Structure,Classification,andFunctionsof Carbohydrates

Introduction

Carbohydratesarenecessaryforalllivingthings,includingpeople,plants,andmicrobes. They are essential to our diet and may be found in many different foods, such as fruits, grains, vegetables including potatoes, milk, honey, and table sugar.

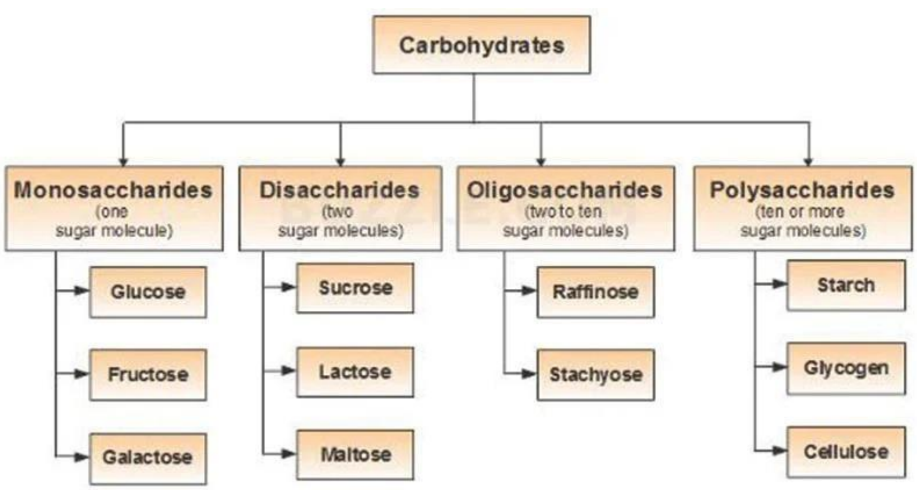
Outofthefourmacromolecules—proteins,fats,andnucleicacids—carbohydrateswerethe last to catch scientists' interest for investigation and further study.

WhatareCarbohydrates?

Carbohydratesaredefinedasbiomoleculescontainingagroupofnaturallyoccurring carbonylcompounds(aldehydesorketones)andseveralhydroxylgroups.Itconsistsof carbon(C),hydrogen(H),andoxygen(O)atoms,usuallywithahydrogen-oxygenatom ratioof2:1(asinwater).It'srepresentedwiththeempiricalformula$C_m(H_2O)_n$(wherem and n may or may not be different) or $(CH_2O)_n$.

Butsomecompoundsdonotfollowthisprecisestoichiometricdefinition,suchasuronic acids.Andtherearesothersthat, despitehavinggroupssimilartocarbohydrates, arenot classified as one of them, e.g., formaldehyde and acetic acid.

ClassificationofCarbohydrates



Carbohydratesaredividedintofourmajorgroupsbasedonthedegreeofpolymerization: monosaccharides, disaccharides, oligosaccharides, and polysaccharides. Given below is a brief account of the structure and functions of carbohydrate groups.

1. Monosaccharides

Monosaccharidesarethesimplestcarbohydratesandcannotbehydrolyzedintoother smaller carbohydrates. The "mono" in monosaccharides means one, which shows the presence of only one sugar unit.

Theyarethebuildingblocksofdisaccharidesandpolysaccharides. Forthisreason,theyare also known as simple sugars. These simple sugars are colorless, crystalline solids that are soluble in water and insoluble in a nonpolar solvent.

ThegeneralformularepresentingmonosaccharidestructureisCn(H_2O)nor CnH_2nOn. Dihydroxyacetone and D- and L-glyceraldehydes are the smallest monosaccharides – here, n=3.

The monosaccharides containing the aldehyde group (the functional group with the structure,R-CHO)areknownasaldolasesandtheonecontainingketonegroupsiscalled ketoses (the functional group with the structure RC(=O)R′). Some examples of monosaccharides are glucose, fructose, erythrulose, and ribulose.

D-glucose is the most common, widely distributed, and abundant carbohydrate. It's commonlyknownasdextroseandit'sanaldehydecontainingsixcarbonatoms,called aldohexose. It's present in both, open-chain and cyclic structures.

Mostmonosaccharidenamesendwiththesuffix-ose.Andbasedonthenumberofcarbons, which typically ranges from three to seven, they may be known as trioses (three carbons), tetroses (four carbons), pentoses (five carbons), hexoses (six carbons), and heptoses (seven carbons)

Althoughglucose,galactose,andfructoseallhavethechemicalformulaof$C_6H_{12}O_6$,they differ at the structural and chemical levels because of the different arrangement of functional groups around their asymmetric carbon.

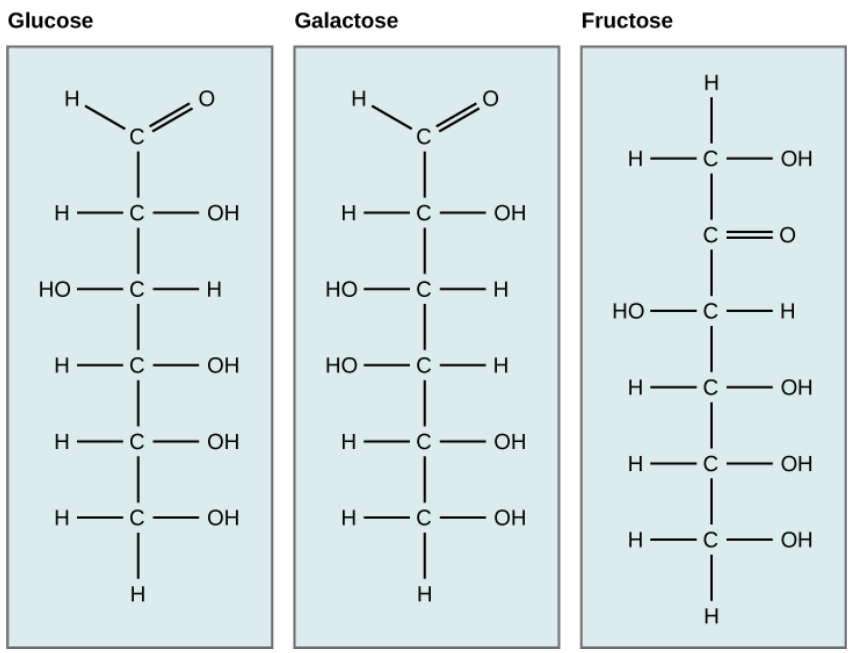


Figure:Astructuralrepresentationofglucose,fructose,and galactose.

StructureofMonosaccharides

Monosaccharides are either present as linearchainsorring-shapedmolecules.Ina ring form, glucose’s hydroxyl group (-OH) can have two different arrangements aroundtheanomericcarbon(carbon-1that becomes asymmetric in the process of ring formation).

If the hydroxyl group is below carbon number1inthesugar,itissaidtobeinthe alpha (α) position, and if it is above the plane,itis saidtobeinthebeta(β) position.

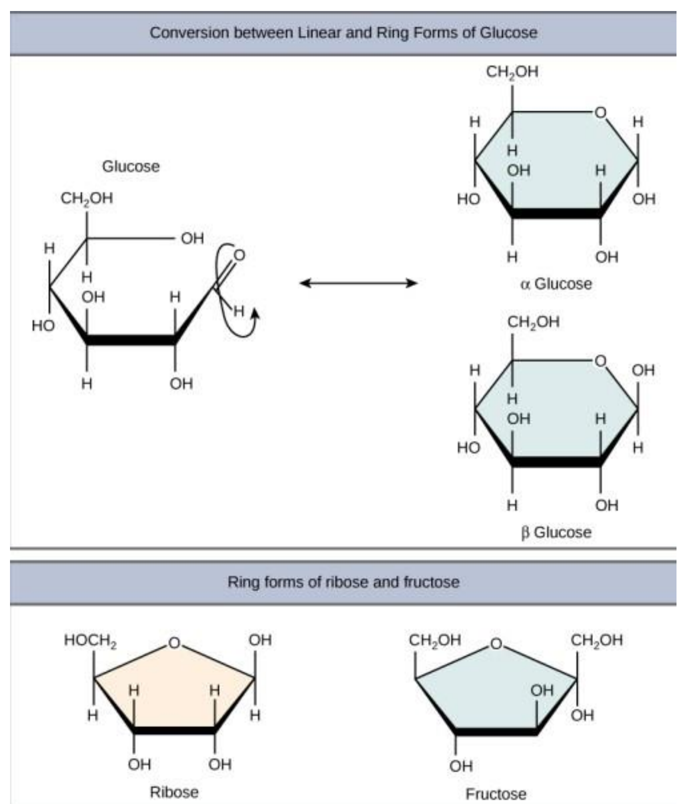


Figure:Astructuralrepresentationofringformsofglucose and fructose.

FunctionsofMonosaccharides

- Glucose ($C_6H_{12}O_6$) is an important source of energy in humans and plants. Plants synthesize glucose using carbon dioxide and water, which in turn is used for their energy requirements. They store the excessglucoseasstarchwhichhumansandherbivoresconsume.
- The presence of galactose is in milk sugar (lactose), and fructose in fruits and honey makes these foods sweet.
- Riboseisastructuralelementofnucleicacidsandsome coenzymes.
- Mannose is a constituent of mucoproteins and glycoproteins required for the proper functioning of the body.

2. Disaccharides

Disaccharides consist of two sugar units.Whensubjectedtoadehydration reaction (condensation reaction or dehydrationsynthesis),theyreleasetwo monosaccharide units.

In this process, the hydroxyl group of one monosaccharide combines with the hydrogen of another monosaccharide through a covalent bond, releasing a molecule of water. The covalent bond formedbetweenthetwosugarmoleculesis known as a **glycosidic bond**.

The glycosidic bond or glycosidic linkage canbealphaorbetatype.Thealphabondis formedwhentheOHgrouponthecarbon-1 of the first glucose is below the ring plane, and a beta bond is formed when the OH group on the carbon-1 is above the ring plane.

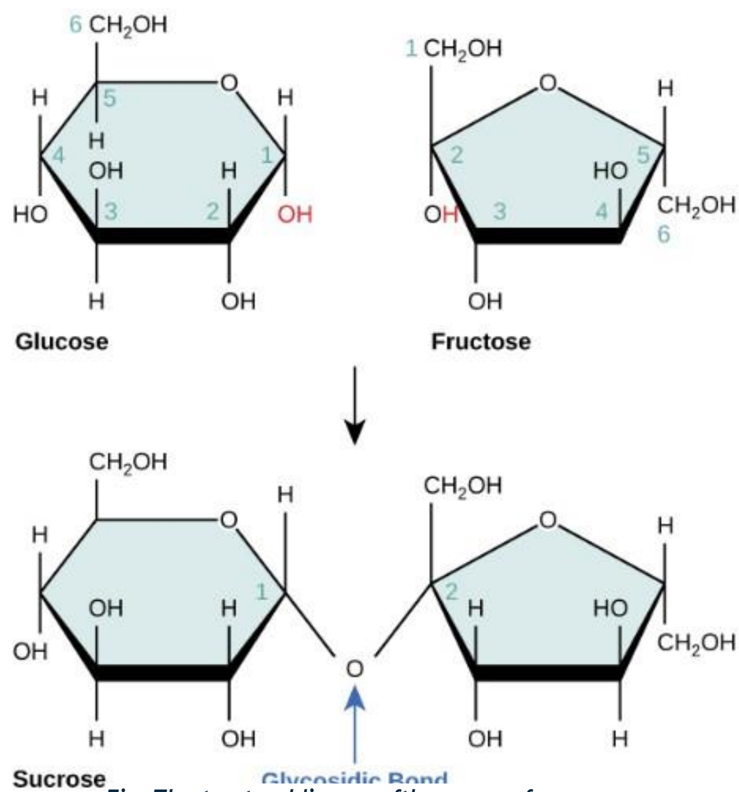


Fig.:Thestructuraldiagramoftheprocessof glycosidicbondformationbetweentwosugarunits (glucoseandfructose)formingadisaccharide (sucrose).

Some examples of disaccharides are lactose, maltose, and sucrose. Sucrose is the most abundant disaccharide of all and is composed of one D-glucose molecule and one D-fructosemolecule.ThesystematicnameforsucroseisO-α-D-glucopyranosyl-(1→2)-D-fructofuranoside.

LactoseoccursnaturallyinmammalianmilkandiscomposedofoneD-galactosemolecule and one D-glucose molecule. The systematic name for lactose is O-β-D-galactopyranosyl-(1→4)-D-glucopyranose.

Disaccharidescanbeclassifiedintotwogroupsbasedontheirabilitytoundergooxidation-reduction reactions.

- **Reducingsugar:**Adisaccharideinwhichthereducingsugarhasa free hemiacetal unit serving as a reducing aldehyde group. Examples include maltose and cellobiose.
- **Non-reducing Sugar:** Disaccharidesthatdonothaveafree hemiacetalbecause theybond throughan acetallinkagebetween their anomeric centers. Examples aresucrose and trehalose.

Someotherexamplesofdisaccharidesincludelactulose,chitobiose,kojibiose,nigerose, isomaltose, sophorose, laminaribiose, gentiobiose, turanose, maltulose, trehalose, palatinose,gentiobiulose,mannobiose,melibiose,melibiulose,rutinose,rutinulose, and xylobiose.

Alistofdisaccharideswiththeirmonomerunitsisgivenbelow:

Disaccharide	MonomerUnits
Sucrose	GlucoseandFructose
Lactose	GalactoseandGlucose
Maltose	GlucoseandGlucose(alpha-1,4linkage)
Trehalose	GlucoseandGlucose(alpha-1,alpha-1 linkage)
Cellobiose	GlucoseandGlucose(beta-1,4linkage)
Gentiobiose	GlucoseandGlucose(beta-1,6linkage)

FunctionsofDisaccharides

- Sucroseisaproductofphotosynthesis,whichfunctionsasamajor source of carbon and energy in plants.
- Lactoseisamajorsourceofenergyinanimals.

- Maltoseisanimportantintermediateinstarchandglycogen digestion.
- Trehaloseisanessentialenergysourceforinsects.
- Cellobioseisessentialincarbohydratemetabolism.
- Gentiobioseisaconstituentofplantglycosidesandsome polysaccharides.

3. Oligosaccharides

Oligosaccharides are compounds that yield 3 to 10 molecules of the same or different monosaccharides on hydrolysis. All the monosaccharides are joined through glycosidic linkage.Andbasedonthenumberofmonosaccharidesattached,theoligosaccharidesare classified as trisaccharides, tetrasaccharides, pentasaccharides, and so on.

The general formula of trisaccharides is $C_n(H_2O)_{n-2}$, and that of tetrasaccharides is $Cn(H_2O)n-3$,andsoon.Theoligosaccharidesarenormallypresentasglycans.Theyare linkedtoeitherlipidsoraminoacidsidechainsinproteinsbyN-orO-glycosidicbonds known as glycolipids or glycoproteins.

Theglycosidicbondsareformedintheprocessofglycosylation,inwhichacarbohydrateis covalently attached to an organic molecule, creating structures such as glycoproteins and glycolipids.

- **N-LinkedOligosaccharides:** Itinvolvestheattachmentof oligosaccharides to asparagine via a beta linkage to the amine nitrogenofthesidechain.Ineukaryotes,thisprocessoccursatthe membraneoftheendoplasmicreticulum.Whereasinprokaryotes,it occurs at the plasma membrane.
- **O-Linked Oligosaccharides:** It involves the attachment of oligosaccharides to threonine or serine on the hydroxyl group of the side chain. It occurs in the Golgi apparatus, where monosaccharideunitsareaddedtoacompletepolypeptidechain.

FunctionsofOligosaccharides

- Glycoproteins are carbohydrates attached to proteins involved incritical functions such as antigenicity, solubility, and resistance to proteases. Glycoproteins are relevant as cell-surface receptors, cell-adhesion molecules, immunoglobulins, and tumor antigens.

- Glycolipidsarecarbohydratesattachedtolipidsthatareimportant for cell recognition and modulate membrane proteins that act as receptors.
- Cellsproducespecificcarbohydrate-bindingproteinsknownas lectins, which mediate cell adhesion with oligosaccharides.
- Oligosaccharidesareacomponentoffiberfromplanttissues.

4. Polysaccharides

Polysaccharides are a chain of more than 10 carbohydrates joined together through glycosidicbondformation.Theyareubiquitousandmainlyinvolvedinthestructuralor storage functions of organisms. They are also known as glycans.

These compounds' physical and biological properties depend on the components & the architectureoftheirbindingorreactingmoleculesandtheirinteractionwiththeenzymatic machinery.

Polysaccharidesareclassifiedbasedontheirfunctions,thetypeofmonosaccharideunits they contain, or their origin.

Basedonthetypeofmonosaccharidesinvolvedintheformationofpolysaccharide structures, they are classified into two groups: homopolysaccharides and heteropolysaccharides.

Homopolysaccharides:

They are composed of repeating units of only one type of monomer. A few examples of homopolysaccharides include cellulose, chitin, starches (amylose and amylopectin), glycogen,andxylans.Andbasedontheirfunctionalroles,thesecompoundsareclassified into structural polysaccharides and storage polysaccharides.

- Cellulose is a linear, unbranched polymer of glucose units joined by beta 1-4 linkages. It's one of the most abundant organiccompounds in the biosphere.

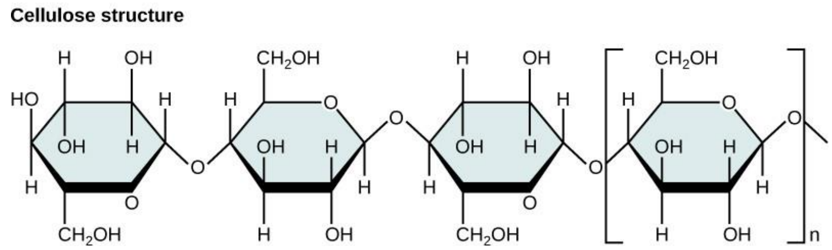


Figure:Astructuralrepresentationofcellulose.

- Chitin is a linear, long-chain polymer of N-acetyl-D-glucosamine (a derivative of glucose) residues/units, joined by beta 1-4 glycosidic linkages. It's the second most abundant natural biopolymer after cellulose.
- Starch is made of repeating units of D-glucose that are joined together by alpha-linkages. It's one of the most abundant polysaccharides found in plants and is composed of a mixture of amylose (15-20%) andamylopectin (80-85%).

Heteropolysaccharides:

They are composed of two or more repeating units of different types of monomers. Examplesincludeglycosaminoglycans,agarose,andpeptidoglycans.Innaturalsystems, they are linked to proteins, lipids, and peptides.

- Glycosaminoglycans (GAG) are negatively charged unbranched heteropolysaccharides.Theyarecomposedofrepeatingunitsof disaccharideswiththegeneralstructuralformulan.Aminoacids like N-acetylglucosamine or N-acetylgalactosamine and uronic acid (like glucuronic acid) are normally present in the GAG structure.
- **AlistcontainingmajorGAGsismentionedbelow:**

GAGs	Acidicsugar	Aminosugar
Hyaluronicacid	**D-Glucuronicacid**	**N-acetylglucosamine**
Chondroitinsulfate	**D-Glucuronicacid**	**N-acetylgalactosamine**
Heparansulfate	**D-GlucuronicacidorL-iduronic acid**	**N-acetylglucosamine**
Heparin	**D-GlucuronicacidorL-iduronic acid**	**N-acetylglucosamine**
Dermatansulfate	**D-GlucuronicacidorL-iduronic acid**	**N-acetylgalactosamine**

Keratansulfate	**D-Galactose**	**N-acetylglucosamine**

- PeptidoglycanisaheteropolymerofalternatingunitsofN-acetylglucosamine (NAG) and N-acetylmuramic acids (NAM), linked together by beta-1,4-glycosidic linkage.
- Agarose is a polysaccharide composed of repeating units of adisaccharide, agarobiose, consisting of D-galactose and 3,6-anhydro-L-galactopyranose.

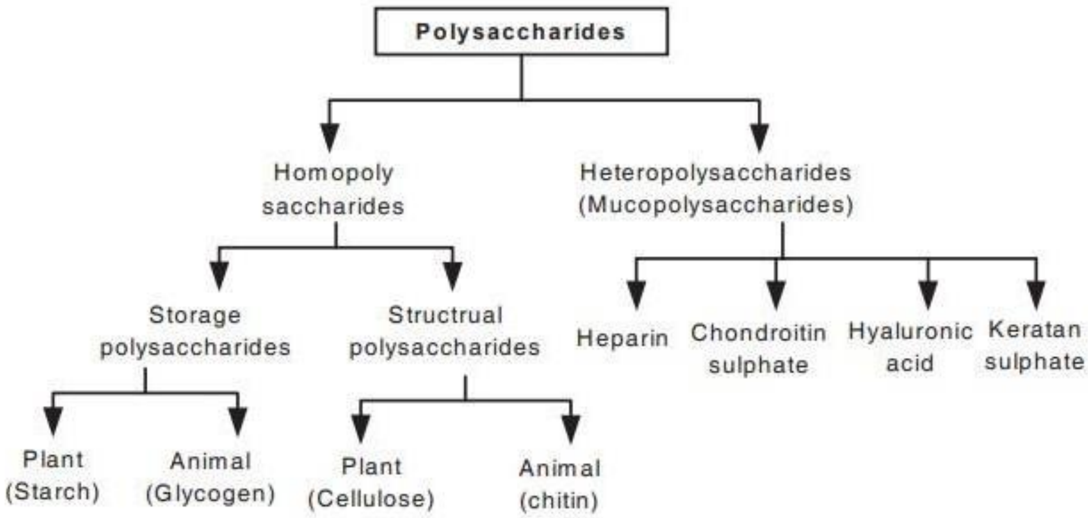


Figure:Aclassificationsummaryofpolysaccharidesintodifferentsub-groups.

FunctionsofPolysaccharides

- **Structural polysaccharide:**They provide mechanical stability to cells, organs, and organisms. Examples include chitin and cellulose. Chitin is involved in the synthesis of fungal cell walls, while cellulose is an important constituent of diet for ruminants.
- **Storage polysaccharides:**They are carbohydrate storage reserves that release sugar monomers when required by the body. Examples include starch, glycogen, and inulin. Starch stores energy for plants, and in animals, it is catalyzed by the enzyme amylase (found insaliva)tofulfilltheenergyrequirement.Glycogenisa polysaccharide food reserve of animals, bacteria, and fungi, while inulin is a storage reserve in plants.

- Agarose provides a supporting structure in the cell wall of marine algae.
- Peptidoglycan is an essential component of bacterial cell walls. It provides strength to the cell wall and participates in binary fission during bacterial reproduction.
- Peptidoglycanprotectsbacterialcellsfromburstingby counteracting the osmotic pressure of the cytoplasm.
- Hyaluronicacidsareanessentialcomponentofthevitreoushumor intheeyeandsynovialfluid(alubricantfluidpresentinthebody’s joints).It’salsoinvolvedinotherdevelopmentalprocesseslike tumor metastasis, angiogenesis, and blood coagulation.
- Heparinactsasanaturalanticoagulantthatpreventsbloodfrom clotting.
- Keratan sulfate is present in the cornea, cartilage, and bones. In joints, it acts as a cushion to absorb mechanical shocks.
- Chondroitin is an essential component of cartilage that provides resistance against compression.
- Dermatan sulfate is involved in wound repair, blood coagulation regulation,infectionresponses, and cardiovascular diseases.

Monosaccharides

Monosaccharides are the simplest carbohydrates and have many functions, including storing energy and forming more complex carbohydrates:

- **Occurrence**

  Monosaccharides are found in nature, with glucose and fructose being the most common. Fructose is often found in fruits, flowers, root vegetables, honey, and corn syrup.

- **Structure**

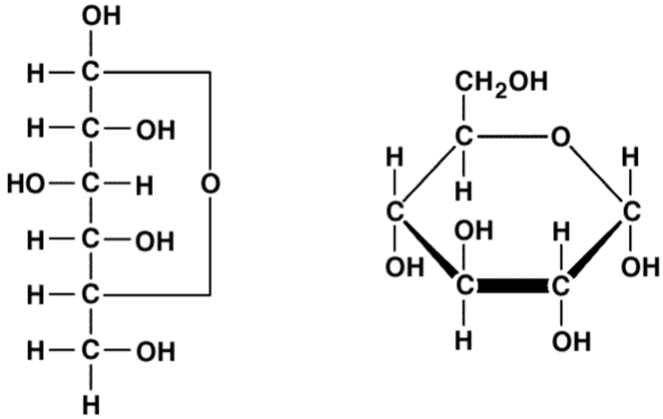
  Monosaccharides are made of carbon, hydrogen, and oxygen, and have a chain of three to six carbon atoms. They can exist in a straight chain or a ring structure. The ring structure is also known as the Haworth's projection formula, while the straight chain structure is also known as the open chain structure.

- **Function**

  Monosaccharides are the primary source of energy for cells in the body. They are also used to build more complex carbohydrates.

- **Classification**

Monosaccharides are classified by the number of carbon atoms in their chain, and the functional group attached to the chain. Monosaccharides that contain an aldehyde group are called aldoses, while those that contain a ketone group are called ketoses.



Glucose

Glucose has many properties, including:

- **Appearance**: Glucose is a white or colorless crystalline solid at room temperature.
- **Solubility**: Glucose is highly soluble in water, forming a clear, colorless solution. It is less soluble in non-polar solvents like chloroform or ether.
- **Taste**: Glucose is moderately sweet.
- **Melting point**: Glucose melts at around 146°C (295°F).
- **Optical activity**: D-glucose rotates plane-polarized light to the right, while L-glucose rotates it to the left.
- **Hygroscopic**: Glucose absorbs moisture from the surrounding environment.
- **Molecular weight**: Glucose has a molecular weight of 180.16 g/mol.
- **Density**: Glucose has a density of 1.54 g/cm³.
- **Chemical formula**: Glucose has the chemical formula C6H12O6.
- **Functional groups**: Glucose contains an aldehyde group, an alcohol group, and an ester group.
- **Ring structure**: Glucose forms a pyranose ring structure.
Glucose is a monosaccharide, a simple sugar, and a preferred source of energy for organisms. It is used to treat hypoglycemia, hyperkalemia, and as a starting point for synthesizing many compounds.

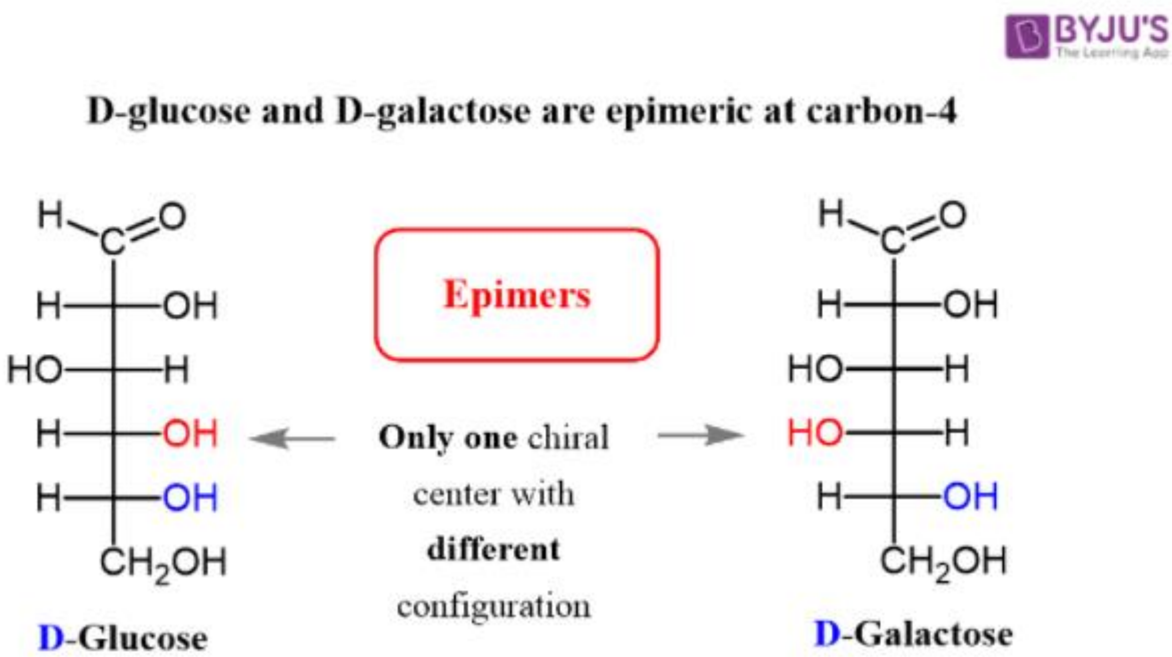
Anomers, epimers, enantiomers, and mutarotation are all related to carbohydrates:

- **Anomers**

A type of epimer that occurs in certain carbohydrates. Anomers differ in orientation at the anomeric carbon (C1). They are given alpha and beta forms of the same molecule, instead of being given different names.

- **Epimers**

  A type of stereoisomer that differs in orientation at one or more chiral centers. For example, D-mannose and D-galactose are both epimers of D-glucose.



- **Enantiomers**

  Enantiomers are non-superimposable mirror images of each other, while mutarotation is the process of adjusting the balance between two anomers in a stereo center.

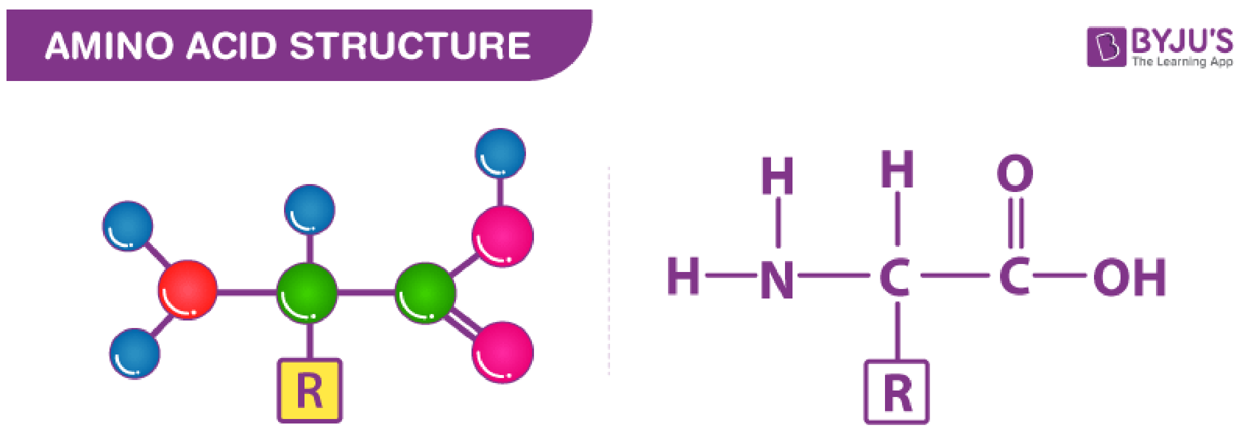
- **Mutarotation**

  The process by which a solution of a carbohydrate changes in optical rotation. This occurs when one anomer is converted to the other through the open-chain form. The chemical process that occurs is called anomerization.

Define amino acids:

In simpler terms, Amino acids are organic compounds containing the basic amino groups (-NH_2) and carboxyl groups (-COOH).

"Amino Acids are the organic compounds that combine to form proteins, hence they are referred to as the building components of proteins. These biomolecules are involved in several biological and chemical functions in the human body and are the necessary ingredients for the growth and development of human beings. There are about 300 amino acids that occur in nature."



There are 20 naturally occurring amino acids and all have common structural features – an amino group (-NH_3^+), a carboxylate (-COO^-) group and a hydrogen-bonded to the same carbon atom. They differ from each other in their side-chain called the R group. Each amino acid has 4 different groups attached to α- carbon.

These 4 groups are:

- **Amino group,**
- **COOH,**
- **Hydrogen atom,**
- **Sidechain (R).**

General properties of Amino acids

- **They have a very high melting and boiling point.**

- **Amino acids are white crystalline solid substances.**
- **In taste, few Amino acids are sweet, tasteless, and bitter.**
- **Most of the amino acids are soluble in water and are insoluble in organic solvents.**

Sources of Amino acids

Foods rich in amino acids include plant-based products like broccoli, beans, beetroots, pumpkin, cabbage, nuts, dry fruits, chia seeds, oats, peas, carrots, cucumber, green leafy vegetables, onions, soybeans, whole grain, peanuts legumes, lentils, etc. Fruits rich in amino acids are apples, bananas, berries, figs, grapes, melons, oranges, papaya, pineapple, and pomegranates. Other animal products include dairy products, eggs, seafood, chicken, meat, pork etc.

Essential and Non-essential Amino acids

Out of 20 amino acids, our body can easily synthesize a few on its own, which are called non-essential amino acids. These include alanine, asparagine, arginine, aspartic acid, glutamic acid, cysteine, glutamine, proline, glycine, serine, and tyrosine.

Apart from these, there are other nine amino acids, which are very much essential as they cannot be synthesized by our body. They are called essential amino acids, and they include isoleucine, histidine, lysine, leucine, phenylalanine, tryptophan, methionine, threonine, and valine.

Functions of Amino acids

- **Functions of Essential Amino acids**
  - **Phenylalanine helps in maintaining a healthy nervous system and in boosting memory power.**
  - **Valine acts as an important component in promoting muscle growth.**
  - **Threonine helps in promoting the functions of the immune system.**
  - **Tryptophan is involved in the production of vitamin B3 and serotonin hormones. This serotonin hormone plays a vital role in maintaining our appetite, regulating sleep and boosting our moods.**

- **Isoleucine plays a vital role in the formation of haemoglobin, stimulating the pancreas to synthesize insulin, and transporting oxygen from the lungs to the various parts.**
- **Methionine is used in the treatment of kidney stones, maintaining healthy skin and also used in controlling invade of pathogenic bacteria.**
- **Leucine is involved in promoting protein synthesis and growth hormones.**
- **Lysine is necessary for promoting the formation of antibodies, hormones, and enzymes and in the development and fixation of calcium in bones.**
- **Histidine is involved in many enzymatic processes and in the synthesizing of both red blood cells (erythrocytes) and white blood cells (leukocytes).**

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- **Functions of Non-Essential Amino acids**
    - **Alanine functions by removing toxins from our body and in the production of glucose and other amino acids.**
    - **Cysteine acts as an antioxidant and provides resistance to our body; it is important for making collagen. It affects the texture and elasticity of the skin**
    - **Glutamine promotes a healthy brain function and is necessary for the synthesis of nucleic acids – DNA and RNA.**
    - **Glycine is helpful in maintaining the proper cell growth, and its function, and it also plays a vital role in healing wounds. It acts as a neurotransmitter.**
    - **Glutamic acid acts as a neurotransmitter and is mainly involved in the development and functioning of the human brain.**
    - **Arginine helps in promoting the synthesis of proteins and hormones, detoxification in the kidneys, healing wounds, and maintaining a healthy immune system.**
    - **Tyrosine plays a vital role in the production of the thyroid hormones -T3 and T4, in synthesizing a class of neurotransmitters and melanin, which are natural pigments found in our eyes, hair, and skin.**
    - **Serine helps in promoting muscle growth and in the synthesis of immune system proteins.**
    - **Asparagine is mainly involved in the transportation of nitrogen into our body cells, formations of purines and pyrimidine for the synthesis of DNA, the development of the nervous system and improving our body stamina.**

- **Aspartic acid plays a major role in metabolism and in promoting the synthesis of other amino acids.**
- **Proline is mainly involved in the repairing of the tissues in the formation of collagen, preventing the thickening and hardening of the walls of the arteries (arteriosclerosis) and in the regeneration of new skin.**

Deficiency of Amino acids

. The deficiency of amino acids may include different pathological disorders, including:

- **Edema.**
- **Anemia.**
- **Insomnia.**
- **Diarrhea.**
- **Depression.**
- **Hypoglycemia.**
- **Loss of Appetite.**
- **Fat deposit in the liver.**
- **Skin and hair related problems.**
- **Headache, weakness, irritability, and fatigue.**

Lipids Definition

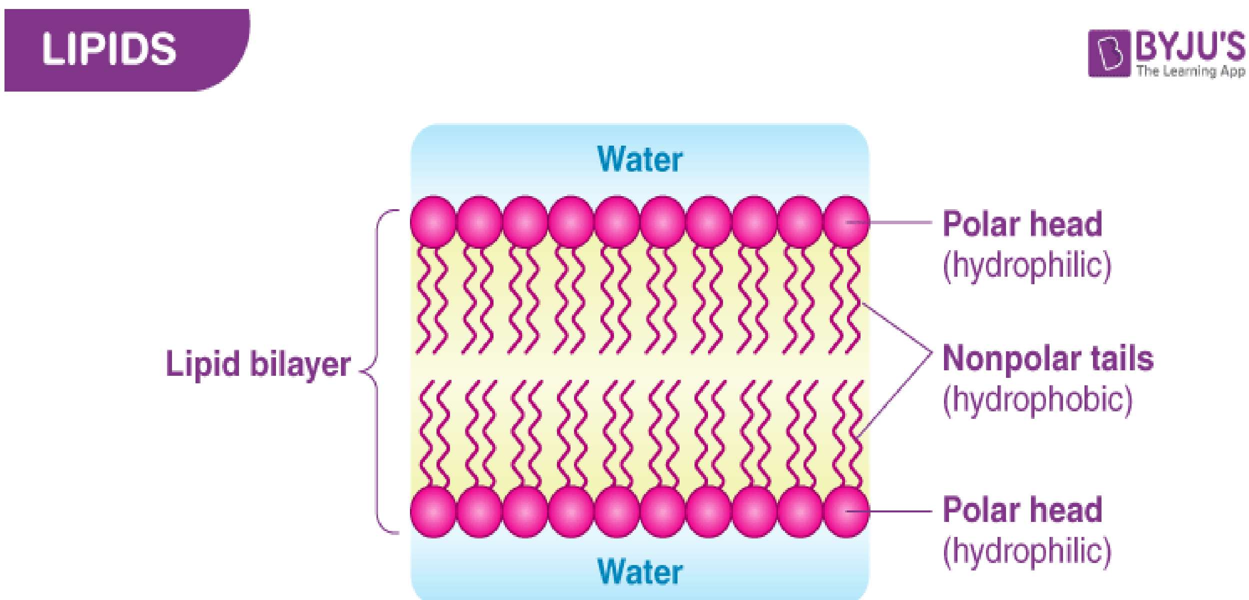
"Lipids are organic compounds that contain hydrogen, carbon, and oxygen atoms, which form the framework for the structure and function of living cells."

What are Lipids?

These organic compounds are nonpolar molecules, which are soluble only in nonpolar solvents and insoluble in water because water is a polar molecule. In the human body, these molecules can be synthesized in the liver and are found in oil, butter, whole milk, cheese, fried foods and also in some red meats.

Let us have a detailed look at the lipid structure, properties, types and classification of lipids.

Also read: Biomolecules



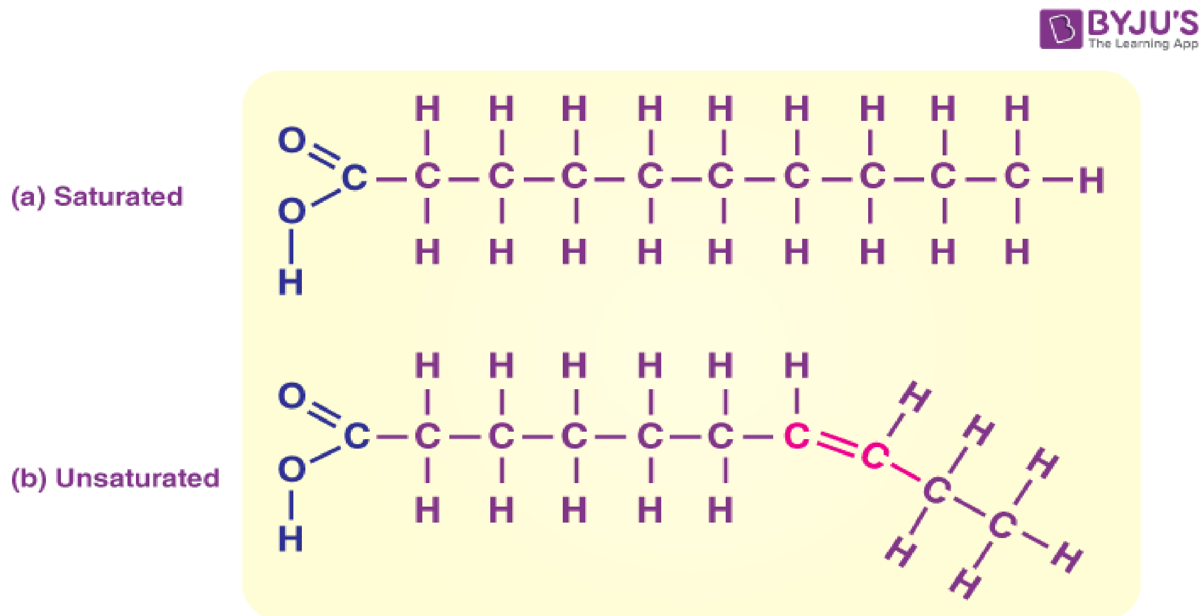
Properties of Lipids

Lipids are a family of organic compounds, composed of fats and oils. These molecules yield high energy and are responsible for different functions within the human body. Listed below are some important characteristics of Lipids.

1. Lipids are oily or greasy nonpolar molecules, stored in the adipose tissue of the body.
2. Lipids are a heterogeneous group of compounds, mainly composed of hydrocarbon chains.
3. Lipids are energy-rich organic molecules, which provide energy for different life processes.
4. Lipids are a class of compounds characterised by their solubility in nonpolar solvents and insolubility in water.
5. Lipids are significant in biological systems as they form a mechanical barrier dividing a cell from the external environment known as the cell membrane.

6. Lipid Structure

7. Lipids are the polymers of fatty acids that contain a long, non-polar hydrocarbon chain with a small polar region containing oxygen. The lipid structure is explained in the diagram below:



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Types of Lipids

Within these two major classes of lipids, there are numerous specific types of lipids, which are important to life, including fatty acids, triglycerides, glycerophospholipids, sphingolipids and steroids. These are broadly classified as simple lipids and complex lipids.

Also read: Biomolecules in Living Organisms

Simple Lipids

Esters of fatty acids with various alcohols.

1. **Fats:** Esters of fatty acids with glycerol. Oils are fats in the liquid state

2. **Waxes**: Esters of fatty acids with higher molecular weight monohydric alcohols

Complex Lipids

Esters of fatty acids containing groups in addition to alcohol and fatty acid.

1. **Phospholipids**: These are lipids containing, in addition to fatty acids and alcohol, phosphate group. They frequently have nitrogen-containing bases and other substituents, eg, in glycerophospholipids the alcohol is glycerol and in sphingophospholipids the alcohol is sphingosine.

2. **Glycolipids (glycosphingolipids)**: Lipids containing a fatty acid, sphingosine and carbohydrate.

3. **Other complex lipids**: Lipids such as sulfolipids and amino lipids. Lipoproteins may also be placed in this category.

Precursor and Derived Lipids

These include fatty acids, glycerol, steroids, other alcohols, fatty aldehydes, and ketone bodies, hydrocarbons, lipid-soluble vitamins, and hormones. Because they are uncharged, acylglycerols (glycerides), cholesterol, and cholesteryl esters are termed neutral lipids. These compounds are produced by the hydrolysis of simple and complex lipids.

Some of the different types of lipids are described below in detail.

Fatty Acids

Fatty acids are carboxylic acids (or organic acid), usually with long aliphatic tails (long chains), either unsaturated or saturated.

- **Saturated fatty acids**

Lack of carbon-carbon double bonds indicate that the fatty acid is saturated. The saturated fatty acids have higher melting points compared to unsaturated acids of the corresponding size due to their ability to pack their molecules together thus leading to a straight rod-like shape.

- **Unsaturated fatty acids**

Unsaturated fatty acid is indicated when a fatty acid has more than one double bond.

“Often, naturally occurring fatty acids possesses an even number of carbon atoms and are unbranched.”

On the other hand, unsaturated fatty acids contain a cis-double bond(s) which create a structural kink that disables them to group their molecules in straight rod-like shape.

Role of Fats

Fats play several major roles in our body. Some of the important roles of fats are mentioned below:

- Fats in the correct amounts are necessary for the proper functioning of our body.
- Many fat-soluble vitamins need to be associated with fats in order to be effectively absorbed by the body.
- They also provide insulation to the body.
- They are an efficient way to store energy for longer periods.

Also Read: Fats

Examples of Lipids

There are different types of lipids. Some examples of lipids include butter, ghee, vegetable oil, cheese, cholesterol and other steroids, waxes, phospholipids, and fat-soluble vitamins. All these compounds have similar features, i.e. insoluble in water and soluble in organic solvents, etc.

Waxes

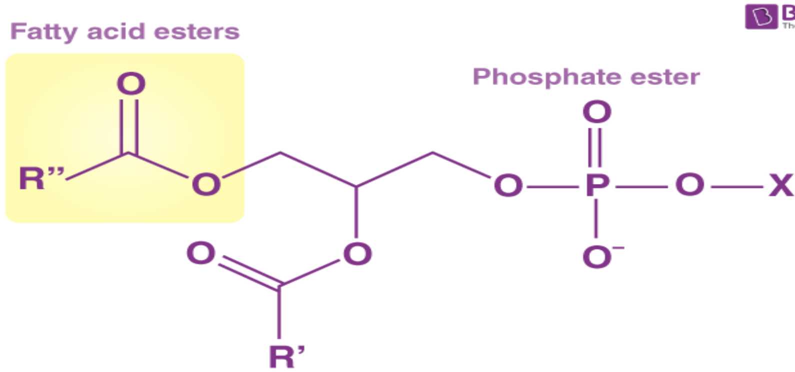
Waxes are “esters” (an organic compound made by replacing the hydrogen with acid by an alkyl or another organic group) formed from long-alcohols and long-chain carboxylic acids.

Waxes are found almost everywhere. The fruits and leaves of many plants possess waxy coatings, that can safeguard them from small predators and dehydration.

Fur of a few animals and the feathers of birds possess the same coatings serving as water repellants.

Carnauba wax is known for its water resistance and toughness (significant for car wax).

Phospholipids



Membranes are primarily composed of phospholipids that are Phosphoacylglycerols.

Triacylglycerols and phosphoacylglycerols are the same, but, the terminal OH group of the phosphoacylglycerol is esterified with phosphoric acid in place of fatty acid which results in the formation of phosphatidic acid.

The name phospholipid is derived from the fact that phosphoacylglycerols are lipids containing a phosphate group.

Steroids

Our bodies possess chemical messengers known as **hormones**, which are basically organic compounds synthesized in glands and transported by the bloodstream to various tissues in order to trigger or hinder the desired process.

Steroids are a kind of hormone that is typically recognized by their tetracyclic skeleton, composed of three fused six-membered and one five-membered ring, as seen above. The four rings are assigned as A, B, C & D as observed in the shade blue, while the numbers in red indicate the carbons.

Cholesterol

- Cholesterol is a wax-like substance, found only in animal source foods. Triglycerides, LDL, HDL, VLDL are different types of cholesterol found in the blood cells.
- Cholesterol is an important lipid found in the cell membrane. It is a sterol, which means that cholesterol is a combination of steroid and alcohol. In the human body, cholesterol is synthesized in the liver.
- These compounds are biosynthesized by all living cells and are essential for the structural component of the cell membrane.

- In the cell membrane, the steroid ring structure of cholesterol provides a rigid hydrophobic structure that helps boost the rigidity of the cell membrane. Without cholesterol, the cell membrane would be too fluid.
- It is an important component of cell membranes and is also the basis for the synthesis of other steroids, including the sex hormones estradiol and testosterone, as well as other steroids such as cortisone and vitamin D.

What are Nucleic Acids?

Nucleic acids are long-chain polymeric molecules, the monomer (the repeating unit) is known as the nucleotides and hence sometimes nucleic acids are referred to as polynucleotides.

Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are two major types of nucleic acids. DNA and RNA are responsible for the inheritance and transmission of specific characteristics from one generation to the other. There are prominently two types of nucleic acids known to us.

Table of Contents

Related Topics

- Nucleic Acids: DNA and RNA
- Vitamins – Classification and Functions

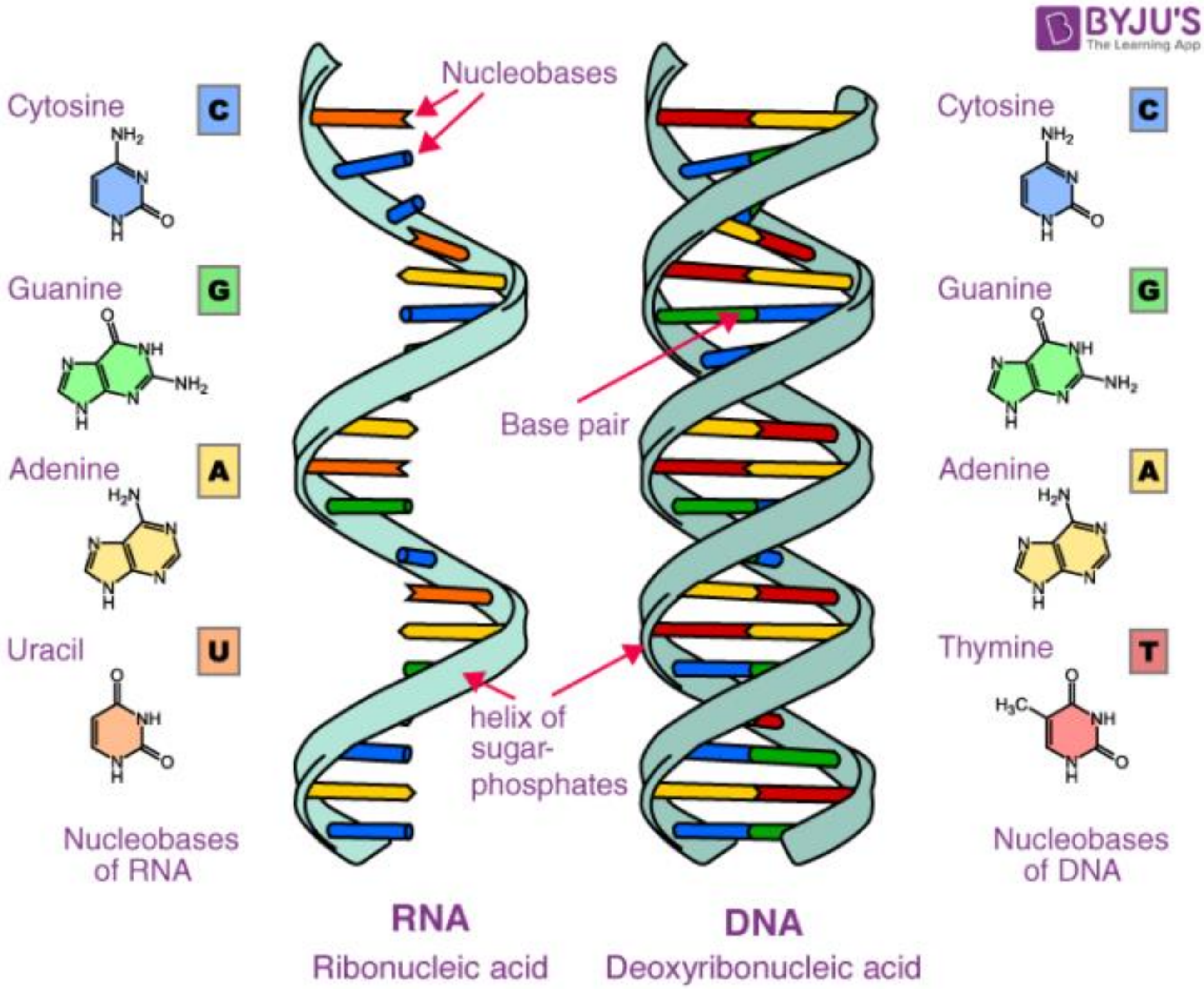
Deoxyribonucleic Acid (DNA)

Chemically, DNA is composed of a pentose sugar, phosphoric acid and some cyclic bases containing nitrogen. The sugar moiety present in DNA molecules is β-D-2-deoxyribose. The cyclic bases that have nitrogen in them are adenine (A), guanine (G), cytosine(C) and thymine (T). These bases and their arrangement in the molecules of DNA play an important role in the storage of information from one generation to the next one. DNA has a double-strand helical structure in which the strands are complementary to each other.

Ribonucleic Acid (RNA)

The RNA molecule is also composed of phosphoric acid, a pentose sugar and some cyclic bases containing nitrogen. RNA has β-D-ribose in it as the sugar moiety. The heterocyclic bases present in RNA are adenine (A), guanine (G), cytosine(C) and uracil (U). In RNA the fourth base is different from that of DNA. The RNA generally consists of a single strand which sometimes folds back; that results in a double helix structure. There are three types of RNA molecules, each having a specific function:

1. **messenger RNA (m-RNA)**
2. **ribosomal RNA (r-RNA)**
3. **transfer RNA (t-RNA)**



The Functions of Nucleic Acids

1. Nucleic acids are responsible for the transmission of inherent characters from parent to offspring.
2. They are responsible for the synthesis of protein in our body
3. DNA fingerprinting is a method used by forensic experts to determine paternity. It is also used for the identification of criminals. It has also played a major role in studies regarding biological evolution and genetics.

DNA denaturation and renaturation processes:

DNA denaturation and renaturation processes are used for genetic research and studies. In the process of denaturation, an unwinding of DNA double-strand takes place, resulting in two separate single strands on applying high temperature, extreme pH, etc. Separate single strands rewind on cooling and the process is known as renaturation.

Denaturation and renaturation kinetics are used to determine the size and complexity of the genome. It is also used to understand the relativity of two genomes and repetitive sequences present in a genome.

Difference between Denaturation and Renaturation of DNA

The table below shows the main difference between Denaturation and Renaturation of DNA

Denaturation of DNA	**Renaturation of DNA**
Double-stranded DNAs are converted to single strands	Denatured single strands of DNA, which are complementary, form double strands
Denaturation occurs on heating	Renaturation occurs on cooling
Unwinding of DNAs take place	Rewinding of DNAs take place
In this process, hydrogen bonds between complementary base pairs of two DNA strands are broken	There is a formation of hydrogen bonds between complementary base pairs of two strands to form double strands
The rate of UV absorbance (260nm) increases	The rate of UV absorbance decreases

Viscosity decreases	Viscosity increases

What is Denaturation?

DNA has a double-stranded helical structure. There are various factors that affect the stability of the DNA structure.

In the denaturation process, the hydrogen bonds between two strands are broken giving rise to two single strands. The covalent bonds of DNA remain unaffected.

Denaturation can be brought by various methods:

1. **Thermal denaturation:** Denaturation can be done by heating (>80-90℃). The temperature at which DNA is half denatured is called critical temperature or melting temperature, **Tm**. Tm is dependent on the length and composition of the DNA bases and other factors such as pH and denaturing agents.
2. **Extreme pH:** At high pH (>11.3), hydrogen bonds between base pairs of two strands of DNA dissociate due to presence of abundant OH^- ion. It results in denaturation of DNA.
3. **Other denaturing Agents:** Low salt concentrations destabilise hydrogen bonds. Formaldehyde and urea have a tendency to form hydrogen bonds with nitrogen bases and aldehydes also prevent hydrogen bonding between base pairs by modifying electronegative centres of nitrogenous bases.

Effect of denaturation of DNA:

- Increased absorption of UV light at 260nm wavelengths. The rate of absorption is directly proportional to the rate of denaturation
- Viscosity decreases, which reflects the physical change occurred in the DNA structure

What is Renaturation?

Renaturation is also known as annealing. When the temperature and pH return to optimum biological level, the unwound strand of DNA rewind and give back the dsDNA.

If the DNA is not completely denatured, the renaturation process is fast and a one-step process, but if the DNAs are completely denatured then the renaturation process occurs in a two-step process. First complementary strands come together by random collision and then rewinding takes place forming a double helix.

Renaturation occurs when the denatured DNAs are cooled in suitable conditions. Renaturation also depends on temperature, pH, length and constituents of the DNA structure. The renaturation rate is directly proportional to the number of complementary sequences present.

With renaturation, absorption of UV (260nm) decreases and viscosity increases again.

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