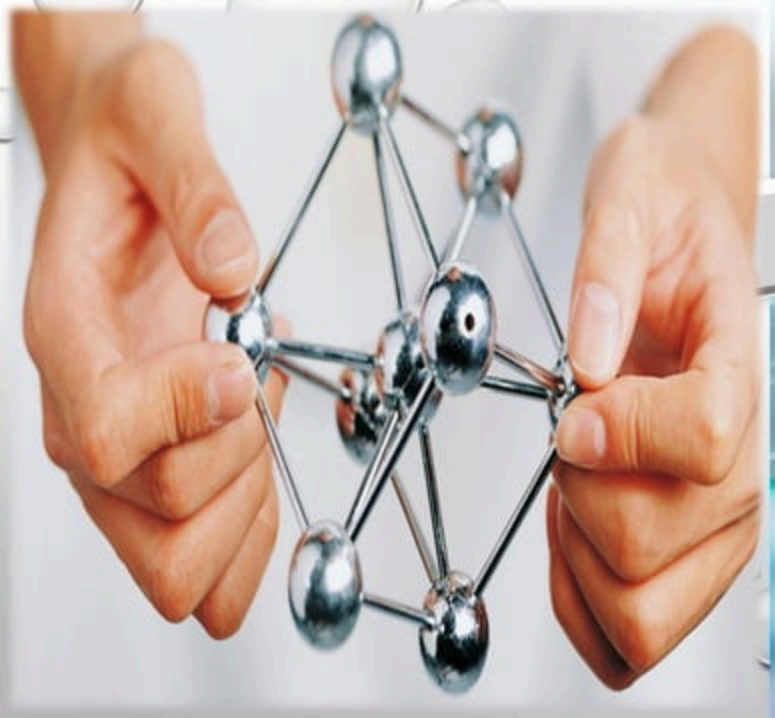

BIOMOLECULES

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Puducherry.

1. INTRODUCTION

2. CLASSIFICATION

3. CHEMICAL NATURE & BIOLOGICAL ROLE OF

- CARBOHYDRATES
- LIPIDS
- NUCLEIC ACIDS
- AMINO ACIDS
- PROTEINS

BIOMOLECULES

1. INTRODUCTION

- ARE THE **MOLECULES** OCCURRING IN **LIVING ORGANISMS**
- USED FOR **MAINTENANCE & METABOLIC PROCESSES** OF LIVING ORGANISMS
- TWO TYPES

Macromolecules (Large molecules)

- Proteins
- Carbohydrates
- Lipids
- Nucleic acids

Micromolecules (Small Molecules)

- Natural products
- Primary & Secondary metabolites

IMPORTANT BIOMOLECULES

Elements constitute about 90% of Human Body.
Biomolecules are endogenous but rarely exogenous like Pharmaceutical drugs from natural / synthetic

SMALL MOLECULES	DERIVED MACROMOLECULE	ATOMIC CONSTITUENTS
Amino acids	Proteins	C,H,O,N
Sugars	Starch	C,H,O
Fatty acids	Fats, oils	C,H,O
Purine & Pyrimidine	Nucleic acids	C,H,O,N
Nucleotide	DNA & RNA	C,H,O,N,P

Biomolecules characteristics

- Organic compounds
- Mostly asymmetric
- Specific shapes & dimensions
- Determination of structure and function of the cell
- Chemical properties based on functional groups of molecules
- Involved in exchange of energy

Chemical Nature Of Biomolecules

- Are organic compounds mainly contain carbon
- Linked with each other by covalent bond
- Proteins, lipids, polysaccharides and nucleic acids → complex biomolecules
- Ribosomes, lipoproteins → supra macromolecules
- Micromolecules → linked together → form macromolecules

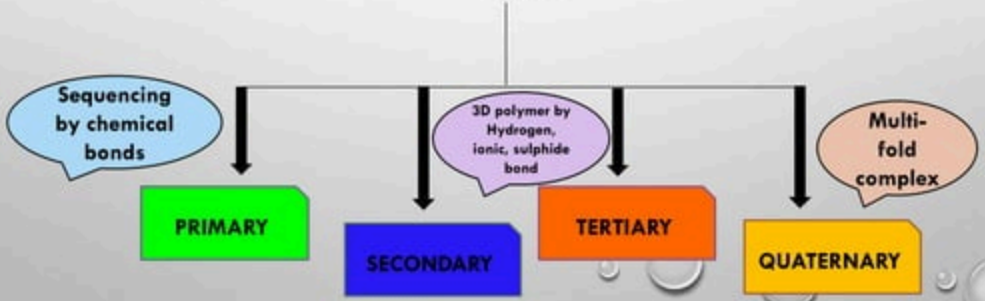
Eg:

Glucose → glycogen

Amino acid → protein

Biomolecules structure

- Intricately Folded Three Dimensional Structure
- Formed By Proteins, **RNA & DNA**
- 4 Types



Biomolecules functions

Human body → 60% water, 15% proteins & lipids, 2% carbohydrates & 8% minerals

Biomolecules	Monomers	Examples	Functions
Carbohydrates	Monosaccharides	Glucose, Fructose, Lactose cellulose	Provides cell energy & constitution of cell membrane
Proteins	Amino acids	Hemoglobin, Insulin, Enzymes, Antibodies	Provide structure of the body, energy, improve rate of rxn & immunity
Lipids	Glycerol & fatty acids	Fats, oils, waxes	Stores energy as insulator & protector
Nucleic acids	Nucleotides	DNA, RNA	Genetic information for growth & development
Enzymes	Amino acids	Citric acid synthetase, topoisomerase, Estrases, Fumarase	Biocatalyst

CARBOHYDRATES: THE POWER NUTRIENT

CARBOHYDRATES
$C_n(H_2O)_n$

- Carbohydrates → Polyhydroxyaldehydes Or Ketones Or Compounds Which Produce Them On Hydrolysis
- Also Known As Saccharides → Sakcharon – sugar.
- 3 types → Mono & Oligo saccharides → Sweet in taste (called sugars)
- Poly → tasteless (Non- sugars)
- Glycome → entire spectrum of carbohydrates of an organism
- Glycomics → study of glycomes that includes physiological, pathological, genetics & various aspects
- Glycobiology → study of carbohydrates in health & diseases.

CARBOHYDRATES

$C_n(H_2O)_n$

Bonds shared between two monosaccharides are the glycosidic bonds

Monosaccharide
Eg: Glucose , Fructose

Disaccharides
Eg: Sucrose, Maltose

SIMPLE

- Sweet simple sugars
- Composed of 3-7 C- atoms
- Easily soluble
- LMW compounds
- Reducing Sugars

COMPLEX

Polysaccharide
Eg: starch, dextrin

- Polymer / complex sugars
- Tasteless
- Insoluble
- HMW compounds
- Reducing Sugars

2. CLASSIFICATION

CARBOHYDRATES

Monosaccharides

Trioses (3C) to Decoses (10C)

Monosaccharide
Eg: Glucose , Fructose

Oligosaccharide

2 – 10 Monosaccharides

Polysaccharide
Eg: starch, dextrin, amylopectin, glycoprotein

Derived Monosaccharides

- Uric acid
- Aroic acid
- Aminosaccharides
- Phosphosaccharides
- Glycosides

Homo Polysaccharides

Hetero Polysaccharides

Disaccharides
Eg: Sucrose, Maltose

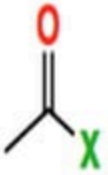
Trisaccharides
Eg: Raffinose

Tetrasaccharides
Eg: Stachylose

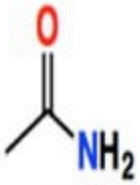
COMMON FUNCTIONAL GROUP

aldehyde

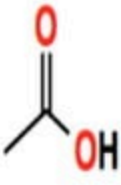
ketone



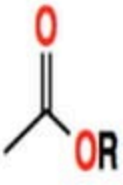
acid halide



amide

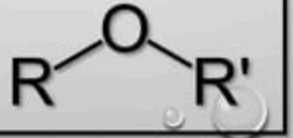


carboxylic acid



ester

Ether



ALDOSES

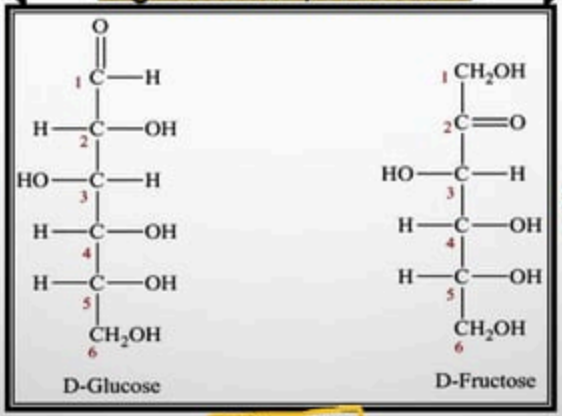
(Functional group in Monosaccharides is aldehydes)

Monosaccharide

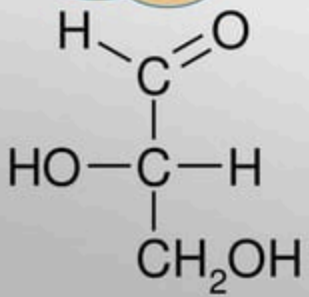
Eg: Glucose , Fructose

KETOSES

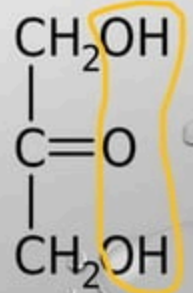
(Functional group in Monosaccharides is Ketones)

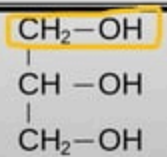


Glucose
Glyceraldehyde



Fructose
Dihydroxyacetone





DIFF B/W MONO, OLIGO & POLYSACCHARIDES

Character	Monosaccharides	Oligosaccharides	Polysaccharides
Glycoside bond	Absent	Present	Present
Reducing sugar	Always reducing sugar	May or may not be	Always non reducing sugar
Molecular Weight	Low	Moderate	High
Taste	Sweet taste	Minimally sweet	No taste
Solubility	Soluble	Soluble	Insoluble Nature
Examples	Glucose, fructose	Sucrose, Maltose	Starch, dextrin, cellulose

Properties of carbohydrates

- Act as **energy reserves**, also stores fuels, and metabolic intermediates.
- Ribose and deoxyribose sugars forms the structural frame of the **genetic material, RNA and DNA.**
- Polysaccharides like **cellulose** are the structural elements in the cell walls of bacteria and plants.
- Carbohydrates ➔ linked to proteins and lipids - play important roles in **cell interactions.**
- Carbohydrates are organic compounds ➔ aldehydes or ketones with many hydroxyl groups.

CHEMICAL NATURE OF CARBOHYDRATES

- Optically Active Polyhydroxy Aldehydes Or Ketones On Hydrolysis
- Based On Hydrolysis ➔ Classified As Mono Di & Polysaccharides
- Glucose Is Monosaccharides → Procured From Hydrolysis Of Starch
- Monosaccharides Are **Optically Active**
- **2 Monosaccharides** Joined Together With **Glycosidic Linkage** ➔ Form **Disaccharides**
- **Long Chain Monosaccharides** Joined Together With Glycosidic Linkage ➔ Form **Polysaccharides**

Hydrolysis Form Sugar Alcohol ⟹ **Monosaccharides** ⟸ **Oxidation Form Sugar Acids**

Monosaccharides

-Also known as simple sugars

-Classified either by the number of carbon atoms or by the nature of functional group-aldoses or ketoses

-Most of the carbohydrates (99%) are straight chain compounds

-D-glyceraldehyde is the simplest of the aldoses (aldotriose)

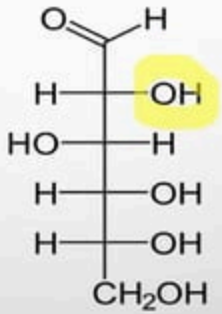
-All other sugars have the ending ose
(glucose, galactose, ribose, lactose, etc…)

Classification of Monosaccharides

No. of Carbon	Type of sugar	Aldoses	Ketoses
3	TRIOSES	Glyceraldehydes	Dihydroxyacetone
4	TETROSES	Erythrose	Erythrulose
5	PENTOSES	Ribose, Xylose	Ribulose, xylulose
6	HEXOSES	Glucose, Galactose	Fructose
7	HEPTOSES	Glucoheptose	Sedoheptulose

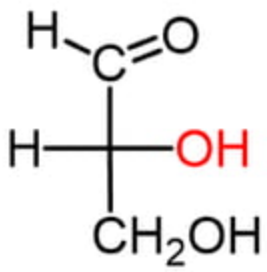
Chemistry Of Carbohydrates

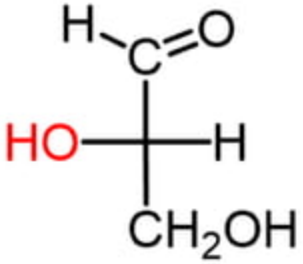
- **Steroisomerism** - Compound having Same Structural Formula But They Differ In Spatial Configuration.
- Eg: They Are **D-glucose And L-glucose**.
- Carbon is asymmetric – attached with 4 different Atoms
- Glucose- 4 asymmetric carbons & 16 isomers
- Glyceraldehyde – one asymmetric carbons & 2 stereoisomers ➔ reference carbohydrates



D-Glucose

L-Glucose





enantiomers

D-glyceraldehyde

L-glyceraldehyde

D & L ISOMERS

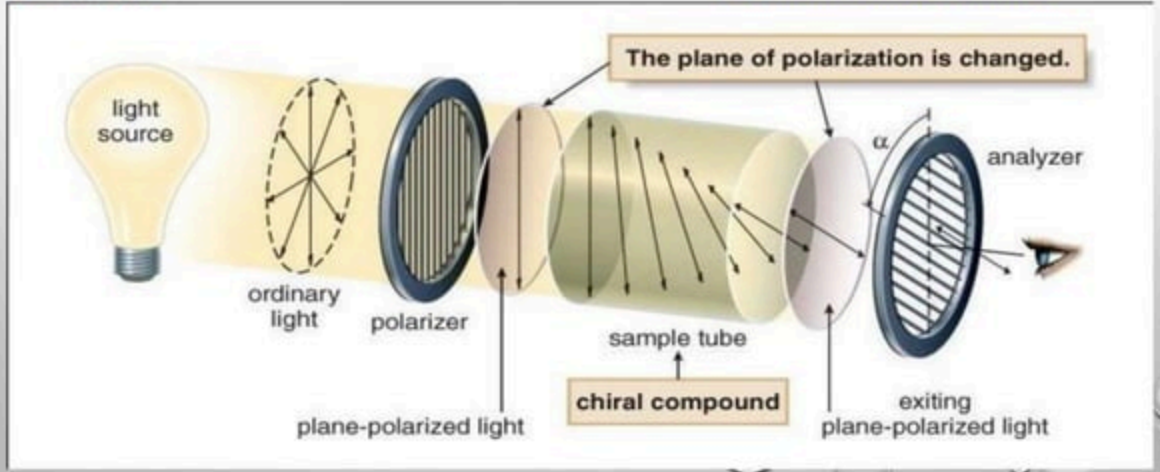
- **Mirror Images Of Each Other**
- **Spatial Configuration / Orientation Of –H & -OH Groups On C-atoms Adjacent To Primary Alcohol Determines Whether The Sugar Is D Or L Isomers**

D-Glucose

L-Glucose

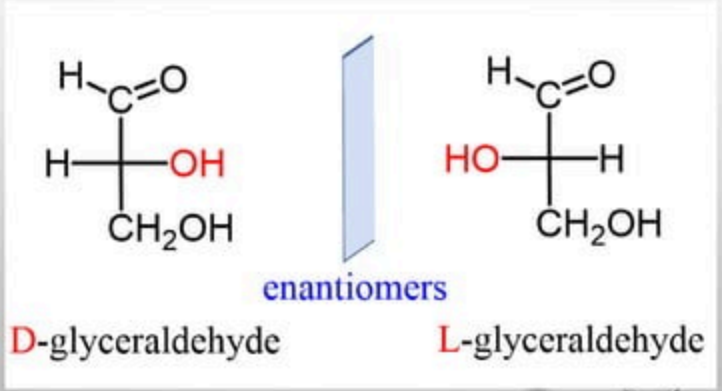
Optical Activity

- The Rotation Of Plane Polarized Light Forming **(+) Glucose And (-) Glucose**.



ENANTIOMERS

- SPECIAL TYPE OF STEREO ISOMERS → MIRROR IMAGES TO EACH OTHER



EPIMERS

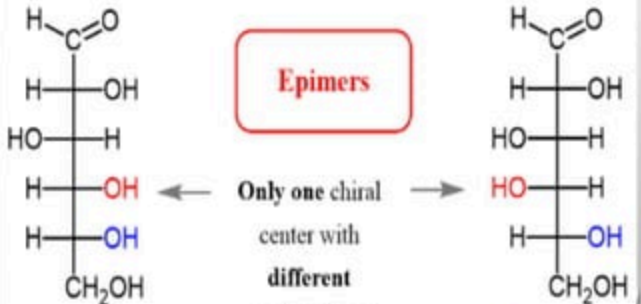
Monosaccharides differ from each other in a

configuration around a single C-atom

Interconversion of epimers

EPIMERIZATION

D-glucose and D-galactose are epimeric at carbon-4



CONFIGURATION

D-Aldoses

- Using killiani fischer synthesis – glyceraldehyde as aldotriose to aldohexose by increase chain length of C-1 at a time

D-Ketoses

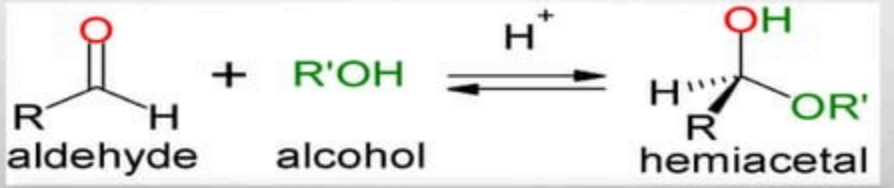
- Starts from DHA→ Form 5 keto sugars

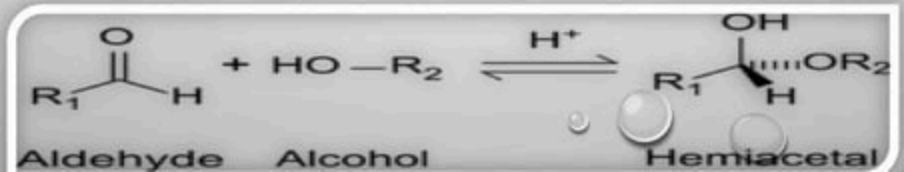
STRUCTURE OF GLUCOSE

Fischer projection

Haworth projection

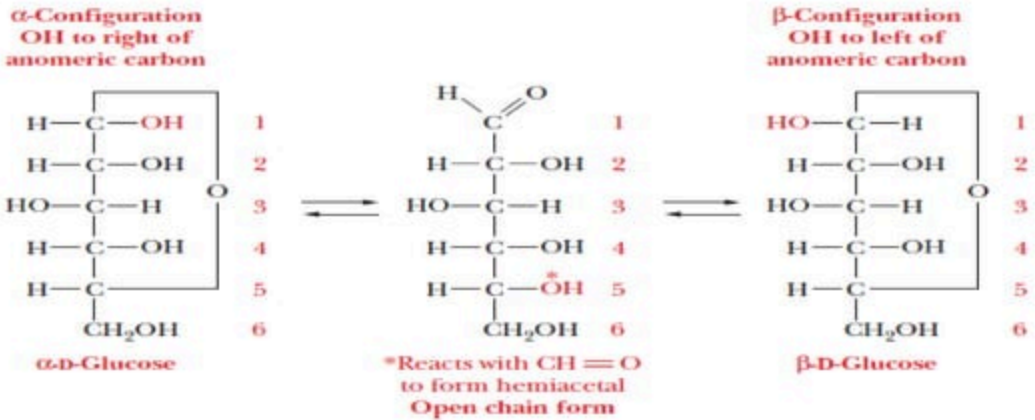
FORMATION OF HEMIACETALS / HEMIKETALS



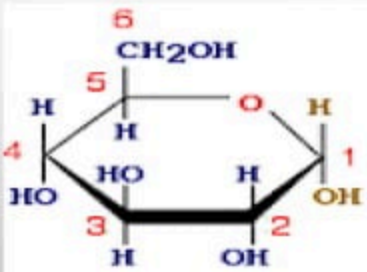


FISCHER PROJECTION

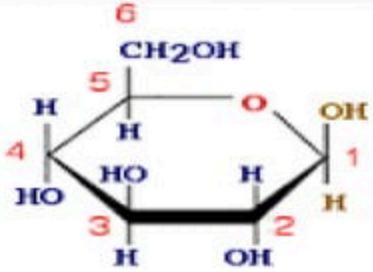
Aldehyde group of glucose at C-1 reacts with alcohol group of C-5 to form α and ß glucose forms



CYCLIC FORMS



α-D-glucopyranose
(α-D-glucose)



β-D-glucopyranose
(β-D-glucose)

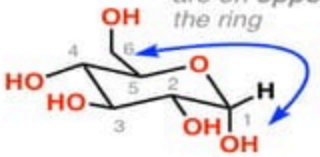
ANOMERS & MUTAROTATION

Alpha (α) and beta (β) isomers ("anomers") differ in the orientation of the OH at the C-1 hemiacetal carbon

Example: D-glucose

"alpha" (α) isomer:

*C_5-CH_2OH (up) and C_1-OH (down) are on **opposite** faces of the ring*



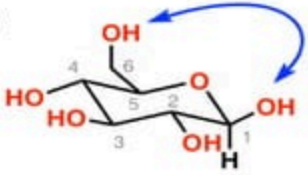
α-D-Glucose

drawn as "chair"

Specific rotation: $[\alpha]_D^{20}$ + 112°

"beta" (β) isomer:

*C_5-CH_2OH (up) and C_1-OH (up) are on the **same** face of the ring*



β-D-Glucose

drawn as "chair"

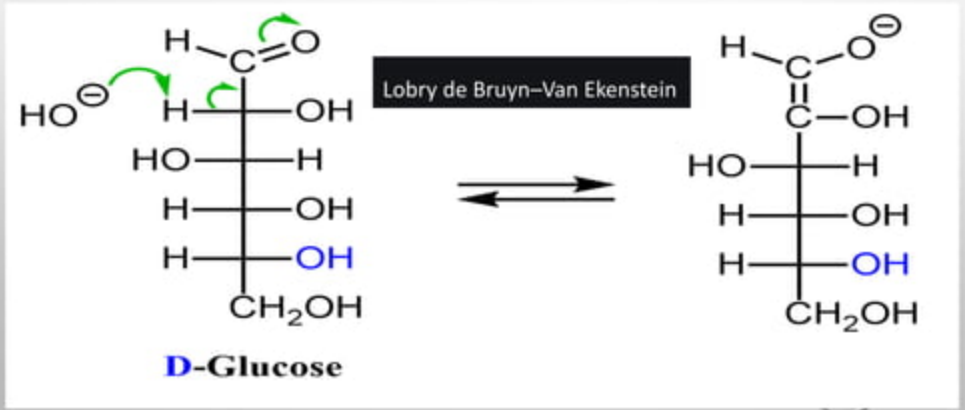
Specific rotation: $[\alpha]_D^{20}$ + 18.7°

Note different specific rotations!

REACTIONS OF CARBOHYDRATES

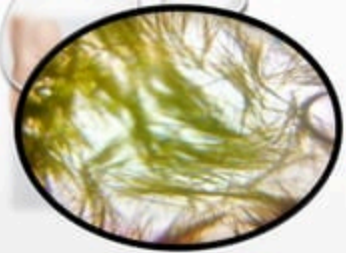
TAUTOMERISATION

SHIFTING OF HYDROGEN ATOM FROM ONE CARBON TO ANOTHER → FORM ENEDIOLS



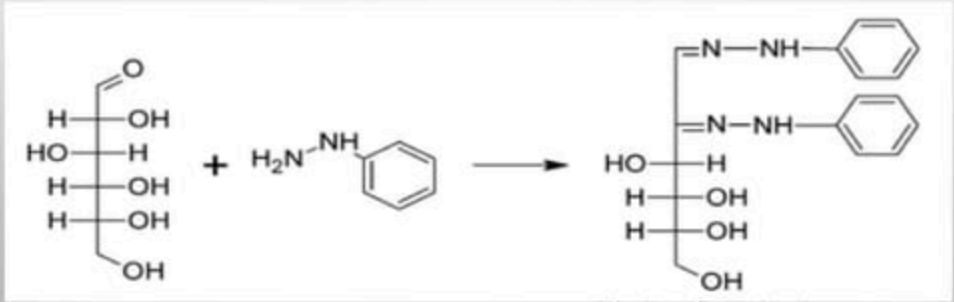
Reducing Properties of Monosaccharides

Hexose sugars with a free or potentially free **aldehyde or ketone group** have reducing properties in alkaline solutions. These reducing sugars can reduce cupric ions (Cu^{+2}) into cuprous ions (Cu^{+1}).



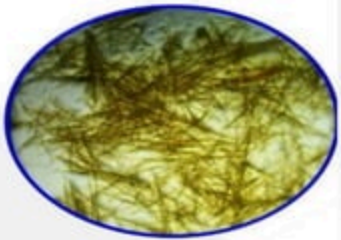
OSAZONE FORMATION WITH PHENYLHYDRAZINE & GLUCOSE

When Reducing Sugars Are Reacted With Excess Of Phenylhydrazine At Boiling Temperatures ➔ forms Osazones

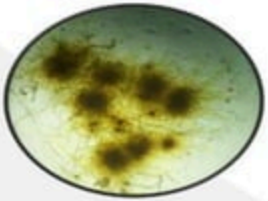


Fructosazone

- Needle/broom stick shaped crystals

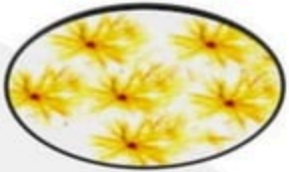


Lactosazone



Powderpuff or hedgehog shaped crystals

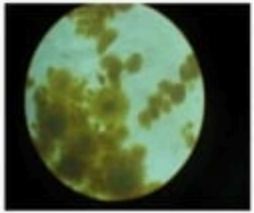
Maltosazone

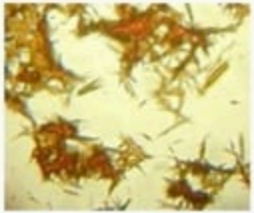


Sunflower shaped crystals

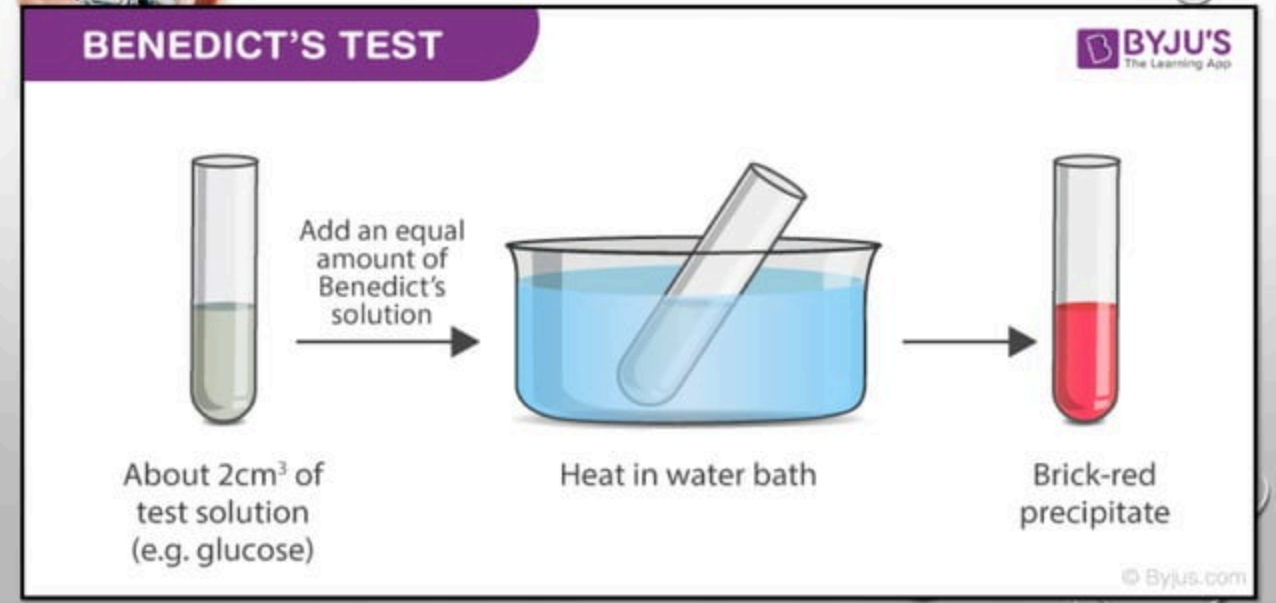
- Viewed under the microscope: Galactosazone

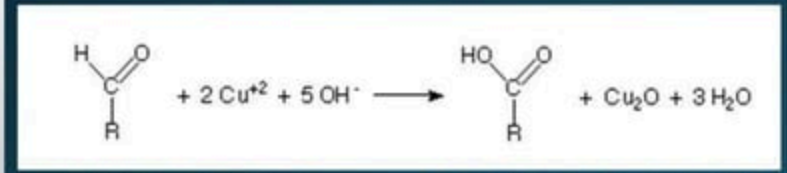
Rhombic plates like crystals





BENEDICTS TEST



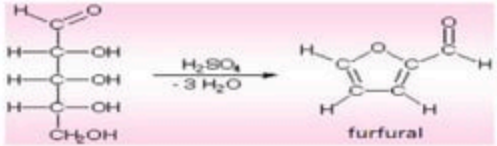


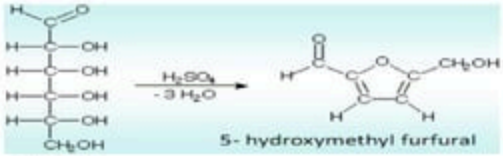
Aldehyde Cupric ions Carboxylic acid Cuprous oxide

Precipitate Colour	% of Reducing Sugar
Green	0.5%
Yellow	1.0%
Orange	1.5%
Red	2%

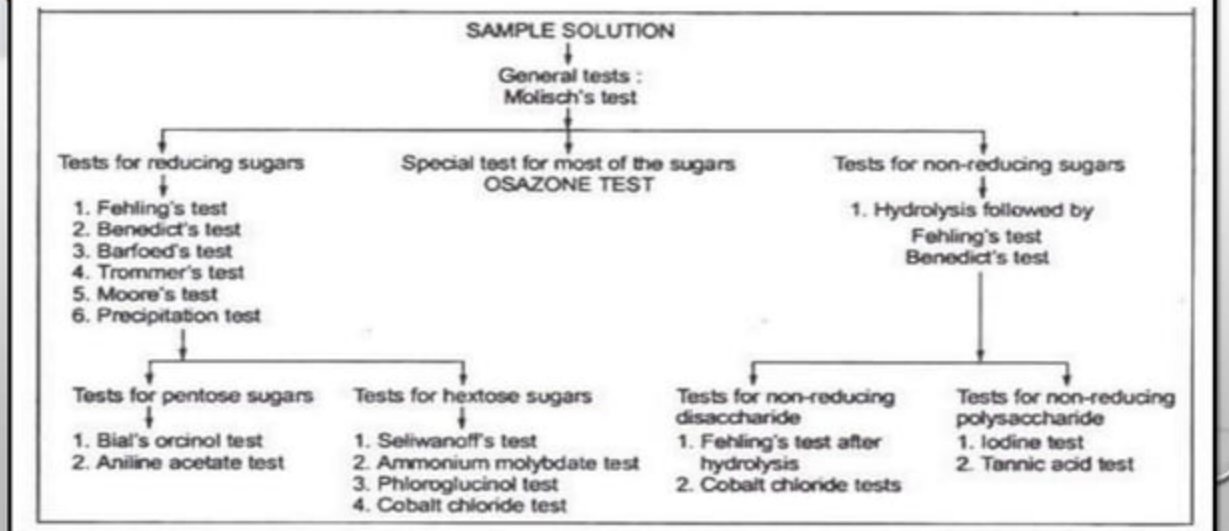
Benedict's Test

MOLISH TEST


H_2SO_4
- 3 H_2O
furfural
α-naphthol
[Present in the reagent]
Purple ring
Pentose


H_2SO_4
- 3 H_2O
5- hydroxymethyl furfural
α-naphthol
Purple ring
Hexose

TEST FOR CARBOHYDRATES

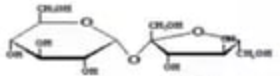


DISACCHARIDES

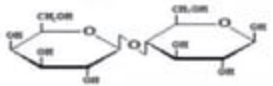
Carbohydrates that are made up of **2** monosaccharide units

- These are also of **low molecular weight** and **soluble in water**
- Sweet to taste.
- **Example** – Lactose, Sucrose, maltose (Digestible disaccharides in food)

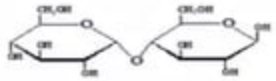
Sucrose
(Glucose-fructose)

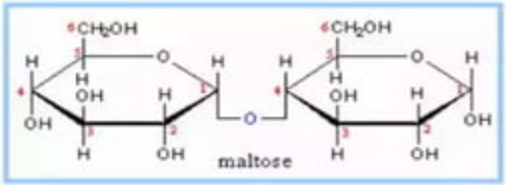


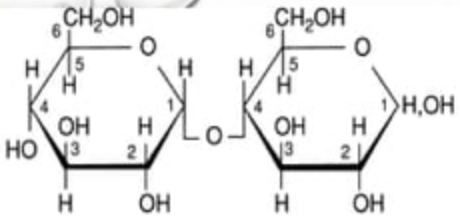
Lactose
(Galactose-glucose)



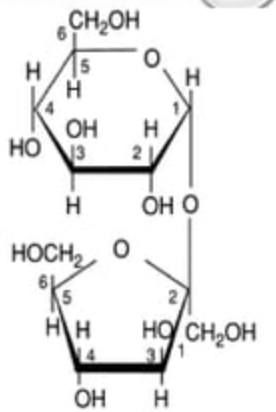
Maltose
(Glucose-glucose)



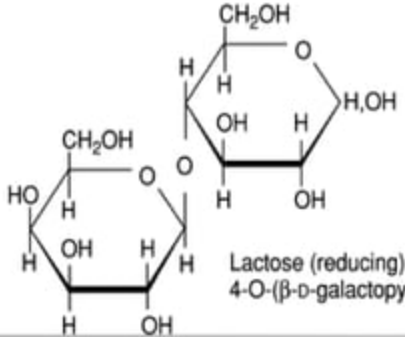




Maltose (reducing)
4-O-(α-D-glucopyransyl)-D-glucopyranose
or O-α-D-glucopyranosyl-(1→ 4)-α-D-glucopyranoside



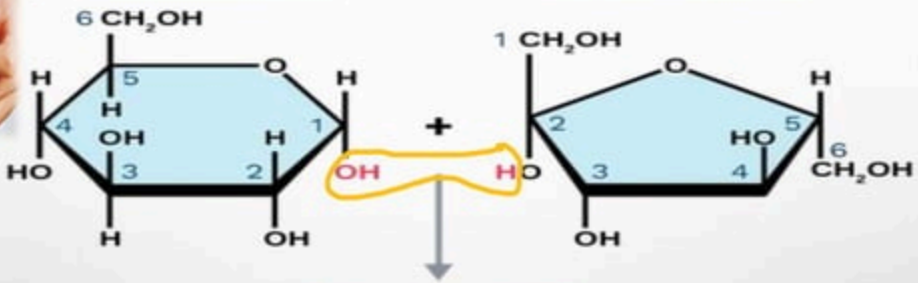
Sucrose (non-reducing)
α-D-glucopyranosyl-β-D-fructofuranoside
or (β-D-fructopyranosyl)-α-D-glucopyranoside
or O-α-D-glucopyranosyl-(1→ 2)-β-D-fructopyranoside



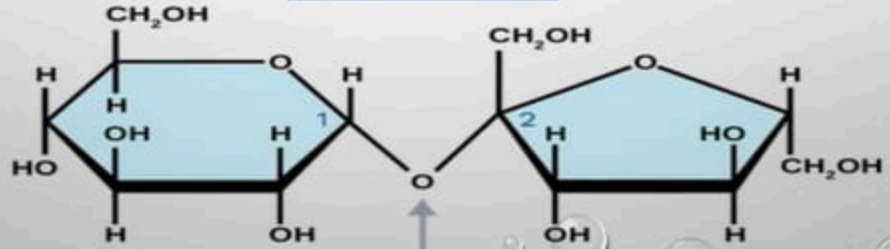
Lactose (reducing)
4-O-(β-D-galactopyranosyl)-D-glucopyranose

Glucose

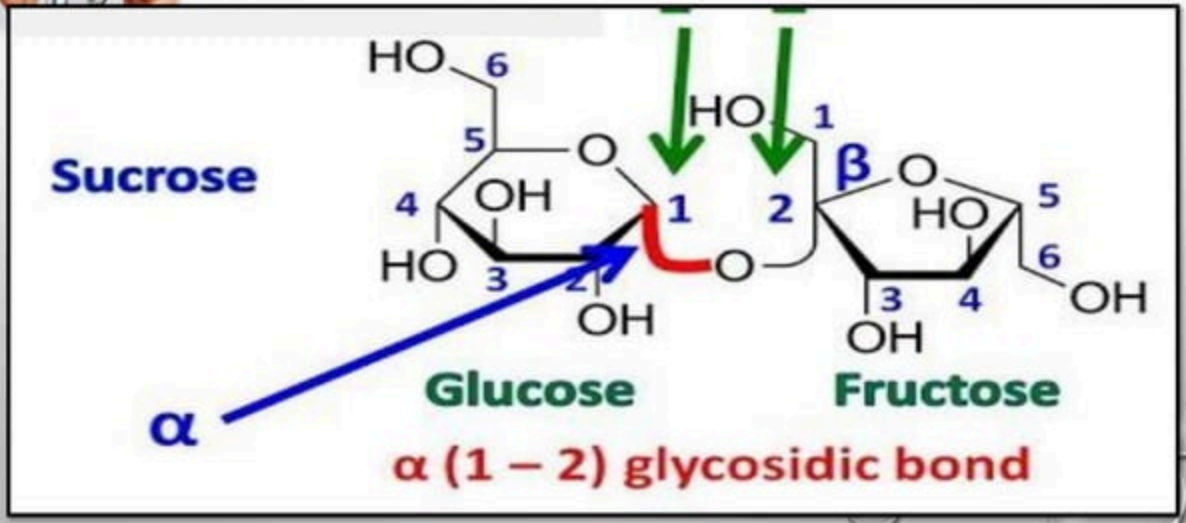
Fructose



Sucrose

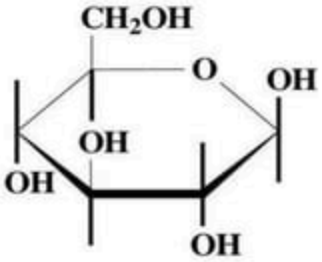


SUCROSE GLYCOSIDAL LINKAGE

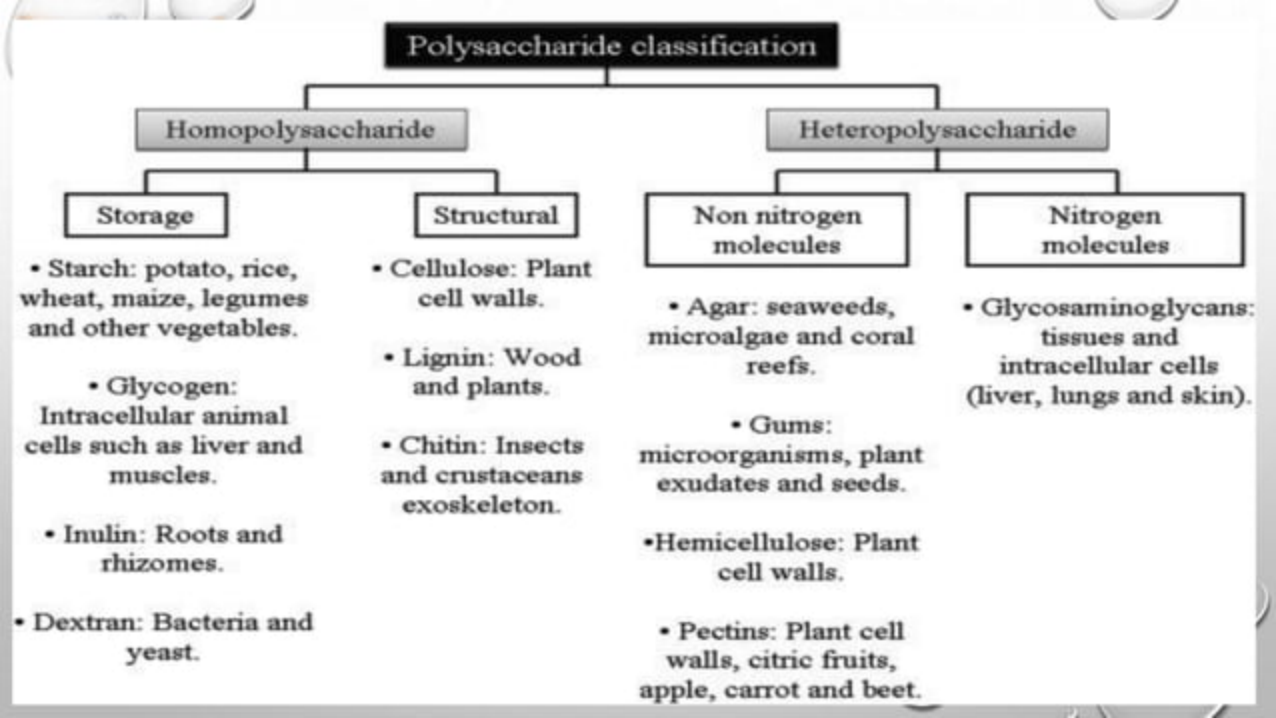


POLYSACCHARIDES

- Polysaccharides are polymers of D-glucose
- Important polysaccharides are:
  - Starch (Amylose and Amylopectin)
  - Glycogen
  - Cellulose
  - Chitin



D-Glucose


Polysaccharide classification
Homopolysaccharide
Heteropolysaccharide
Storage
Structural
Non nitrogen molecules
Nitrogen molecules
• Starch: potato, rice, wheat, maize, legumes and other vegetables.
• Glycogen: Intracellular animal cells such as liver and muscles.
• Inulin: Roots and rhizomes.
• Dextran: Bacteria and yeast.
• Cellulose: Plant cell walls.
• Lignin: Wood and plants.
• Chitin: Insects and crustaceans exoskeleton.
• Agar: seaweeds, microalgae and coral reefs.
• Gums: microorganisms, plant exudates and seeds.
•Hemicellulose: Plant cell walls.
• Pectins: Plant cell walls, citric fruits, apple, carrot and beet.
• Glycosaminoglycans: tissues and intracellular cells (liver, lungs and skin).

HETEROPOLYSACCHARIDES

Having uronic acid & amino sugars.

H	Heparan Sulphate	Glucosamine	Glucuronic acid
H	Heparin	Glucosamine	Iduronic acid
Hy	Hyaluronic acid	N Ac Glucosamine	Glucuronic acid
K	Keratan sulphate	N Ac Glucosamine	Galactose
C	Chondroitin sulphate	N Ac Galactosamine	Glucuronic Acid
D	Dermatan sulphate	N Ac Galactosamine	Iduronic acid

Functions of carbohydrates

- SOURCE OF ENERGY
- STORED AS GLYCOGEN
- MAINTAIN GLUCOSE LEVEL OF PLASMA
- CONTROL BODY TEMPERATURE
- METABOLISM OF AMINO & FATTY ACIDS
- EXCESS OF CARBOHYDRATES CONVERTS TO FATS
- INCREASE PERISTALTIC MOVEMENT OF FOOD

BIOLOGICAL ROLE OF CARBOHYDRATES

Biologically active monosaccharides are D- sugars	• Provide mechanical support to the plants
Supply carbon for synthesis of cell	• Provide energy through oxidation
Provide Nucleic acids	• DNA & RNA provides genetic information
Store chemical energy	• Part of antibiotic drugs streptomycin / aminoglycosides
Participate in biological transport	• cell-cell communication and activation of growth factors
Chief energy source	• Glucose is broken down by glycolysis/ kreb's cycle to yield ATP.

FOODS RICH IN CARBOHYDRATES

- **Strachy Foods**
- **Legumes, Starchy Vegetables, Whole-grain Breads And Cereals.**
- Occur Naturally With **Vitamins And Minerals In Foods Like Milk, Fruits, And Milk Products.**
- Found In Refined And Processed Products Like **Candy, Carbonated Beverages, And Table Sugar**

REFERENCE BOOK

- BIOCHEMISTRY BY SATYANARAYANA
- BIOCHEMISTRY BY KUNTAL DAS
- BIOCHEMISTRY BY PANKAJ NAYAK

THANK YOU…

For contact…..!!

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