Etege Menen Girls' Boarding Secondary School

Biology Department

Grade 11

Prepared by; Genene Teshome

UNIT 2
BIOCHEMICAL MOLECULES

- **2.1 INORGANIC MOLECULES**
  - WATER
- **2.2 ORGANIC MOLECULES**
  - I. CARBOHYDRATES
  - II. LIPIDS
  - III. PROTEINS
  - IV.NUCLEIC ACIDS

Unit 2
Biochemical molecules

- Biological molecules can be classified into two main types:
  - **Inorganic molecule; ;**
    - Contain either carbon or hydrogen or neither of them
    - Relatively small and simple compound
    - E.g. **minerals and water**
  - **Organic molecules**.
    - Always contain both carbon and hydrogen
    - The main structural component of living cell
    - Regulate metabolic reaction and provide energy for life process
    - Includes **lipids carbohydrates, proteins** and **nucleic acids**

Activity 2.1: Grouping Molecules into organic and inorganic and make a table.

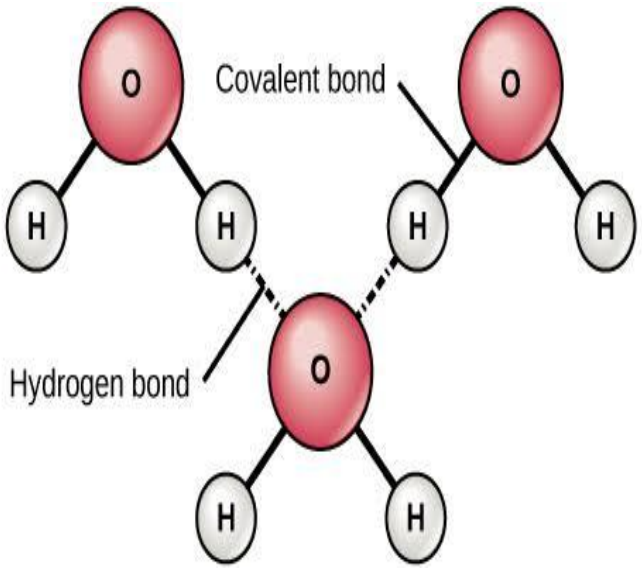
1. $C_{12}H_{22}O_{11}$ **(sucrose)**
2. CO **(carbon monoxide)**
3. $C_5H_{10}O_4$ **(deoxyribose)**
4. $C_{18}H_{36}O_2$ **(stearic acid – a fatty acid)**
5. NO_2 **(nitrogen dioxide)**
6. H_2SO_4 **(sulphuric acid)**
7. $C_3H_6O_3$ (lactic acid)
8. $C_6H_{14}N_2O_2$ **(lysine – an amino acid)**
9. $C_{10}H_{16}N_5O_{13}P_3$ (ATP)
10. NaCl **(sodium chloride**

2.1 INORGANIC MOLECULES

- Inorganic molecules are molecules that contain either carbon or hydrogen or neither of them. E.g. **water H_2O, Carbon dioxide CO_2, Calcium carbonate $CaCo_3$**
- The most common elements in many cells are that make up 95% of the body weight of organisms
  - **Hydrogen 59%**
  - **Oxygen 24%**
  - **Carbon 11%**
  - **Nitrogen 4%**
  - **phosphorus and Sulphur 2%**
- **Other that are important for humans are**
  - **Calcium (Ca)** for bones, teeth and muscles,
  - **Chlorine (Cl)** for digesting food
  - **Fluorine (F)** for tooth enamel

WATER

- The most abundant component of the living cell.
- Chemical formula for water – H_2O.
- Have bent into a ‘v’ shape.
- It is formed by hydrogen bond
- **Hydrogen bonds** are an electrostatic interaction between molecules of compound in which hydrogen atoms bounded to electronegative atoms such as oxygen.



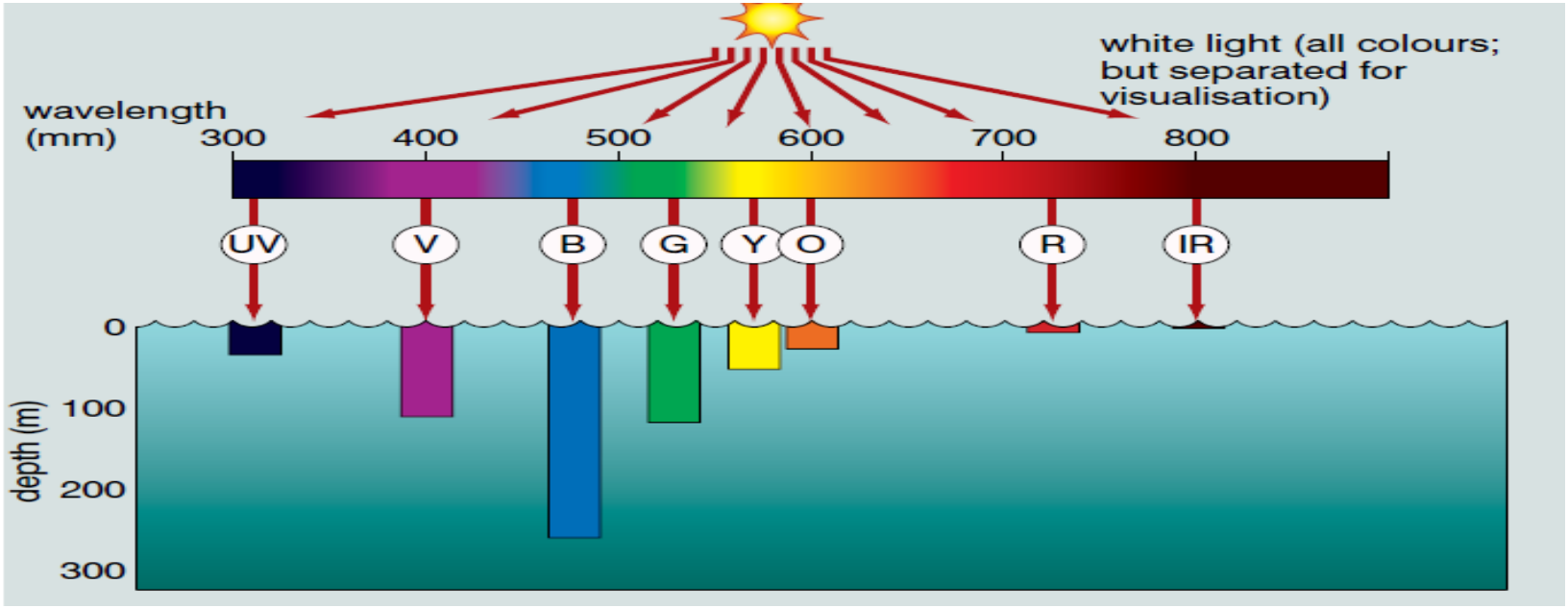
Importance of water

- Water has many important to living things in a number of ways, such as:
  - a place to live for the varieties of organisms
  - a transport medium
  - a reactant in many chemical reaction
  - a place for other reactions to take place
  - Water is a vital chemical constituent of living cells

Water exhibit the following properties

1. Transparent; allow light to pass, which is important for photosynthetic activities of plants and algae found in aquatic habitats

- Different wavelengths of light penetrate to different depths. **Red and indigo** wavelengths are **soon lost**. **Blue and green** wavelengths **penetrate deeper** than others.



2. Water has a high specific heat capacity.

- Specific heat capacity; **the amount of heat required to rise the temperature of one gram of substance by one degree celsius.**
- Water has a specific heat capacity 4.2 J of energy to heat one gram of water by one degree celsius
- Because of its high specific heat capacity, **organisms resist changing its temperature when it absorbs or loss heat.**
- Water high specific heat capacity help the organism
  - To maintain a constant internal temperature
  - Minimize fluctuations in temperature inside cells.

3. Water has a high latent heat of vaporization.

- **Latent heat of vaporization** the amount of energy needed to converting one gram a liquid to a gas at constant temperature
- Water requires a lot of energy to change liquid water into vapor (or steam).
- High heat of vaporization **use as a cooling mechanism in animals** as water evaporates from the surface of animals

4. High heat of fusion

- Latent heat of fusion the measure of heat energy to melt the solid (ice).
- Ice water requires relatively large amount of energy to melt it
- Melting of 1 mole of ice water requires 5.9KJ of energy
- Similarly liquid water loss large amount of energy to freeze
- Therefor the **contents of cells and their environment less likely to freeze**

5. Solid water (ice) is less dense than liquid water.

- The density of water decrease below 4^0 C and ice tend to floats
- This is because water expands when it freezes. in cold weather, water freezes from the top down.
- So water insulated under the ice enables life to persist under the frozen water.

6.Water has a high surface tension.

- Surface tension is the tension at the surface of a liquid resulting from unbalanced forces acting on the molecules at the surface
- High surface tension of water is due to strong attraction force of water molecule called **cohesion.**
- High surface **tension allows organisms to live on and just below the surface**

6. Water is a good solvent for many substances

- Many organic and inorganic substances dissolve in water.
- Solvent property of water use
  - To transport dissolved substance through osmosis, diffusion and active transport
  - To transport dissolved minerals upwards from the roots through xylem vessels.
  - To **transport dissolved organic substances through phloem tubes all over the plant.**

8.Water has the ideal viscosity for a transport medium.

- Viscosity is a measure of how a fluid flows easily or the measure of resistance to flow
- It helps for effective transportation of substance in the body and cells
- If water were more viscous (less fluid) than it is;
  - Blood cells do not move through the blood vessels.
  - delicate organelles in the cells would be damage
- If water were less viscous (more fluid) than it is,
  - It would flow too easily and, inside cells, the organelles would not be supported.
  - A less viscous liquid would not move the blood cells around the system as efficiently

9. Water as a reactant.

- Many reactions in living things need water as a raw material.
  - ✓**Photosynthesis**: water is the source of hydrogen ion to reduce CO_2 to sugar
  - ✓**Hydrolysis** : water molecules are used to split large food molecules into smaller ones that can be absorbed into the bloodstream
  - ✓Important in the transport of carbon dioxide around the body as hydrogen carbonate ions.

10. Water as a medium for chemical reactions.

- Many chemical reactions are taking place inside cells.
- Many of these take place on the membrane systems of the cell, but others take place in the liquid ‘cytosol’ of the cytoplasm.
- Many of the reactions of photosynthesis and respiration take place in the liquid inner regions of chloroplasts and mitochondria.
- Water is an ideal medium for these reactions, some of the reasons are;
  - ✓ It can dissolve many substances; the reactions will only take place effectively in solution.
  - ✓ It has a low viscosity; the particles can move around and come easily into contact with each other.

Summery of water biology

Water property	Significance for life
❖ High transmission	❖ Light can pass through the cell for photosynthesis
❖ high latent heat of vaporization.	❖ Use as a cooling mechanism in animals by evaporation
❖ Ice less dense than water	❖ Ice form an insulating layer under water
❖ high surface tension	❖ allows organisms to live on and just below the surface
❖ Solvent property	❖ Used for transport dissolved substance and medium of reaction
❖ Ideal viscosity	❖ Effective transportation of substance in the body and cells

2.2 ORGANIC MOLECULES

- **Organic molecules** are molecules that contain carbon and hydrogen
- There are four classes of organic compound in any living things
  1. **Carbohydrates**
  2. **Proteins**
  3. **Lipids**
  4. **Nucleic acid**

I. CARBOHYDRATES

- All **carbohydrates** biological molecule that contain the elements carbon, hydrogen and oxygen atoms in the proportion of 1:2:1 respectively. (E.g. glucose, **$C_6H_{12}O_6$**, and maltose, **$C_{12}H_{22}O_{11}$**).
- The ratio **hydrogen** and **oxygen** atoms always 2:1

General property of carbohydrates

1) Carbon chain contains **carbonyl functional** group either aldehyde **(aldose)** or ketone groups **(ketoses).**
   - Aldehyde are easily oxidized because they have a hydrogen atom attached to the carbonyl group.
   - Ketones do not have hydrogen bond attached to the carbonyl group and hence resist oxidation.
2) Contain several **hydroxyl group** on the carbon chain
   - The hydroxyl group determines the property of water

Carbohydrates have a range of functions:

1. They are used as the main source of energy for the body
2. **Serves as storage form of energy in plants and animals.**
   - **Starch:** storage form of carbohydrates plants
   - **Glycogen:** storage form of carbohydrates animals
3. **They are used as structural components include:**
   - **Cellulose;** the main constituent of cell wall of plants
   - **Chitin**; the components of **cell walls of fungi** and the **exoskeletons of insects**
   - **Peptidoglycan**; the components bacterial cell walls
4. Use as a cell surface marker for cell to cell identification

Classification of carbohydrates

- Carbohydrates categories into three major groups depending on the complexity of the molecules:
  1) **Monosaccharaides/** simple sugars/
  2) **Disaccharides** /double sugars /
  3) **Polysaccharides/** complex sugars/

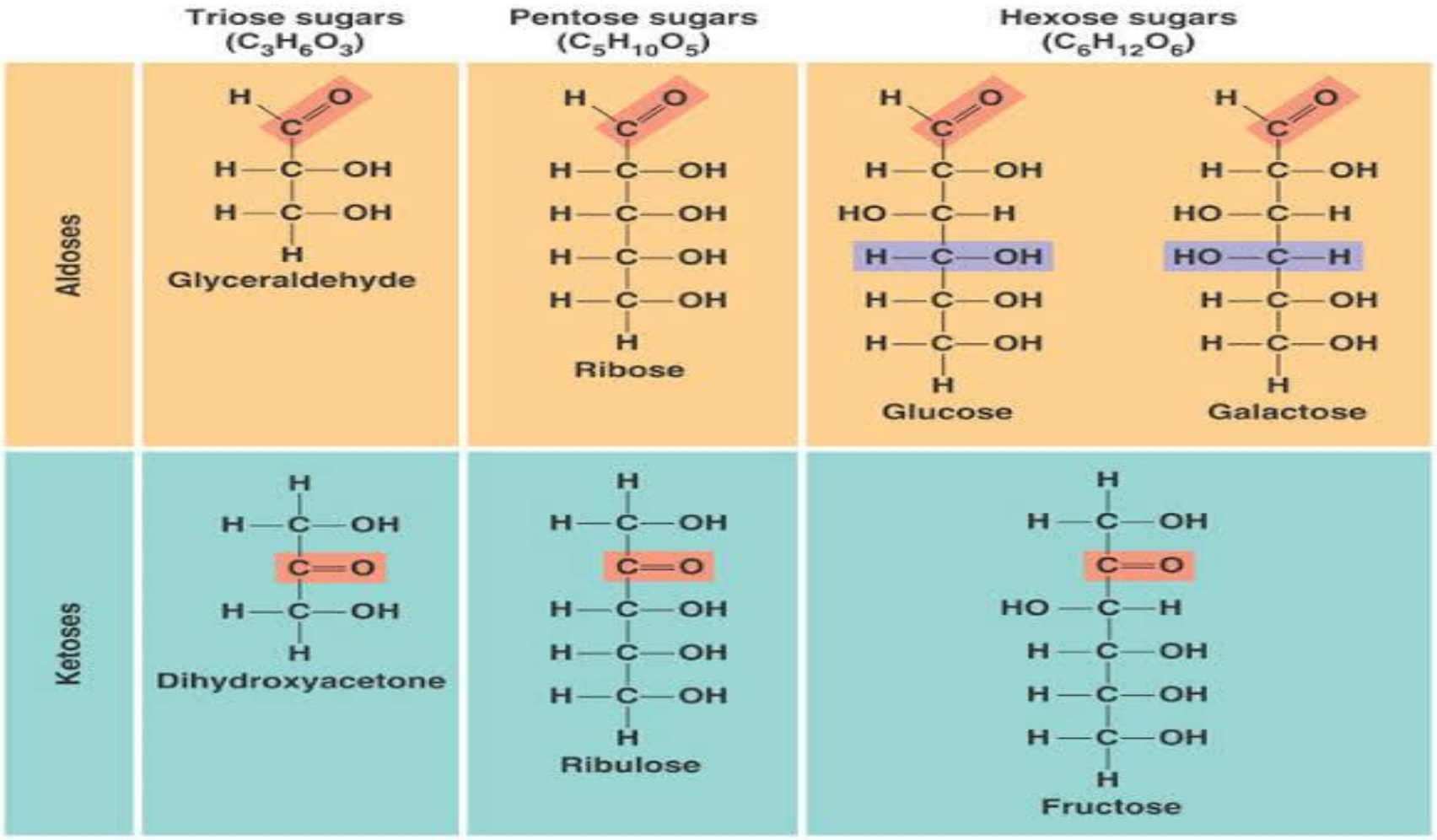
1) Monosaccharaides

- **Monosaccharaides comes from Greek:**
  - **MONOS,** single /one/
  - **SACCHAR, sugar**
- They are made up of a one sugar unit.
- They are the simplest form carbohydrates.
- Cannot broken down to simpler sugar by hydrolysis
- They are soluble in water, sweet and crystalline
- All have the formula **Cn (H_2O)n,** where the number of carbon atom in the chain can be **3-7**

There are two functional groups in monosaccharaides:

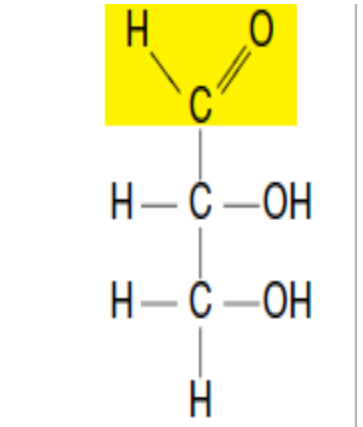
1. **Aldehyde (CHO);** monosaccharaides with this group are **aldoses**
   - **E.g. Glyceraldehyde, Ribose, Glucose, Galactose**
2. **Ketone group (C=O):** monosaccharaides with this group are **ketoses**.
   - **E.g. dihydroxyaceton, Ribulose, Fructose**

Aldose and ketoses sugar

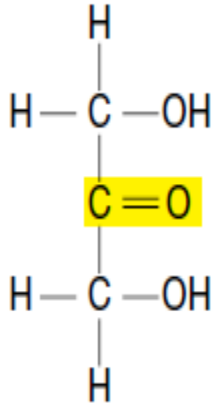


Monosaccharaides can be classified according the carbon atoms present in the molecule.

- **Triose** ($C_3H_6O_3$) contains three carbon atoms.
  - **Glyceraldehyde** and **dihydroxyaceton** are intermediate molecule in photosynthesis and respiration.
  - Glyceraldehyde and dihydroxyaceton are isomers
  - **Isomers** are molecule with the same chemical composition, but a different arrangements of atoms



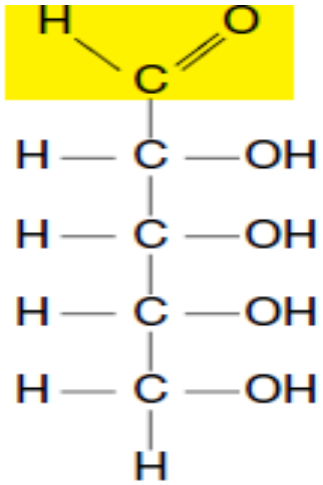
Glyceraldehyde



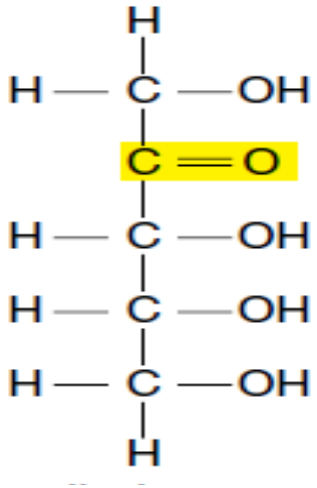
Dihydroxyaceton

Pentose

- **A pentose ($C_5H_{10}O_5$)** monosaccharide has five carbon atoms.
  - **Ribose** and **deoxyribose** are found in nucleic acid.
  - **Ribulose** is intermediate molecule in photosynthesis



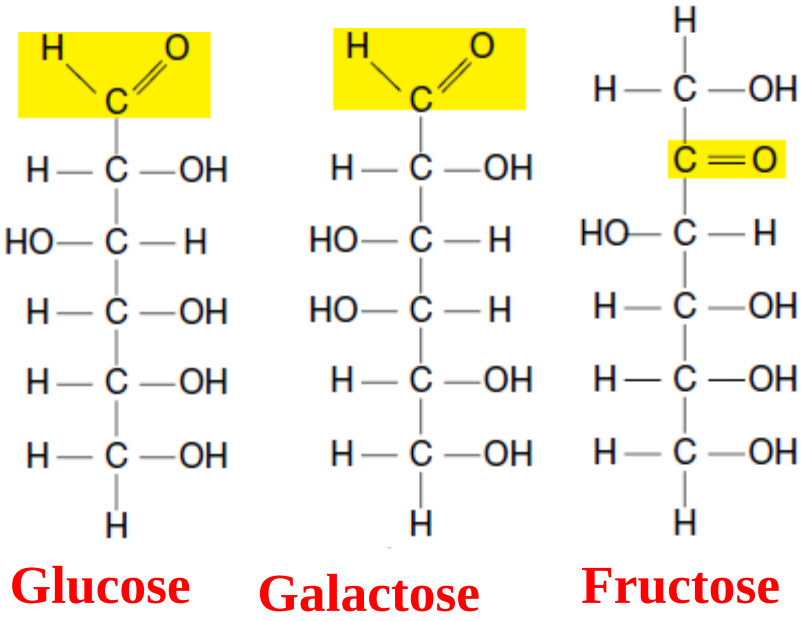
Ribose



Ribulose

Hexose

- **Hexose** ($C_6H_{12}O_6$) monosaccharide has six carbon atoms. **Glucose, Galactose, Fructose** are the most commonly known hexose.
- Glucose "blood sugar" immediate source of energy for cellular respiration
- **Fructose;** a sugar found in **honey, fruit and nectar**
- Glucose is the hexose produced in photosynthesis and used in respiration.



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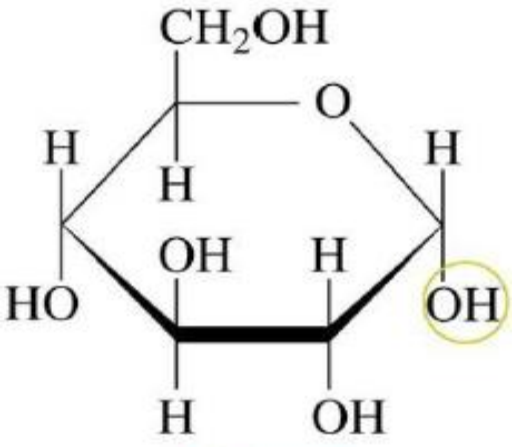
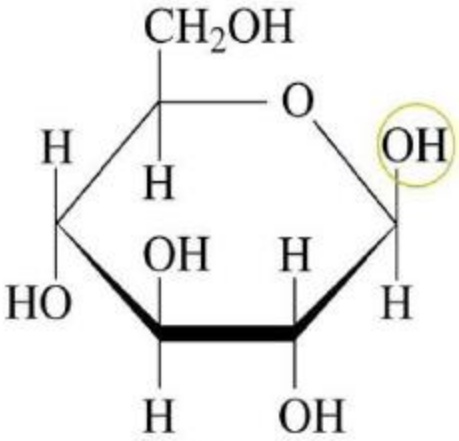
- The significant difference of aldose and ketose sugar are lies on their ability to form polymers.
- Nearly all the polysaccharides found in living things are polymers of aldose monosaccharaides.
- Monosaccharaides can form either straight chain or ring structure.
- When glucose molecule in are in aqueous solution, they forms **α-glucose** and **β-glucose** ringed structure
- The difference between α glucose and β-glucose is the position of –OH on the first carbon



α-Glucose



β-Glucose

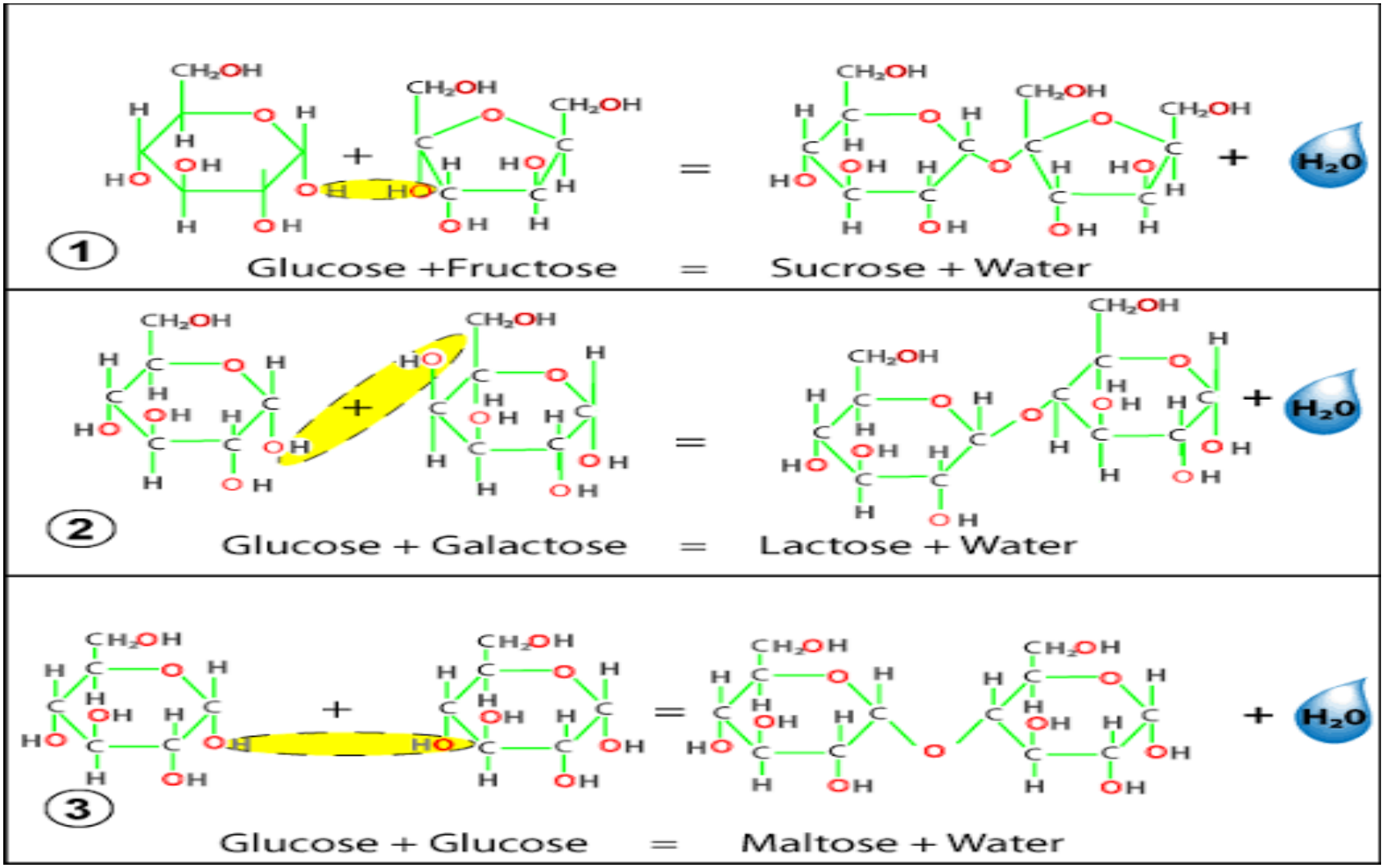
2) Disaccharide;

- Disaccharides are made up of two simple sugars **joined** together by **condensation reaction**.
- Condensation reaction joins two simple sugars to form a double sugar, and a molecule of water (H_2O) is removed.
- The bond formed between two simple sugar are **glycosidic bond**
- The formula of disaccharide is $\mathbf{C_{12}H_{22}O_{11}}$

Some of the common double sugars are :

- **Maltose (malt sugar); $C_{12}H_{22}O_{11}$**
  - is derived from two **α-glucose** molecules
  - two α-glucose molecules is linked by α 1,4 glycosidic bond
  - it is a reducing sugar (reduce Benedict's reagent)
- **Sucrose (table sugar) $C_{12}H_{22}O_{11}$**
  - is derived from an **α-glucose** and a **β fructose** molecule
  - it is a non-reducing sugar (do not reduce Benedict's reagent)
  - **α-glucose** and a **β fructose** molecule is linked by α **1,2 glycosidic bond**
- **Lactose (milk sugar) $C_{12}H_{22}O_{11}$**
  - Is derived from a **β-glucose** and **α-galactose** molecule.
  - it is a reducing sugar (reduce Benedict's reagent)
  - β-glucose and α-galactose molecule is linked by **β 1,4 glycosidic bond**

Disaccharide formation



3) Polysaccharides;

- **Polysaccharides** are long chain of many monosaccharaides joined by glycosidic bonds
- They are polymers that are formed by condensation reaction
- Thy have two functions:
  - **Energy storage** (starch and glycogen)
  - **Structural material** (cellulose and chitin)
- Complex and stable forms of carbohydrates
- It is insoluble so it does not change the water potential of the cell

Condensation (dehydration)

☞ formation of macromolecule by removing water

Hydrolysis

☞ break a macromolecule into its unit of molecules by adding water

Some biological important polysaccharides

I. Starch

- Starch is a major energy storage in plants,
- Starch is a mixture of **amylose** and **amylopectin**.
- Both are polymers of **α-glucose,** but the arrangement is different.

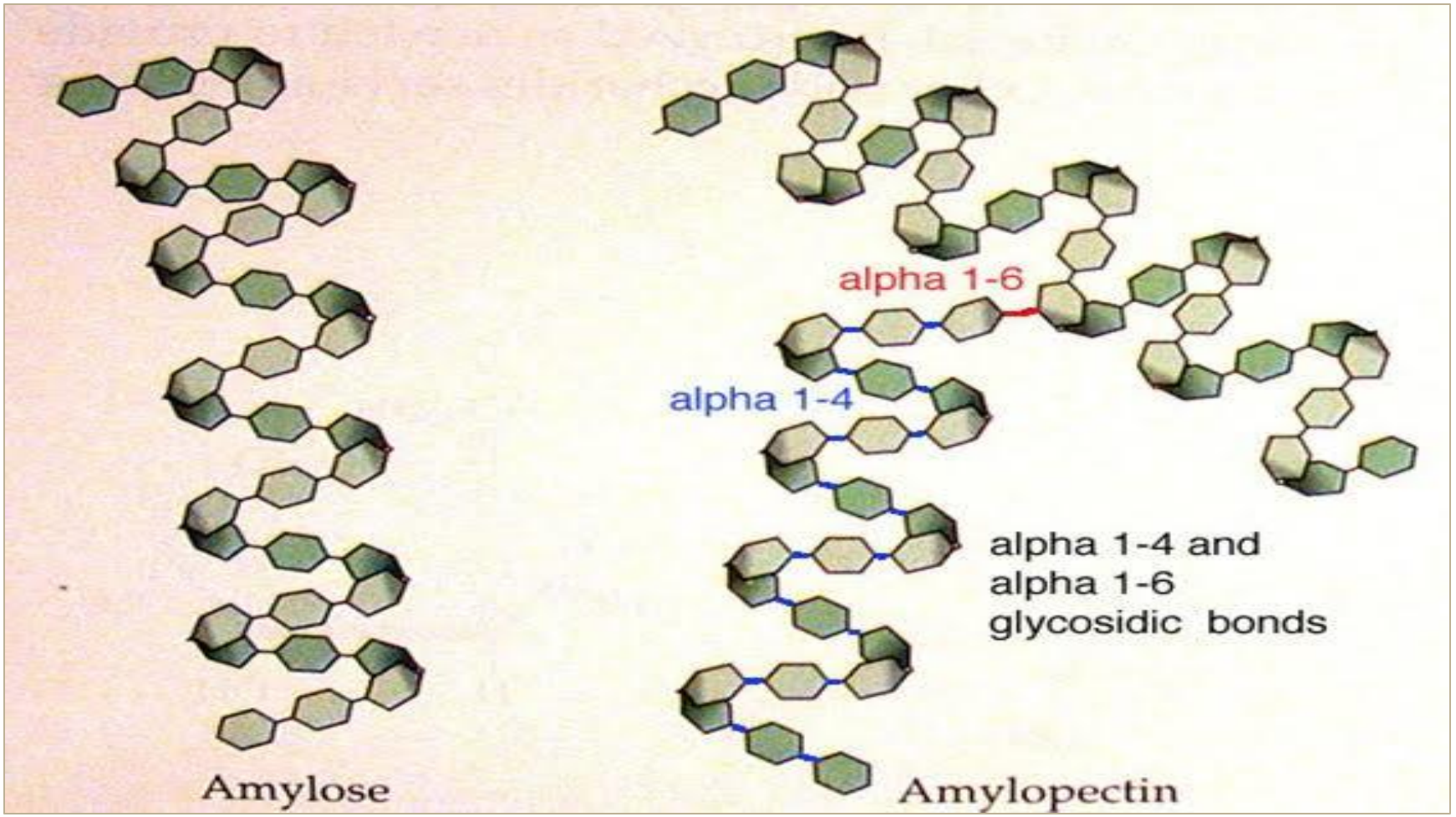
Amylose

- Amylose is liner; a straight chain polymer of α-glucose units
- The bonding involved is **α-1, 4-glycosidic bonds.**
- The long chain α-glucose winds itself into a helix.

Amylopectin

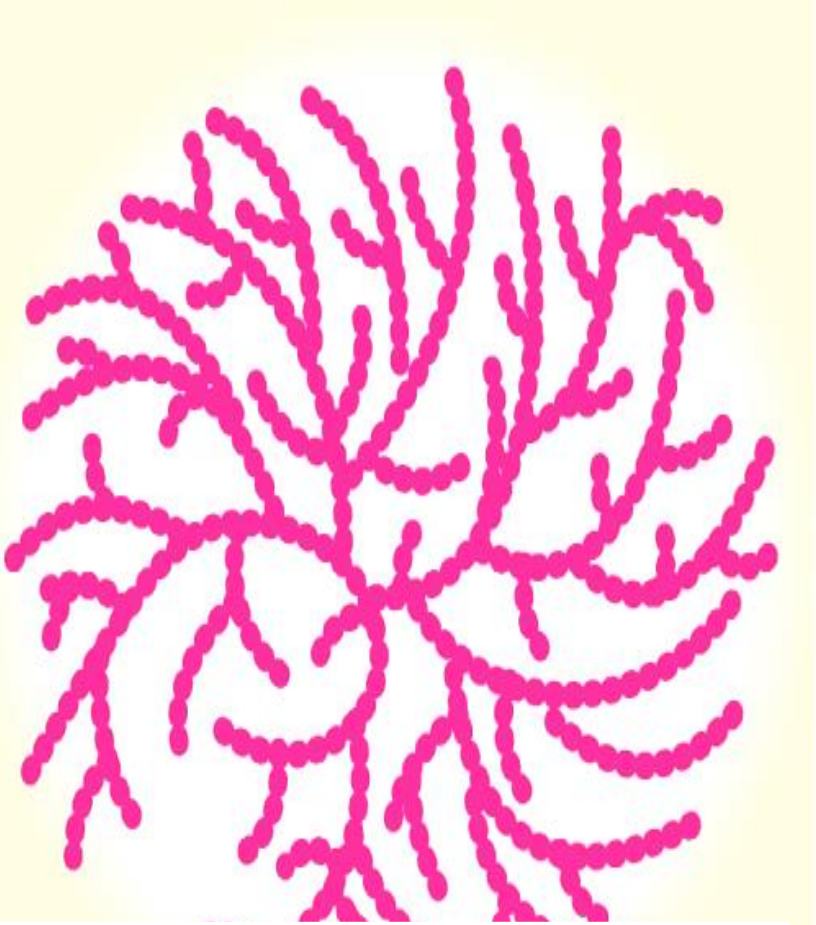
- Amylopectin is a branched chain polymer of **α-glucose** units
- The bonding involved is;
  - **α-1, 4-glycosidic** linkage for straight chain
  - **α-1, 6-glycosidic** linkage for branched chain
- Amylopectin having a branching chain, this gives many ‘ends’ to the molecule.
- Branching chain allows amylopectin to be hydrolysed quickly by **amylase enzymes** and release glucose for respiration.

Amylose and Amylopectin



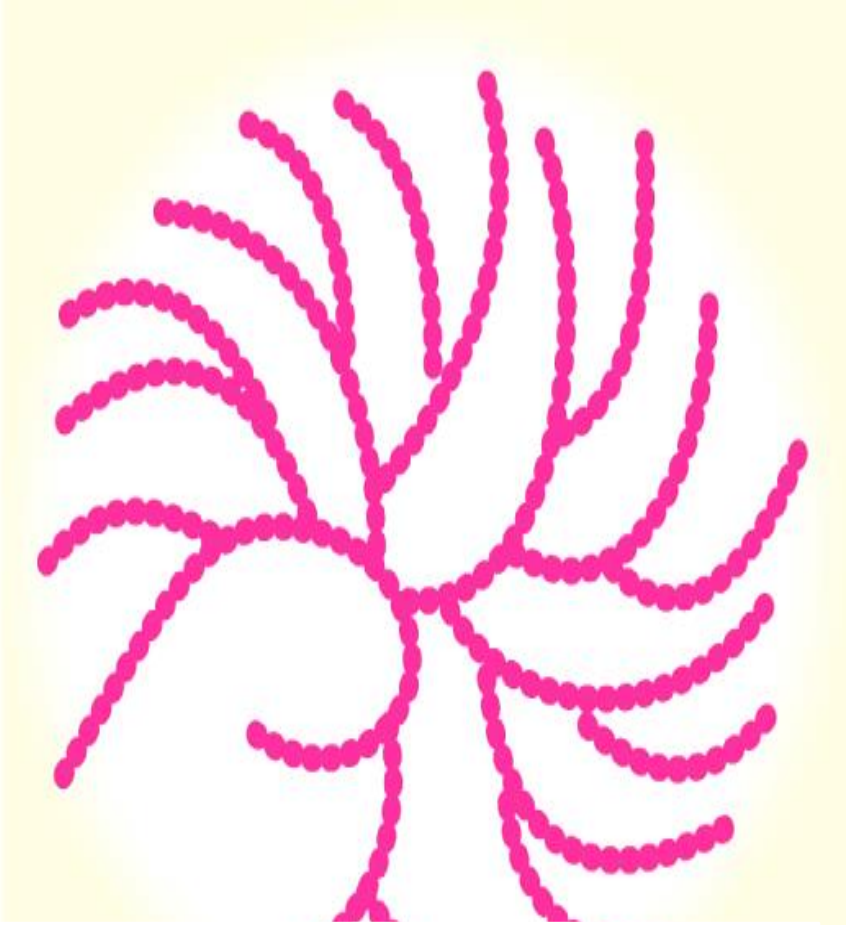
II. Glycogen

- Glycogen is a storage carbohydrate in animal cells.
- **Short and highly branched** chain of **α-glucose**
- The bond involved are **α-1,4 glycosidic bond** and **α-1,6 side branches**,
- Glycogen has similar structure with amylopectin but it have more α-1,6 side branches
- Because of this, it can be hydrolysed more easily during respiration to release more glucose than starch.
- This is important because animals to supply high amount energy more quickly .



A short highly branched chain α-glucose

Glycogen



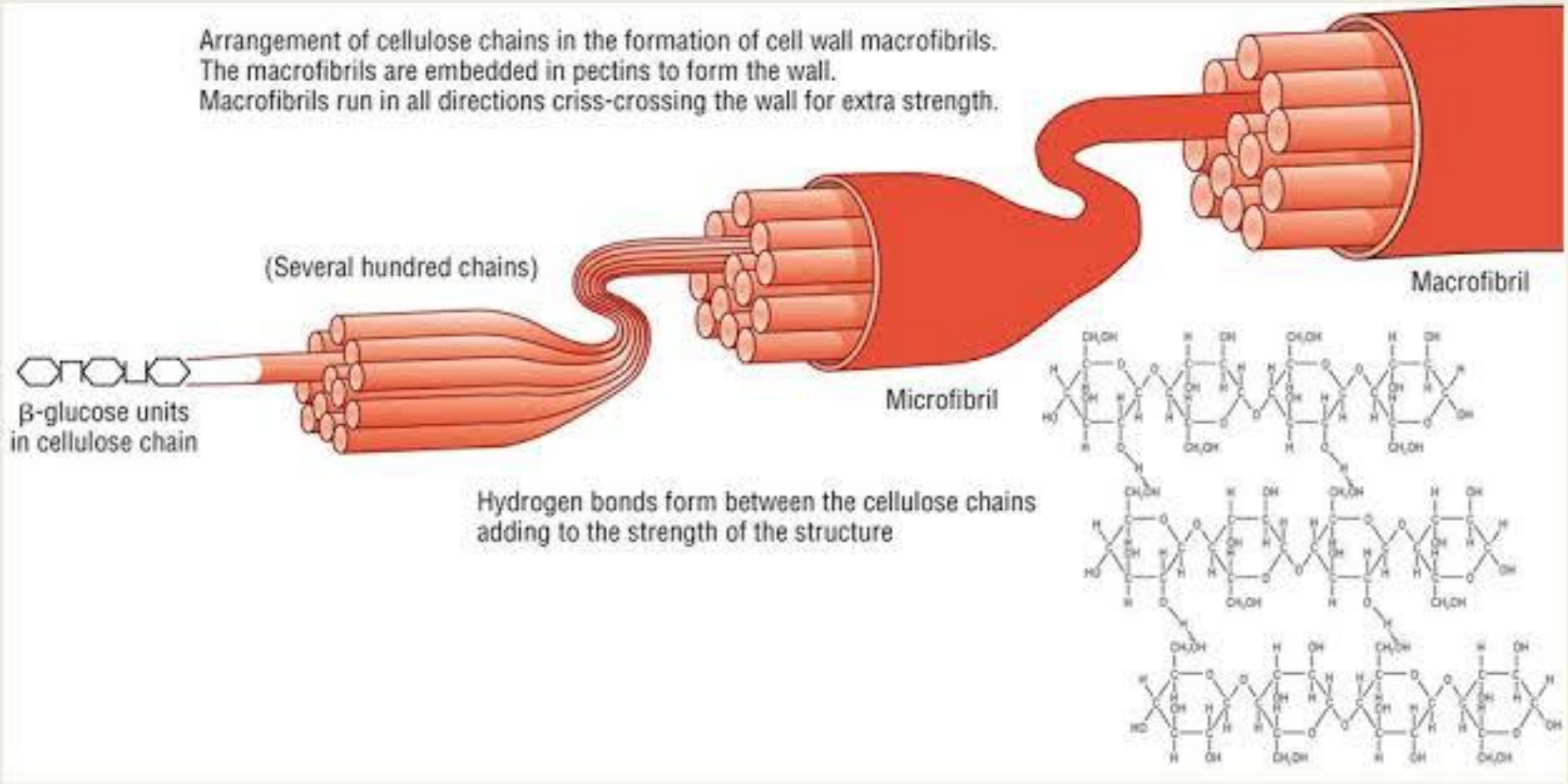
A less branched chain α-glucose compare to glycogen

Amylopectin

III. Cellulose

- The main component of cell walls.
- The most abundant organic molecule on the earth
- Cellulose is a polymer of **β-glucose** molecules joined by **β-1,4 -glycosidic bonds**,
- Has straight, unbranched chains that run parallel to one another
- Allowing **H-bonds** to form cross-links between adjacent chains
- So many hydrogen bonds help to strengthen to cellulose
- Cellulose does this by grouping together to form **microfibrils → fibres**
- Human cannot hydrolysis cellulose because they do not possess enzyme necessary to break down β-glucose glycosidic linkage

Cellulose chain, microfibrils and macrofibril (fibre)



II. LIPIDS

- Lipids are made of **carbon, hydrogen** and **oxygen,** but they contain much less oxygen than carbohydrates.
- Some of the lipids found in the myelin sheath that surrounds nerve cells are **sphingolipids**. These are unusual lipids as they contain nitrogen as well as carbon, hydrogen and oxygen.
- Lipids contain **much energy** per gram than carbohydrates and proteins
- A lipid molecule is **hydrolyzed into** three **fatty acid** molecules and **glycerol**
- They are **insoluble in water** and **soluble in organic solvent** like aceton, ether, alcohol etc.

Contd.

- Lipids **includes triglycerides, oils, fats, waxes, phospholipids, steroids**
- Three different function of lipids in our bodies
  - Energy storage **E.g. Triglycerides**
  - Forming the membrane around the cell E.g. **Phospholipids**
  - Hormone and enzymes **E.g. Steroids**

Lipids are a varied group of compounds that include:

- **Triglycerides** – formed from glycerol and three fatty acids
- **Phospholipids** – formed from glycerol, two fatty acids and a phosphate group
- **Waxes** – formed from fatty acids and long-chain alcohols

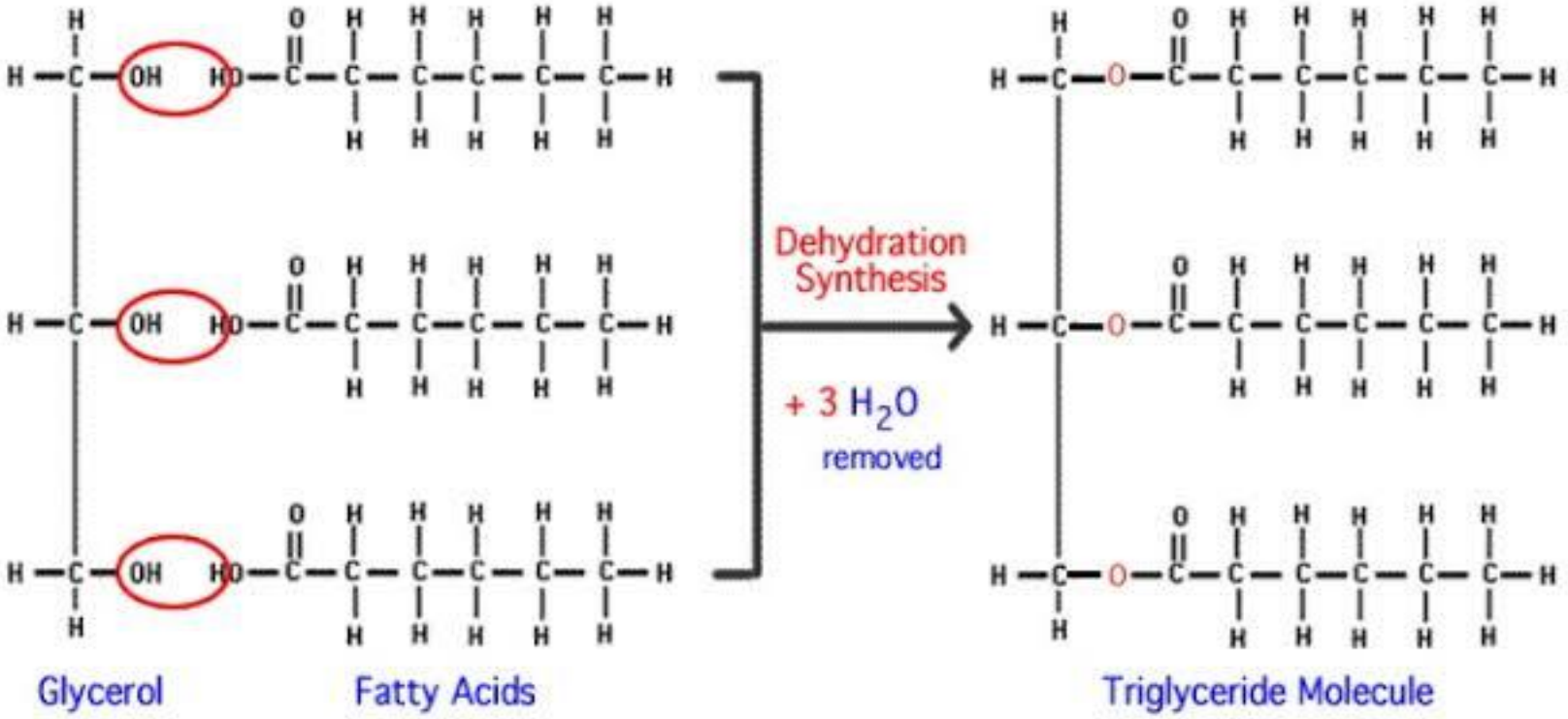
Lipids have several functions including:

- **Respiratory substrate** –yields many molecules of ATP (twice as much energy) per gram than a molecule of glucose.
- **Thermal insulation** – the cells of adipose tissue found under the skin used as insulation layer under skin
- **Buoyancy** – lipids are less dense than water (oil floats on water), so the presence of large amounts of lipid reduces the density of an animal, making it more buoyant
- **Waterproofing** – the oils secreted by some animals onto their skin are lipids

1. Triglycerides

- The most commonly lipids in nature
- Formed from **one glycerol** and **three fatty acid molecules.**
  - Glycerol and fatty acids combines using condensation reaction
    - In making triglycerides three molecule of water is removed
- The bond that link glycerol and fatty acid are called **ester bonds**
  - Ester bonds formed between a **carboxyl group** fatty acid and a hydroxyl group **glycerol.**

Formation of triglyceride



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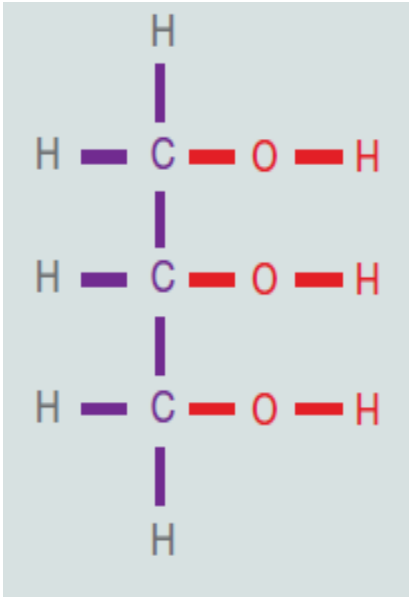
- **Glycerol** is a poly hydroxyl alcohol that contain 3 hydroxyl (–OH) functional group.
- **Fatty acids consists;**
  - Covalently bonded **hydrocarbon chain.**
  - The **carboxyl functional group (-COOH)**
- The nature of the hydrocarbon chains in fatty acids can differ in two main ways:
  - **The length of the carbon chain**
  - **The degree of saturation.**



Glycerol

Saturated fatty acid

- Carbon atoms are joined by **a single covalent bond.**
- Carbon chain are fully saturated with hydrogen's (more energetic)
- More common in animals lipids
- Solid at room temperature
- Saturated fat, in diet are not good for our long- term health
- E.g. butter, animal fat

Unsaturated fatty acid

- The carbon chains have one or more double bonds in them.
- Carbon chain are not fully saturated with hydrogen's (less energetic)
- more common in plant lipids
- liquid at room temperature
- E.g. vegetable oils
- **Monounsaturated fatty acid** one carbon–carbon double bond
- **Polyunsaturated fatty acid** more than one carbon–carbon double bonds
  - Polyunsaturated fatty acid generally expected to **give better health benefit** present in human diet.

Brainstorming

1. Which of the following molecule is **not** a polymer?

A. Cell wall B. Enzymes C. Lipid D. Starch

2. A compound with the following formula $C_5 H_{11} COOH$ Would be

A. Amino acids B. Nucleic acids

C. Fatty acids D. Carbohydrates

3. How many glycerol and fatty acids, respectively, are needed to form 100 molecule of triglycerides

A. 100 and 300 C. 50 and 50

B. 100 1nd 100 D. 150 and 400

4. Some animal like polar beer have a thick layer of fat under the skin, for what purpose does the polar beer mainly use this

A. used as body building C. Water proofing layer

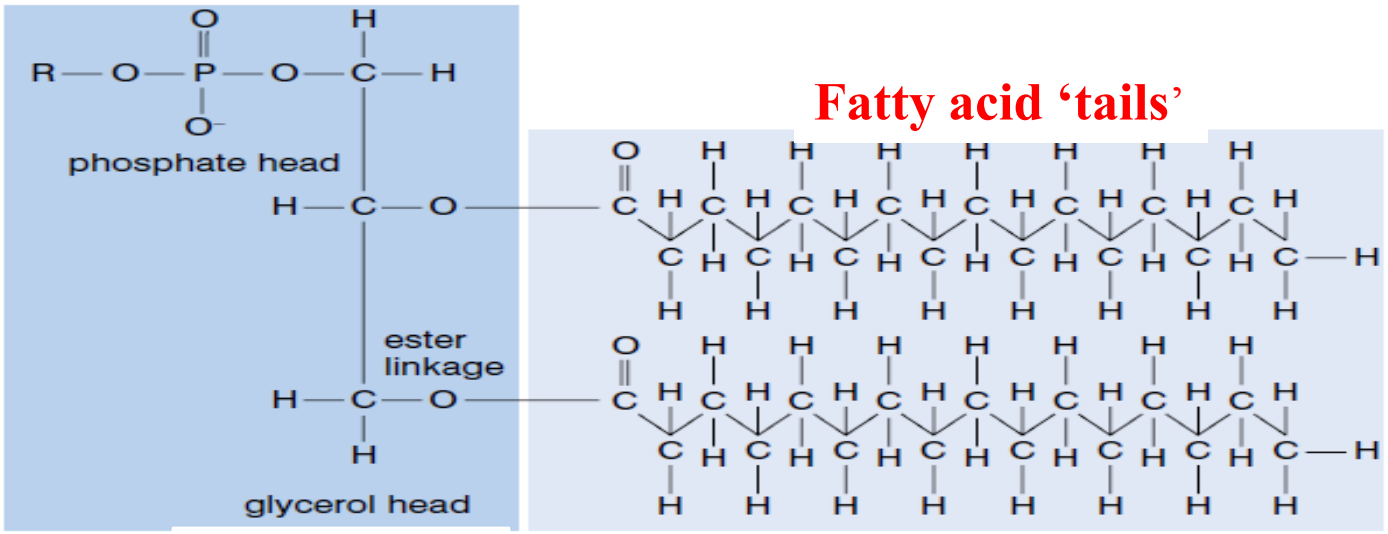
B. Used as insulation layer D. Make a beer bayonet

5. In equal amount of the following food is hydrolysed which one of the following generate high amount of energy?

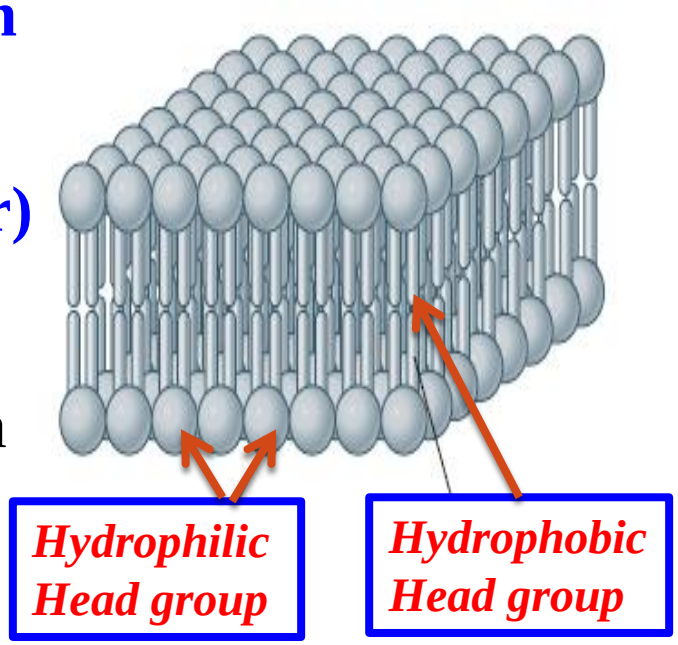
A. Honey B. Bean C. Olive oil D. Dabo

2. Phospholipids= one glycerol molecule + two fatty acid + a phosphate group.

- There are two distinct regions to a phospholipid molecule:
  - **Hydrophilic** (water-loving) polar region, consisting of the phosphate group
  - **Hydrophobic** (water-hating) non polar region, consisting of the fatty acid chain



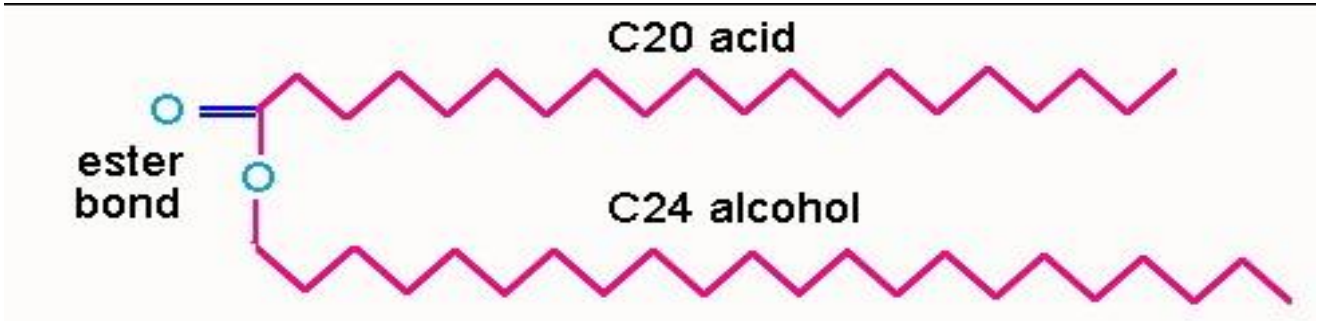
- **Phospholipids** are called **amphipathic lipids** due to
  - Phosphate **hydrophilic tail (soluble in water)**
  - Hydrocarbon/fatty acid chain/ **hydrophobic tail (insoluble in water)**
- Phospholipids are important constituent of plasma membranes.
- **In water,** phospholipids organized into a **bilayer**.
  - The hydrophilic heads face outwards into the water
  - The hydrophobic tails face inwards, away from the water.
- Phospholipid bilayer are the base of plasma membrane



A	B
1. Carbon atom are joined by a single bond	**A. Unsaturated fatty acids**
2. Formed from one glycerol and three fatty acid molecules	**B. Dehydrogenation**
3. The carbon chains have one or more double bonds	**C. Triglycerides**
4. lipid containing glycerol molecule, two fatty acids and a phosphate group.	**D. Saturated fatty acids**
5. They are called amphipathic lipids	**E. Phospholipids**
6. Used in making plasma membrane	**F. Glycerol**
7. Reaction convert oil into solid	**G. Hydrogenation**

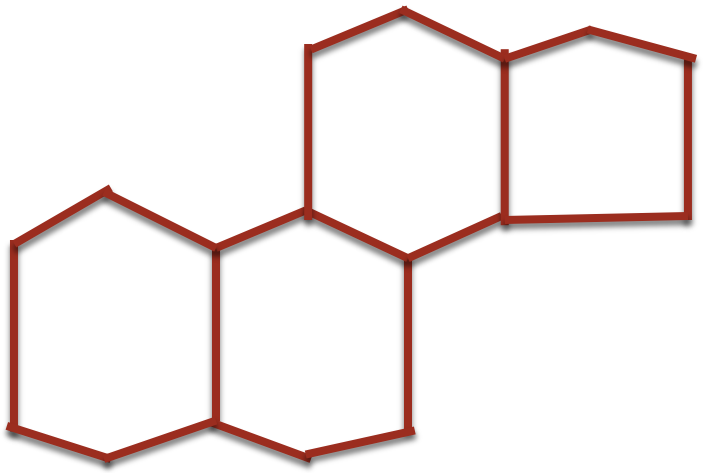
3. Waxes

- Formed from **fatty acid** and a **long chain of monohydric alcohol**
- Commonly found wherever **water proofing is needed** such as;
  - Leaf cuticle, Insects exoskeletons
  - Birds feathers”
  - Mammals fur



4 Steroids

- Lipids characterized by **4 bonded carbon ring**
- Lipids with **no fatty acids chain**
- **Classified as lipids b/c** they are insoluble in water
- Different steroids differ from each other by their side group.
- Examples of steroids.
  - **Cholesterol**
  - **Steroids hormone**
    - **Progesterone**
    - **Testosterone**
    - **Cortisol**
  - **Vitamin D**
  - **Adrenal hormones**
  - **Bile salts**



Matching

A	B
1. Chemical reaction convert lipid into glycerol and fatty acid	**A. Waxes**
2. Chemical reaction make lipids from fatty acid and glycerol	**B. Hydrolysis**
3. Used as water proofing such as leaf cuticle	**C. Dehydration**
4. Lipids without fatty acids chains	**D. Steroids**
5. Formed from fatty acid and a long chain of monohydric alcohol	**E. Phospholipids**
6. Water molecule is used up	**F. Neural fat**
7. Its back bone is four bonded carbon ring	**G. Triglycerides**
8. Used in making hormone and vitamins	

Summary questions

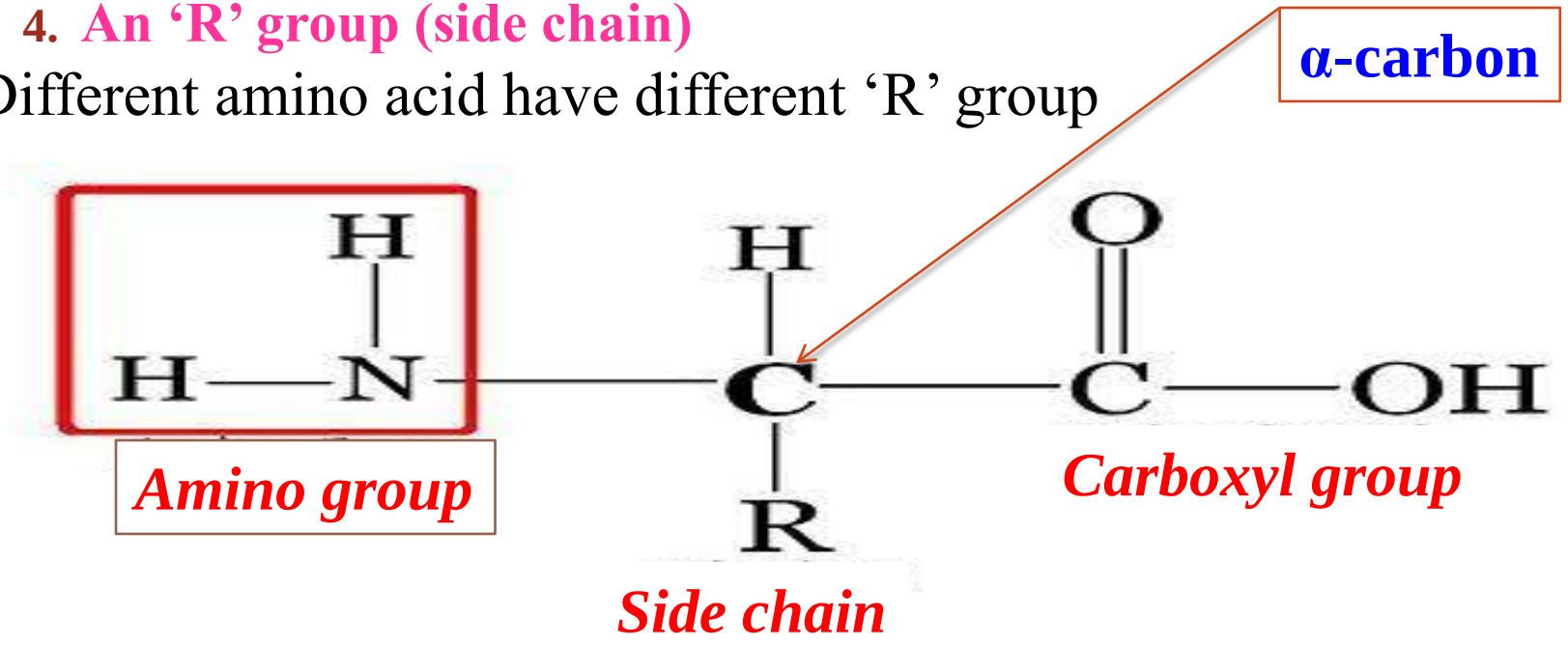
1. What makes phospholipids molecules arrange themselves into bilayer in a water molecule?
2. What makes phospholipids Amphipathic in nature?
3. What determine the fluidity of lipids?
4. Why lipids are insoluble in water?
5. Why lipids contain much energy per gram than carbohydrates and proteins?

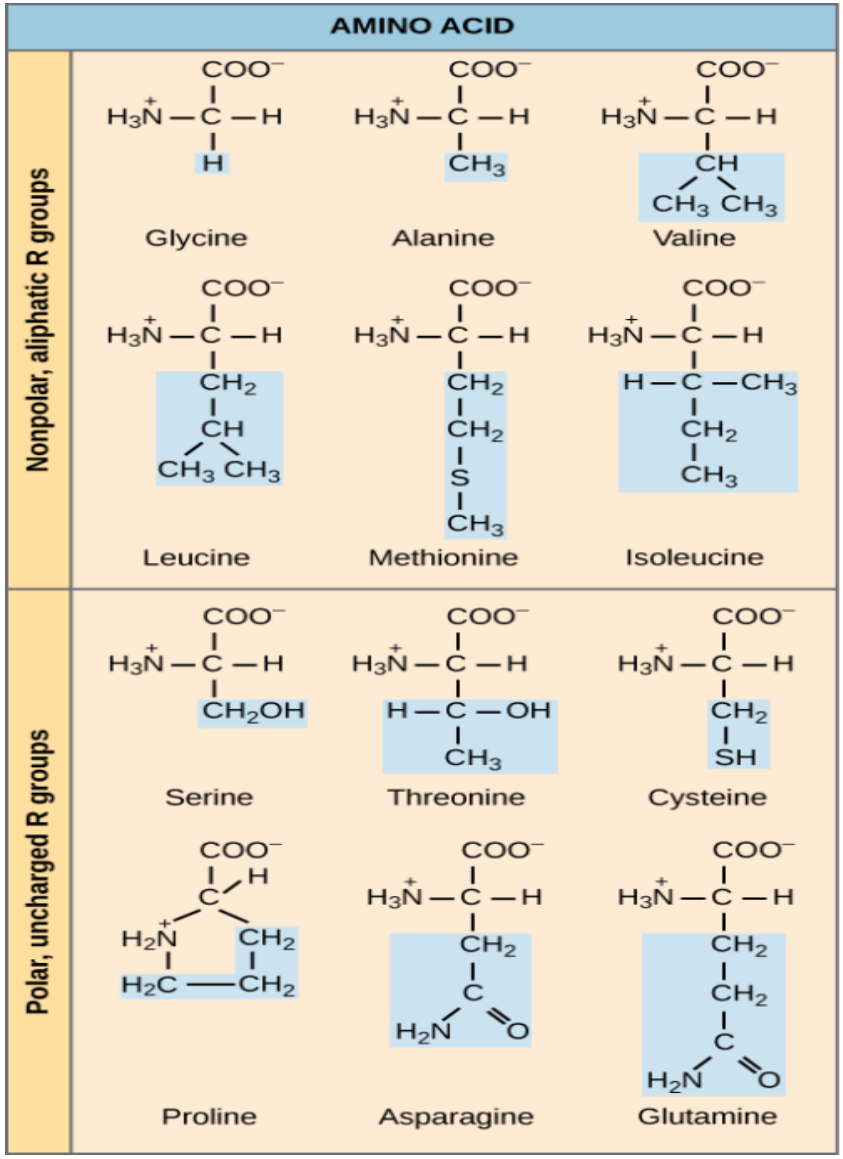
III. PROTEINS

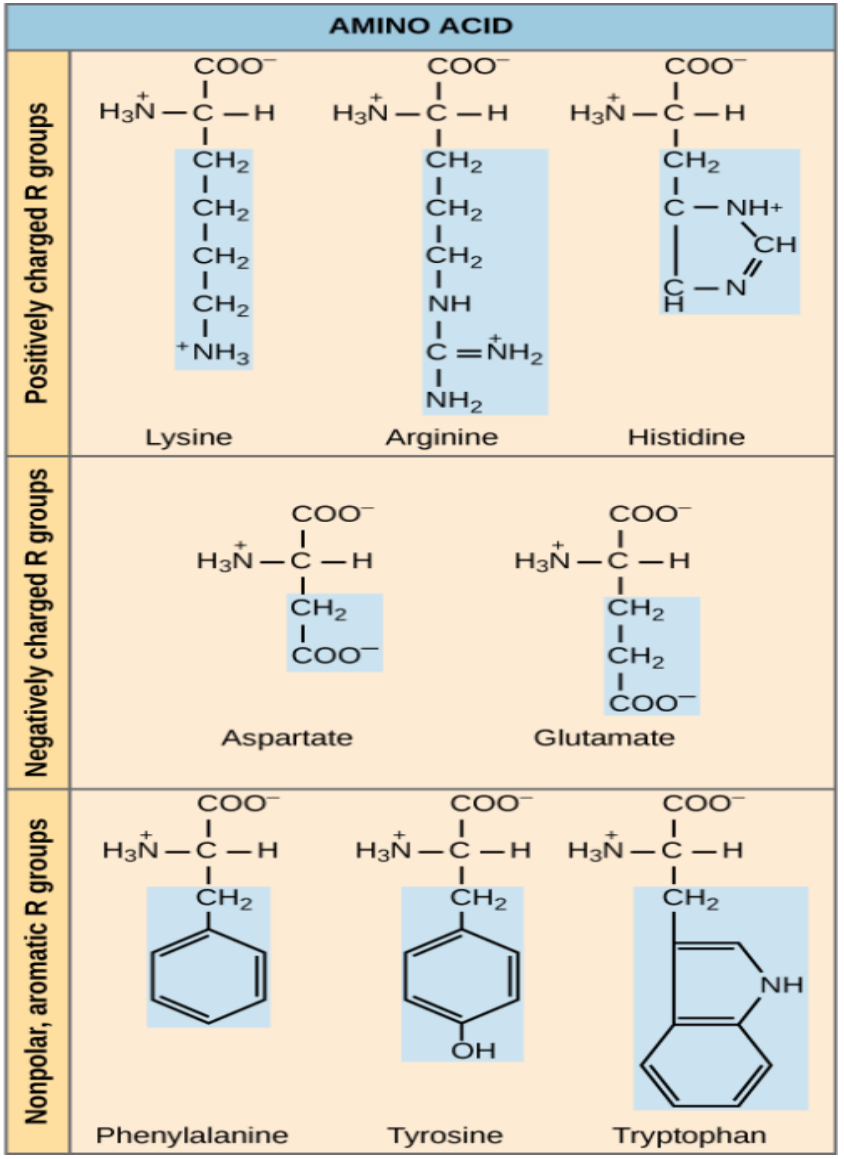
- Proteins are extremely important substances that are needed to form all living cells.
- Contain the elements **carbon, hydrogen** and **oxygen** but also contain **nitrogen** and **sulphur.**
- Protein requires a **templates molecule** for its synthesis.
- Protein molecules are polymers of **amino acids.** However, there are usually twenty different amino acids in any given protein
- Formed by amino acid condensation and a molecule water is released

Typical amino acid structure

- All amino acid have to four chemical groups attached to **α-carbon (central carbon)**
  1. **A hydrogen atom**
  2. **An amino group (–NH2)**
  3. **A carboxyl group (–COOH)**
  4. **An 'R' group (side chain)**
- Different amino acid have different 'R' group

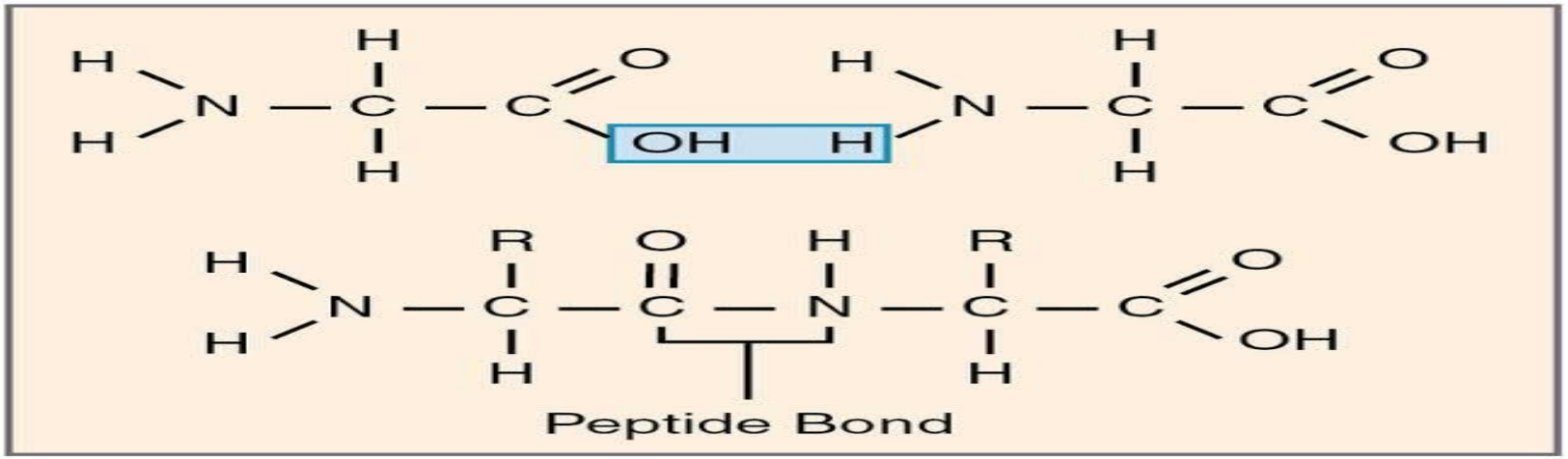



AMINO ACID
Nonpolar, aliphatic R groups
Glycine
Alanine
Valine
Leucine
Methionine
Isoleucine
Polar, uncharged R groups
Serine
Threonine
Cysteine
Proline
Asparagine
Glutamine


AMINO ACID
Positively charged R groups
Lysine
Arginine
Histidine
Negatively charged R groups
Aspartate
Glutamate
Nonpolar, aromatic R groups
Phenylalanine
Tyrosine
Tryptophan

Contd.

- **Amino acids** are a building block of protein with two functional groups with opposite charges:
  1) the amino group - a base
  2) the carboxyl group- an acid
- **Peptide bond** is the bond that link two amino acids.
- The '**H**' from the **amino group** on one amino acid and **'OH'** from the **carboxyl group** on the other amino acid **are lost as water during peptide bond formation.**



Proteins have a range of functions; they are important in:

a) **Protein provide structure:** they are structure of**:**
   - Plasma membrane (such as channel, carrier and receptor protein)
   - Connective tissue (collagen)
   - Hair and nail (keratin)
   - Chromosome (histone)

b) **Regulate body metabolism ;**
   - Enzymes are protein that speed up the rate of chemical reaction in cell.

c) **Transport and store molecule**.
   - Hemoglobin is a complex protein transport oxygen throughout the body.

d) **The immune system** ;
   - Antibodies are proteins that defend the body against foreign antigen.

Level of organization in protein structure

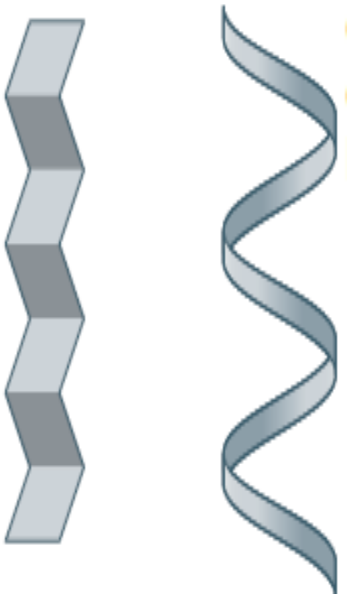
Primary structure

- The sequence of amino acids in a **polypeptide chain**. **E.g. Insulin**

Secondary structure

- The secondary structure is formed by folding of the primary structure into either an α-helix or a β-pleated sheet
- α-helix or a β-pleated sheet are held in shape by **hydrogen bonds**
- The two most common secondary structure are an **α-helix** or a **β-pleated sheet**

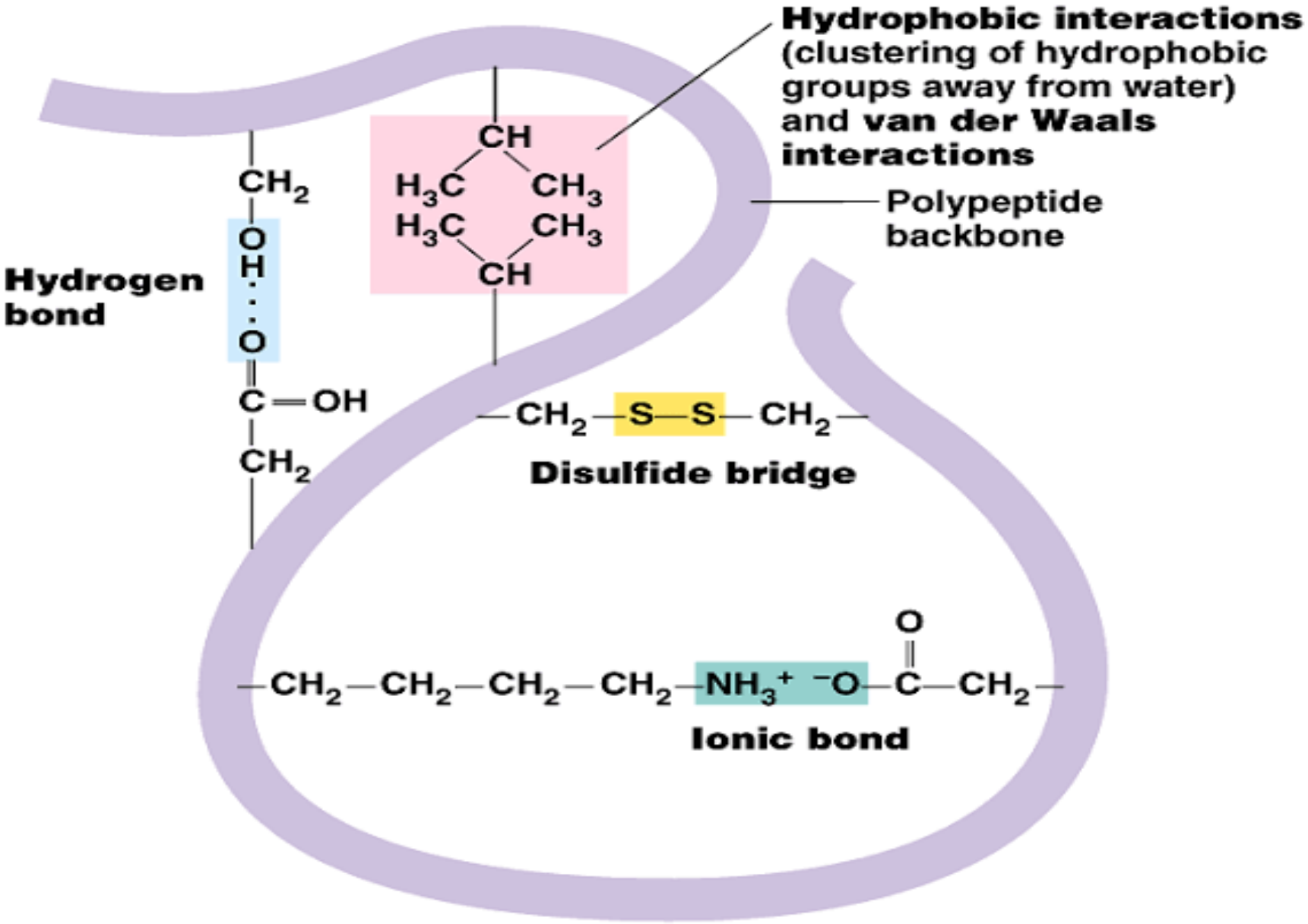
β-Plated sheet **α-Helix**



1) **α-helix** a coiled secondary structure of a polypeptide
   - H-bond occur between atoms with in the same poly peptide chain
2) **β-pleated sheet** a folded secondary structure of a polypeptide
   - H-bond takes place between poly peptide chain

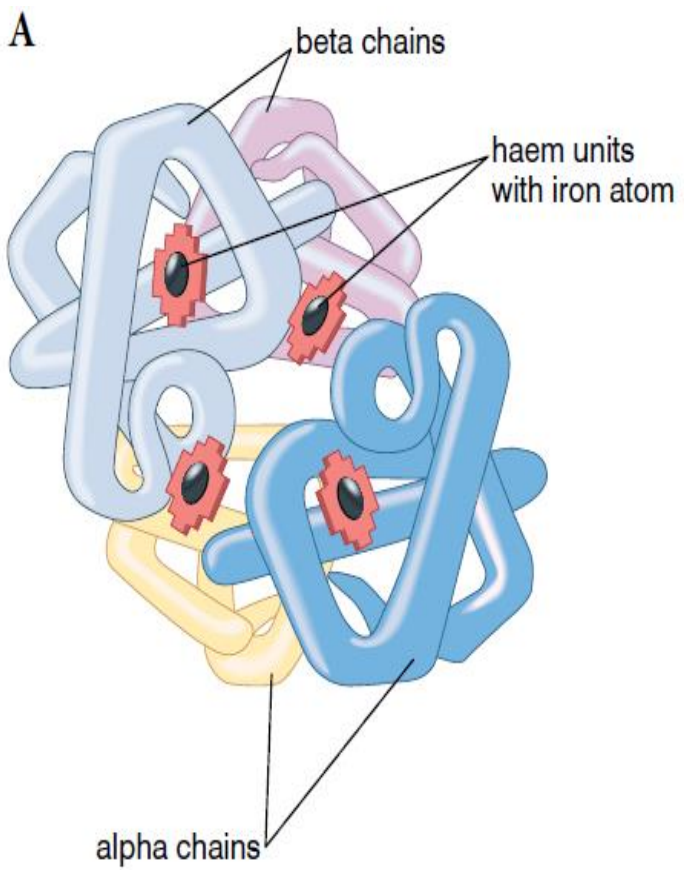
Tertiary structure

- Involves three dimensional folding of the secondary structure
- The new bonds to hold the tertiary structure in place includes;
  - **Hydrogen bonds** – between the R-groups of some amino acids
  - **Disulphide bridges (S-S)**– between amino acids that contain sulphur
  - **Ionic bonds** – between amino acids with positively & negatively charged R-groups
  - **Hydrophobic interaction**
- The tertiary structure of a protein gives each protein a specific function. For example:
  - the shape of the active site of an enzyme
  - the shape of a hormone receptor in the plasma membrane
  - the shape of an antibody to destroy just one antigen



Quaternary structure.

- Quaternary structure structures is formed when **two or more polypeptide chains** folded into a tertiary structure become associated in the final structure of the protein
- Different polypeptide chain are arranged together by **ionic** and **H-bond** between polypeptide chain
- Two important examples are;
  - **Hemoglobin**
  - **Collagen** (the fibrous protein found in many tissues in mammals).



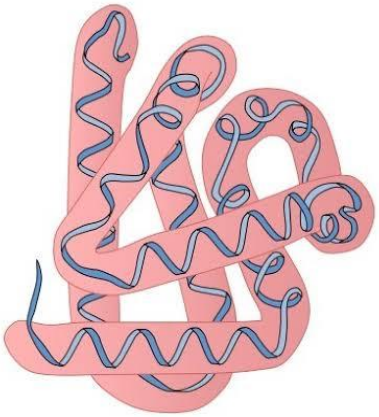
Hemoglobin molecule

Proteins are classified into two main groups, according to their molecular shapes:

Proteins are classified into two main groups, according to their molecular shapes:

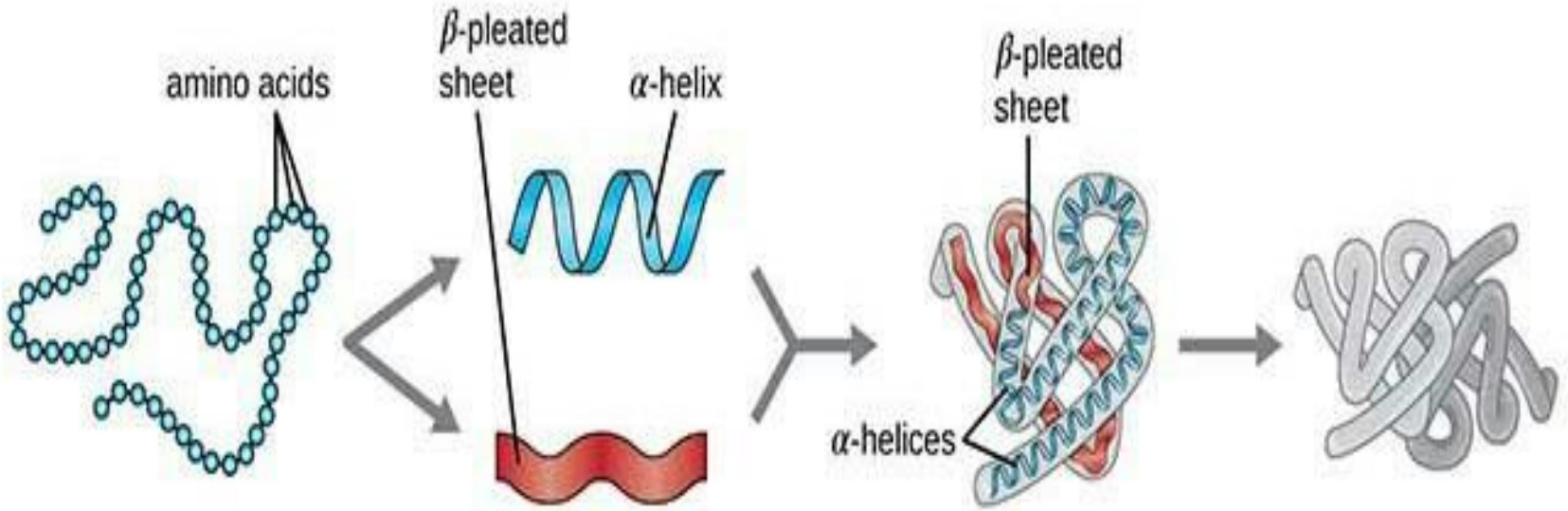
1. **Fibrous proteins;** a long thread like structure, have structural role that have a tertiary structure that resembles a long string or fiber
   - (e.g. **collagen-bone, keratin-hair** and nail**,** **tubulin-**cytoskeleton and **actin-**muscle)
2. **Globular proteins;** resembles a glob or ball shaped
   - E.g. **Enzymes, insulin, hemoglobin, immunoglobulin** and **receptor proteins**.

Fibrous protein



Globular protein

Protein structure



Primary Protein Structure
Sequence of a chain of amino acids

Secondary Protein Structure
Local folding of the polypeptide chain into helices or sheets

Tertiary Protein Structure
three-dimensional folding pattern of a protein due to side chain interactions

Quaternary Protein Structure
protein consisting of more than one amino acid chain

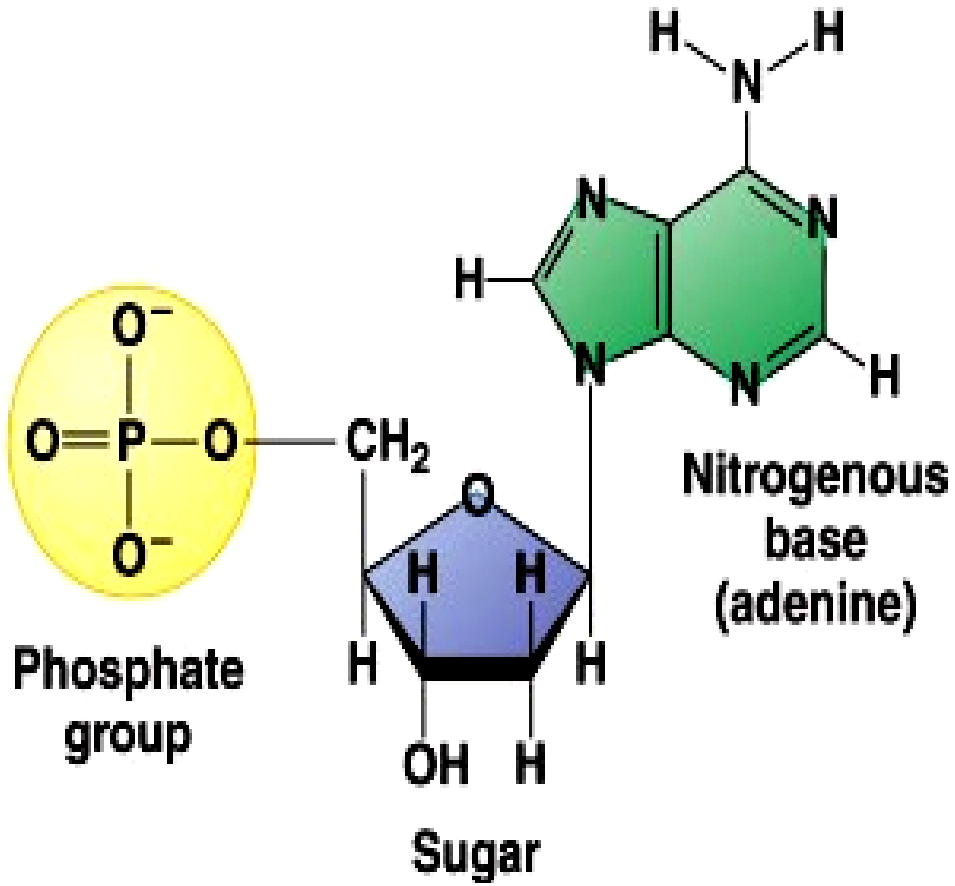
IV. NUCLEIC ACIDS

- Nucleic acid are the forth major organic compound.
- They are molecule which make up genetic material of the cell.
- Nucleic acids allow organisms to transfer genetic information from one generation to the next.

- There are two class of nucleic acids found in cells
  - **DNA** or **Deoxyribo nucleic Acid**
  - **RNA** or **Ribonucleic Acid**:
- All nucleic acids are made up of the same monomer called **nucleotides**
- Nucleic acids are **a polymer** of **nucleotides**

Components of nucleotides

- Nucleotides made up of three components:
  - **Phosphate group**
  - **Pentose sugar**
  - **Nitrogenous bases**
- Phosphate group and nitrogenous base are covalently bonded to sugar

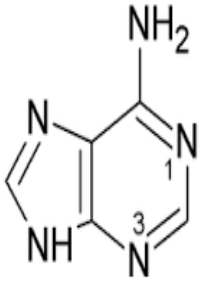


Two types of nitrogenous bases

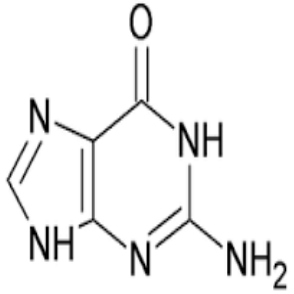
1) **Purine**
   - Have double ring
   - **Adenine** and **Guanine**

2) **Pyrimidine**
   - Have single ring
   - **Cytosine, Thymine, Uracil**

Purine

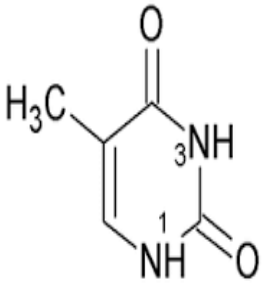


Adenine

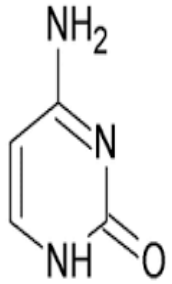


Guanine

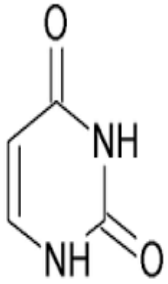
Pyrimidine



Thymine



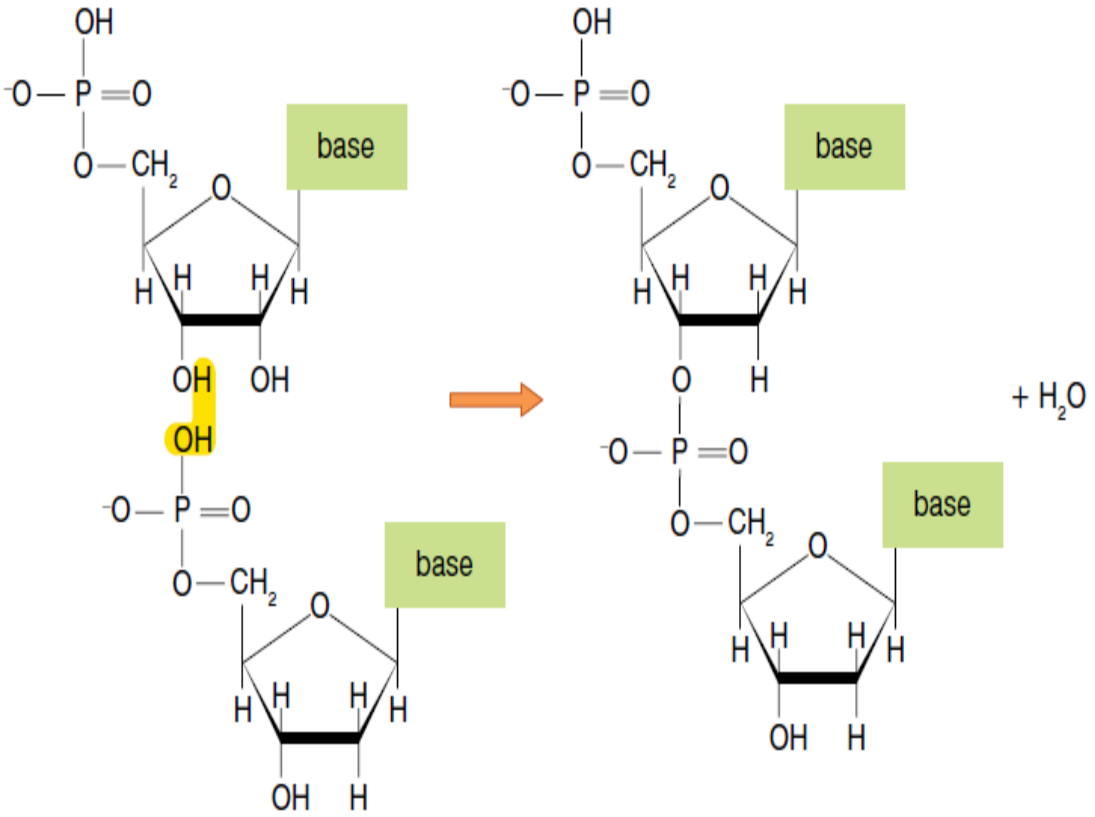
Cytosine



Uracil

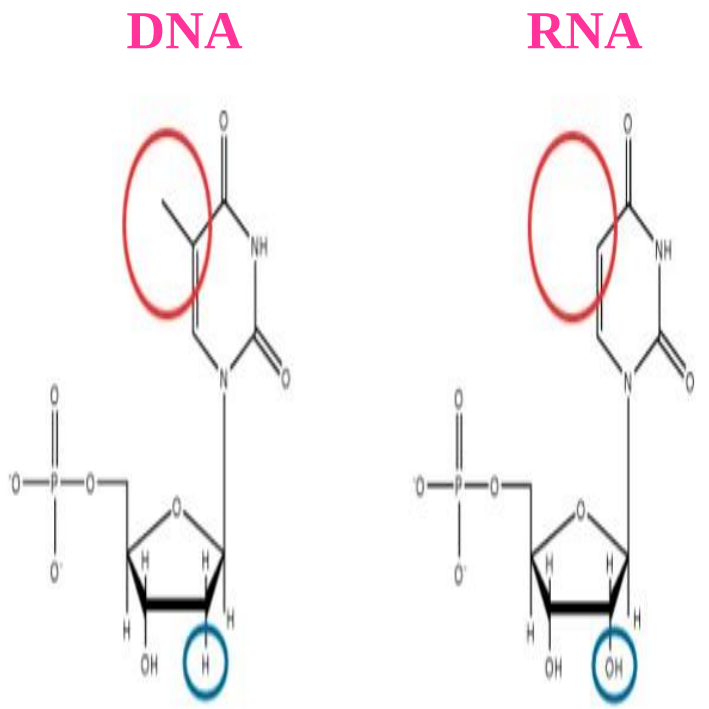
Phosphodiester bond formation

- **Phosphodiester bond** is the bond that link two nucleotides The '**H**' from the **sugar** on one nucleotide and '**OH**' from the **phosphate** on the other nucleotide **are lost as water** during **phosphodiester bond formation.**

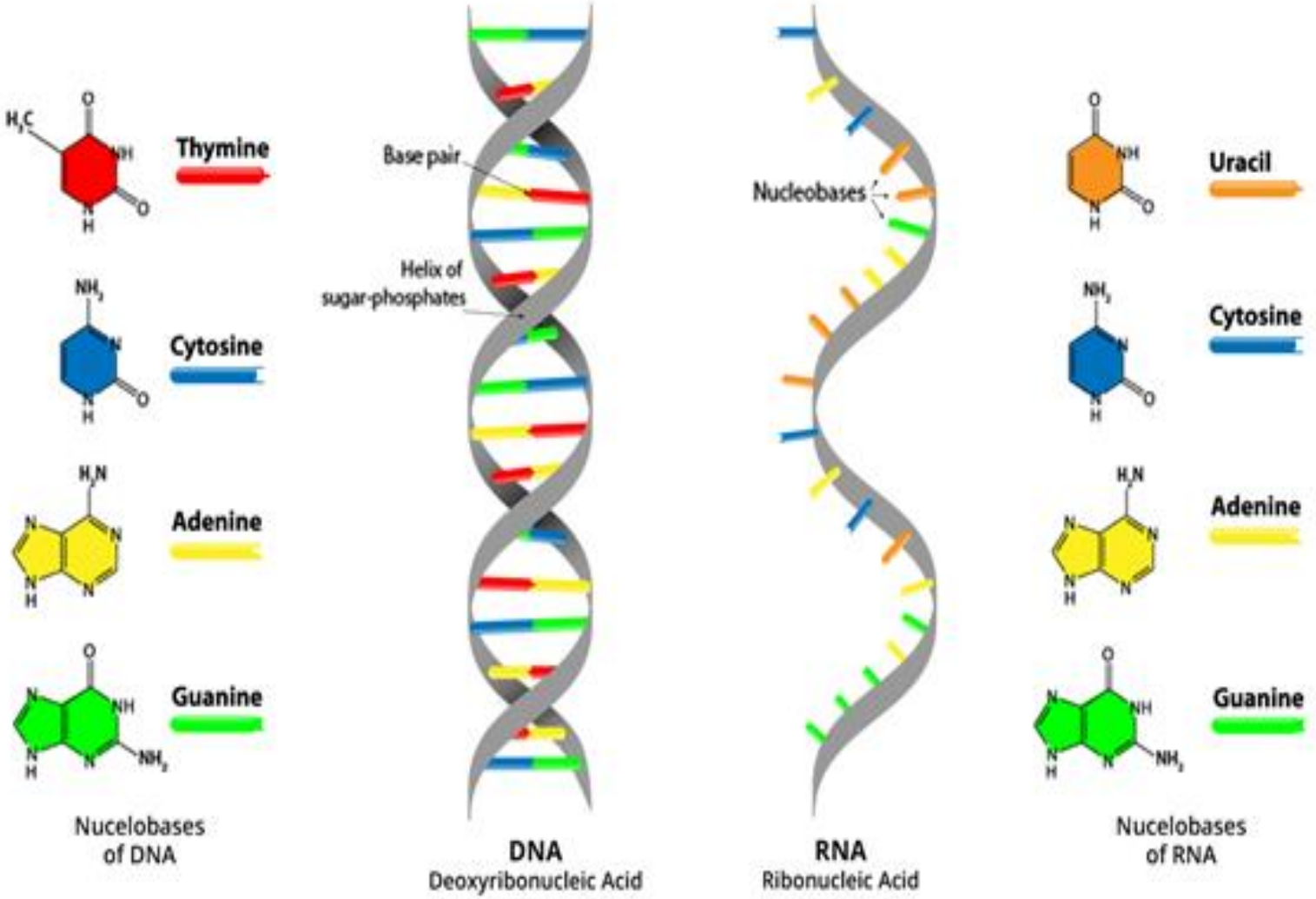


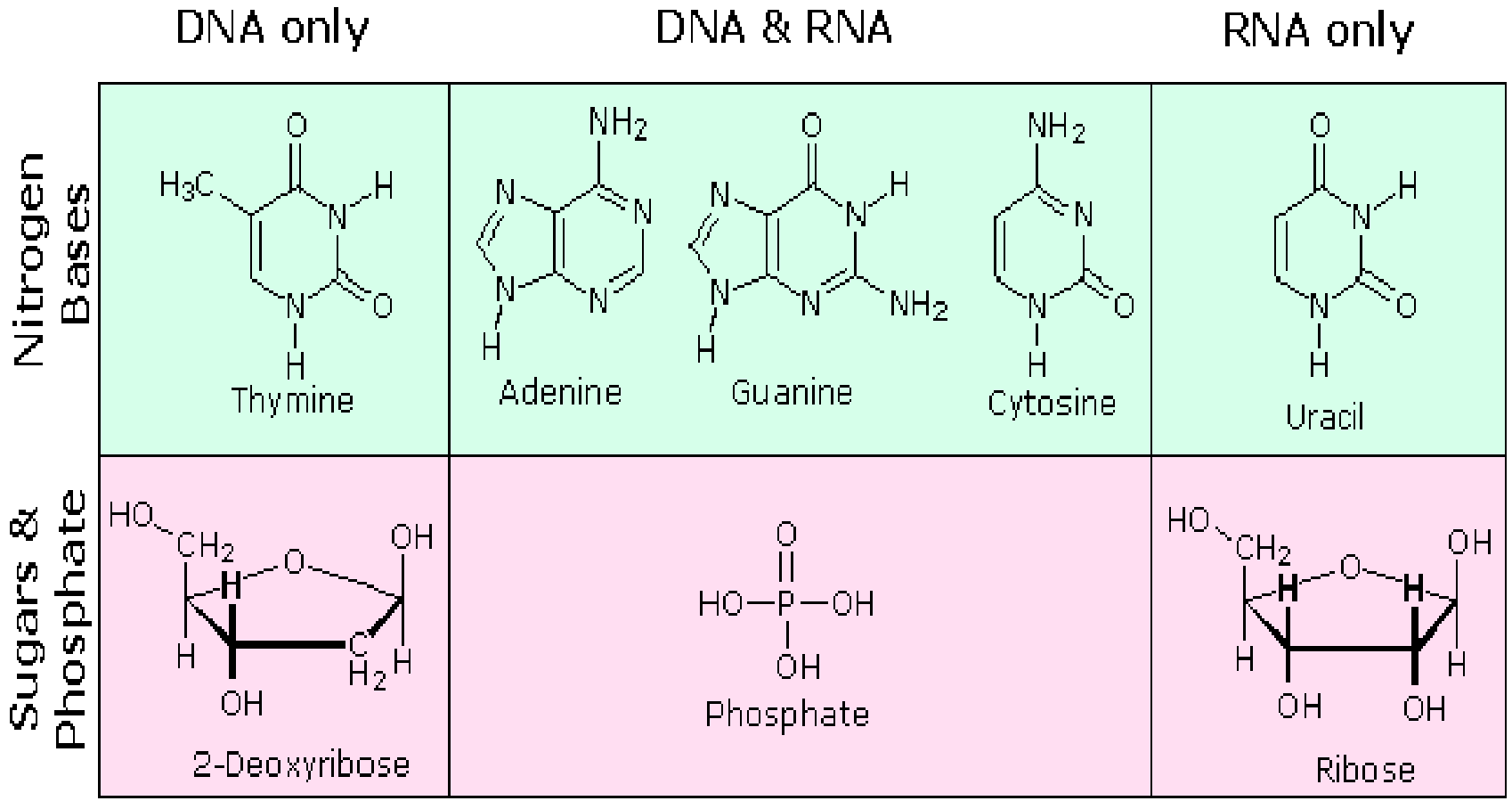
Two class of nucleic acids

- **DNA or Deoxyribo Nucleic Acid**
  - DNA nucleic acid containing the genetic information
  - DNA is made up of **two polynucleoti chain**.
  - DNA molecule has twisted double he structure
  - DNA back bone is made of **deoxyribose sugar** and **phosphate**.
- **RNA or Ribonucleic Acid**
  - RNA composed of a **single polynucleotide chain**
  - RNA found both in the nucleus and th cytoplasm.
  - RNA is much smaller



The structure of DNA and RNA




DNA only
DNA & RNA
RNA only
Nitrogen Bases
Sugars & Phosphate
Thymine
Adenine
Guanine
Cytosine
Uracil
2-Deoxyribose
Phosphate
Ribose

Feature	DNA	RNA
Structure	➢ Double stranded molecule	➢ Single stranded molecule
Sugar	➢ Deoxyribose	➢ Ribose
Nitrogen bases	➢ Adenine, Thiamine, Cytosine and Guanine	➢ Adenine, Uracil, Cytosine and Guanine
Location	➢ Found in nucleus and mitochondria	➢ Found in nucleus and cytoplasm
Size	➢ Huge.	➢ Much smaller.
Stability	➢ Very stable	➢ Less stable
Function	➢ DNA replicates and stores genetic information	➢ RNA transfer genetic information from the nucleus to ribosome to make protein
Base pair	➢ (Adenine - Thymine) ➢ (Cytosine -Guanine)	➢ (Adenine-Uracil) ➢ (Cytosine-Guanine)

Food test

Food	Reagent used	Positive result
Carbohydrates		
❖ Starch	❖ Iodine solution	❖ **Blue black color**
❖ Reduced sugar. E.g. glucose	❖ Benedicts solution	❖ **Orange /red** / precipitates
❖ Non-Reduced sugar. E.g. sucrose	❖ Benedicts solution and hydrochloric acid	❖ **Orange /red /** precipitates
Proteins		
❖ Biuret test	❖ Biuret reagent	❖ **Purple color**
Lipids		
❖ Emulsion test	❖ Ethanol solution	❖ White or cloudy layer ❖ **Milky suspension**

- ***Reducing sugars will act as reducing agents in an alkaline solution because reduce copper (II) ions (blue) to copper (I) ions (brick red)***