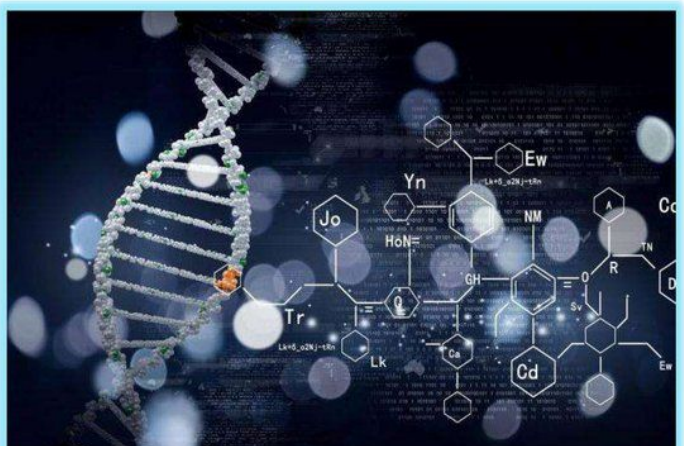
What is Biochemistry?

- **Simplest definition: "Chemistry of the living cell"**

Uses basic laws of chemistry and biology to explain processes of living cells.

- **Biochemistry: is the science concerned with studying the various molecules that occur in living cells and organisms and with their chemical reactions.**

Biochemistry, sometimes called biological chemistry, is the study of chemical processes within and relating to living organisms.

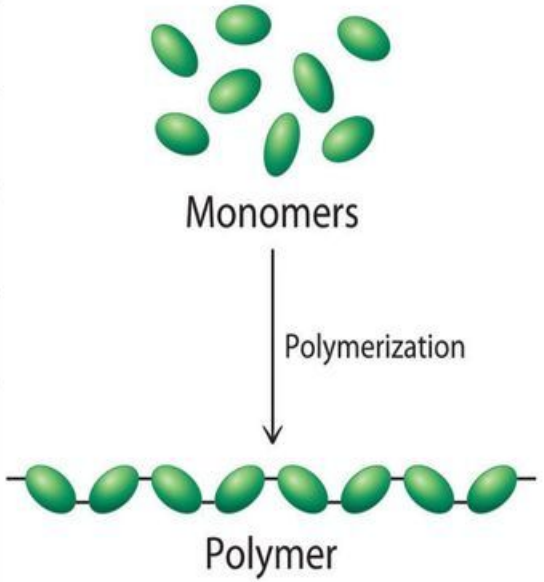


Biochemistry and Organization of Cells

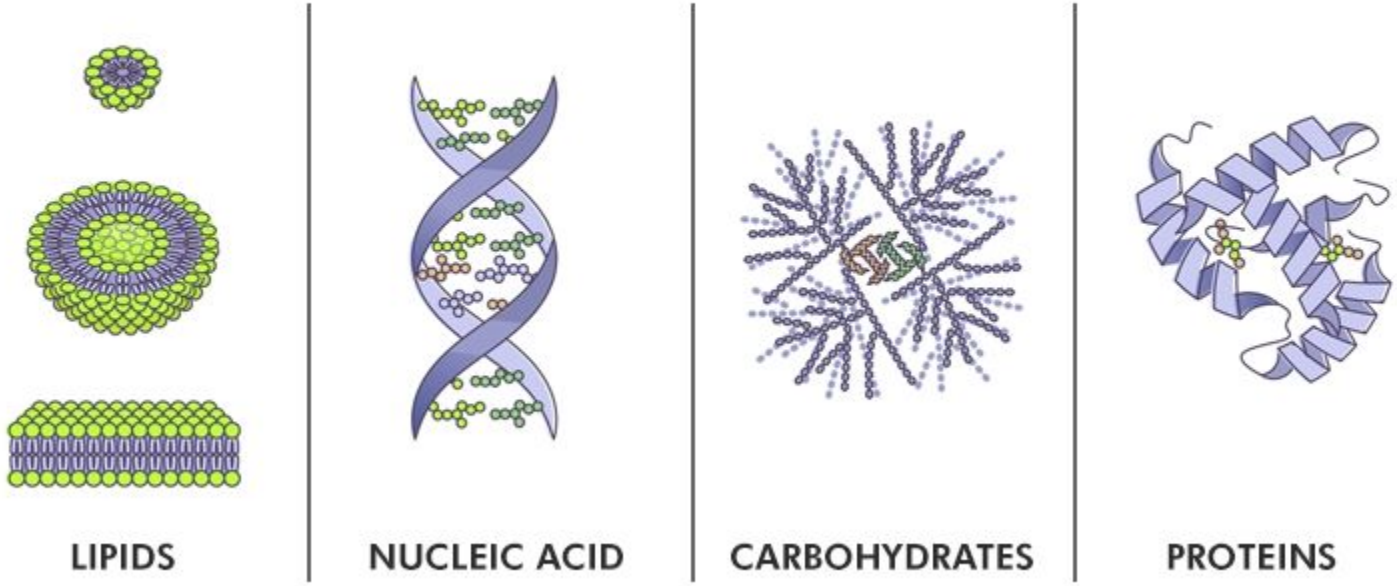
- Complex living organism originate from simple elements. Carbon, hydrogen, oxygen, sulfur, and nitrogen combine to make up many different kind of biomolecules such as carbohydrates, fatty acids, amino acids which combine to make proteins.
- In turn phosphorus is the most ingredients for making DNA and RNA. A collection of interacting molecules, becomes a cell the basic unit of life.

FOUR MAIN CLASSES OF BIOMOLECULES

Biomolecules	Monomers
Proteins	Amino Acids
Carbohydrates	Monosaccharide
Nucleic Acids (DNA & RNA)	Nucleotides
Lipids (non-polymeric molecules with large molecular mass)	Hydrocarbon chains

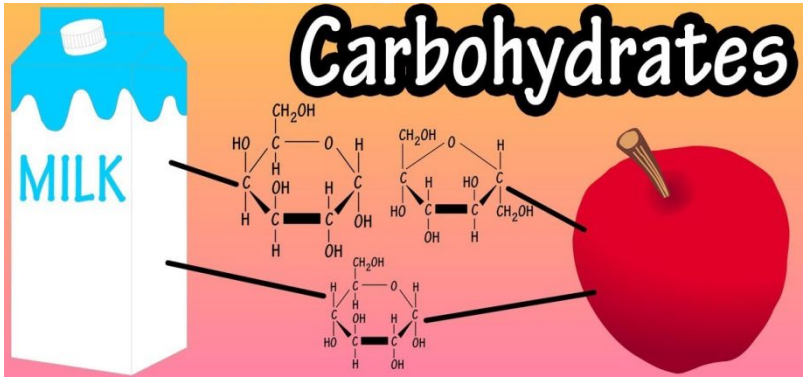


BIOMOLECULES



Biomolecules are biological molecules produced by the cells of the living organism. They are critical for life as it helps organisms to carry out basic biological processes such as growth and reproduction

Carbohydrates



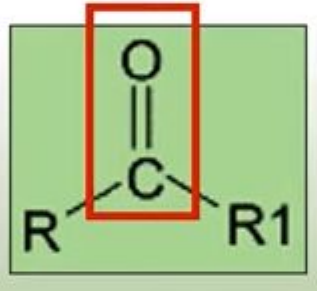
Topics
Topics
Carbohydrate: Definition and classification.
Functions
-D & L forms of carbohydrates
-Reducing and Non reducing sugars

Prepared by,
Dr. Vijay Kant Pandey
HOD, Deptt of Agriculture
(Ph.D., GATE, CSIR-UGC-NET, ARS-NET)

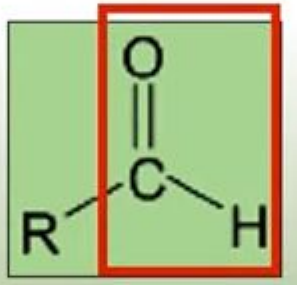
Carbohydrates: Definition

Substances containing carbon, hydrogen and oxygen having the general formula $C_n(H_2O)_n$

Polyhydroxy aldehydes
or
ketones derivatives
or
compounds which yield these derivatives on hydrolysis.



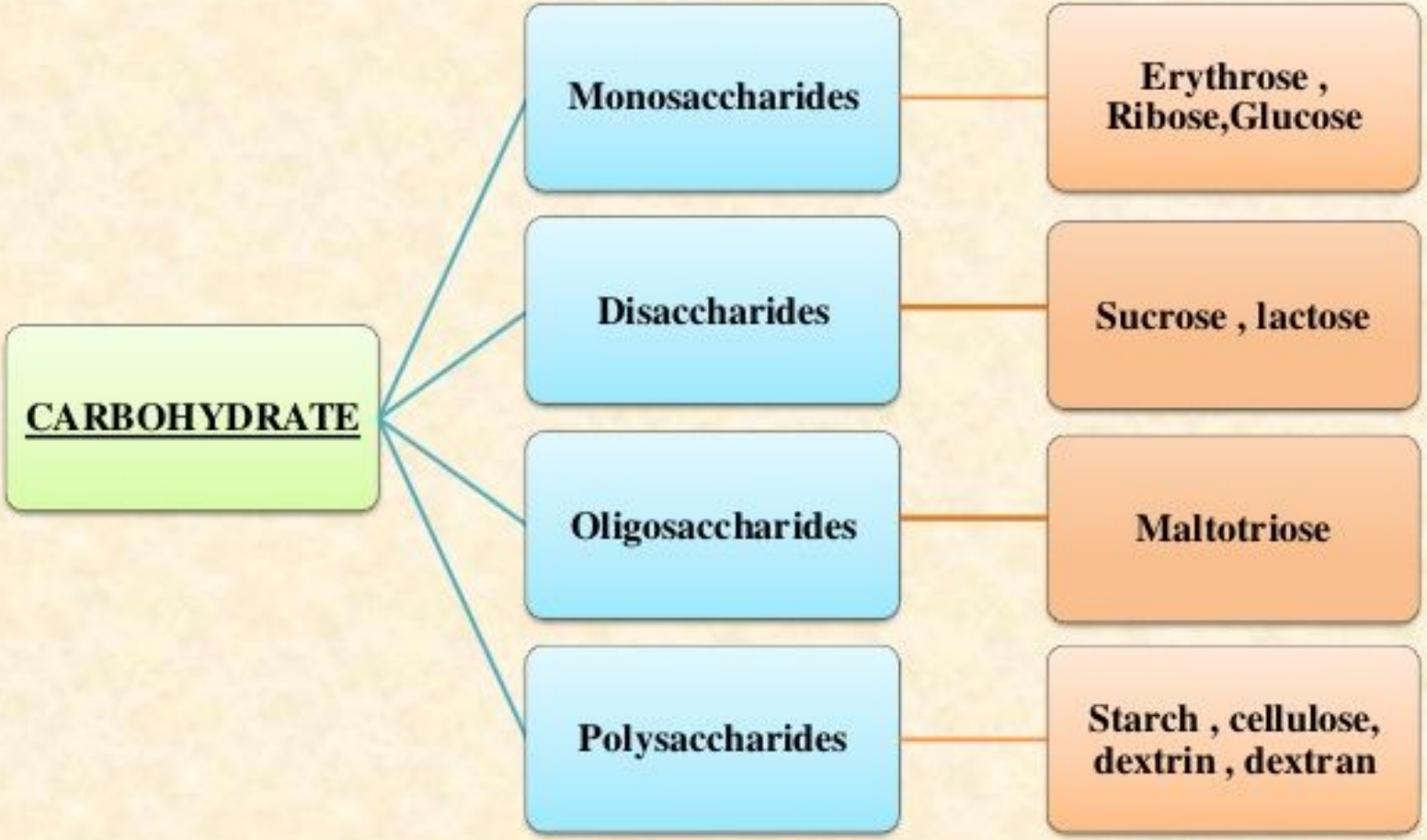
Keto group

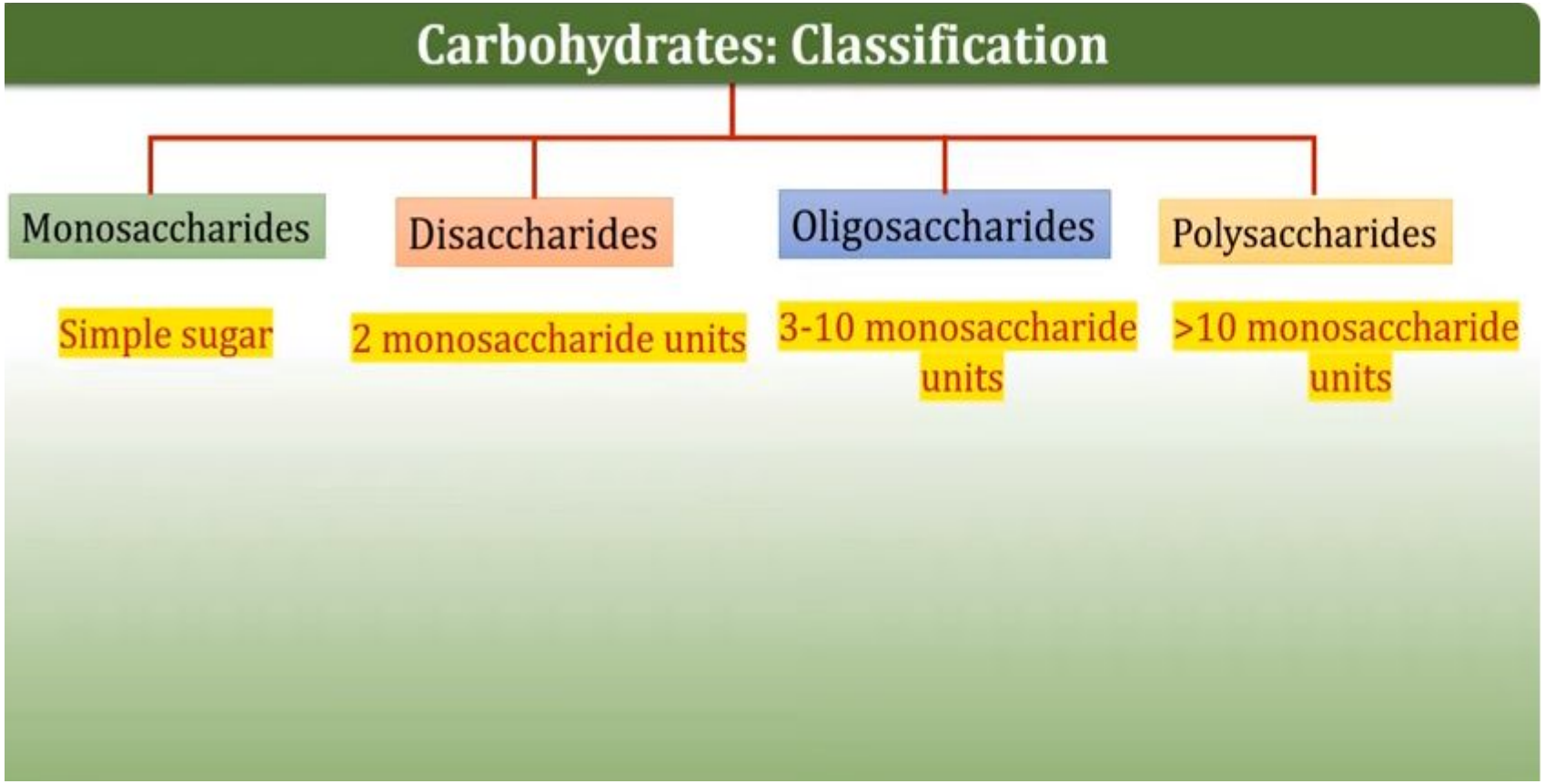


Aldehyde group

The common sugars such as Glucose , Fructose and Sucrose

CLASSIFICATION OF CARBOHYDRATE




Carbohydrates: Classification
Monosaccharides
Disaccharides
Oligosaccharides
Polysaccharides
Simple sugar
2 monosaccharide units
3-10 monosaccharide units
>10 monosaccharide units

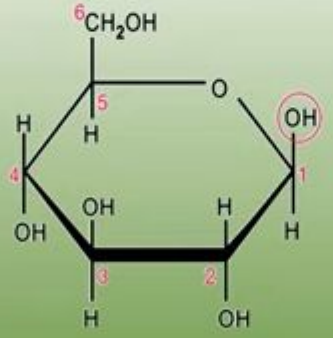
Carbohydrates: Classification

- **Monosaccharides**
- Disaccharides
- Oligosaccharides
- Polysaccharides

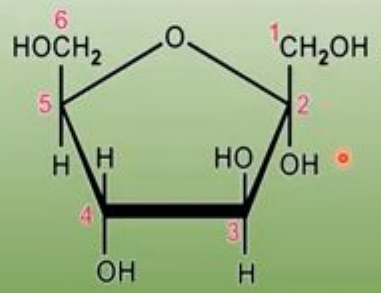
Simple sugar

- Molecules having only one actual or potential sugar group
- They cannot be further hydrolysed into smaller units

Aldoses	Ketoses	
Glyceraldehyde	Dihydroxyacetone	Trioses (3C)
Erythrose	Erythrulose	Tetroses (4C)
Ribose	Ribulose	Pentoses (5C)
Glucose	Fructose	Hexoses (6C)
Glucoheptose	Sedoheptulose	Heptoses (7C)



βD-Glucose



αD-Fructose

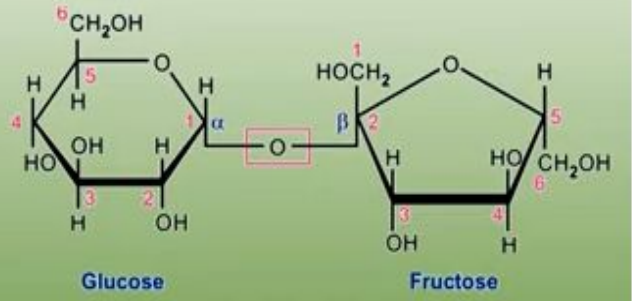
Carbohydrates: Classification

- Monosaccharides
- Disaccharides
- Oligosaccharides
- Polysaccharides

2 monosaccharide units

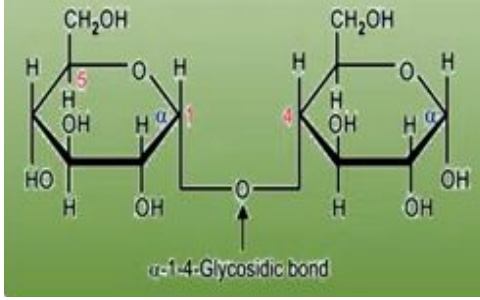
- Reducing
- Non-Reducing → **Sucrose**

(αDGlucose + β Dfructose)



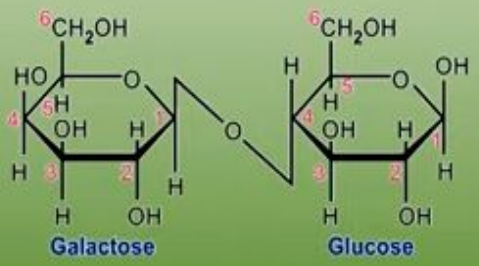
Maltose

(αD-Glucose + αD-Glucose)



Lactose

(β DGalactose + β DGlucose)



Carbohydrates: Classification

- Monosaccharides
- Disaccharides
- Oligosaccharides
  - 3-10 monosaccharide units
- Polysaccharides

- Do not occur as free entities
- Occur as glycoconjugates (Glycoprotein, Glycolipids)

Raffinose	α-D-glucose, β-D-galactose,β-D-fructose
Stachyose	2 Galactose + Glucose + Fructose
Verbascose	3 Galactose + Glucose + Fructose

Carbohydrates: Classification

- Monosaccharides
- Disaccharides
- Oligosaccharides
- Polysaccharides

Homoglycans | **Heteroglycans**

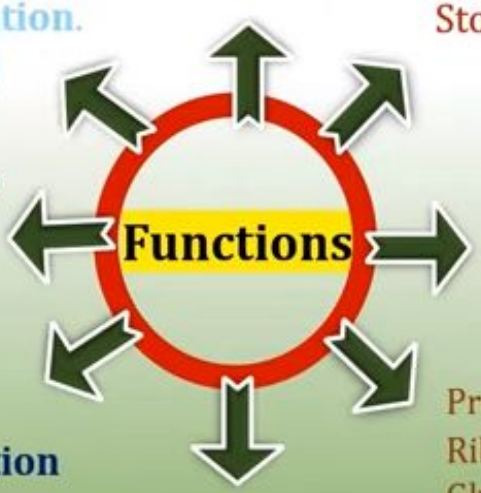
Homopoly-saccharides	Heteropolysaccharides
Starch	Agar, Agarose
Dextrin	Gum & Pectin
Glycogen	Hyaluronic acid
Cellulose	Chondroitin sulfate
Inulin	Keratan Sulfate
Dextran	Dermatan Sulfate
Chitin	Heparan Sulfate

Glycosaminoglycans (GAGs)
(Mucopolysachharides)

>10 monosaccharide units

- Homopolysaccharides
  - Same type of monosaccharide unit
- Heteropolysaccharides
  - ≥ 2 different types of monosaccharide units or their derivatives.

Carbohydrates: Functions



Most abundant dietary source of **energy** (4 C/gm)

Storage form of energy in the form of **Glycogen.**

Non-digestible carbohydrates cellulose, agar, gum and pectin Serve as **dietary fibers.**

Precursors of organic compounds Ribose, deoxyribose(DNA,RNA) Glycolipids, Glycoproteins & proteoglycans

Participate in **structure of cell membrane.** Glycolipids, Glycoproteins

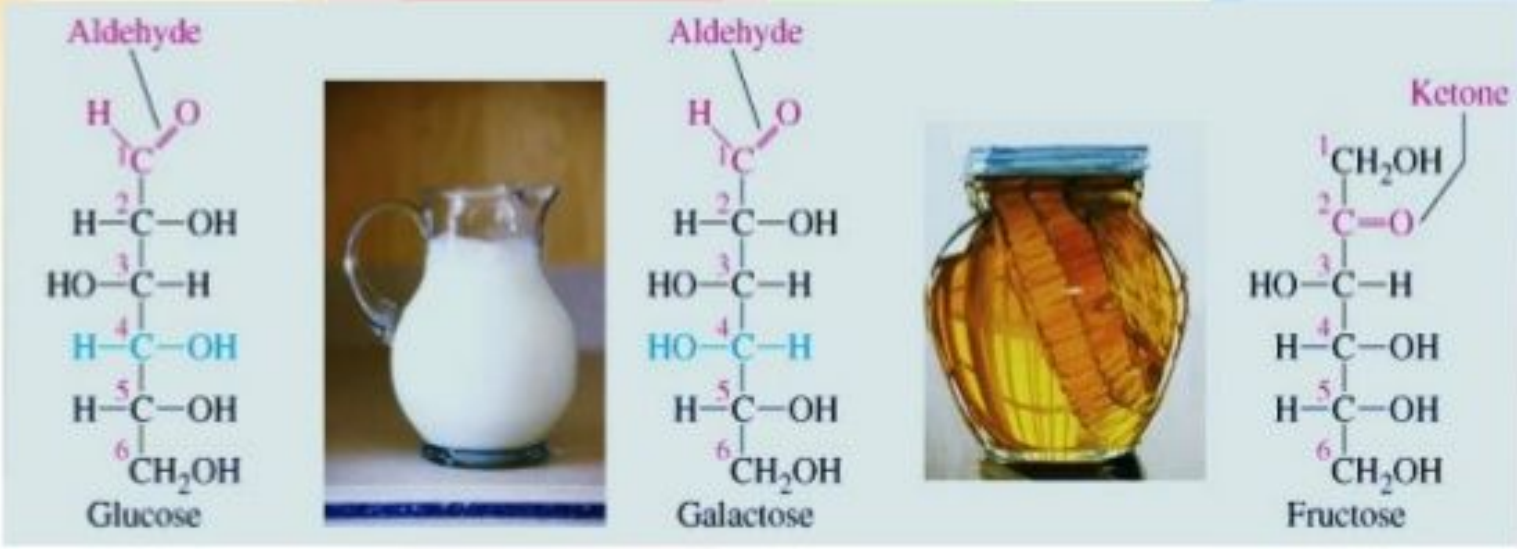
Play a role in **lubrication, cellular intercommunication and immunity.**

Serve as **structural component,** glycosaminoglycans in human, cellulose in plants and chitin in insects

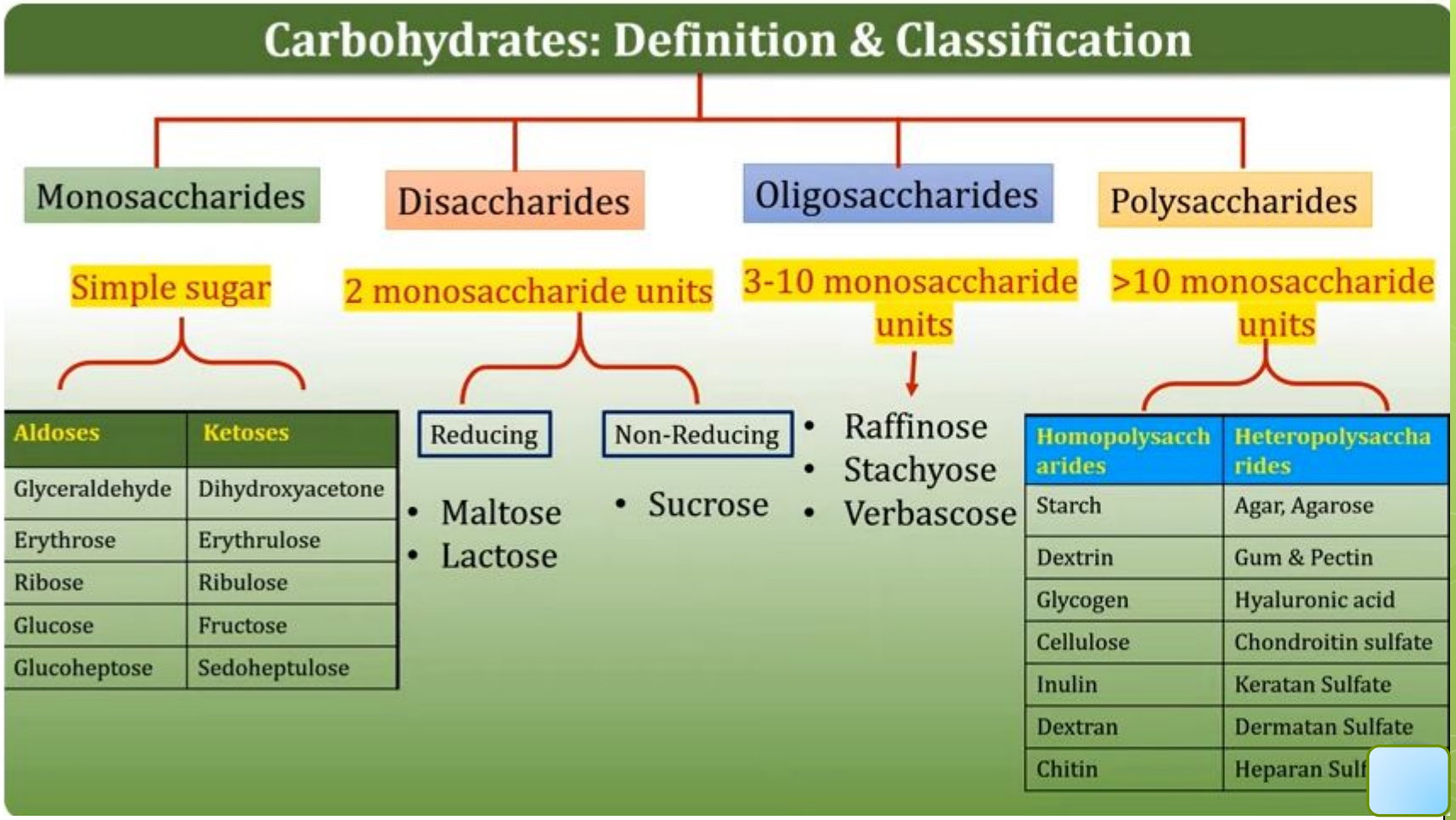
Involved in **detoxification.** (glucuronic acid)

Function of Carbohydrates in Cells

- ✓ Major source of energy for the cell
- ✓ Major structural component of plant cell
- ✓ Immediate energy in the form of GLUCOSE
- ✓ Reserve or stored energy in the form of GLYCOGEN



Carbohydrates: Definition & Classification



Aldoses	Ketoses
Glyceraldehyde	Dihydroxyacetone
Erythrose	Erythrulose
Ribose	Ribulose
Glucose	Fructose
Glucoheptose	Sedoheptulose

Homopolysaccharides	Heteropolysaccharides
Starch	Agar, Agarose
Dextrin	Gum & Pectin
Glycogen	Hyaluronic acid
Cellulose	Chondroitin sulfate
Inulin	Keratan Sulfate
Dextran	Dermatan Sulfate
Chitin	Heparan Sulf

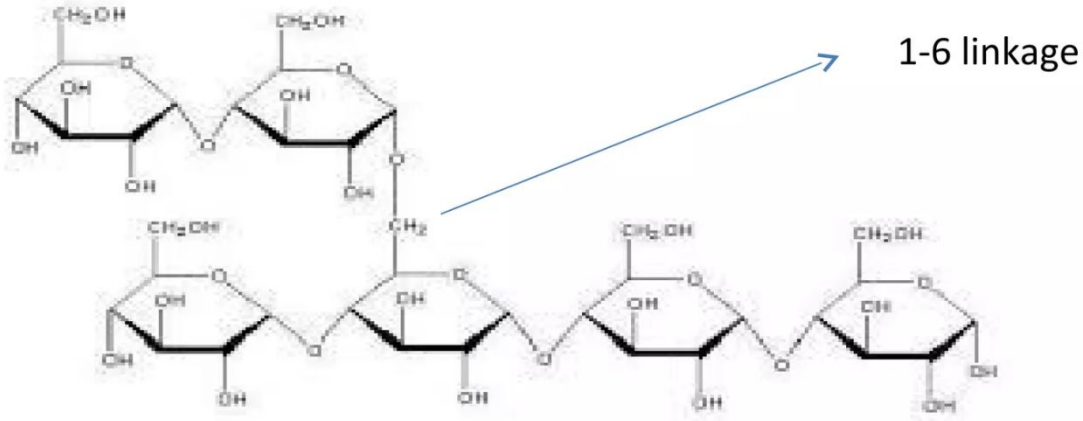
1. Starch

- High content of starch is found in cereals, roots, rice, maize etc.
- It is homopolysaccharide composed of D-glucose and held by glycosidic bond.
- Starch consists of 2 polysaccharides

Amylose- which is water soluble (it is unbranched chain with 200-1000 glucose lingae held by 1-4 glycosidic bond)

Amylopectin- water insloluble (it is branched consisting of few thousands of glucose held by 1-6 glycosidic bond).

- Starch is hydrolyzed by enzyme amylase.



Cellulose

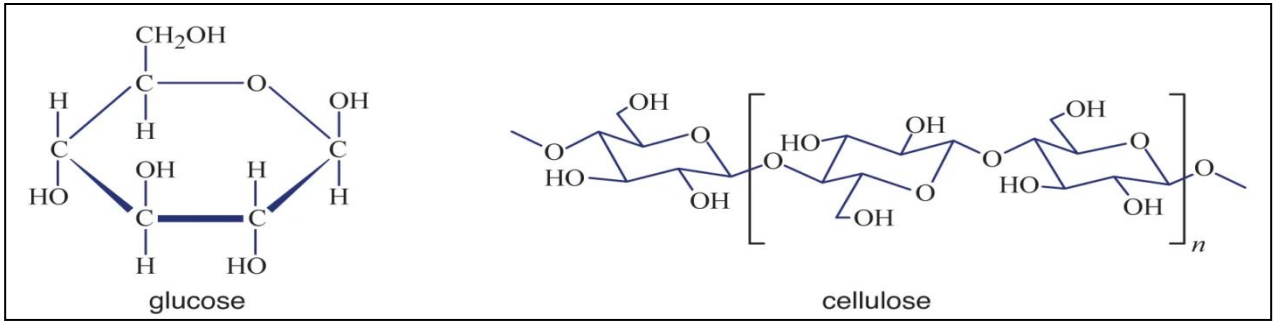
Cellulose is an important structural component of the primary cell wall of green plants, many forms of algae and the oomycetes

It is a Homopolymer of **Glucose**

It is a Carbohydrate composed of **Carbon(49.39%)**, **Oxygen (44.4%)** and **Hydrogen (6.17%).**

The molecular formula is $(C_6H_{10}O_5)n$

Unbranched chained polymer of glucose



Inulin

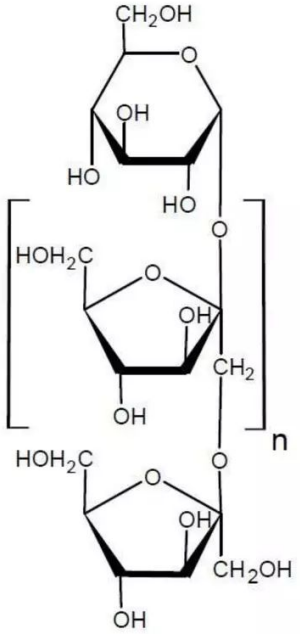
It is a polymer of fructose.

Occurs in garlic, onion,dahlia bulbs.

Chemical structure of Inulin

Inulin is a linear polymer of D-fructose joined by β (2→ 1) bond and terminated generally with a D-glucose molecule linked to fructose by an α (1 → 2) bond, as In sucrose.

Formula : $C_{6n}H_{10n+2}O_{5n+1}$



Disaccharides

- Composed of 2 monosaccharides
- cells can make disaccharides by joining two monosaccharides by biosynthesis.

Glucose + fructose = sucrose

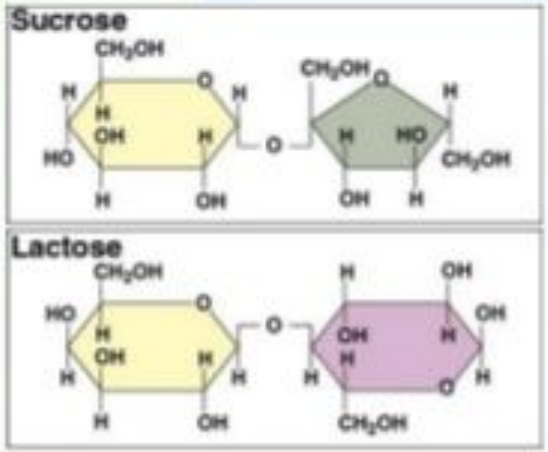
- Table sugar
- Found naturally in plants: sugar cane, sugar beets, honey, maple syrup
- Sucrose may be purified from plant sources into Brown, White and Powdered Sugars.

Glucose + galactose = lactose

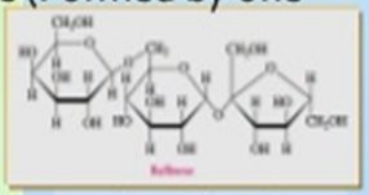
- The primary sugar in milk and milk products.
- Many people have problems digesting large amounts of lactose (lactose intolerance)

Glucose + glucose = Maltose

- Produced when starch breaks down.
- Used naturally in fermentation reactions of alcohol and beer manufacturing.



Trisaccharides: Composed of three monosaccharide ex: Raffinose (Formed by one mole of each i.e. glu, fruc, galac)



Tetrasaccharides :

ex: Stachyose (composed of two moles of galactose one mole of glu & one mole of fruct)

- Glucose 
- Fructose 
- Galactose 

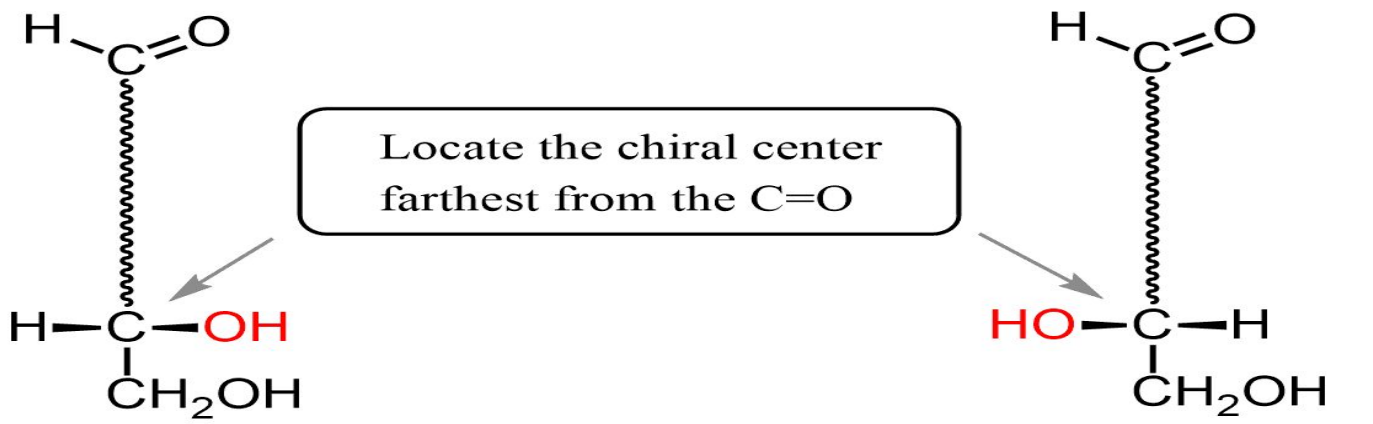
- Maltose (glucose + glucose) 
- Sucrose (glucose + fructose) 
- Lactose (glucose + galactose) 

D and L in the carbohydrates

The letters D and L represent the position of the second last hydroxyl group in a carbohydrate.

- **If the carbohydrate has the hydroxyl group at the last chiral carbon towards the right side, it is denoted by the letter D and**
- **if the hydroxyl group at the last chiral carbon lies towards the left side, it is denoted by the letter L.**

D and L Configuration of Carbohydrates



OH on the right

D-sugar

(D = OH faces to the right side)

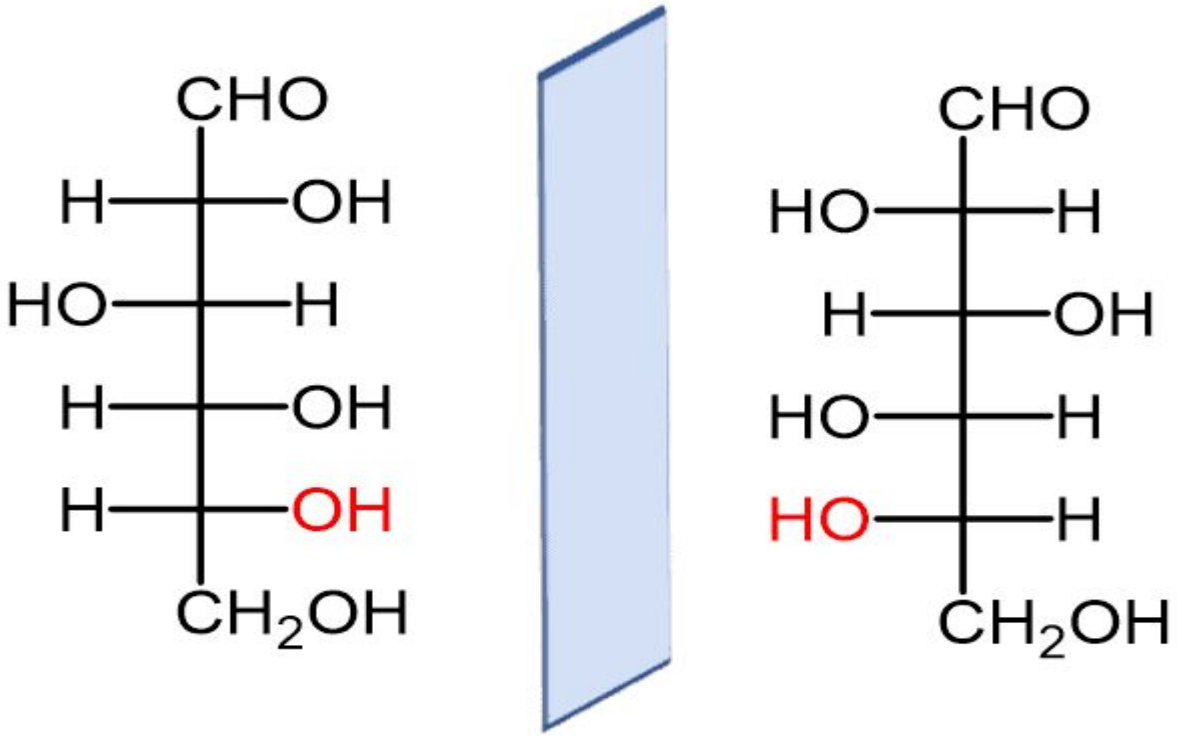
OH on the left

L-sugar

(L= OH faces to the left side).

Enantiomers

Enantiomers are isomers which differ in their absolute configurations at every chiral center and its mirror image



D-glucose L-glucose

Enantiomers

Reducing and non-reducing sugar

a) Reducing sugars

- Any sugar which is capable of acting as reducing agent because of the free aldehyde group present is known as reducing sugar.
- They have a free carbonyl group which act as reducing agent.
- They are classified as reducing sugars since they reduce the Cu^{2+} to Cu^{+} which forms as a red precipitate, copper (I) oxide.

Examples : glucose, fructose,lactose,maltose

b) Non reducing sugars

In case of polysaccharides the free carbonyl group is blocked, such carbohydrates in which there is no free carbonyl group are known as non reducing sugars.

Example: sucrose, raffinose

REDUCING SUGAR	NON REDUCING SUGAR
Possesses free aldehyde/keto group	Lacks free aldehyde group
Can reduce Cu2+ ions to Cu+ ions in Fehling's or benedicts solution	No such reaction takes place
The free carbonyl group acts as reducing agents	No free carbonyl group present as it is blocked due to formation of glycoside bond

Reducing sugars

- Monosaccharides
  - Glucose
  - Fructose
  - All others
- Di and oligosaccharides s
  - Maltose
  - Lactose

Non-reducing Sugars

- Monosaccharides
  - None
- Di and oligosaccharides
  - Sucrose
  - Raffinose
  - Stacchyose