M.Sc Zoology- Softcore paper

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MZO-1.5 Biological chemistry

Block-1

Unit-1 Carbohydrates

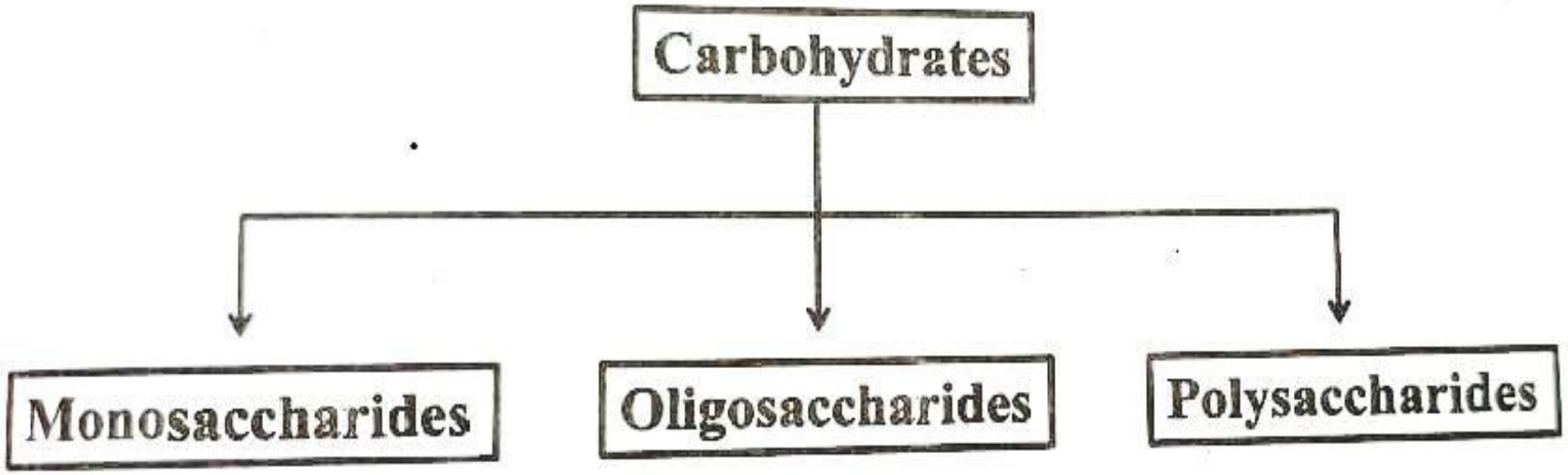
- What are Carbohydrates
- Classification of Carbohydrates
- Monosaccharides
- Disaccharides
- Polysaccharides
- Hetero and Homo polysaccharides
- Pepidoglycan
- Blood group polysaccharides

What are Carbohydrates

- Carbohydrates are defined as organic compounds that contain polyhydroxy aldehyde or polyhydroxy ketones in addition to alcohol group and which on hydrolysis yield derivation of aldehyde or ketone
- Carbohydrates are organic compounds contain elements of carbon, hydrogen and oxygen with general formula $C_n(H_20)_{n-1}$
- Earlier Carbohydrates are defined as hydrates of carbon because of Hydrogen and oxygen combined with same ration as in H_20 (2:1) ratio
- For example; Glucose $C_6H_{12}0_6$, but certain carbohydrates like Rhamnose and Deoxyribose don't follow the same ration of 2:1

Classification of Carbohydrates

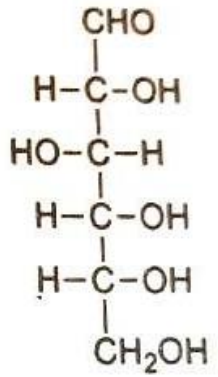
- Carbohydrates are also known as **Saccharides** (Greek word Sakcharon= sugar or sweetness)
- Carbohydrates are classifies based on the number of monosaccharide units present in the sugar.



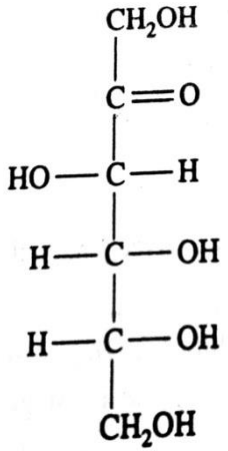
MONOSACCHARIDES

(Gr; Mono= one ; Saccharide = sugar unit)

- Monosaccharides are simple sugars which cannot undergo further hydrolysis into smaller subunits of molecules
- The common monosaccharides are Glucose, Fructose, Erythrose, Ribose etc.
- The monosaccharides are compounds which contains aldehyde CHO group and Ketone C=O group



Glucose



Fructose

Monosaccharides

- Monosaccharides are further classified based on two important character
- i. one with presence of number of carbon atoms
- ii. On the presence of nature of functional groups in their structure

Name	Formula (Based on number of Carbon atom)	Aldose (Aldehyde group)	Ketose (Ketone group)
Trioses	$C_3H_6O_3$	Glycerose (Glyceraldehyde)	Dihydroxy acetone
Tetroses	$C_4H_8O_4$	Erythrose	Erythrulose
Pentoses	$C_5H_{10}O_5$	Ribose	Ribulose
Hexoses	$C_6H_{12}O_6$	Glucose	Fructose

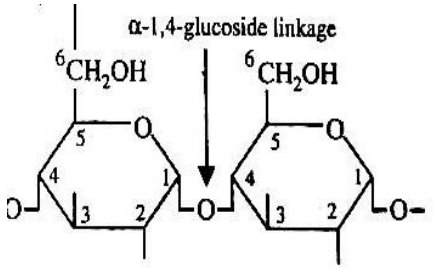
- Some time Hexose containing aldoses and ketoses is also named with suffix-oses is used for aldoses sugar For example Glucose is named as hexoses
- Similarly Ketoses is named with suffix Ulose is used For example Fructose is named as Hexulose

Oligosaccharides

- These are carbohydras which on hydrolysis gives 2 or more monosaccharides units
- The common oligosaccharides are Sucrose, Lactose, Maltose, Raffinose and Stachyose
- The oligosacharides are further classified on the basis of monosaccharide subunits it contains
- Accordantly
- **Disaccharides**- which gives 2 monosaccharide units on hydrolysis Example- Sucrose, Lactose, Maltose, Cellobiose.
- $C_{12}H_{22}O_{11} + H_2O$ ----------→ $C_6H_{12}O_6 + C_6H_{12}O_6$
- **Trisaccharides**- which gives 3 monosaccharide unit on hydrolysis Example- Raffinose, Rhamninose
- $C_{18}H_{32}O_{16} + 2H_2O$----------→ $C_6H_{12}O_6 + C_6H_{12}O_6 + C_6H_{12}O_6$
- **Tetrasaccharides** – which gives 4 monosaccharide units on hydrolysis Example- Stachyose, Scorodose.
- $C_{24}H_{42}O_{21} + 3H_2O$ ----------→ $C_6H_{12}O_6 + C_6H_{12}O_6 + C_6H_{12}O_6 + C_6H_{12}O_6$

Disaccharides

- Disaccharides are formed by the union of 2 constituent monosaccharide subunit by glycosidic linkage
- **Maltose**- it is formed by two D- glucose units in 1, 4 glycosidic linkages.



- **Lactose** –It yields D-Galactose and D-glucose on hydrolysis.
- **Sucrose**- or cane sugar is a disaccharide of glucose and fructose. The hydrolysis of sucrose to D-glucose and D-fructose is often called inversion since it is accompanied by a net change in optical rotation from **Dexro to Levo**

Polysaccharides

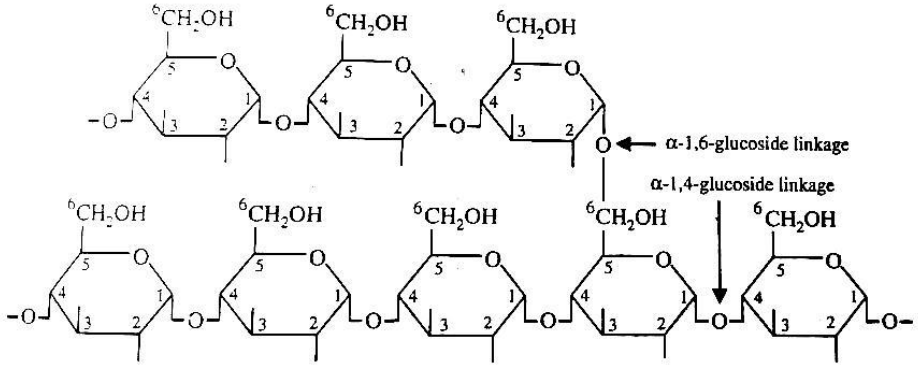
(Gr; Poly-Many; Saccharides-Sugar unit)

- These are High Molecular weight compound sugars which on hydrolysis yield more than10 monosaccharide units
- They are polymers of monosaccharides. They have branched chain and also linear chain structure.
- Polysaccharides are concerned with many important functions
- 1. Storage of energy such as starch and glycogen
- 2. As structural frame work of cell wall in plants – cellulose and plasm membrane- peptidoglycan
- 3. They also act as supporting function of bone and tissues

- Based on presence of Common or different Monosaccharide unit they are classified into
- I. Homopolysaccharides
- II. Heteropolysaccharides

Homopolysaccharides

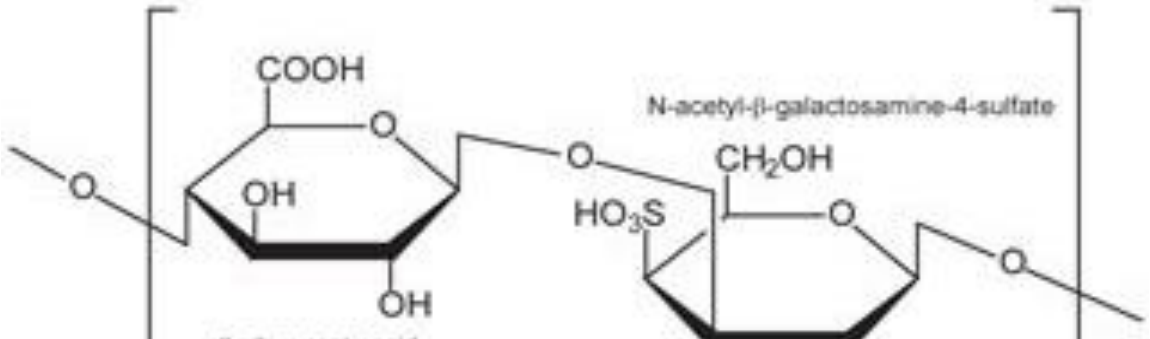
- Homopolysaccharides are sugars which on hydrolysis yields same or common type of monosaccharide units
- Examples like starch, glycogen, dextrin, cellulose, chitin etc
- Starch is reserved food material in plants, its structure contains long unbranched Amylopectin and coiled branched Amylose both are made up of D-Glucose units



- Similarly, Glycogen is highly branched D-glucose units linked by 1,4-glycosidic and 1,6-glycosidic bonds.

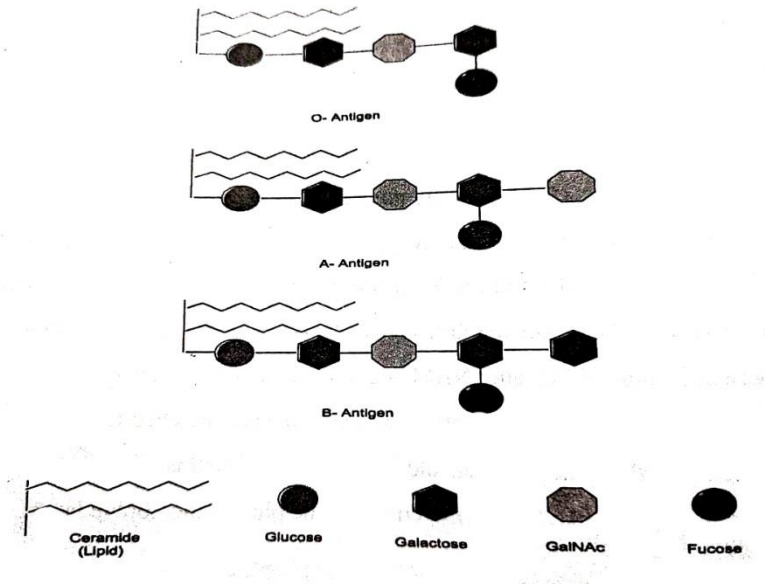
Heteropolysaccharides

- These which on hydrolysis yield mixture of different types of monosaccharide units
- Examples like Heparin, Glycorinic acid , Hyaluronic acid and Chondritin sulphate. They are mainly supportive functions of tissues and bones.
- Hyaluronic acid – help in lubrication of skeleton joints
- Heparin – act as anticogulation of blood
- Chondritin sulphate- is an major components of Cartilage ,tendons and bones.



Blood Group Polysaccharides

- Antigens are the complex oligosaccharides present on the RBC
- The A and B antigens contains complex oligosaccharides differing in terminal sugar.
- In A antigen contains N-acetylgalctosamine is present and in B- antigen contains Galactose
- The membrane bound carbohydrates present in glycolipids is a part in antigenic determinants.



MZ0-1.5 Biological Chemistry
Block-1 of Unit -2

- Sterochemistry
- D- L isomers
- Epimers
- Straight chain, Chair and boat structure of Glucose
- Structure of Fructose
- Biological importance of Carbohydrates
- Clinical significance of Carbohydrates
- Diabetes mellitus.

STEREOISOMERS

- What is an isomer ?

The term isomer was originally applied to different compounds with the same molecular formula but different structural formulae. This phenomenon is called isomerism.

This isomerism is of two types 1) Structural isomers 2) stereoisomers

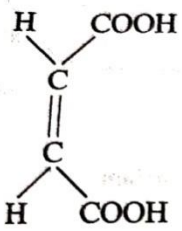
- Structural isomer – have same formula but different structures
- Stereoisomers- have same formula and same structure

Further, The sterioisomers are of two types

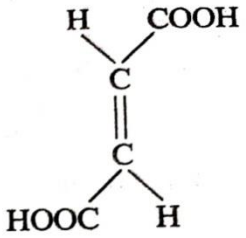
i. Geometrical isomers
ii. Optical isomers

Geometric isomers

- Geometric isomers are illustrated by Cis-trans pair (Cis= same side, Trans= across the plane)

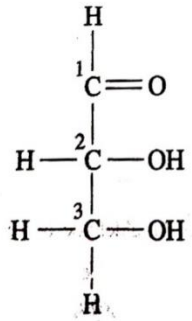


Maleic acid
(*cis* form)

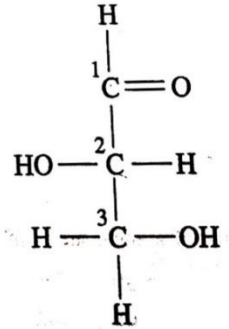


Fumaric acid
(*trans* form)

- Optical isomers (enantiomers) are mirror images of each other and they differ in spaces of asymmetric carbon atoms



D-glyceraldehyde



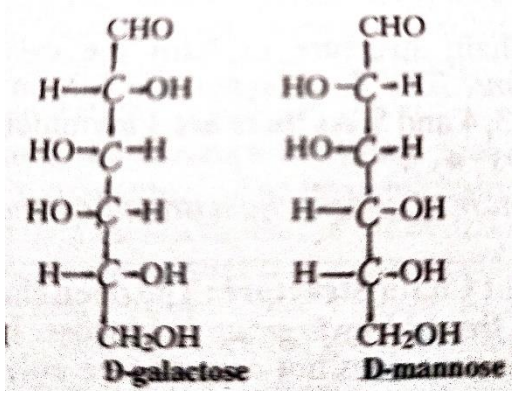
L-glyceraldehyde

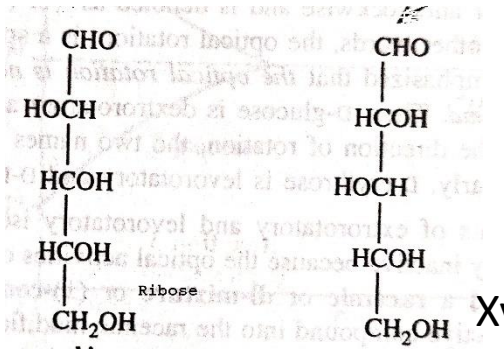
Dextro and Levo rotation

- Glucose and other sugars have the property to rotate the plane of polarized light either to left or right through certain angle such sugar are called optically active compounds
- Glucose exists both right rotation D-form (+ Dextral) and other rotate to left L-form (-Levo) , accordingly D-Glucose and L-Glucose
- This rotation of plane polarized light depends on the number of asymmetric carbon atoms present in the structure.
- Certain isomeric compounds exists in nature. D-Glucose is predominant in nature and optically active while L-fructose form is also exists in fruits.
- Majority of Monosaccharides found in human body are D-type such as D-Glucose, D-ribose, D-arabinose etc.,

Epimerism

- The molecules containing more than one asymmetric carbon or in other words carbohydrates which vary in position of –OH group are called epimers
- For example Galactose and Mannose are two epimers of glucose.



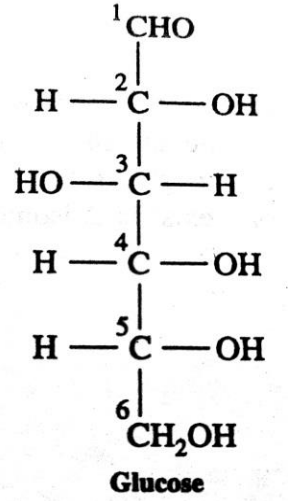


Xylose

- According to Le Bel-van't Hoff rule – the position of asymmetric carbon can result in two isomeric forms i.e, 2^n where n represents two or more asymmetric carbon atoms. Such carbohydrates can exists in 4 forms
- Some sugars like D-Glucose, D-ribose, D-arabinose similarly L-Fructose, L-arabinose is named. The D and L forms depends on the number of asymmetric carbons

Structure of Glucose

- Baeyer's Open chain structure of Glucose



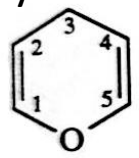
Glucose

- He concluded that D- Glucose is pentahydroxyhexnal represented with one aldehydre group and 5 hydroxyl group and one alcohol group in its structure.
- Further Emil Fischer's projection formula described that there are 4 asymmetric carbon atoms in glucose and exists in two stereoisomers.

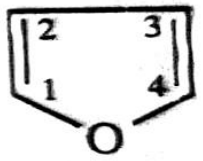
Cyclic structure or Ring structure of Glucose

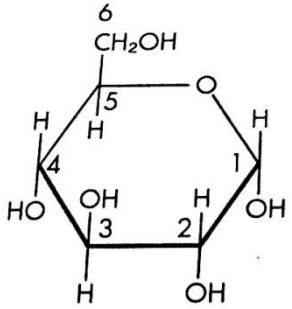
- Fischer's open chain projection formula fail to explain other properties of Glucose
- In open chain structure glucose conatian aldehyde group can readily react with other hydroxyl groups and alcohols groups.
- Hence glucose also exists as 6-membered ring (Pyranose form) or 5-membered ring (Furanose form). This new finding by Haworth answered many problems in structure of glucose

Pyranose

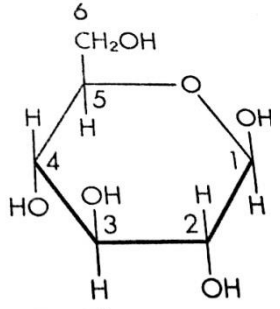


Furanose





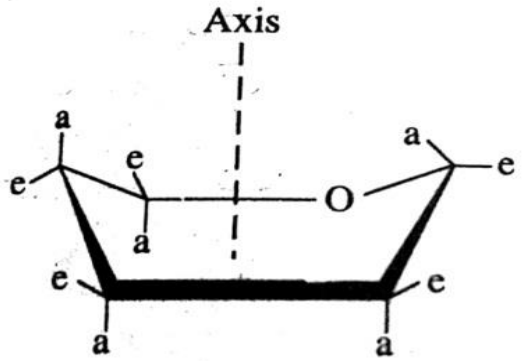
α-D-Glucose
(α-D-Glucopyranose)



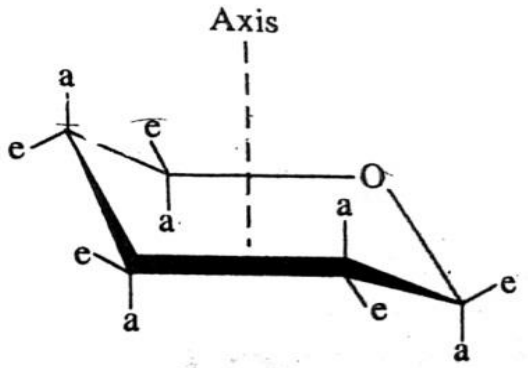
β-D-Glucose
(β-D-Glucopyranose)

Haworth projection formulas of Glucose

- Haworth clearly explained predominant chair structure and boat structural isomerism exists in solution
- As a result of torsion the O atom and OH groups are placed opposite to each other



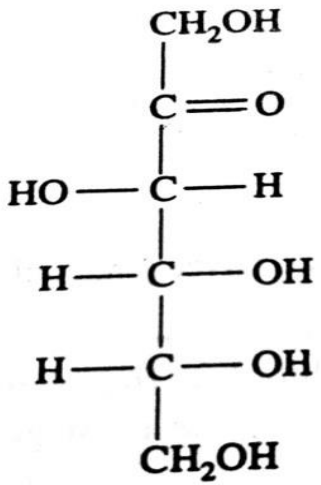
Boat form of
a pyranose



Chair form ot
a pyranose

Structure of Fructose

- Fructose is a pentahydroxyhexanal – containing ketone group (ketohexose) it is represented by open chain structure as



Fructose

- Glucose and Fructose are called reducing sugars
- While Disaccharides like sucrose, maltose , trehalose are nonreducing sugars

Biological importance of Monosaccharides

- Glucose- is a major metabolic fuel of cells and tissues which provides ATP

Occurs abundantly in free state in many fruits, honey etc

They glucose units found as constituent of disaccharides and polysaccharides are digested by enzymes for yield of energy

- Fructose- they play important role in carbohydrate metabolism as intermediate products, They are occurs in fruits, honey and plants.
- Ribose- They are essential component of nucleotides of DNA and RNA

In DNA they exists as deoxyribose sugar and in RNA as Ribose sugar, They are also found in large components of nucleoproteins

Biological importance of Disaccharides / Polysaccharides

- Sucrose- Common table sugar often used for sweet taste, table sugar, They are formed by 1 molecule of Glucose and one molecule of Fructose with 1-2- glyosidic linkages. Levorotatory (invert sugar)
- Lactose- Milk sugar of animal origin often used to feed infants. Composed of 1 molecule of glucose and one molecule of Galactose, linked by 1-4 glyosidic linkages.
- Starch- serve as reserve food material in plants cerals, rice, potates
- Glycogen- are major storage reserved food in animal also called animal starch
- Heparin-are mainly acts as a anticogulation

Clinical significance of Carbohydrates

- Diabetes mellitus
- Diabetes mellitus is a clinical syndrome characterized by hyperglycemia and also due to insufficient insulin synthesis from pancreas.
- In healthy adults the normal fasting glucose level is 80-100 mg/100ml of blood
- Glycogenesis- the biosynthesis of glycogen from glucose when glucose level rises in blood
- Gluconeogenesis – occurs when the carbohydrates in the diet is insufficient in the body.

Unit-3

- Bioenergetics
- Glycolysis cycle
- TCA cycle
- Electron transport system
- Proton motive force and ATP synthesis
- Energy budget