. It prevents it from coiling
- Hydrogen bonds form between different chains. This causes the chains to associate into bundles called **microfibrils.**





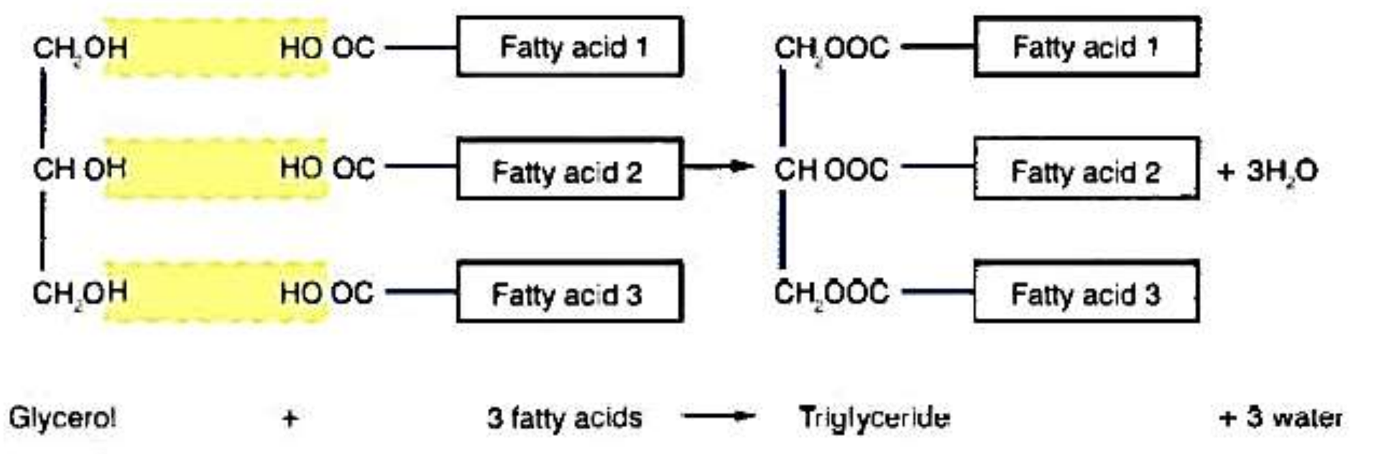
Importance
➢ microfibrils are very strong.
➢ This makes cellulose an excellent material for plant cell walls,
➢ Prevents a plant cell from bursting if the plant cell swells as it absorbs water.
➢ The microfibrils are also very difficult to digest, because few organisms have an enzyme that can break the β 1 – 4 glycosidic bonds.

Lipids

- Lipids, like carbohydrates, also contain carbon, hydrogen and oxygen,
- but there is a much smaller proportion of oxygen.
- Lipids include triglycerides and phospholipids.
- All lipids are insoluble in water.

Triglycerides

- A triglyceride molecule is made of a glycerol molecule and
- three fatty acids are attached to it
- by ester bonds.



Glycerol

An alcohol which has 3 (-OH) i.e Hydroxyl groups attached with it

Draw structure of glycerol

Fatty acids

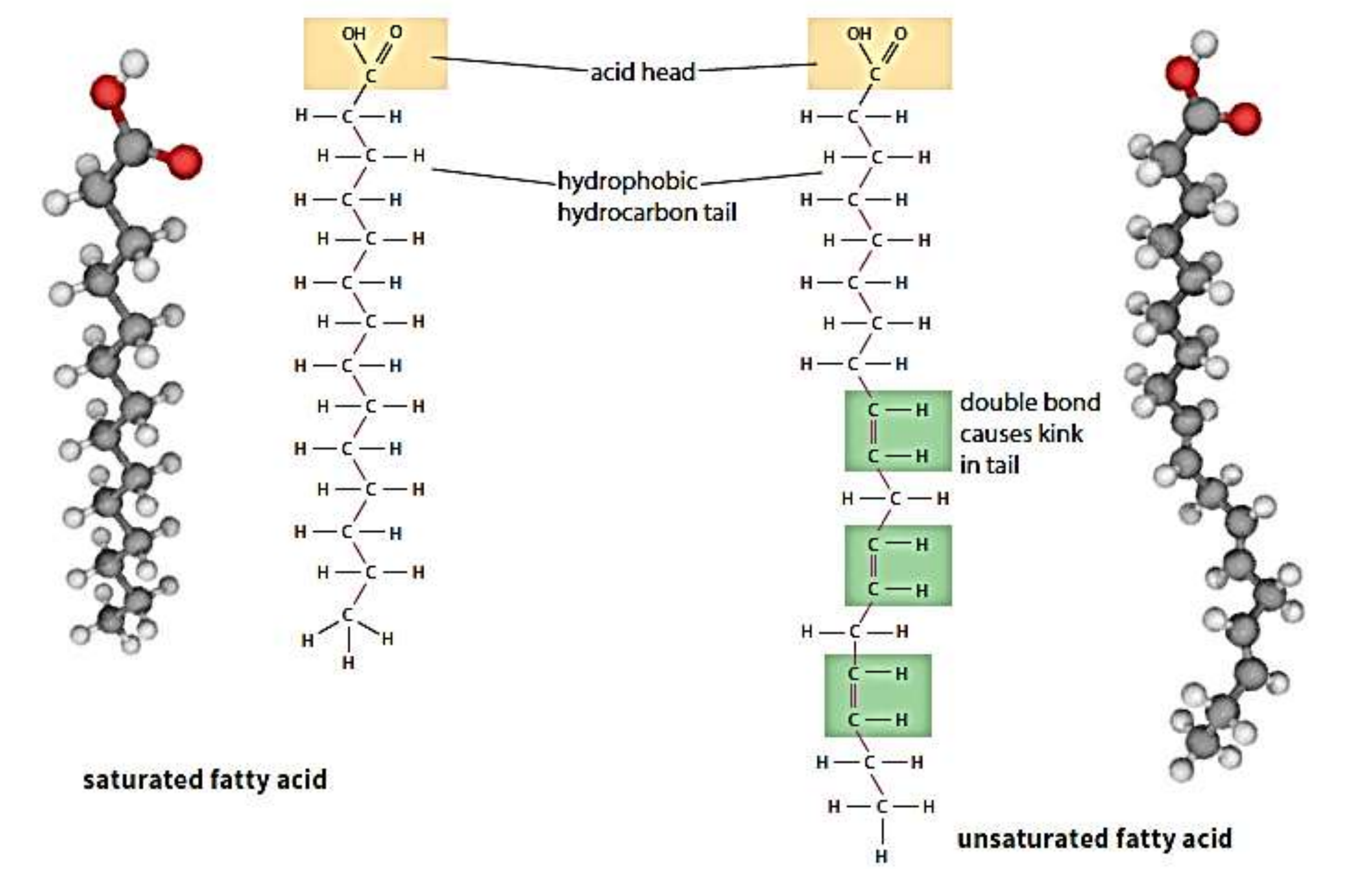
- Fatty acids have long chains made of carbon and hydrogen atoms and a carboxyl group attached with them
- The carbon and hydrogen chain is hydrophobic where as the carboxyl acid group is hydrophilic

$CH_3.CH_2.\ CH_2.\ CH_2.\ CH_2.\ CH_2.\ CH_2.\ CH_2.\ CH_2.\ CH_2.\ CH_2.COOH$

OR

R.COOH

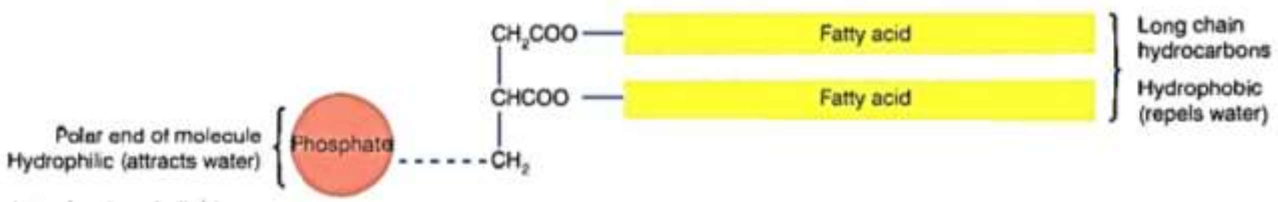
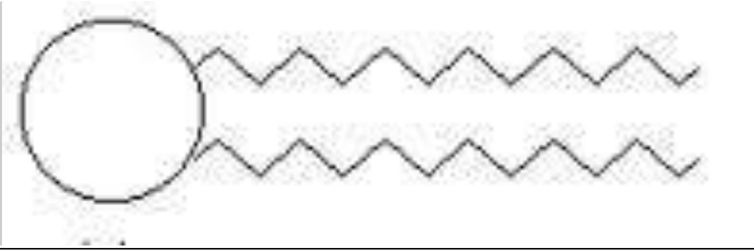
Two types of fatty acids



Saturated fatty acids	Unsaturated fatty acids
Hydrophobic tail has single bonding between carbon and carbon. Found in fats Solid at room temperature.	Carbon and hydrogen tail has one or more double bonding between carbon and carbon. Monounsaturated fatty acids have one double bond where as a polyunsaturated fatty acid has more than one double bond Found in oils Liquid at room temperature

Uses of triglycerides

- Triglycerides are used as energy storage compounds in plants, animals and fungi.
- Their insolubility in water helps to make them suitable for this function.
- They contain more energy per gram than polysaccharides, so can store more energy in less mass. Triglycerides have higher hydrogen to oxygen ratio than carbohydrates so the release more energy per gram than carbohydrates during respiration.
- Insulate the body against heat loss.
- Increases buoyancy of aquatic animals
- Forms a protective layer around some of the body organs; for example the kidneys.
- In plants, triglycerides often make up a major part of the energy stores in seeds.

Phospholipids
A phospholipid molecule is like a triglyceride in which one of the fatty acids is replaced by a phosphate group.
Phospholipid molecule
1. Has two hydrophobic tails and
2. A hydrophilic head.


Differences between triglycerides and phospholipids

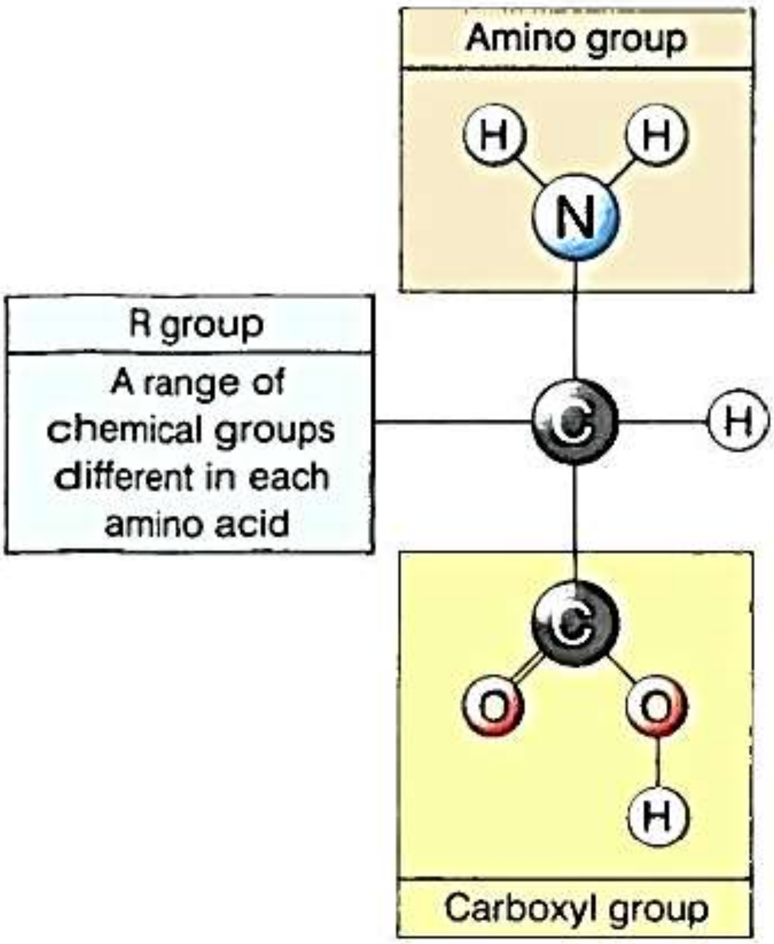
Phospholipids	**Triglycerides**
Has two fatty acid chains	Has three fatty acid chains
Has a phosphate group	No phosphate group
Polar head and non polar tails	Non polar

Proteins

- Proteins are large molecules made of long chains of amino acids.
- Contain C,H,O and N
- They also contain S rarely.

Amino acids

- Basic unit of all proteins
- Amino acids are monomer units
- Each amino acids has the same basic structure, with an amine group and a carboxyl group attached to a central carbon atom.
- twenty different types of amino acid,
- differ in the atoms present in the R group.



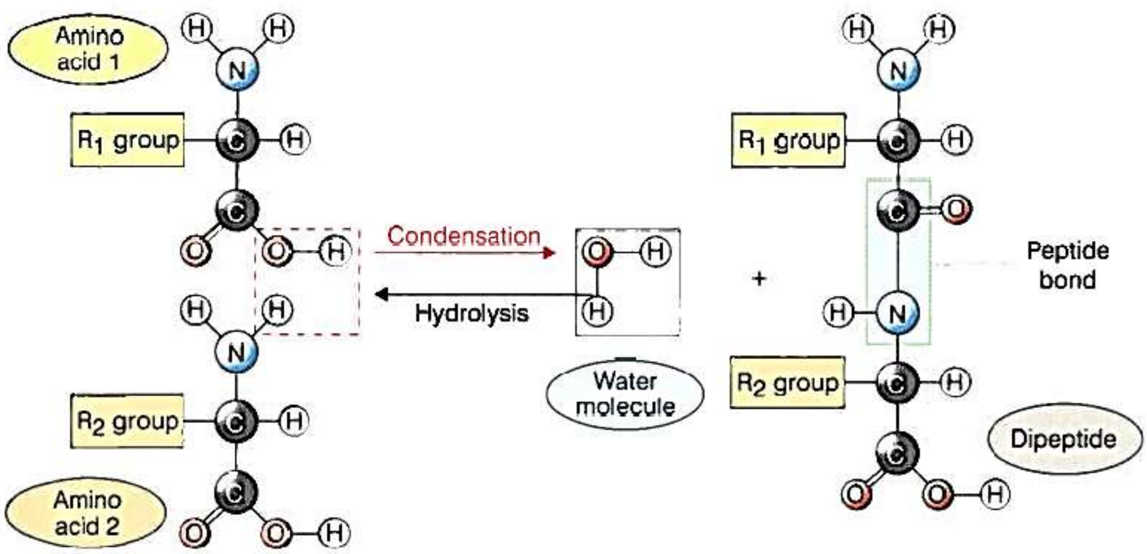
An amino acid

Draw an amino acid structure

Dipepetides

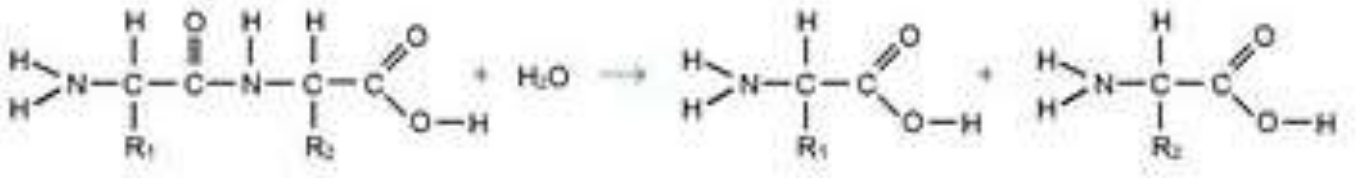
- Two amino acids can link together by a condensation reaction to form a dipeptide.
- The bond that links them is called a **peptide bond**
- Condensation is a reaction of joining two monomers together by removal of a water molecule.

Formation of a dipeptide by condensation



Show process of condensation to make a dipeptide

Break down of a dimer(dipeptide) by addition of a water molecule is called hydrolysis.



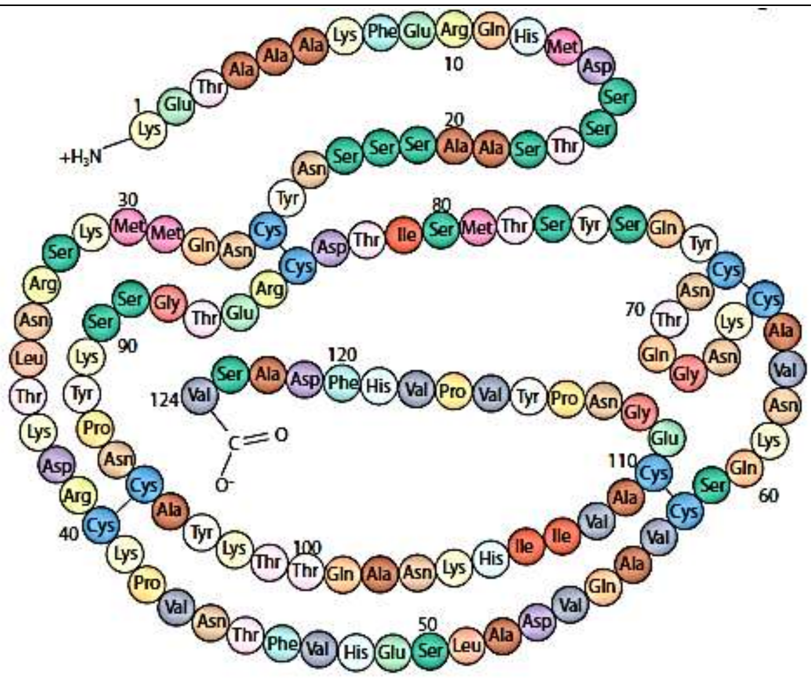
Hydrolysis of a dipeptide

Structure of protein molecules

- Amino acids can be linked together in any order to form a long chain called a **polypeptide**.
- A polypeptide may be coiled or folded on its own, or it may associate with other polypeptides to form a protein molecule.
- A protein may have the following structural levels.

The primary structure of a small part of a polypeptide

The number and arrangement of amino acids in a polypeptide or protein molecule is called its **primary structure**.



Val – Leu – Ser – Pro – Als – Asp – Lys – Thr – Asn – Val – Lys – Ala

Secondary structure

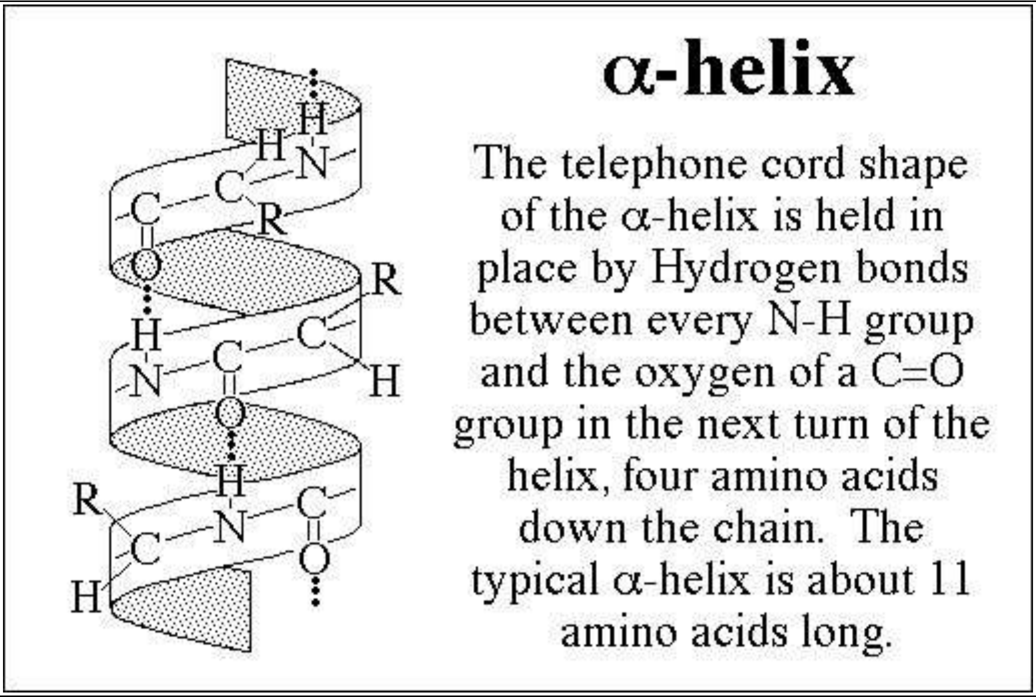
The chain of amino acids often folds or curl upon itself. It has two types

Alpha helix

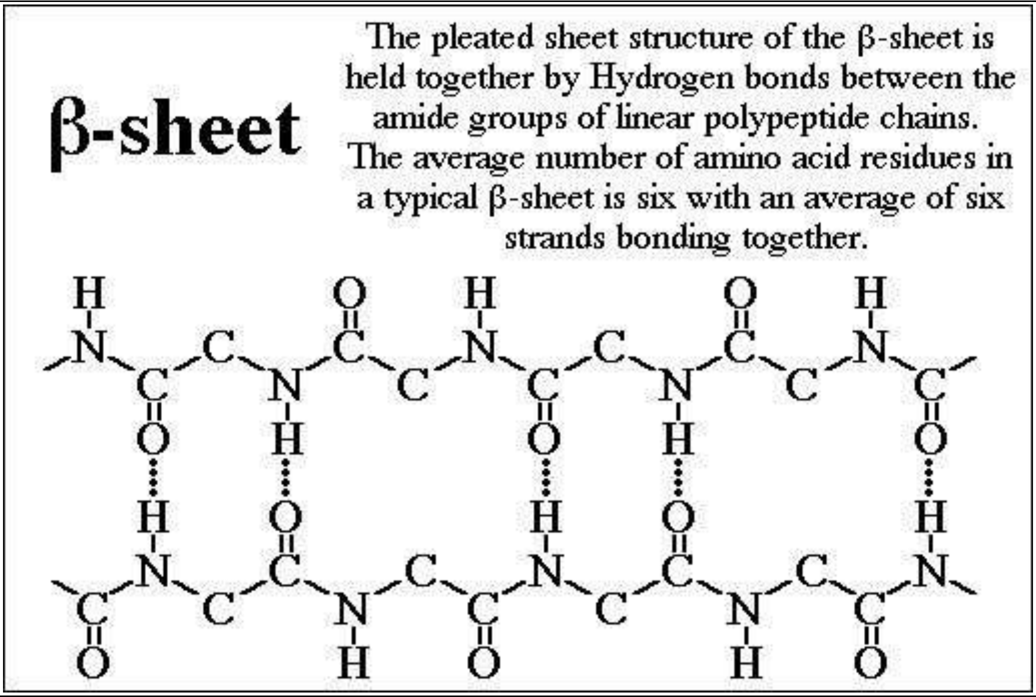
Beta pleated sheets

alpha helix.

hydrogen bonding of every amino acids in a poly peptide chain with another amino acid four places ahead in the chain. This regular bonding coils the chain into right handed helix and is an example of **secondary structure** of a protein.



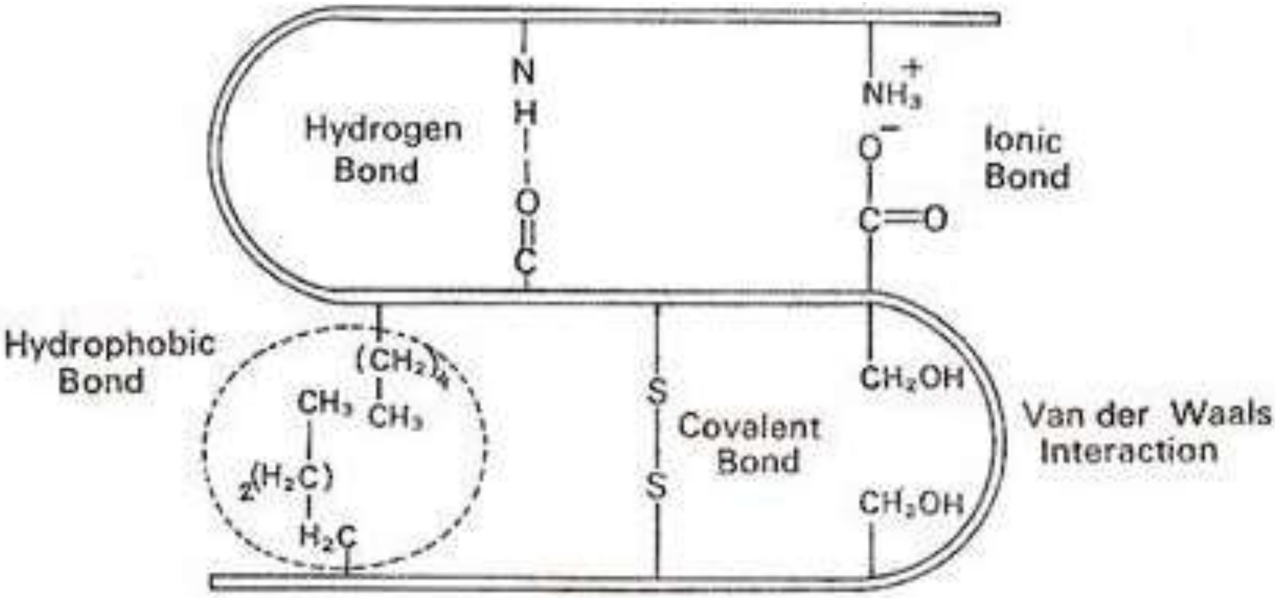
Beta pleated sheets



Tertiary structure

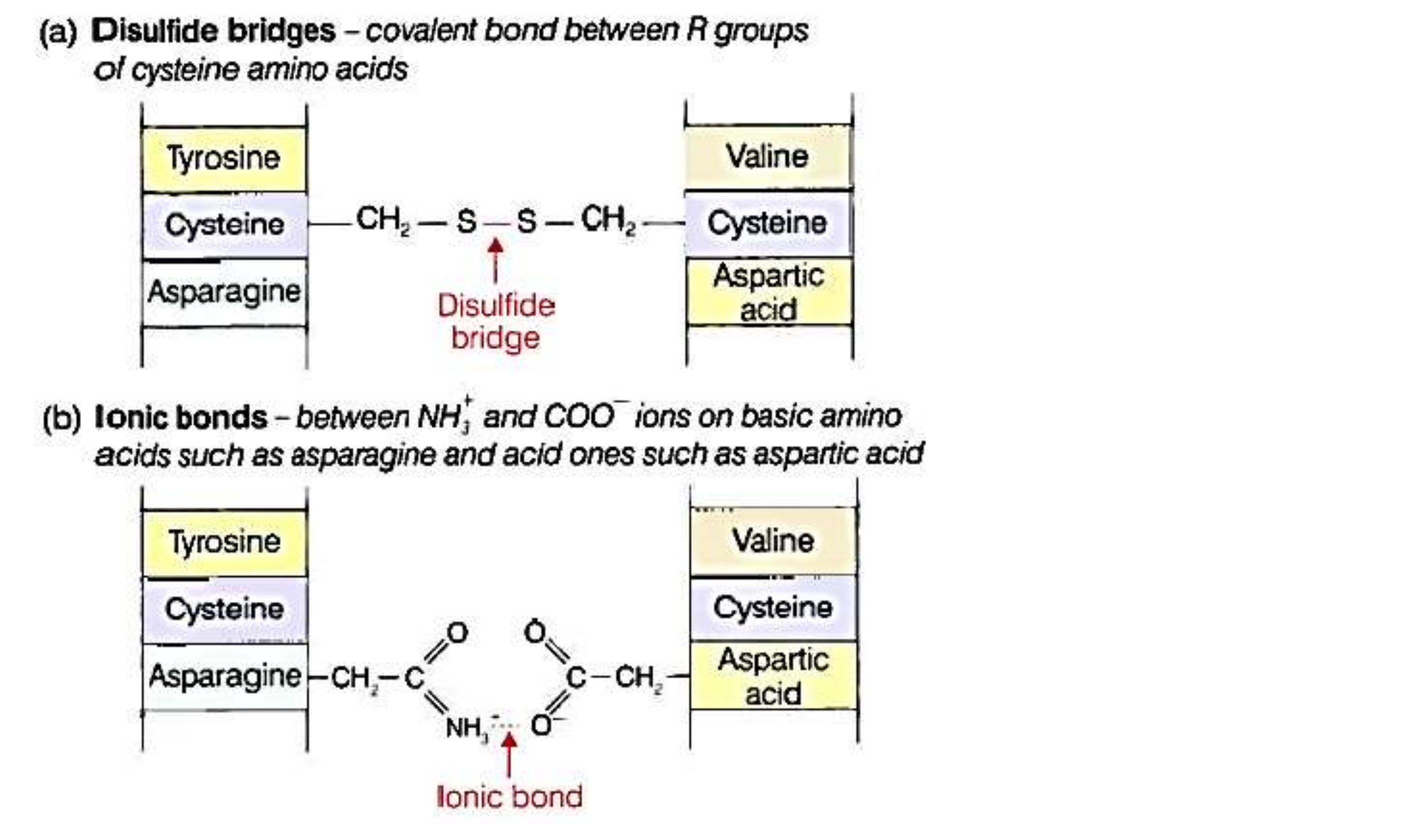
- Single polypeptide chain may also fold around on itself to form a more complex three dimensional shape.
- hydrogen bonds between amino acids at different points in the chain help to hold it in its particular 3 – D shape.
- the other bonds involved, including **ionic bonds, disulfide bonds** and **hydrophobic interactions**.
- Only globular

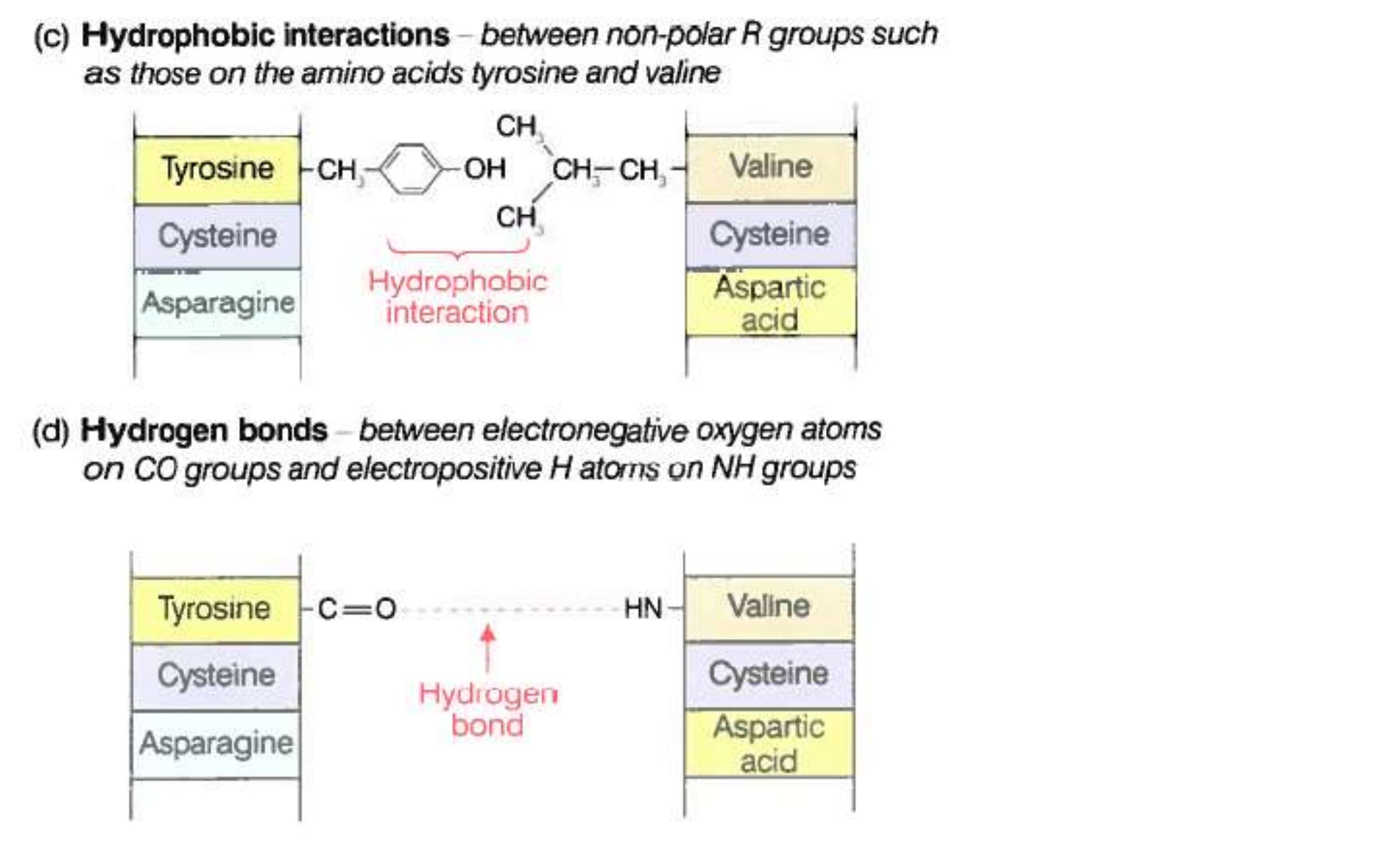
Different bonding in tertiary and quaternary structure.



(a) **Disulfide bridges** – *covalent bond between R groups of cysteine amino acids*

Describe Disulfide linkage



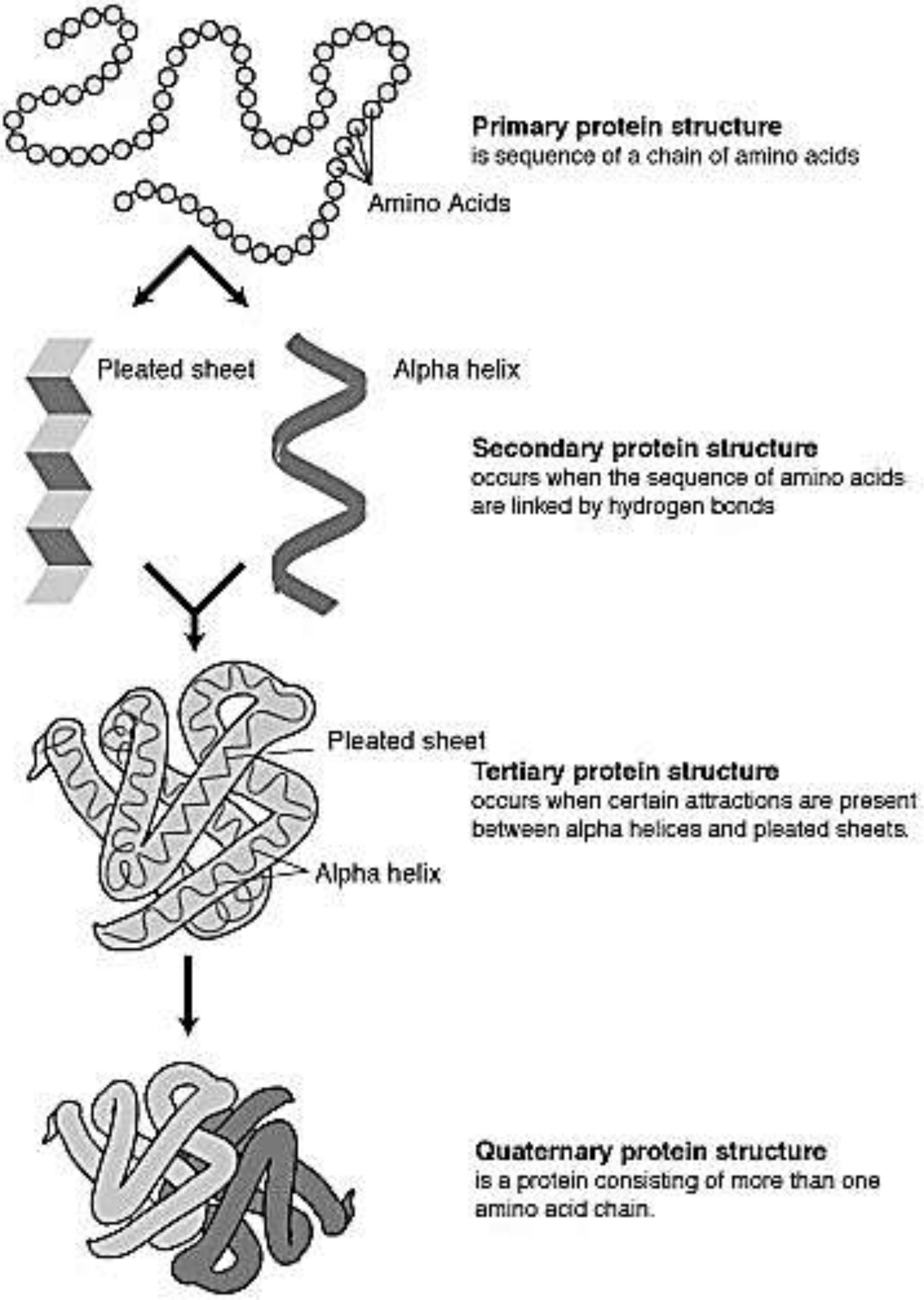


Quaternary structure

- More than one polypeptide
- The polypeptides held together by Hudrogen bonding, hydrophobic interactions, ionic bonding and disulphide linkages

• Unstable structure, changes in pH and temperature can alter it
• May be fibrous or globular

Structure of proteins

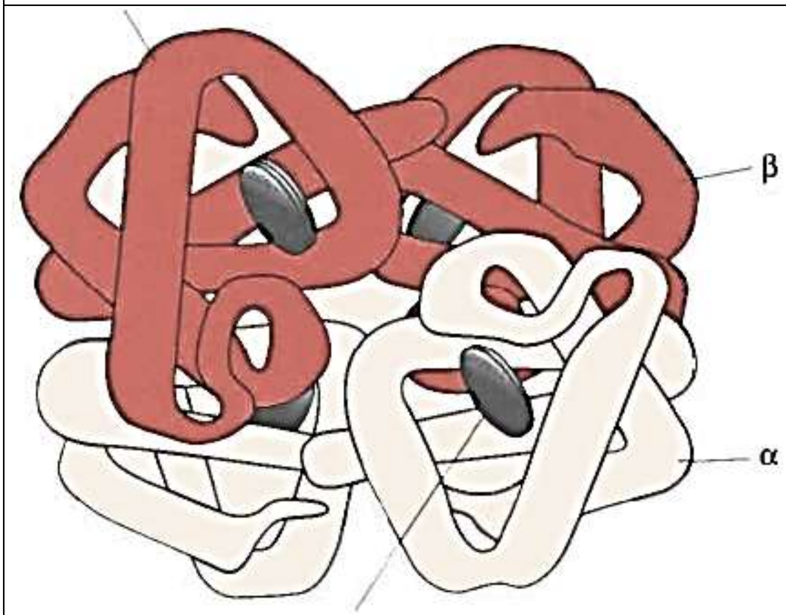


Haemoglobin

- Consists of 2 alpha and 2 beta polypeptide chains
- Each alpha polypeptide chain contains 141 amino acids
- Alpha polypeptides have more common alpha helices
- Each beta polypeptide contains 146 amino acids
- Beta polypeptides have more beta-pleated sheets

However each polypeptide chain has both alpha helices and beta-pleated sheets further folded together to make a globular 3D tertiary structure. The four polypeptides are held together by the following forces, hydrogen bonds, hydrophobic interactions, ionic bonding and disulphide linkages.

Each polypeptide has a haem group attached with it which can combine with an oxygen molecule.



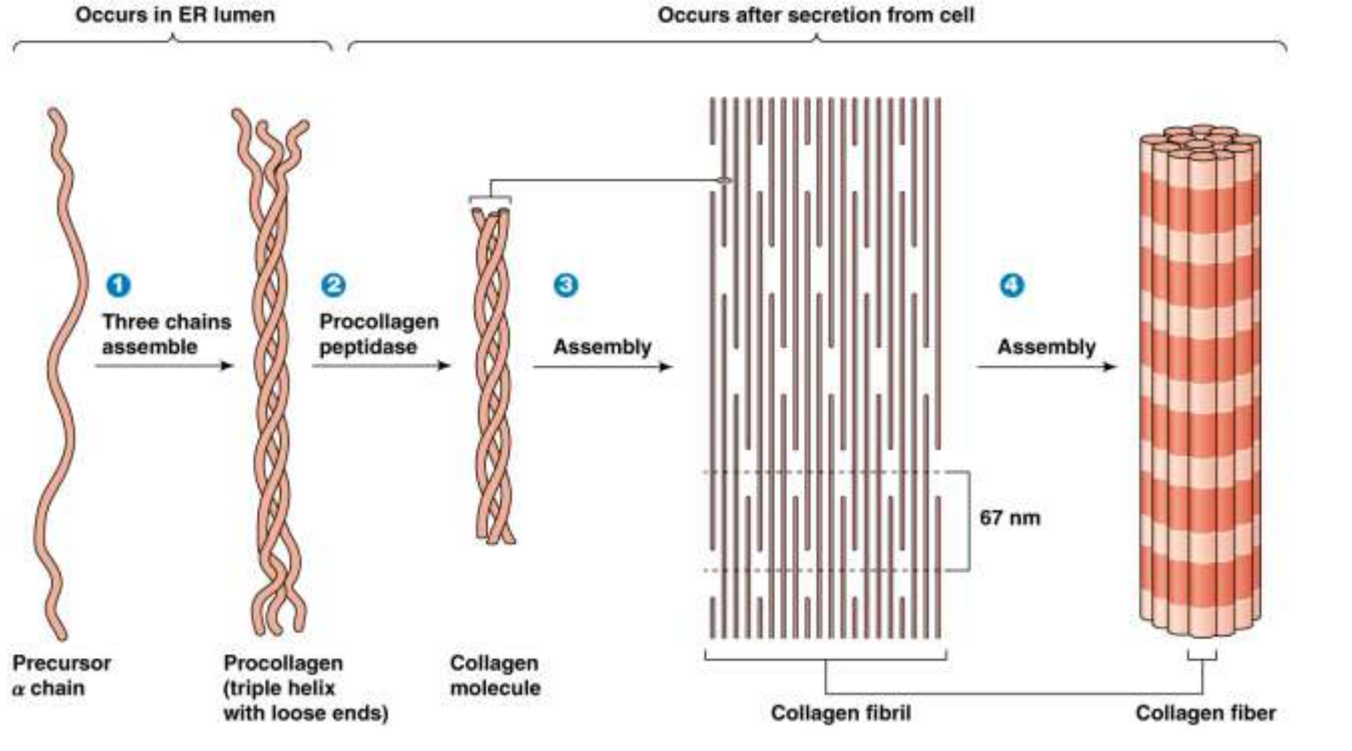
Relationship between structure and function in heamoglobin

- Found in RBC's
- Transport of O_2
- **Solubility**
  - The quaternary structure of heamoglobin makes it soluble.
  - The four polypeptide chains are held together in such a way that their hydrophilic R groups are towards outside of the molecule.
  - They therefore from hydrogen bonds with water molecules.
  - Hydrophobic R groups are directed inside of the molecule.
- **Ability to combine with oxygen**
  - Each polypeptide chain enables has a haem group
  - A haem group contains Iron ion which combines with an oxygen molecule to make oxyhaemoglobin.

- **Pick-up and release of oxygen**

At higher partial pressure of Oxygen in lungs Haemoglobin binds with oxygen to make Oxyhaemoglobin. In the respiring tissues oxyhaemoglobin dissociates to release oxygen

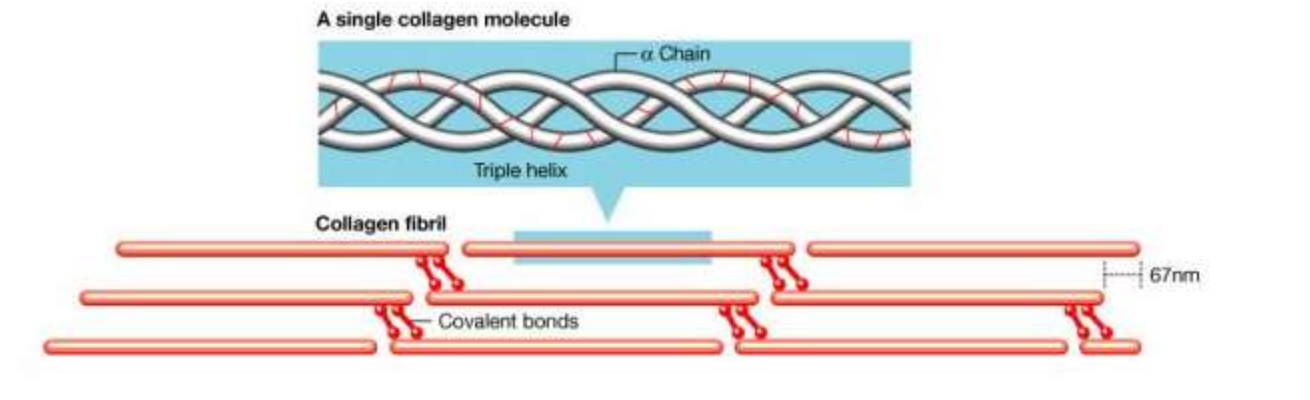
Collagen – a fibrous protein



Relationship between structure and function in collagen

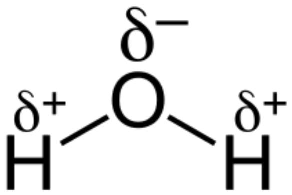
The function of collagen is to provide support and some elasticity in many different animal tissues, such as human skin, bone and tendons.

- **Insolubility** Collagen molecules are very long and are too large to be able to dissolve in water.
- **High tensile strength** Three polypeptide chains wind around one another, held together by hydrogen bonds, to form a three-stranded molecules that can withstand quite high pulling forces without breaking. This structure also allows the molecules to stretch slightly when pulled.
- **Compactness** Every third amino acid in each polypeptide is glycine, whose R group is just a single hydrogen molecule. Their small size allows the three polypeptide chains in a molecule to pack very tightly together.
- **Formation of fibres** There are many lysine molecules in each polypeptide, facing outwards from the three-stranded molecule. This allows covalent bonds to form between the lysine R groups of different collagen molecules, causing them to associate to from fibers.

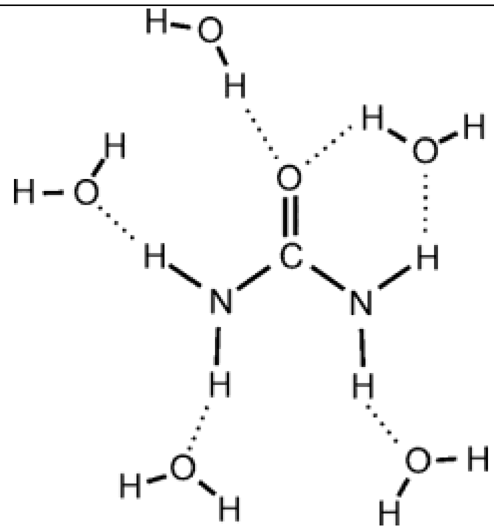

A single collagen molecule
α Chain
Triple helix
Collagen fibril
67nm
Covalent bonds

Water

- About 80% of the body of an organism is water.
- Water has unusual properties compared with other substances, because of the structure of its molecules.
- Each water molecule has a small negative charge (δ^-) on the oxygen atom and a small positive charge (δ^+) on each of the hydrogen atoms. This is called dipole.



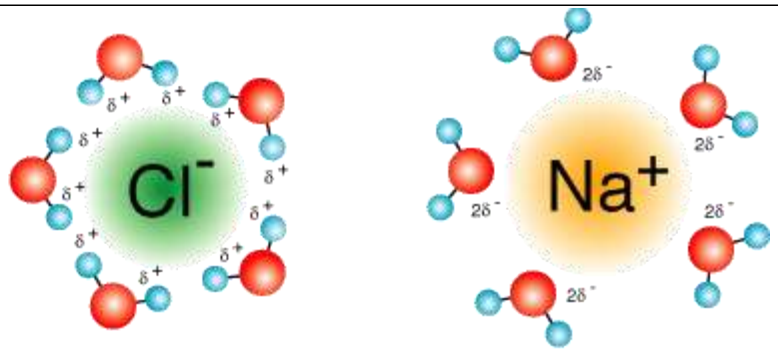
- There is an attraction between the δ^- and δ^+ parts of neighbouring molecules. This is called a hydrogen bond.



Solvent properties of water

The dipoles on water molecules make water an excellent solvent. For example, if you stir sodium chloride into water, the sodium and chloride ions separate and spread between the water molecules – they dissolve in the water. This happens because the positive charge on each sodium ion is attracted to the small negative charge on the oxygen of the water molecules. Similarly, the negative chloride ions are attracted to the small positive charge on the hydrogens of the water molecules.

Any substance that has fairly small molecules with charges on them, or that can separate into ions, can dissolve in water.



Slightly positive hydrogen are attracted to chlorine anions

Slightly negative oxygen are attracted to sodium cations

Water as a solvent

Because it is a good solvent, water helps to **transport** substances around the bodies of organisms. For example, the blood plasma of mammals is mostly water, and carries many substance in solution, including glucose, oxygen and ions such as sodium. Water also acts as a **medium** in which metabolic reactions can take place, as the reactants are able to dissolve in it.

Thermal properties of water

Water is liquid at normal Earth temperatures.

The hydrogen bonds between water molecules prevent them flying apart from each other at normal temperatures on Earth. Between 0°C and 100°C, water is in the liquid state. The water molecules move randomly, forming transitory hydrogen bonds with each other. Other substances whose molecules have a similar structure, such as hydrogen sulfide (H_2S) are gases at these temperatures, because there are no hydrogen bonds to attract their molecules to each other.

Water has a high latent heat of evaporation.

Large amount of heat is added to break hydrogen bonding between the water molecules which hold water molecules together Water molecules absorb heat energy from surface of skin And fly off into air Called evaporation It lowers skin temperature which causes cooling.

Water has a high specific heat capacity.

- Specific heat capacity is the amount of heat energy that has to be added to a given mass of a substance to raise its temperature by 1°C.
- A lot of heat energy has to be added to water to raise its temperature
- So the temperature water does not fluctuates too readily as that of air
- During hot weather water bodies absorb heat and during cold release slowly so the temperature of the coastal areas is not too extreme.

- It means that oceans or a lake, do not change their temperature as easily as air does. It also means that the bodies of organisms, which contain large amounts of water, do not change temperature easily.

Water freezes from the top down.

- Like most substances, liquid water becomes more dense as it cools, because the molecules lose kinetic energy and get closer together.
- However, when it becomes a solid (freezes), water becomes less dense than it was at 4°C, because the molecules form a lattice in which they are more widely spaced than in liquid water at 4°C, Ice therefore floats on water.
- The layer of ice then acts as an insulator, slowing down the loss of heat from the water beneath it, which tends to remain at 4°C.
- The water under the ice therefore remains liquid, allowing organisms to continue to live in it even when air temperatures are below the freezing point of water.