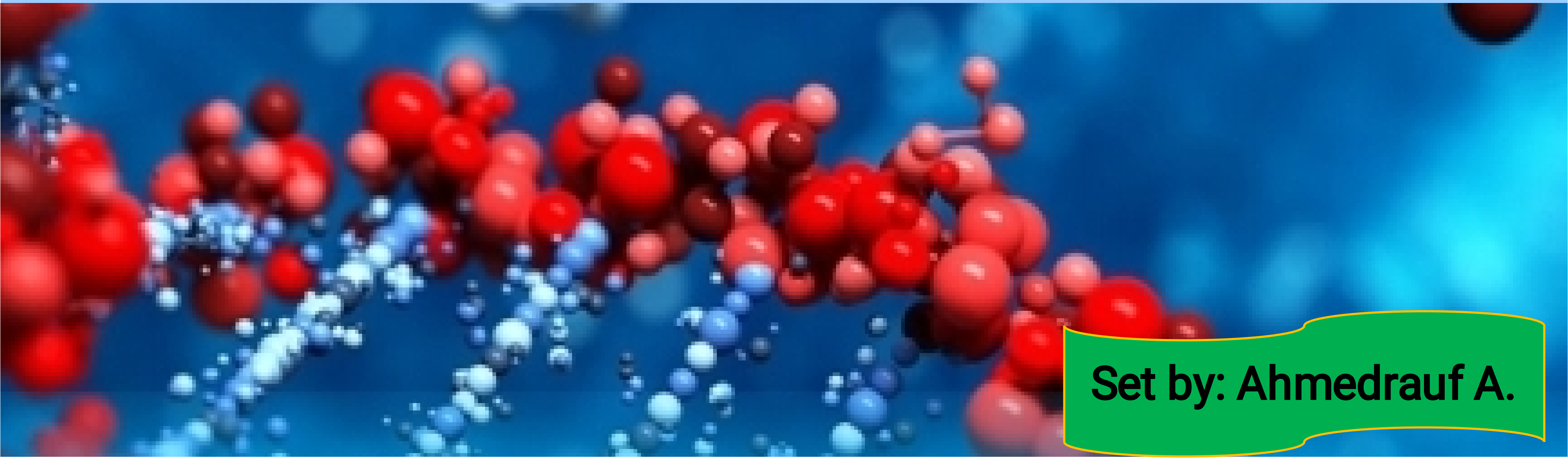
BIOLOGY GRADE 10

UNIT 3

Biochemical molecules



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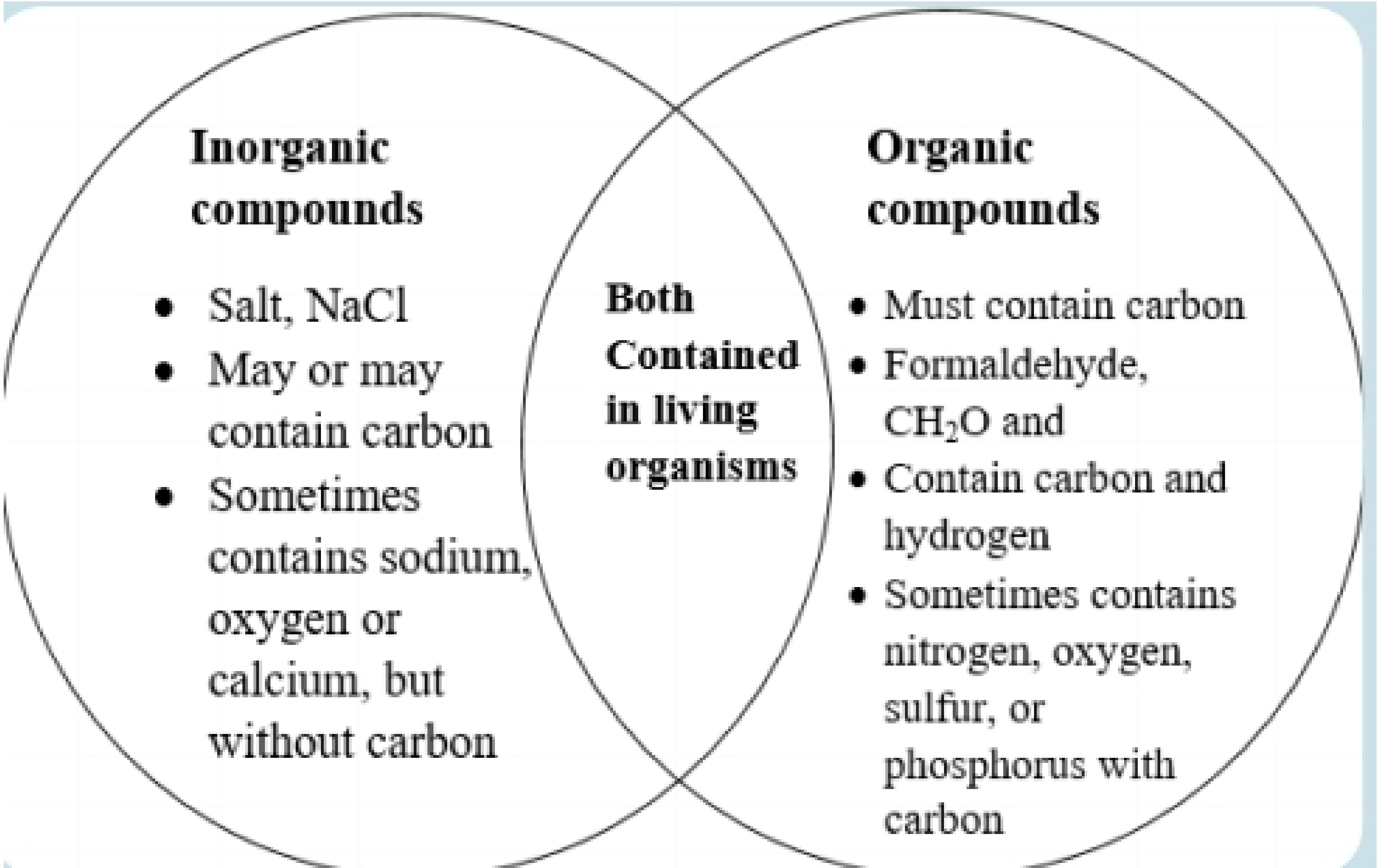
3.1. Biochemical Molecules

- Are contained in living organism
- Our body is made up of two types of biochemical molecules:

✓ organic and

✓ inorganic molecules.



1. **Inorganic molecules** do not contain carbon and were not created through biological means except oxides ($CO2$, CO) and carbonate ions (HCO_3 , $NaCO_3$).

- do not contain both carbon and hydrogen simultaneously (contain either hydrogen or carbon).
- Many inorganic compounds include hydrogen atoms
- EX. H_2O and HCl
- Only a few inorganic compounds contain carbon atoms.
- One of such examples is carbon dioxide (CO_2).

2. **Organic molecules** are made up of both carbon and hydrogen atoms.

- Covalent bonds are used to make organic compounds in living creatures, including the human body.

❖in your body

- Carbon are the second most abundant element
- Hydrogen is the third most abundant element.

3.1.1 Inorganic molecule: Water

The properties of water

- Water is composed of two elements: hydrogen and oxygen.
- H_2O is its chemical formula.
- composed of two hydrogen atoms linked to a single oxygen atom.
- Life would not exist on our planet if it did not have access to water.
- 70 to 95 percent of the cells mass.
- You are around 60% water.
- Water covers three -quarters of the planet and on the remaining one-quarter, which is land,
- Water is a polar molecule: because of unequal sharing of electrons between H & O.
- This unequal electron sharing creates two electric dipoles in the water molecule

✓ O_2 bears partial –ve charge and

✓ H bears partial +ve charge

- In the O-H bonds in water, oxygen is more electronegative than hydrogen.
- The polarity of water has important chemical implications conferring its typical properties.
- Another important consequence of the polarity of the water molecule is that water molecules attract one another.
- hydrogen bond is formed between H of one water & O of other water molecule.

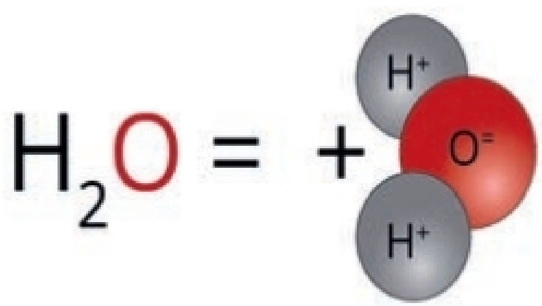


Figure 3.1 Structure of water molecule

☆ Some typical properties of water are:

1. Water as a solvent

- Water is an effective solvent for ions and polar molecules such as sugars and glycerol
- because the water molecules are attracted to the ions and polar molecules, causing them to congregate and separate.
- Water has the ideal / best viscosity for a transport medium.
- **Viscosity** is a measure of how fluid a liquid is - how easily it flows.
- non-polar molecules such as lipids are insoluble in water.
- if surrounded by water, tend to be pushed together by the water,

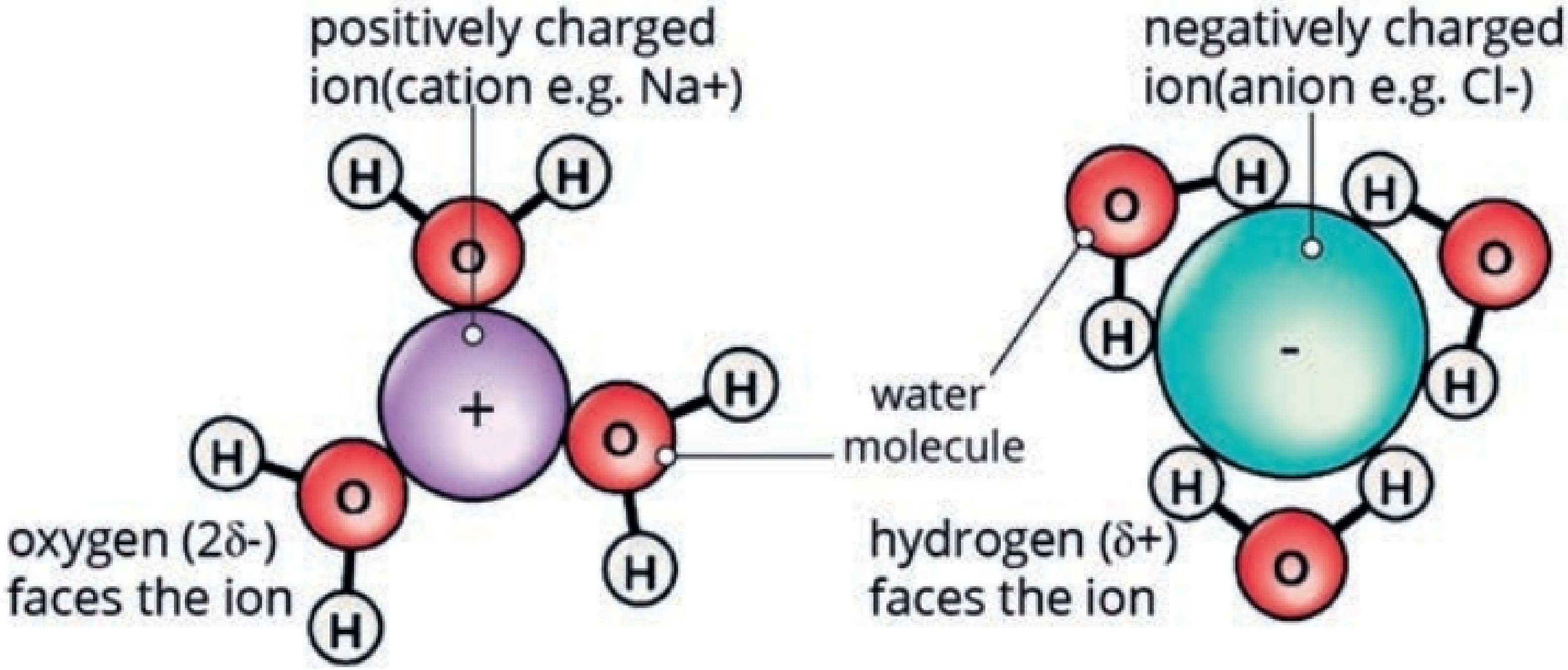


Figure 3.2 Distribution of water molecules around ions in a solution

2. High specific heat capacity

- It is the amount of heat energy necessary to raise the temperature of one kilogram of water by one degree Celsius.
- Or it takes quite a **lot of energy** to heat water up.
- Water also loses heat **quite slowly**.
- The heat capacity of water is rather high.
- To raise the temperature of a liquid, the molecules must obtain energy and so move more quickly.
- Water's high heat capacity has crucial biological results since it makes the water more resistant to temperature changes.

3. High latent heat of vaporization

- It is energy required to vaporize a liquid, converting it from a liquid to a gas. (energy required to transform liquid water into water vapour).
- Water has a comparatively high latent heat of vaporization.
- This is due to its high heat capacity.
- In turn this means that water doesn't vaporise too easily and that ponds don't dry up too quickly in hot weather.
- the organisms in the pond have a better chance of survival.

4. Density and freezing properties

- Water is a unique molecule in that its solid form,
- **ice**, is less dense than its **liquid** form.
- **Water density** begins to fall below **4°C**.
- As a result, ice floats on liquid water and insulates the water beneath it.
- This is because water expands when it freezes.
- So, in cold weather, water freezes from the top down.
- So life can continue in relatively warm water underneath the ice all through the cold weather.

5. High surface tension and cohesion

- Water molecules have very high **cohesion**; in other words, they tend to stick to each other.

➢ Cohesion: the attraction of water molecules to each other.

➢ Adhesion : attraction of water molecules to other molecules.

- This attraction can be stronger than water’s cohesive forces, when the water is exposed to charged surfaces (**capillary tubes).**
- Water “climbs” up the tube placed in a glass of water, causing the water to look higher on the sides of the tube than in the middle.
- This causes **Capillary action.**
- High cohesion also results in high surface tension at the surface of the water.
- This allows **raft spiders**, to exploit the surface of the water, allowing them to settle on or skate over its surface.

- **Capillary action** causes the water within a narrow tube to rise above the surrounding water;
- the adhesion of the water to the glass surface, which draws water upward, is stronger than the force of gravity, which tends to draw it down.

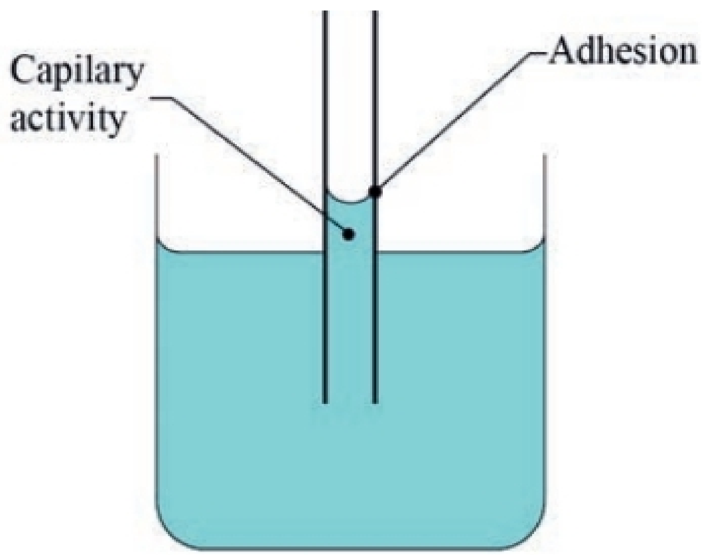


Figure 3.3 Cohesion and adhesion (H2O)

Figure 3.4 Surface tension allowing Raft spider to walk on the water surface

6. Boiling and Freezing Points

- Despite its low molecular weight, it has a very high boiling point (100°C).
- water requires more energy to break its hydrogen bonds before it can begin to boil.
- The boiling and freezing points of water is important for aquatic ecosystems.
- If water is easily frozen or boiled, drastic changes in the environment would affect bodies of water such as oceans or lakes, killing all organisms that live in water.
-

Table 3.1 Boiling and freezing points of water

Compound	Boiling Point	Freezing Point
Ethanol	78.4°C	-114.6°C
Acetic acid	117.9°C	16.6°C
Hydrogen Sulfide	-62°C	-84°C
Water	100°C	0°C

3.1.2 Inorganic ions

- Inorganic ions are charged entities because they are atoms with unshared electrons in their outer shell.
- They are either positively or negatively charged.
- They are virtually usually coupled with an oppositely charged ion.
- Inorganic ions are found in living bodies in two forms:

✓ free and dissolved in the cytoplasm and

✓ associated with complex organic substances.

- They participate in a variety of critical functions in living things.
- Any variations in their concentration inside the human body can have catastrophic implications.
- Inorganic ions in the context of the human body, referred to as minerals.

❖ Classification of inorganic ions

- Based on their requirement in the daily diet of a normal individual inorganic ions or minerals in the human body are divided into two categories;

✓ **Macro-nutrients** – nutrients that your body requires in bigger quantities such as carbohydrates, proteins & fats.

- these gives our bodies **energy** or **calories**.
- requires to grow & function normally.

✓ **Micro-nutrients** - nutrients that your body requires in small amounts such as vitamins & minerals.

- gives our bodies to **be healthy** & **digest** those macronutrients.

Table 3.2 Macro and micro-nutrients in living systems

Macro-nutrients: required in bigger quantities in the daily diet	Micro-nutrients/trace elements: required in small amounts
Sodium, Phosphorus, Magnesium, Potassium, Sulfur, Chloride	Iron, Copper, Iodine, Manganese, etc

❑ Hydrogen ions

- ✓ The most important ions to maintain balance & equilibrium in living systems.
- ✓ are found in the cytoplasm of cells and body fluid {intercellular fluid, blood, cerebrospinal fluid(CSF)}
- ✓ The higher the pH, the lower concentration of hydrogen ions.
- ✓ The higher the hydrogen ion concentration, the more acidic the solution & the lower the pH.
- ✓ it form HCl in stomach

❖ **Importance of hydrogen ions in cells:**

- ✓ Enzyme action – the preservation of normal pH is critical for all metabolic processes that occur in a cell.
- ✓ ATP synthesis - hydrogen ions are also used in the cellular synthasis of ATP.
- ✓ Oxygen delivery – the presence of hydrogen ions in the blood aids haemoglobin in delivering oxygen to the cells.

❑ Sodium ions (Na+)

- Is the body's second most important positively charged ions.
- Higher concentration in extracellular fluid and low concentration within cell cytoplasm (the conc. of Na+ in extracellular fluids is higher than in cell cytoplasm).
- It is an extracellular cation
- It is a critical nutrient that must be consumed in order for human body to function normally.
- The average person's salt need is between 3 & 6 grams per day.
- **Source** is common salt found in our foods.
- Average sodium intake exceeds the body's requirements.
- The urines of the body eliminate excess salt to maintain normal blood pressure.
- in patients with high blood pressure, lesser salt intakes are required.

❑ Potassium ions (K+)

- Are positively charged ions abundantly present in bodies.
- Are the major intracellular cations
- Higher concentration within cell cytoplasm and low concentration in extracellular fluid.
- Potassium is one of the body's electrolytes that carry on electric charge when dissolved in body fluid such as blood.
- The average must intake 3 to 4 grams of potassium daily.
- **Source** is in bananas, oranges, potatoes, chicken & liver.
- Potassium is necessary for the normal functioning of cells, nerves and muscles.

❑Calcium ion (Ca+)

- Is the most abundant inorganic ion present in our body.
- **Ca+** mainly present in cytoplasm of cells. (intracellular)
- Bones and teeth are the major organs having a lot of calcium (99% of calcium).
- Calcium makes around 1 to 1.5 kg of our body weight.
- Around 1% of calcium is in cytoplasm of other cells & extracellular fluid.
- The calcium requirements of a healthy human are around 800 mg/day.
- **Source** milk and milk products, leafy vegetable, egg yolk, fish and beans.
- It’s used in regulating almost all biological functions of the body such as the heart & muscle concentration, neuro information transmission.

❑ Phosphate ions (PO4-)

- Are negatively charged inorganic ions abundantly present in our bodies.
- It is more abundantly present in the cells.
- The body of an average man contains around 1 Kg of phosphate ions.
- Its requirements are equivalent to calcium.
- Mostly present combined with calcium in bones & teeth.
- An adult male needs to take 800 mg of phosphate ions daily in his diet.
- The plasma concentration of phosphate ions is around 3-4 mg/dl.
- Sources : milk, cereals, meat & eggs.

❑ Chloride ions (Cl-)

- Negatively charged ions present in extracellular fluids.
- Its concentration almost similar to that of sodium ions
- Average daily requirement is 5 to 10 grams.
- It is usually taken along with sodium in the form of NaCl present in cooked food.

- Perform their role combine with sodium ions.
- They are involved in maintaining the osmotic pressure, fluid balance, and acid-base balance in our body, just like sodium
- Required to make HCl (to digest proteins in the stomach, kills bacteria and other pathogens in food)
- Activates Salivary amylase (enzyme that digest starch)

❑Iron ions

- 70% of iron ions in our body are present in haemoglobin (in RBC)
- Component of haemoglobin & myoglobin(in muscle),
- iron is needed for transport of oxygen & CO2 in our body.
- An essential component of cytochromes that are component of electron transport chain.
- A component of the peroxidase enzyme (in lysosomal) w/c necessary for bacteria & phagocytosed particles in WBCs.
- Source of iron : legumes such as bean, red meat, liver, spinach, pumpkin seeds, fish, etc.

❖ Three clinical conditions

✓ Iron-deficiency Anemia: in individuals with an iron deficient diet.

✓ Hemosiderosis : excess iron in the body.

✓ Hemochromatosis: abnormal iron deposition in liver, spleen, skin & pancreas.

❑Copper ions

- Are needed for the synthesis of haemoglobin, collagen & elastin.
- Required for the normal development of the nervous system.
- Source: shellfish, seeds & nuts, organ meats, wheats, whole-grain, chocolate, etc.
- Wilson disease abnormal copper deposition in the liver and brain (hepatic cirrhosis & brain damage).
- The copper deposition in kidneys can cause renal failure.

❑ Iodine ions

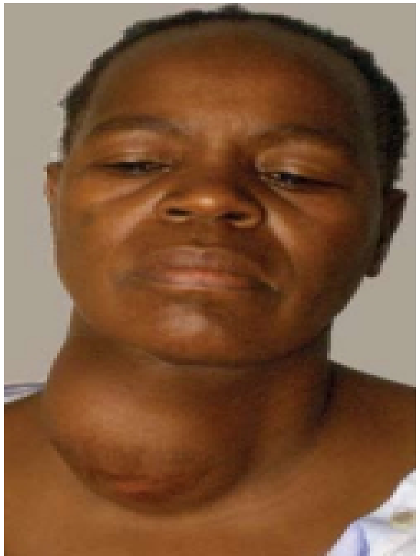
- Found naturally in the earth's soil and ocean waters.
- Thyroid gland regulate hormone production
- These hormones control metabolism, heart health, etc.

- Iodine ions required for the normal body function in adolescents & adults is 150 kg/day.
- **Source** : dairy products, fortified foods, & salty water fish.
- Also available in plant foods that grow in naturally iodine-rich soil.
- Can get by adding iodized salt in your food.
- Iodine deficiency: thyroxin hormone production can decrease.

➢ **Hypothyroidism** : “low” or underactive thyroid gland.

➢ **Hyperthyroidism** : is an over-active thyroid gland.

➢ **Goiter** : is an enlarged thyroid gland as a result of Hypothyroidism or hyperthyroidism.



3.1.3 Organic molecules

- An organic molecule is a compound that contains both carbon and hydrogen and in living things.
- Carbon forms the basis of organic life :- because of its ability to form large & complex molecules by covalent bond.
- Four principal groups of organic compounds :-

✓ Carbohydrates

✓ Lipids

✓ Proteins

✓ Nucleic acids

- Organic molecules are made up of monomers (single molecular units).

❖ **Monomers** link to form polymers through a chemical reaction called a **condensation reaction**.

- Each time a monomer is added to a polymer, a water molecule is released.
- **Monomers** are connected by strong **covalent bonds** to create polymers.

❖ **Polymers** are long chains of molecules formed of many single units bonded one after the other.

- **Large polymers** are called **macromolecules**.

Table 3.3 Elements and monomers forming organic molecules

Organic molecules	Elements forming the molecule	Monomer
Proteins	C, H, O and N	Amino acids
Lipids	C, H, O	Glycerol and fatty acid
Carbohydrates	C, H, O	Monosaccharides Glucose Galactose Fructose
Nucleic acids	C, H, O, N and P	Nucleotides

❖ Carbohydrates :

- Are macromolecule which most consumers are somewhat familiar.
- Natural sources of carbohydrates :- grains, fruits, & vegetables
- Carbohydrates provide energy to the body, particularly through glucose, a simple sugar.
- A monomer of a carbohydrate is called monosaccharide.
- It made of three major elements; carbon, hydrogen, and oxygen.

- **Three main groups of carbohydrates**; monosaccharides, disaccharides, and polysaccharides.

A. Monosaccharides

- Greek mono, “single” + Latin saccharum, “sugar”.
- Are dissolve quickly in water, forming sweet-tasting solution.
- Simplest form of sugar & the most basic units from which all carbohydrates are built.
- Monosaccharides are carbohydrate molecules that cannot be broken down into simpler carbohydrate molecules by a chemical process called hydrolysis.
- General formula $(CH_2O)_n = (C_nH_{2n}O_n)$
- Ratio of carbon to hydrogen to oxygen is 1:2:1
- Based on the number of carbon atoms they contain monosaccharides classified into

✓ Trioses (3C) $(C_3H_6O_3)$

✓ Tetrose (4C) $(C_4H_8O_4)$

✓ Pentoses (5C) $(C_5H_{10}O_5)$

✓ Hexoses (6C) $(C_6H_{12}O_6)$

- $C_6H_{12}O_6$ is the chemical formula(molecular formula) for hexose sugar.

- They all have different structural formula
- **Structural formula** show how the atoms are arranged.

❖ Isomers :- molecules with identical chemical formula but different structural formula

- Glucose, galactose and fructose are isomers of each other.
- **In fructose**, the double-bonded oxygen

is attached to an internal carbon rather

than to a terminal one.

✓ **Fructose** is found in fruits and is the sweetest of monosaccharides,

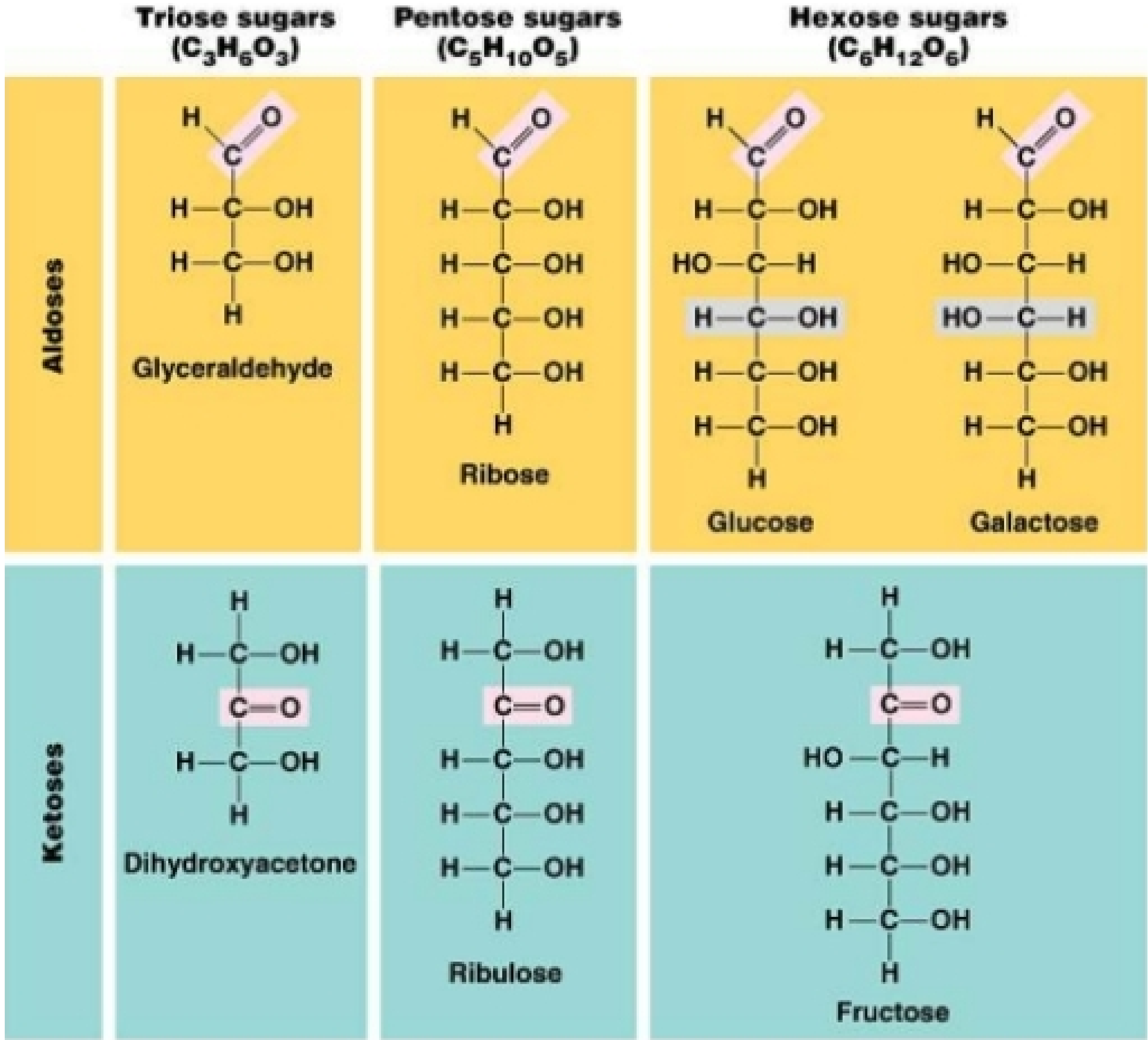
✓ **Galactose** is found in milk.

✓ **Glucose** is a main source of energy for cells.

- **There are two functional groups in monosaccharides:**

✓ the aldehyde group with the formula CHO (monosaccharides with this group are **aldoses**), and

✓ the ketone group, with the formula C=O (monosaccharides with this group are **ketoses**).


Triose sugars
($C_3H_6O_3$)
Pentose sugars
($C_5H_{10}O_5$)
Hexose sugars
($C_6H_{12}O_6$)
Aldoses
Glyceraldehyde
Ribose
Glucose
Galactose
Ketoses
Dihydroxyacetone
Ribulose
Fructose

Roles of monosaccharides in living organisms

Major functions of monosaccharide in include:

1. source of energy in respiration due to a large number of carbon-hydrogen bonds.

- These bonds can be broken to release energy which is used to make ATP from ADP and phosphate
- Most important monosaccharide in energy metabolism is glucose.

2. building blocks for larger molecules

- Glucose is used to make the polysaccharides (starch, glycogen, and cellulose)
- **Ribose** (a pentose sugar) is one of the molecules used to make RNA and ATP
- **Deoxyribose** (also a pentose sugar) is one of the molecules used to make DNA.

B. Disaccharides ($C_{12}H_{22}O_{11}$) (Greek di, "two").

- are formed when two monosaccharides undergo a dehydration synthesis (condensation reaction) by releasing a molecule of water (H2O),
- The bond that holds the two monosaccharide units together is a **glycosidic bond**.
- It is formed between carbon atom 1 of one α-glucose molecule and carbon atom 4 of the other α-glucose molecule.

➢ **In condensation reaction**, glucose and fructose combine to form sucrose.

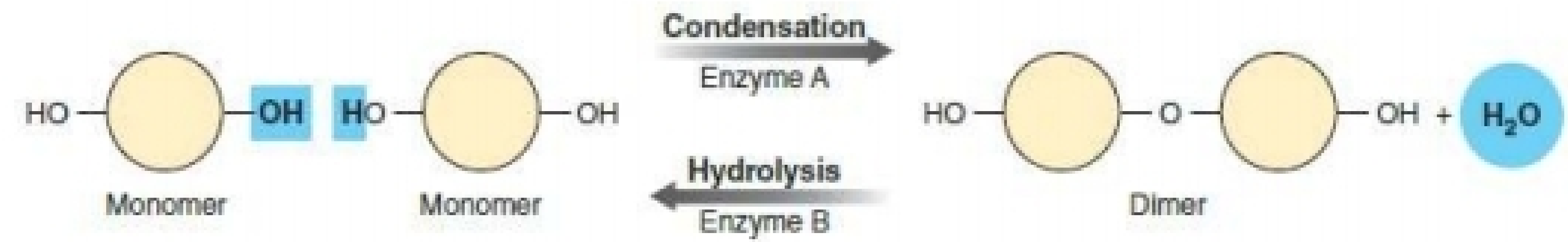
- The glucose molecule releases a **hydrogen ion** & the fructose molecule releases a **hydroxide ion**.
- The OH^- & H^+ ions that are released then combine to produce a H_2O.

➢ **In a hydrolysis reaction**, water is used to break down a polymer(sucrose) into glucose and fructose.

- Hydrolysis is the reverse of a condensation reaction.

▪ **The three most common disaccharides are** :

1. **Maltose** is derived from two α-glucose molecules (glucose + glucose)
2. **Lactose** is derived from a β-glucose molecule and an α-galactose molecule. (glucose + galactose)
3. **Sucrose** is derived from an α-glucose molecule and a fructose molecule (glucose + fructose)



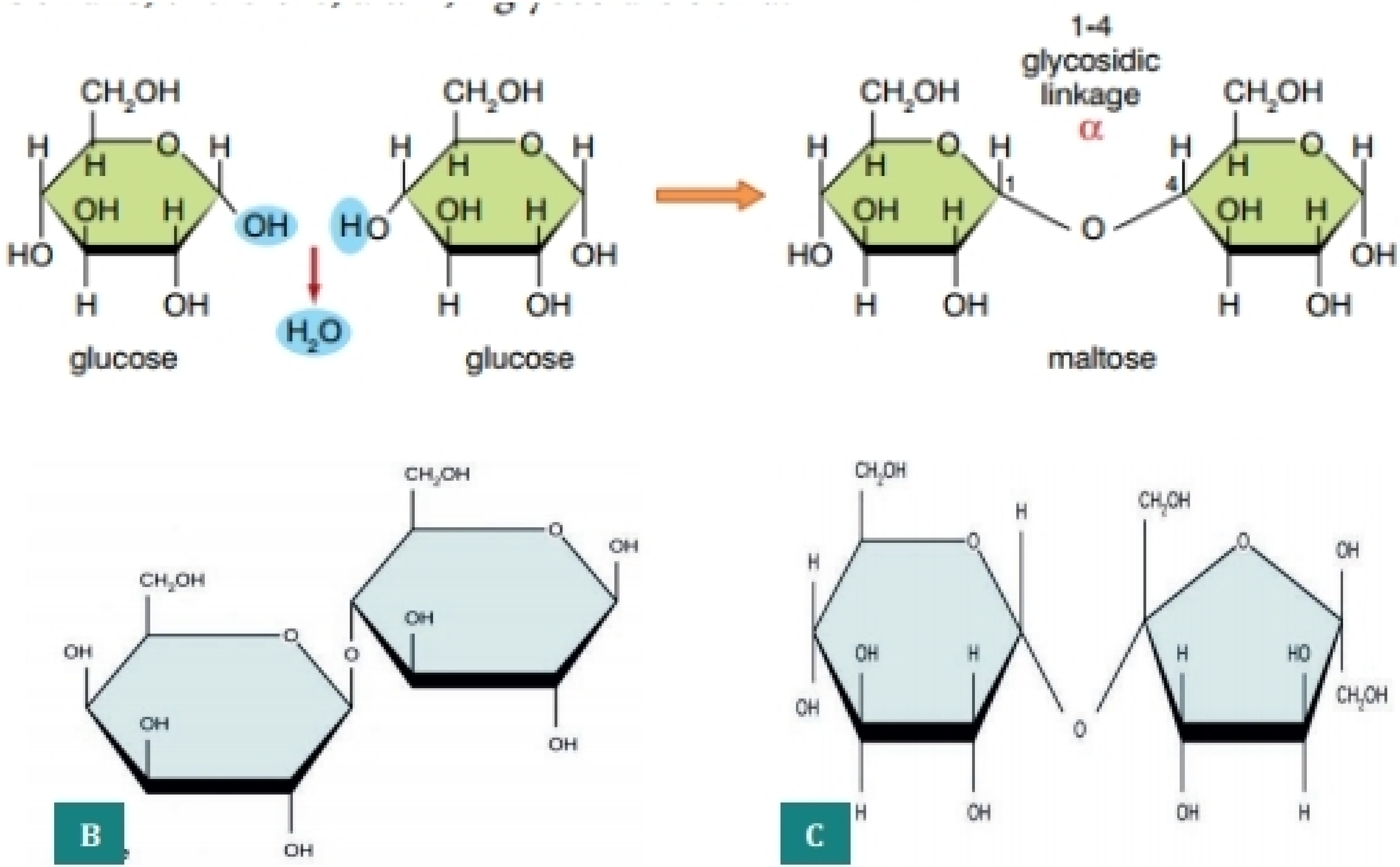


Figure 3.7 Disaccharides a) Maltose b) Lactose c) Sucrose

C. Polysaccharides -$(C_6H_{10}O_5)$-n

- Is a complex molecule composed of three or more monosaccharides.
- Are polymers of **monomer glucose**.
- The most common polysaccharides such as glycogen, starch, and cellulose, are all long chains of glucose, but they differ from one another by their branching patterns.

✓ **Starch** :- storage form of glucose in plants

✓ **Glycogen** :- storage form of glucose in animals

- Free glucose is reactive molecule and can disrupt normal cell chemistry (cell's osmotic properties.)
- Condensation reaction convert glucose to a storage polysaccharide (starch, glycolgen) which is a **convenient**, **compact**, **inert** (un-reactive) and **insoluble** molecule, avoiding damage these tissues.

➢ Starch [-($C_6H_{10}O_5$)]

- Plant's stored form of sugar
- are polymers of α-glucose
- Plants can produce glucose, excess is stored in **root** and **seeds** as starch.
- Animals ingest starch, break it down to glucose and utilize as a source of energy.
- Starch is a mixture of amylose and amylopectin.
- **Amylose** is a linear molecule containing many hundreds of α-glucose molecules joined by **α-1,4- glycosidic bonds**.
- Amylose is an unbranched polymer of αglucose.
- **Amylopectin** also has a linear 'backbone' of α-glucose molecules joined by **α-1,4-glycosidic bonds**.
- But in amylopectin, there are also side branches.

➢ Glycogen [-($C_6H_{10}O_5$)-n]

- Glycogen is made up of monomers of glucose
- are polymers of α-glucose
- Storage form of glucose in humans and animals (animals analogue of starch)
- Highly branched polymer that is often stored in **liver** and **muscle cells**.
- it can be hydrolysed even more quickly to release glucose for respiration.
- If glucose levels fall, glycogen is broken to release glucose.

➢ Cellulose [-($C_6H_{10}O_5$)-n]

- Cellulose is made up of glucose monomers.
- Or is a polymer of β-glucose molecules joined by **β-1,4-glycosidic bonds,** formed by condensation reactions.
- Naturally occurring biopolymer that is abundant.
- The cellulose molecule is unbranched.
- Cellulose make plant cell walls, which provides structural support to the cell.
- Examples of cellulosic materials wood and paper.
- Every glucose monomer in cellulose is densely packed as long as extended chains giving it **rigidity** and **strength** which are critical for plant cell.

❖ **Dietary fibers** is cellulose that passes through our digestive system.

- Human digestive enzymes cannot break down the glucose-glucose linkages in cellulose.
- Herbivores such as cow, buffalos and horses can digest cellulose.
- Certain bacteria live in these animals' rumens secrete cellulase which degrade cellulose into glucose.
- Despite their strength, cellulose fibers are porous, allowing water and solutes to pass between cell & its environment.

Major function of carbohydrates

1. The Primary source of energy for most organisms.

- Glucose in fruit juice, lactose in milk, starch in wheat, potato, rice etc.

2. A storage form of energy in the body.

- Starch in plants
- Glycogen in animals, bacteria, and fungi.
- In mammals up to 10% of liver mass and 1-2% muscle mass is glycogen.

3. cell membrane components that mediate intercellular communication.

4. the structural component of many organisms

✓ Cell walls of bacteria (glycoprotein)/peptidoglycan

✓ Fungi (chitin)

✓ Exoskeleton of many insects(chitin)

❖ The Benedict's test for reducing sugars

✓ Some sugars react readily with **Benedict's solution**.

✓ They reduce copper(II) ions to copper(I) ions and for this reason they are known as **reducing sugars**.

✓ if a reducing sugar is present, the solution will gradually turn through green, yellow, & orange to red-brown as the insoluble copper (I) oxide forms a precipitate.

- **Ex**. glucose, galactose & fructose and maltose lactose, are considered reducing sugars.

❖ The Benedict's test for non-reducing sugars

- If the solution remains blue, there can be no reducing sugars present.
- Add dilute hydrochloric acid, then neutralise .
- The acid will break down the non-reducing sugars into monosaccharides.
- After adding acid, neutralise the solution with sodium carbonate.
- If the solution goes red now but didn't in the first stage of the test, there is no reducing sugar; if there is no colour change, then there is no sugar of any kind present.
- **Ex**. Sucrose is the only common **non-reducing sugar**.

Test for polysaccharides-starch and glycogen

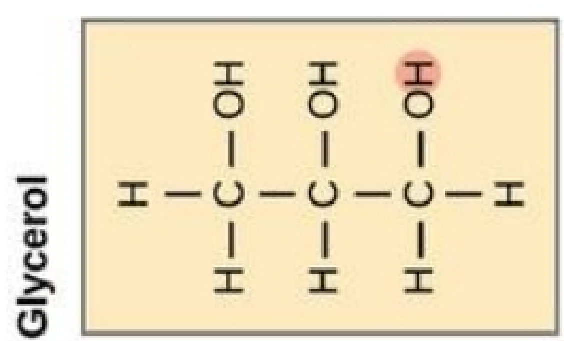
- This test can be used to differentiate between glycogen, and starch.
- the iodine reagent is added to the solution,
- The colour of iodine solution is brown.
- Starch reacts with a solution of iodine in potassium iodide to give a blue-black colour.

Food test

Types of nutrient	Reagents	Positive result	Negative result
Simple sugar	benedict's solution	orange/ red	Blue
Double sugar	benedict's solution	Orange/ red	Blue
Starch	Iodine solution	Blue-black	Brown
Protein	Biuret reagent	Purple to pink	Blue
Lipid	Ethanol reagent	White, cloudy laye form / translucent	No emultion or translucent spot
Vitamin . C	Dichlorophenol indophenol(DCPIP)	Blue black to colorless	Blue

Lipids

- Lipids are polymers of fatty acid and glycerol.
- Are made up of elements carbon, hydrogen and oxygen.
- but they contain much less oxygen than carbohydrates.
- Lipids are one of the major sources of energy for cells.
- Are diverse groups of biomolecules that are insoluble in water but soluble in non-polar solvents(ether, chloroform, and acetone) .
- It includes fats and oils and cholesterols.
- At room temperature, fat is solid & oil is liquid.
- Example of lipids:- Butter, Cooking oil, meat.
- **Glycerol** is an alcohol with three carbons, five hydrogens, and three hydroxyl (OH) groups



Fatty acids

- The general formula of fatty acids is **$CH_3(CH_2)_nCOOH$**
- Contain acidic group and long hydrocarbon tail.
- Acidic group = head= carboxyl group (-COOH)
- The hydrocarbon tail consist of a chain of carbon atoms combined with hydrogen.
- The chain is often 15 or 17carbon atoms long.
- **There are two types of fatty acids(F.A)**
- Based on the presence or absence of double bonds (-C=C-) in their hydrocarbon chain.
- Saturated and unsaturated fatty acids

1. Unsaturated fatty acids :- consist of one or more double bonds in their structure

- Do not contain the maximum possible amount of hydrogen.
- Are liquid at room temperature

- Double bonds make F.A & lipids melt more easily.

✓ Only one double bond is mono-unsaturated

✓ More than one double bond is polyunsaturated.

- Plant lipids are often unsaturated and occur as oils.

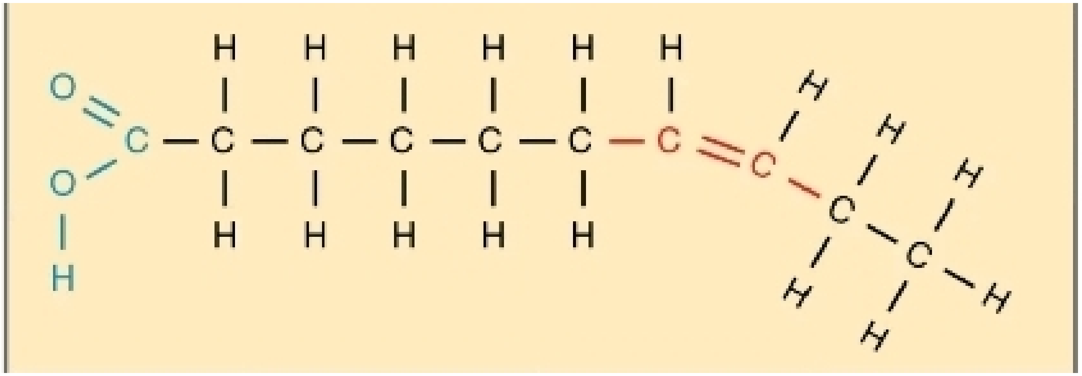
e.g. olive oil & sunflower oil.

❖ Polyunsaturated fatty acids

✓ help to prevent cholesterol being laid down in the linings of arteries (atherosclerosis) and

✓ so help to prevent heart disease.

(b) Unsaturated

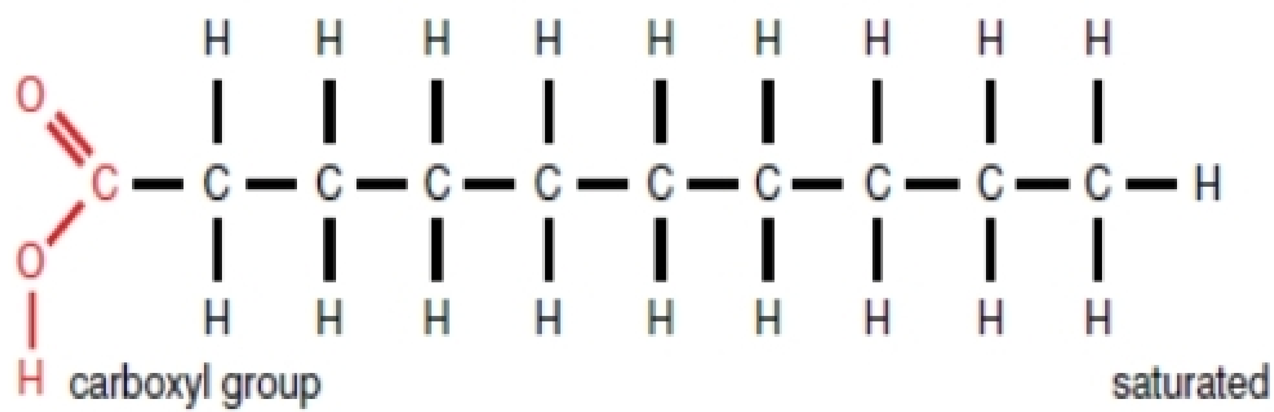


2. Saturated fatty acids :- have no double bonds in their carbon-carbon chain.

- This full saturation with hydrogen atoms makes their structure straight and compact.
- All are solid at room temperature.
- Animal lipids are often saturated and occur as animal fat.

E.g. Meat, dairy products, and certain types of butter.

- Fat storage areas in human : around the kidneys and below skin (act as insulator against loss of heat)



- Lipids are a varied group of compounds that include:

I. **triglycerides** - formed from glycerol and three fatty acids

II. **phospholipids** - formed from glycerol, two fatty acids and a phosphate group

III. **waxes** - formed from fatty acids and long-chain alcoholss

❑ **Phospholipids** :- are subset of lipids.

- One of the three fatty acid molecules that is attached to the glycerol backbone is replaced by a phosphate group.
- So, unusual property of having one water-soluble end.
- Phosphate group is polar and thus dissolve in water.
- **Phospholipids have two parts**

1. **the hydrophilic** (water-loving) head is phosphate group.
2. **the hydrophobic** (water-hating) tails are fatty acids

- This allows the molecules to form a membrane around a cell.

✓ Hydrophilic heads lie in watery solution on the outside of the membrane

✓ Hydrophobic tails form a layer that is impermeable to hydrophilic substances.

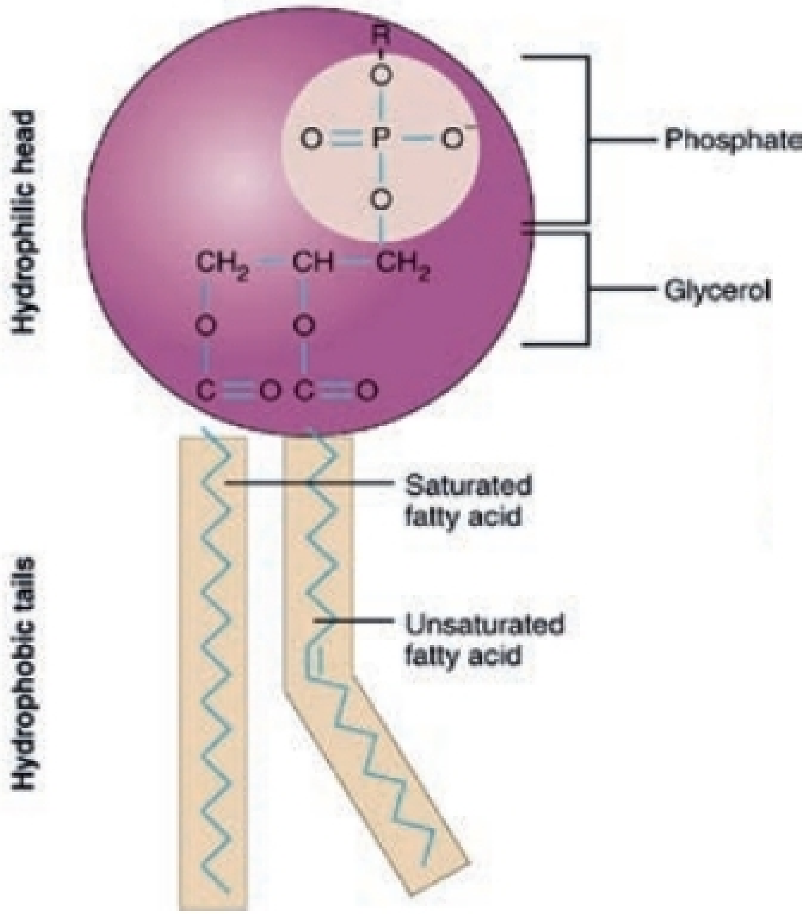


Figure 3.8 A phospholipid molecule

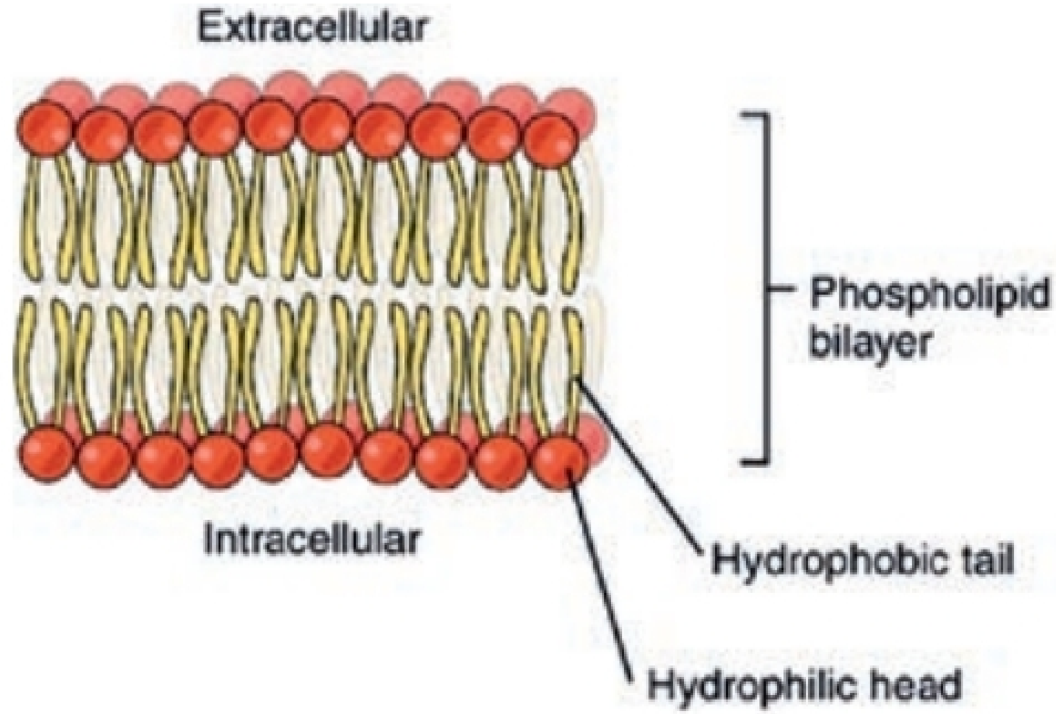
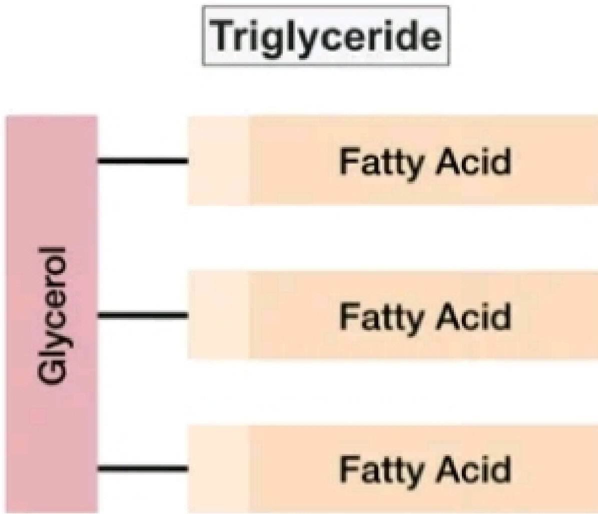
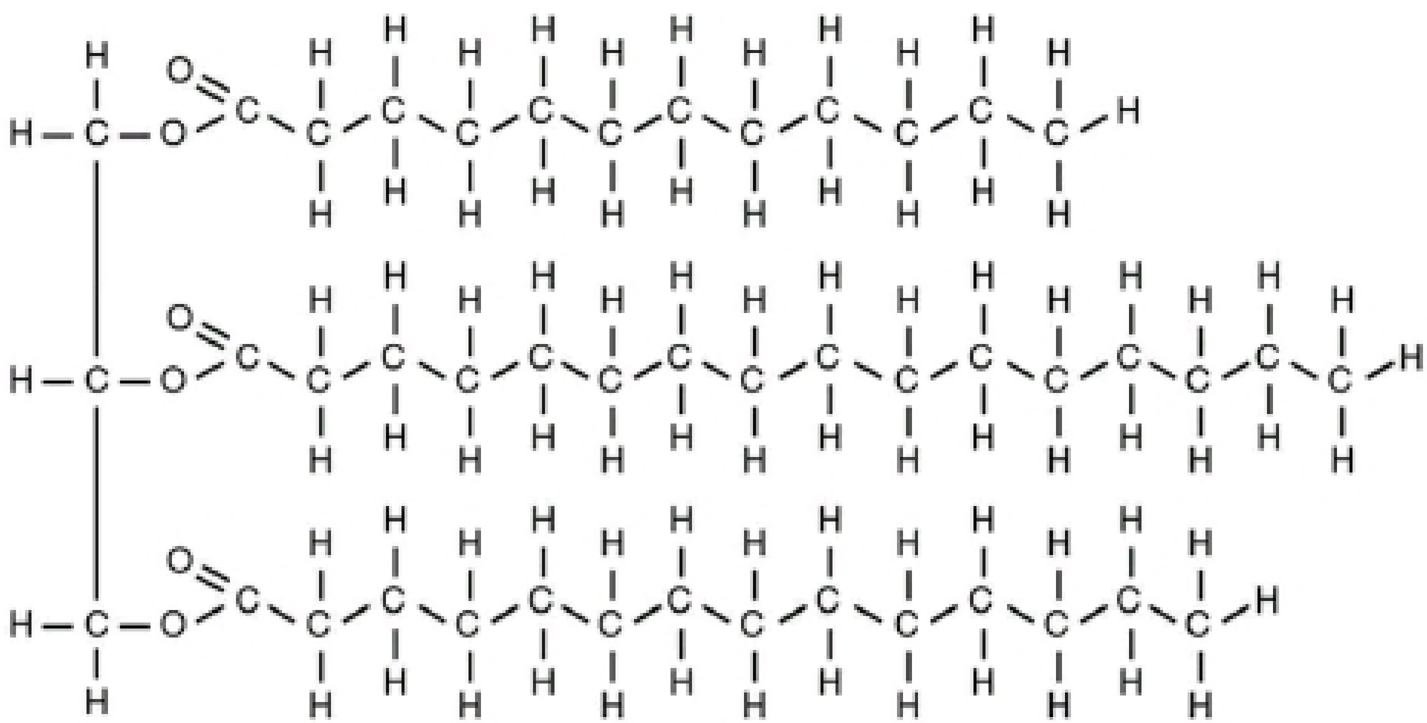


Figure 3.9 Phospholipid bilayer



1. **The Structure of a Triglyceride.**



Major functions of lipids

1. **serve as stored energy** (major fuel store)

- Oil major dietary lipid in plants
- Fat major dietary lipid in animals
- Fats are stored in adipose cells (fat cells) provide insulation at low temperatures.

2. **Serve as structural components in cell membranes**

3. **Precursors for the synthesis of**

- Vitamin D: for bone health
- Bile acids: for digestion & absorption of dietary fat.
- Cortisol and aldosterone(adrenal cortex hormones)
- Progesterone and estrogen (female sex hormone)

4. **Serve as protective coatings** (waxes) on skin, fur and features of animals, birds and fruit and leaves of plants

- Waxes serve as a water barrier and protects against cold.

The emulsion test for lipids

- You will need:
- clean, dry test tubes – they MUST be dry
- ethanol
- cooking oil or cooking fat
- If the test substance contains lipids, a milky-white emulsion forms.

proteins

- Are biological molecules composed of carbon, hydrogen, oxygen and nitrogen and sometimes contain phosphorus and sulphur.
- Are made up of amino acids monomers.
- the general formula $RCH(NH_2)COOH$.
- The most abundant organic molecules in living system
- Have the widest range of functions of any macromolecule.
- Proteins can be structural, regulatory, contractile, or protective.
- They could be toxins or enzymes, or they could be used in transportation, storage, or membranes.
- Each cell in a living system may contain thousands of proteins, each with a distinct function.
- More than 50% of the dry mass of most cells is protein.
- **Protein rich food items** :- meat, cheese, milk, fish, beans, vegetables, etc.

Amino acids

- Amino acid have a central carbon atom which is bonded to

✓ an amine group, $-NH_2$,

✓ a carboxylic acid group, -COOH

✓ a hydrogen atom

✓ the R group (all amino acids have different R group)

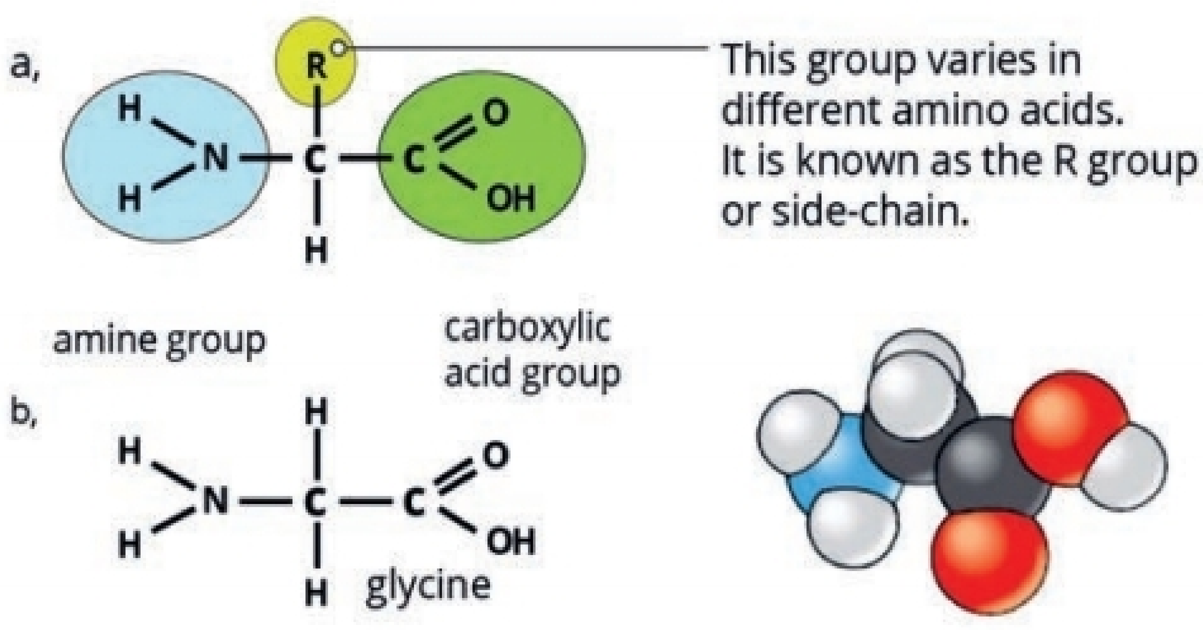
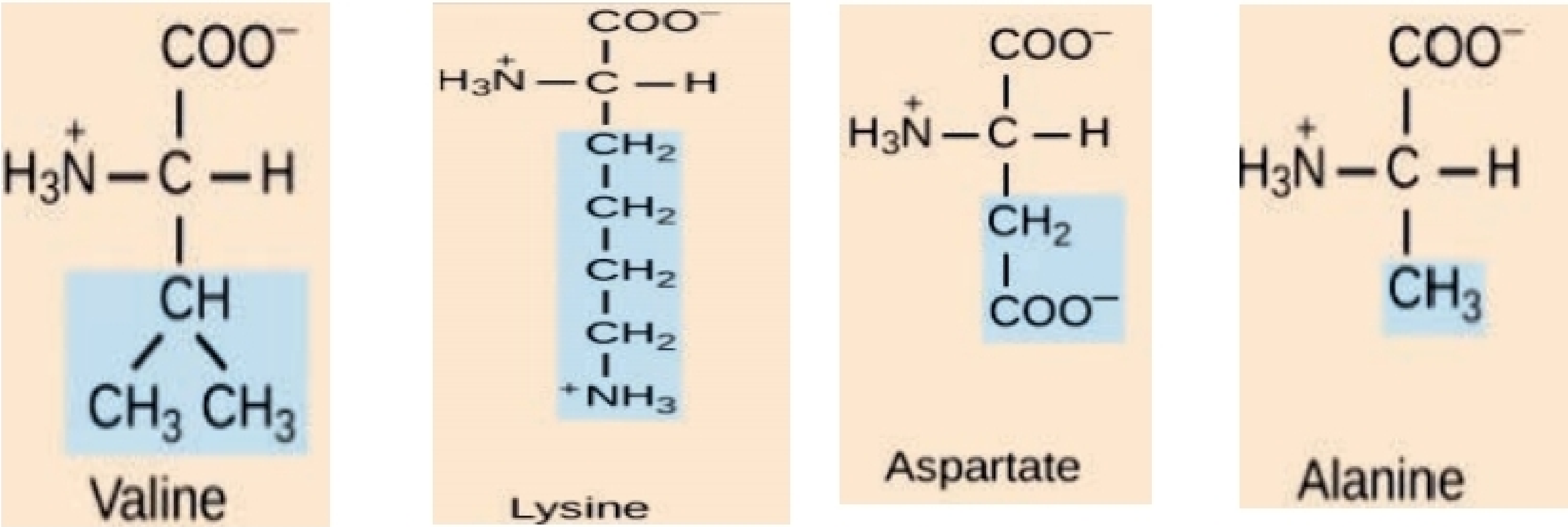


Figure 3.10 General formula of amino acids



- **Figure 3.11** Examples of amino acids

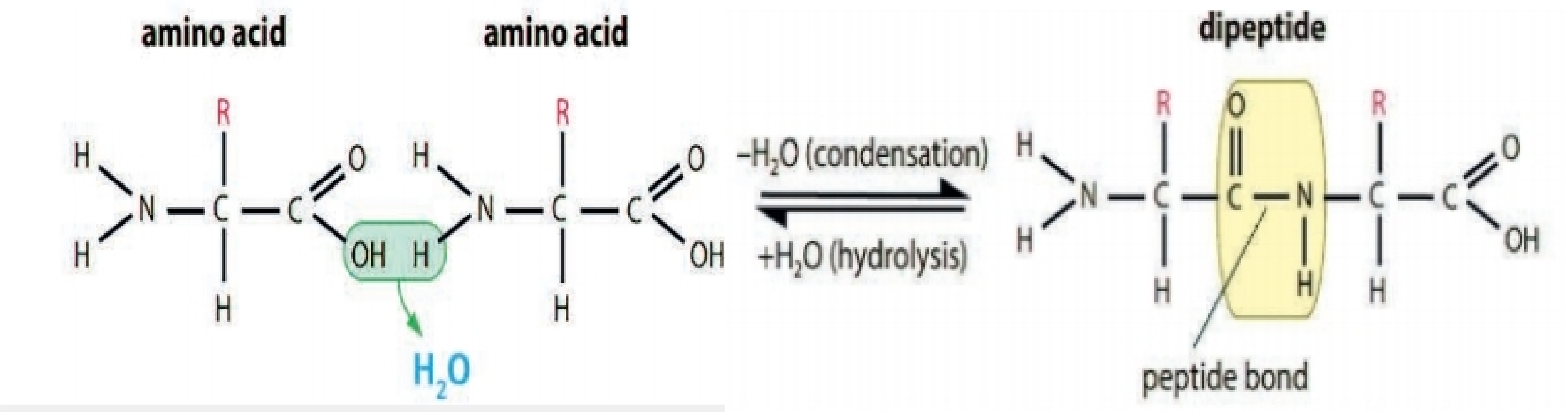
➢ The peptide bond

- Is covalent bond linkage between two amino acid.
- Each amino acid is attached to another amino acid by a **covalent bond**, known as a **peptide bond**, which is formed by a **dehydration reaction**.
- -OH from carboxyl group of one amino acid & -H from amine group of the other are lost to form water (condensation reaction)

✓ Two amino acids linked is dipeptide,

✓ Many amino acids linked together is polypeptide.

- Protein contain only one polypeptide chain, or two or more chains
- Ribosomes are the sites where amino acids are joined together to form polypeptides.
- Protein molecules in food are hydrolyzed into amino acids before being absorbed into the blood (hydrolysis reaction, addition of water)



- **Figure 3.12** amino acids link together by the loss of a molecule of water to form a peptide bond.

❑ Based on their shape proteins are of two type

➢ Globular proteins

- Have ‘ball’ shape
- Usually curl up so that their non-polar, hydrophobic R groups point into the centre of the molecule, away from their watery surruondings.
- Have roles in metabolic reactions.
- These are usually soluble in water.
- Are found in **cells**, and other **aqueous environments** such as blood, tissues fluid and in the phloem of plants.

E.g enzymes, haemoglobin, myoglobin, antibodies, insulin.

➢ Fibrous proteins

- do not coil up into a ball but form long strands.
- Are not usually soluble in water

E.g - keratin forms (hair, nails, wood, silk)

- collagen found in (skin, tendors, cartilage, bones, teeth, and the walls of blood vessels)

Major functions of proteins

1. structural proteins :

- Are fibrous, tough, and insoluble in water
- Make bones, tendons, nails, hair, cartilages, horns, and connective tissues.

Examples :- collagen – provides strength structure to skin, bones ,

- Elastin – gives tissues their elasticity, allowing them to stretch and return to the original shape

- keratin

2. Enzymes :

- Globular proteins that serve as biological catalysts.
- They catalyze metabolic reactions by lowering the activation energy, which increases the reaction rate.
- **Examples** :-

✓ DNA polymerase – involved in DNA replication ,

✓ Lysozyme – breaks down bacterial cell walls,

✓ Nitrogenase – involved in nitrogen fixation converting atmospheric nitrogen into a form that can be used by plants, and

✓ Lipase – aid in the breakdown of fats.

3. Hormones :- are polypeptides that are made up of long chains of linked amino acid.

- Regulate physiological processes in the body:

✓ **Reproduction** (sexual development, menstrual cycle, pregnancy)

✓ **Growth and development -** growth hormone (GH)

✓ **Electrolyte balance** (maintain the balance of minerals and electrolytes in the body, which is important for nerve function, muscle contraction, and maintain hydration)

✓ **sleep** etc.

4. Respiratory pigments :

- are globular protein pigments
- are typically water-soluble (makes them effective in circulating throughout the body in the blood or other bodily fluids)

Examples :-

- Myoglobin provides oxygen to working muscles
- Haemoglobin transports oxygen to all tissues and organs via the blood.

5. Transport proteins :

✓ Structural components of cell membrane.

✓ They create channels in the plasma membrane to transport specific molecules within the cells.

- **Example**. channels & carrier protein in the plasma membrane to transport specific molecules.

✓ Some of them are also found in animal blood and lymph

- **Examples**. Serum albumin transports hemin and fatty acids in blood.

6. Motor proteins :

- Are essential for muscle contraction and relaxation
- They facilitate muscle movement.

Example.

➢ **Actin**: a fundamental protein in musle fibers.

➢ **Myosin**: works alongside actin to enable muscle contraction

Actin and myosin bind together, leading to muscle contraction

➢ **Kinesin**: involved in transporting intracellular components, and

➢ **Dynein**: helps in cell division

7. Storage proteins :

✓ In cells serve as a storage reserve for amino acids and metal ions.

✓ Found in eggs, seeds, and pulses

Example. Ferritin (Fe), ovalbumin (in egg whites), and casein (in milk)

8. Toxins :

- ✓ are harmful substances produced by organisms,
- ✓ disrupt various cellular processes in the host
- ✓ it serves as their defense mechanism
- ✓ Bacteria are the most common producers of these toxin (proteins).
- ✓ Cause cytotoxicity, aid bacteria in attacking and killing their host organism.

Example. Diphtheria toxin, pseudomonas exotoxin, and ribosome inactivating proteins.

The Biuret test for proteins

- a protein in an alkaline solution reacts with copper ions to produce a mauve/purple colour.

1. which food items can be tested for proteins?

- Any food that contains proteins, whether plant-based or animal-based.

2. What is the reason for the colour change?

- The color change is due to the reaction between the peptide bonds in proteins and the copper(II)ions from copper sulfate.
- The reaction results in the formation of a complex between the copper ions and the peptide bonds. This complex has a distinctive color.
- This complex alters how the solution absorbs and reflects light, resulting in a color change that varies depending on the protein concentration.

3. Why do you add a copper (II) sulphate solution?

- Specificity for peptide bonds: copper ions specifically bind to peptide bonds which are unique to proteins.

Nucleic acids

- Nucleic acids are chemical molecules made up of phosphoric acid, sugars, and organic bases that exist naturally.
- They are the cell's principal information-carrying molecules.
- They carry instructions necessary for the functioning and development of all living organisms.
- They determine every living thing's inherited features by directing the process of protein synthesis.
- Inherited traits: physical characteristics (like hair, height)
- The two main types of nucleic acids:

✓ Deoxyribonucleic acid (DNA)

✓ Ribonucleic acid (RNA)

The structure of DNA and RNA

- DNA stands for deoxyribonucleic acid and RNA for ribonucleic acid.
- Nucleic acids such as DNA and RNA, are macromolecules.
- DNA and RNA are therefore polynucleotides.
- Most organisms carry their genetic information in DNA, but a few viruses carry it in RNA.
- Along the length of the DNA is a series of chemical structures called genes.

❖ Nucleotides

▪ Are made up of three smaller components.

✓ a nitrogen-containing base

✓ a pentose sugar

✓ a phosphate group

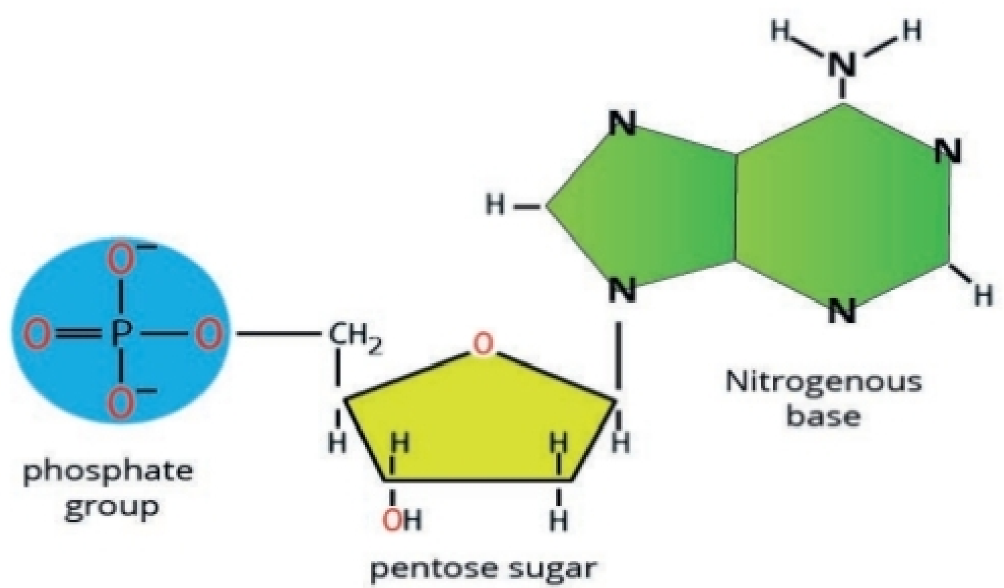


Figure 3.13 The components of nucleotides.

- There are five different nitrogenous bases

[Adenine(A), thymine(T), guanine(G), cytosine(C) and uracil(U)]

✓ Nitrogenous bases in DNA : A, T, G, C

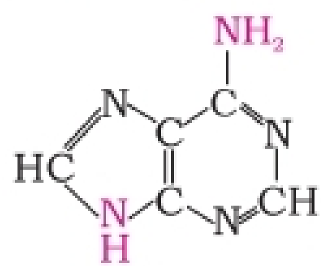
✓ Nitrogenous bases in RNA : A, U, G, C

✓ These bases are often denoted by their first letters: A, T, C, G, and U.

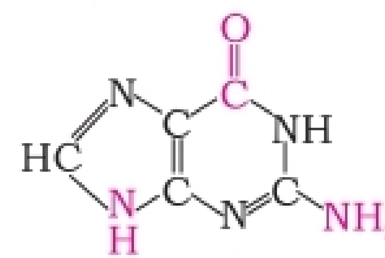
✓ The order and composition of the different nucleotides sequences determines the hereditary function of the nucleic acids.

✓ adenine-thymine: 2 hydrogen bonds

✓ guanine-cytosine: 3 hydrogen bonds

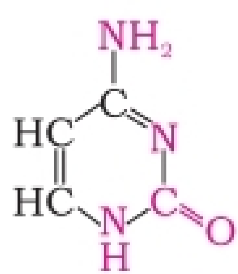


Adenine (A)

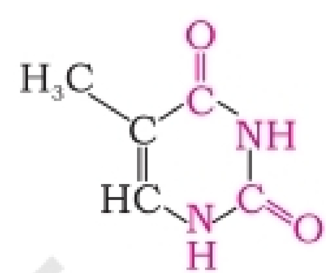


Guanine (G)

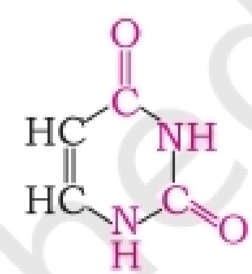
✓ A=T AND C $\equiv$ G



Cytosine (C)



Thymine (T)



Uracil (U)

❖ Two types of organic bases occur in nucleotides.

✓ **purines**, are large, double-ring molecules;

- they are adenine (A) and guanine (G).

✓ **pyrimidines**, are smaller, single-ring molecules;

- they include cytosine, thymine and uracil.

➢ The pentose(5-carbone) sugar can be either ribose ($C_5H_{10}O_5$) (in RNA) or deoxyribose ($C_5H_{10}O_4$) (in DNA).

➢ Deoxyribose is almost the same as ribose, except that it has no oxygen atom on its second carbon atom.

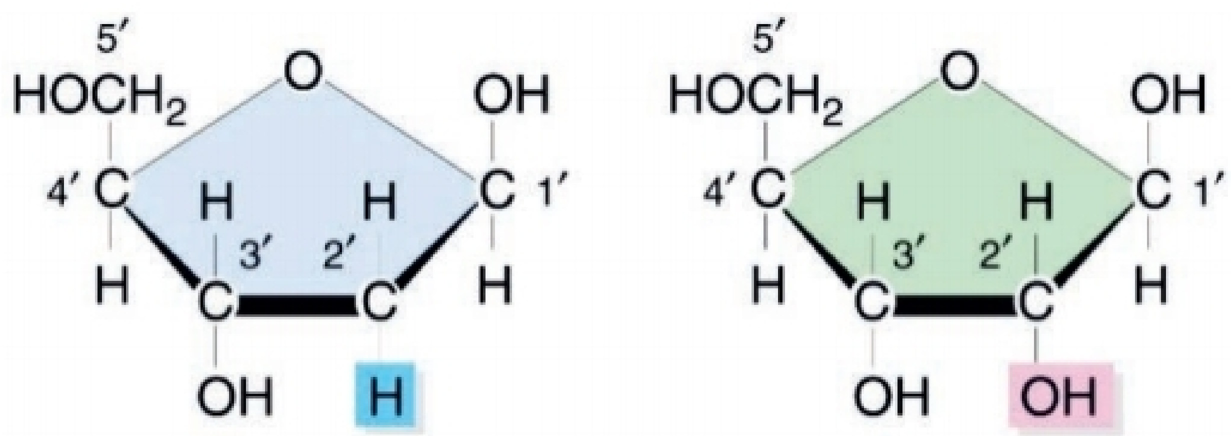


Figure 3.14 Structures of deoxyribose and ribose sugars

❖ **DNA** is a large molecule made up of two strands of nucleotides wounded into a double helix

❖ **RNA** is much smaller and is single stranded

Three types of RNA :

- mRNA (messenger RNA
- rRNA (ribosomal RNA)
- tRNA (transfer RNA)

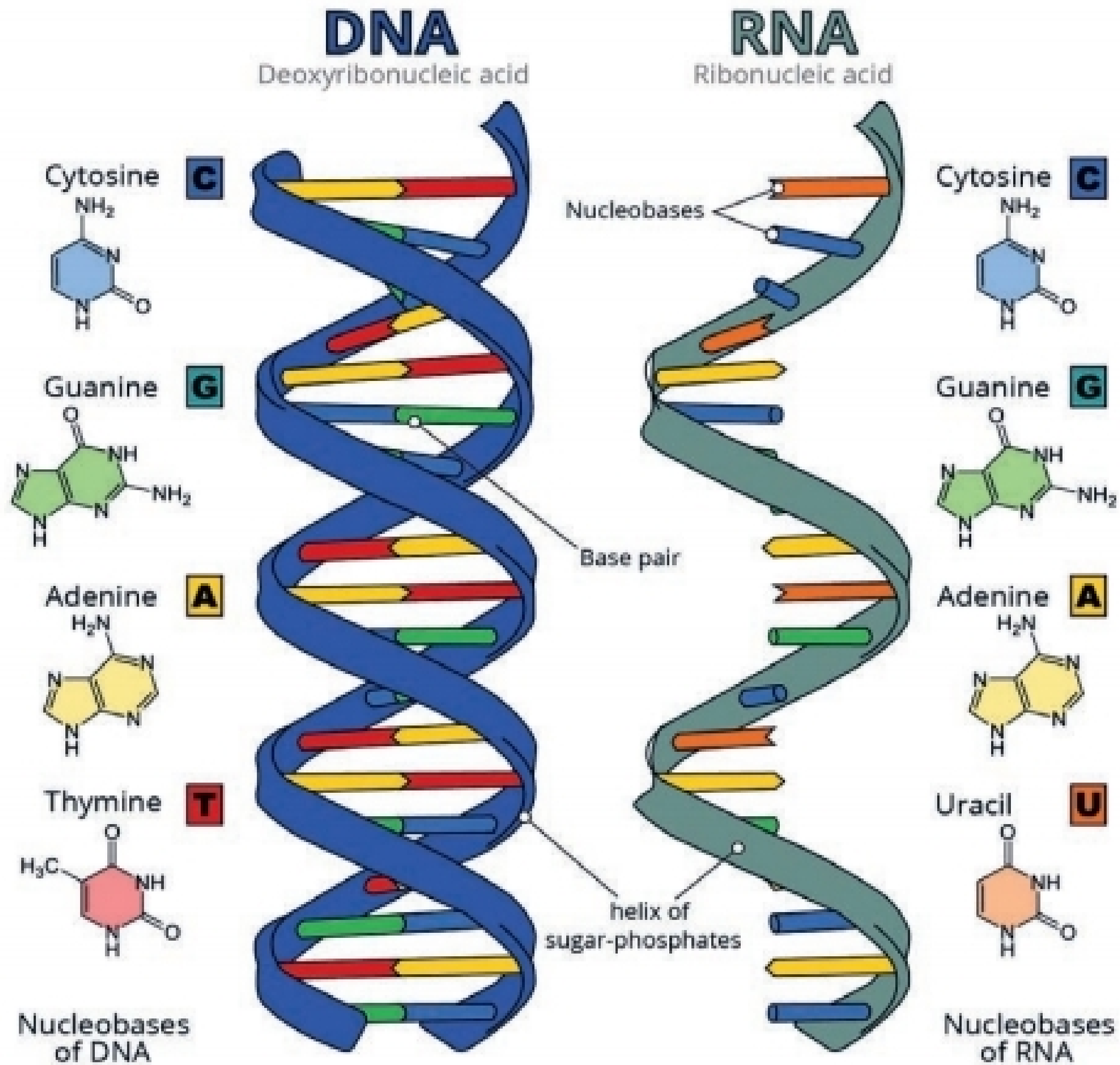


Figure 3.15 The structure of nucleic acids

Table 3.4 Similarities and differences in function and structure of the nucleic acids

Features	DNA	RNA
Nitrogenous bases	Adenine, Guanine, Cytosine, Thymine	Adenine, Guanine, Cytosine, Uracil
Pentose sugar	Deoxyribose sugar	Ribose sugar
Phosphate	Phosphate group	Phosphate group
Size	Huge-allows the molecule to carry the code for many different proteins in the genes	Much smaller-need code for only one protein; small size allows RNA to move out of the nucleus
Stability	Very stable – ensures that the genes remain the same over the generation	Less stable- is degraded quite quickly so does not carry on coding for a protein
Number of strands	Two strands- allow coding of genes and replication during cell division.	Single-stranded- does not replicate

Major function of Nucleic Acids

❑ Deoxyribonucleic acids (DNA)

- It is the genetic material that stores all the information required to be transferred to the next generation.
- The genetic information (code) is stored in its **nucleotide sequences**
- DNA has a unique property of replication or production of its copy that can be transferred to a daughter cell during cell reproduction.
- it carries the genetic code (instructions for protein synthesis)
- proteins are required to build an organism and catalyze its biochemical reactions

❖ process of protein synthesis

1. transcription :- genetic code sequence for particular protein is copied from DNA to mRNA
2. Translation :- the code in the mRNA is then translated into acid sequences of protein

❑ Ribonucleic acids (RNA)

- Has different roles to play in different organisms
- Acts as genetic material in some viruses
- Has enzymatic activity in other organisms is called ribozyme
- mRNA : moves the genetic code from DNA to ribosomes
- Ribosomes : protein synthesizing machinery in the cell
- tRNA : carry amino acids to ribosome for protein synthesis

rRNA + protein = ribosome

Thank you