Chemistry of Carbohydrate

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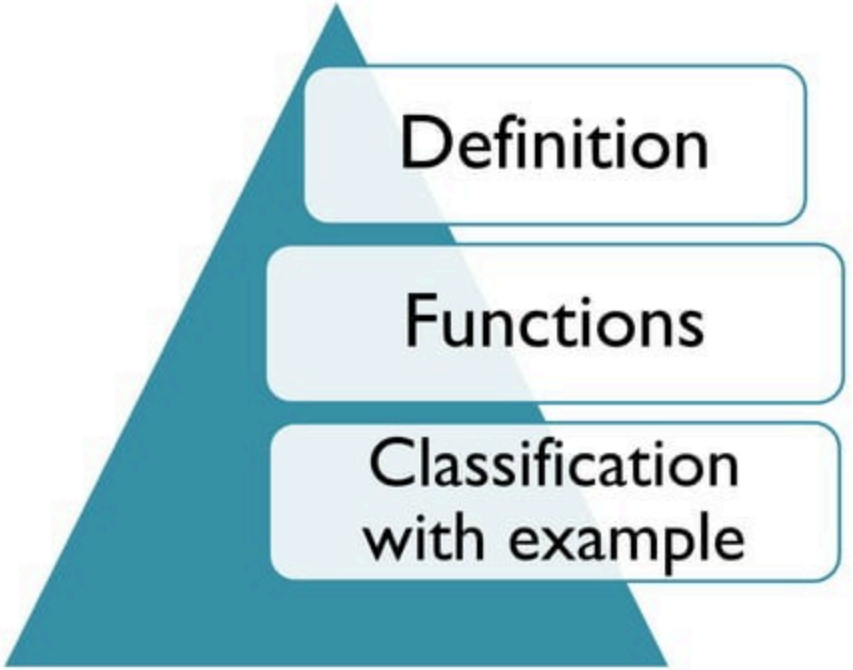
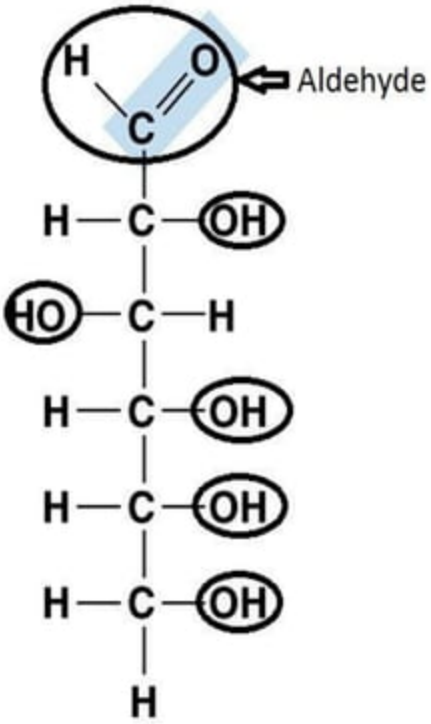
Overview

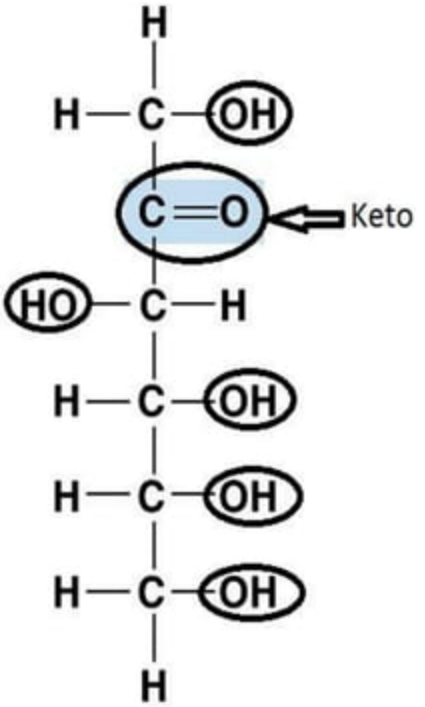


Definition

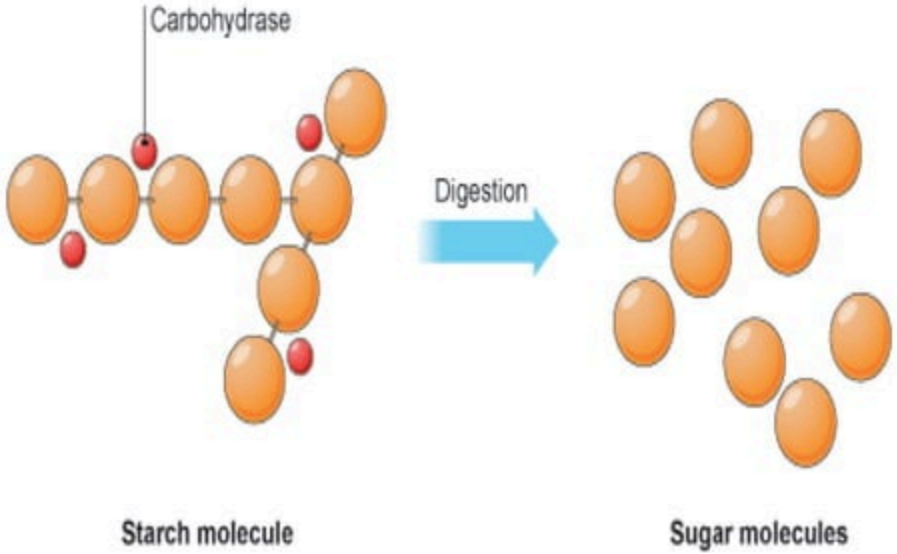
- Carbohydrates may be defined as polyhydroxy aldehydes or ketones or compounds which produce them on hydrolysis.
- Formula = (C.H2O)n



Glucose



Fructose


Carbohydrase
Digestion
Starch molecule
Sugar molecules

Biomedical Importance

- Most abundant dietary source of energy. Brain cells and RBCs are almost wholly dependent on carbohydrates as the energy source.
- Also serve as storage form of energy – Glycogen.
- Carbohydrates are precursors for many organic compounds (fats, amino acids).
- Participate in the structure of cell membrane & cellular functions (cell growth, adhesion and fertilization).
- DM (diabetes mellitus)

Sources


Fats, Oils, & Sweets
Meat, Poultry, Fish, Eggs, Milk, Yogurt, & Cheese
Fruits & Vegetables
Bread, Cereal, Rice, & Pasta

CLASSIFICATION OF CARBOHYDRATE

Classification

1. Monosaccharide
2. Oligosaccharide
3. Polysaccharide

Monosaccharide

Cannot further Hydrolyzed

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

TYPES	EXAMPLE	IMPORTANCE
Trioses	Glyceraldehyde, Dihydroxyacetone	✔ Intermediates of glycolysis, ✔ Precursor of glycerol (for lipid synth)
Tetroses	D-Erythrose	✔ Intermediates of carbohydrate metabolism
Pentoses	D-Ribose	✔ Structural element of nucleic acid, RNA, co-enzymes.
Hexoses	D-Glucose	✔ Main sugar of the body.
	D-Fructose	✔ Converted to glucose & utilized by the body.
	D-Galactose	✔ Synthesized in mammary gland to make the lactose of milk.
	D-Mannose	✔ Constituent of glycoprotein, glycolipids

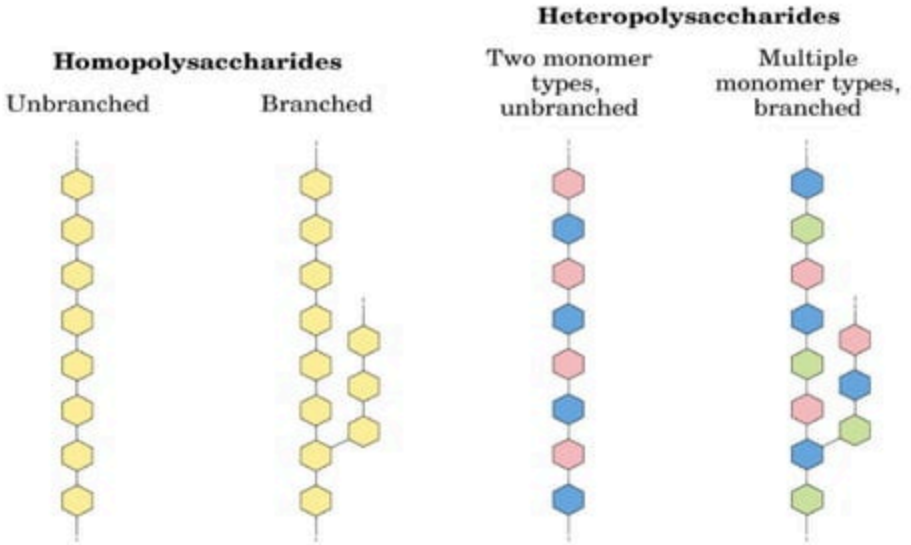
Oligosaccharide

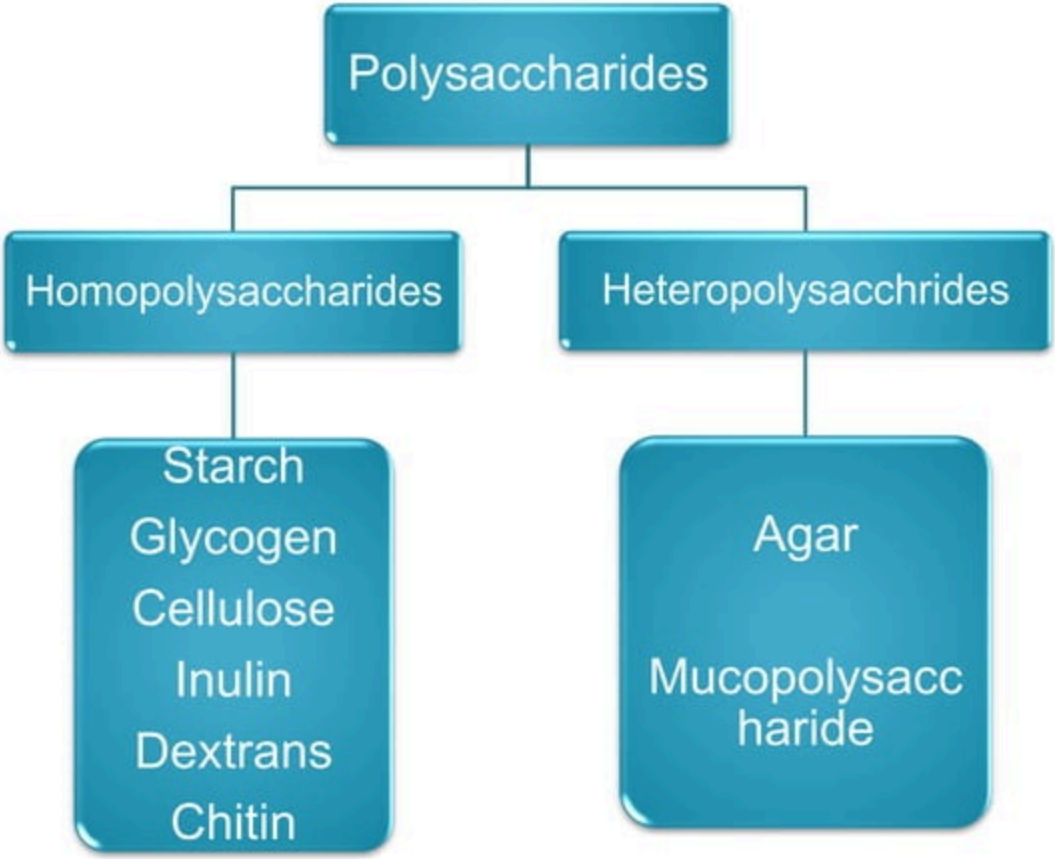
- Oligosaccharides(Greek: oligo-few) contain 2-1O monosaccharide molecules
- Joined by glycosidic bond

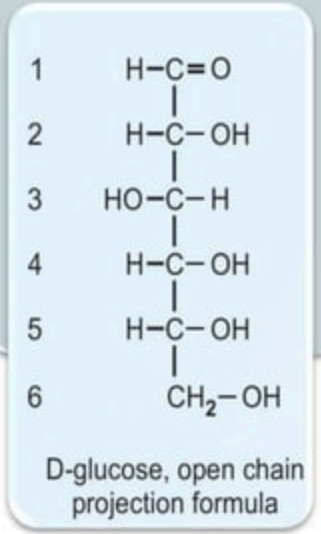
	No "C"	Examples	Type of monosaccharide
Disaccharides	2	Maltose	Glucose + Glucose
		Lactose	Glucose + Galactose
		Sucrose	Glucose + Fructose
Trisaccharides	3	Raffinose	Glu + Fruc + Galactose
Tetra saccharides	4	Stachyose	2 Galactose + Glucose + Fructose
Penta saccharides	5	Verbascose	3 Galactose + Glucose + Fructose

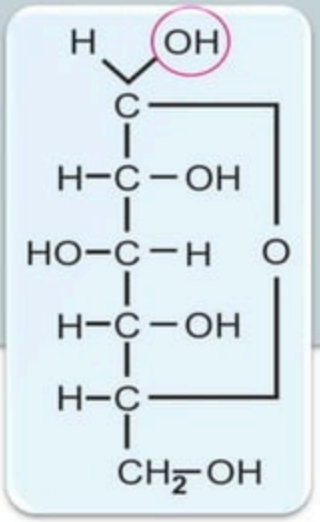
Polysaccharides

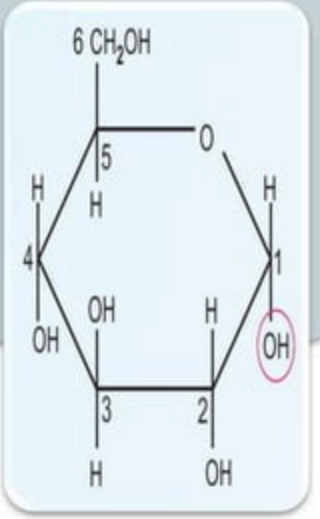
- Contain more than 10 monosaccharide units.




Polysaccharides
Homopolysaccharides
Heteropolysacchrides
Starch
Glycogen
Cellulose
Inulin
Dextrans
Chitin
Agar
Mucopolysacc
haride





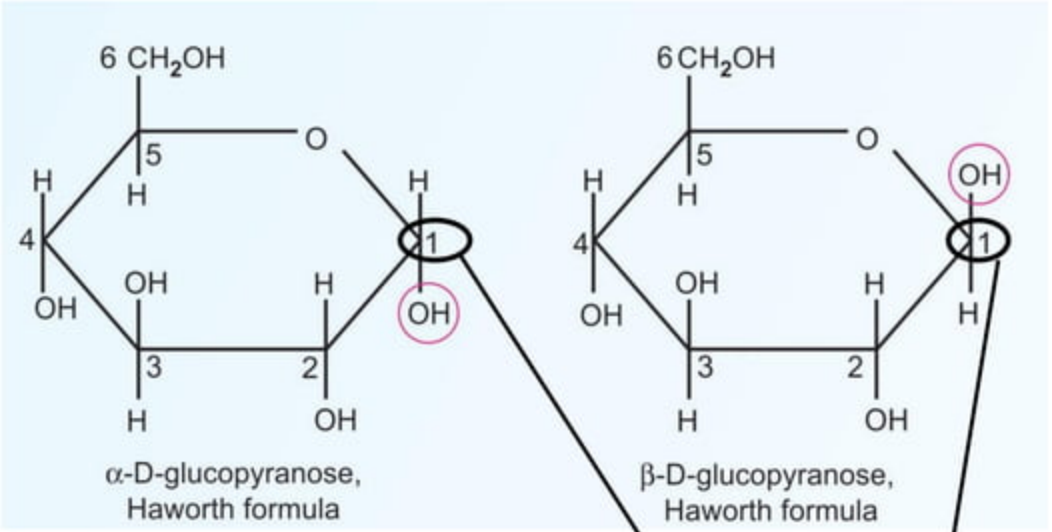


open chain projection formula

Fischer's formula

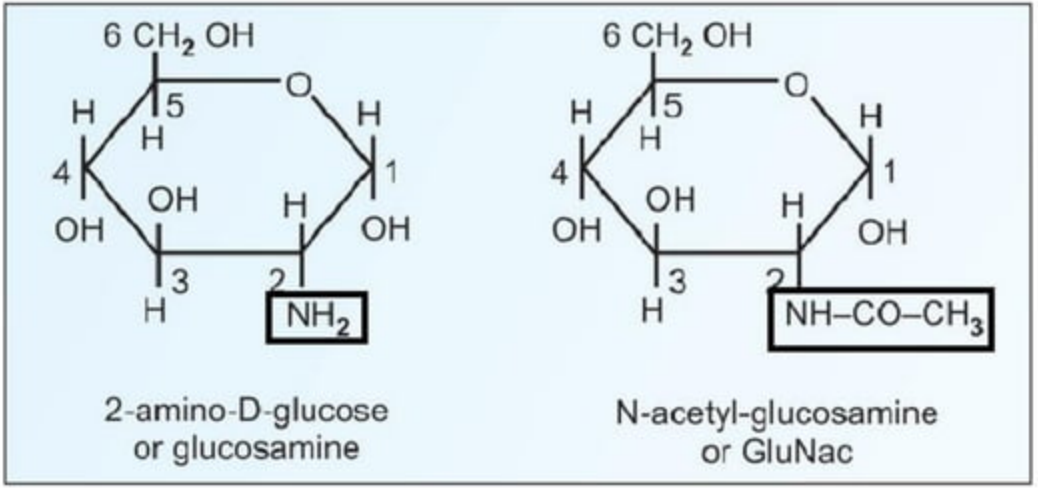
Haworth's formula

Haworth formula



Anomeric carbon atom

Amino sugars

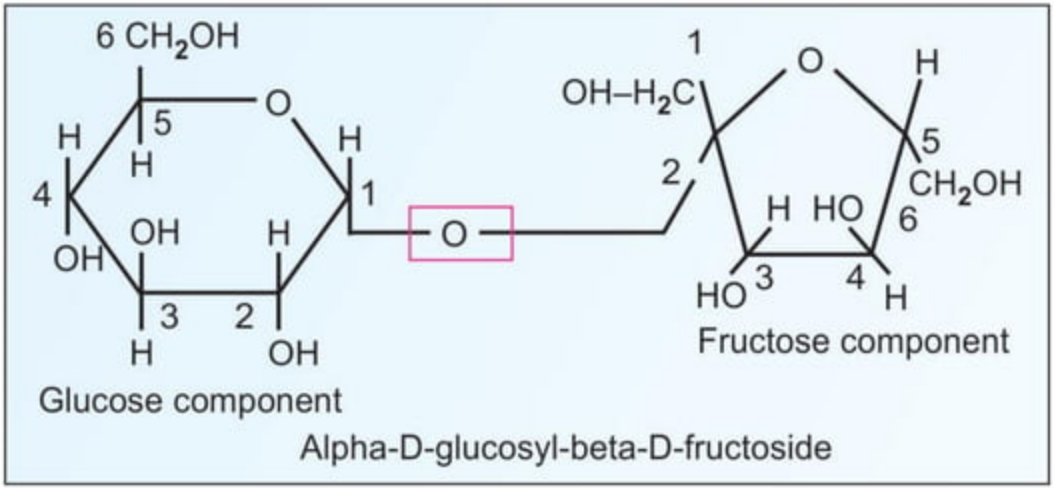


Amino groups may be substituted for hydroxyl groups of sugars to give rise to amino sugars

DISACCHARIDES

- Sucrose
- Lactose
- Maltose
- Isomaltose

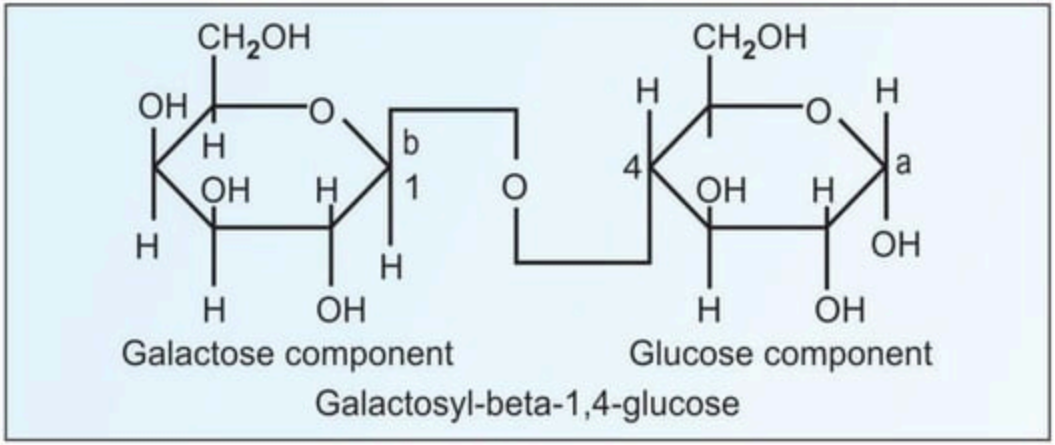
Sucrose



It is the sweetening agent known as cane sugar. It is present in sugarcane and various fruits.

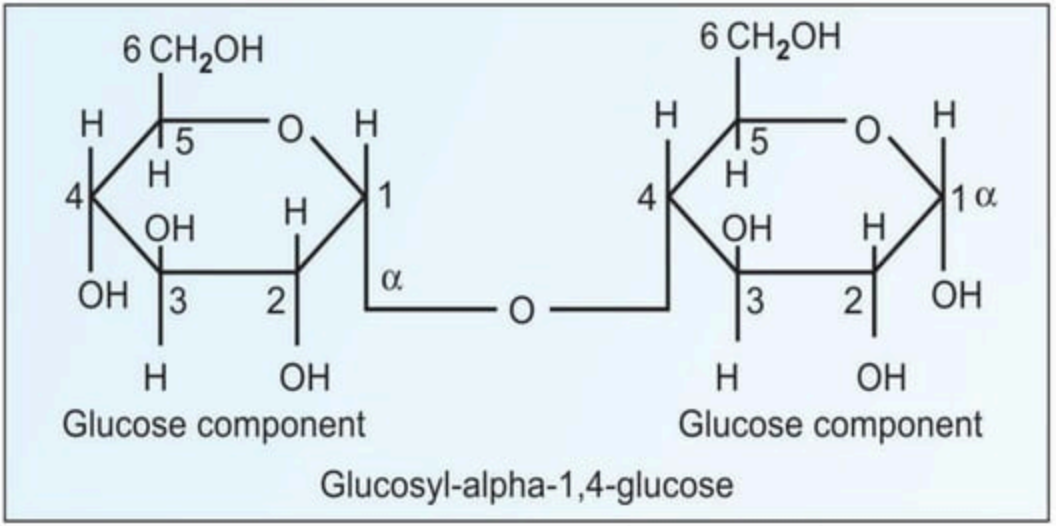
- Hydrolysis of sucrose (optical rotation +66.5°) will produce one molecule of glucose (+52.5°) and one molecule of fructose (–92°). [Explain d and l isomerism]
- Therefore, the products will change the dextrorotation to levorotation, or the plane of rotation is inverted. Equimolecular mixture of glucose and fructose thus formed is called **invert sugar**.
- The enzyme producing hydrolysis of sucrose is called sucrase or invertase.
- Honey contains invert sugar. Invert sugar is sweeter than sucrose.

Lactose

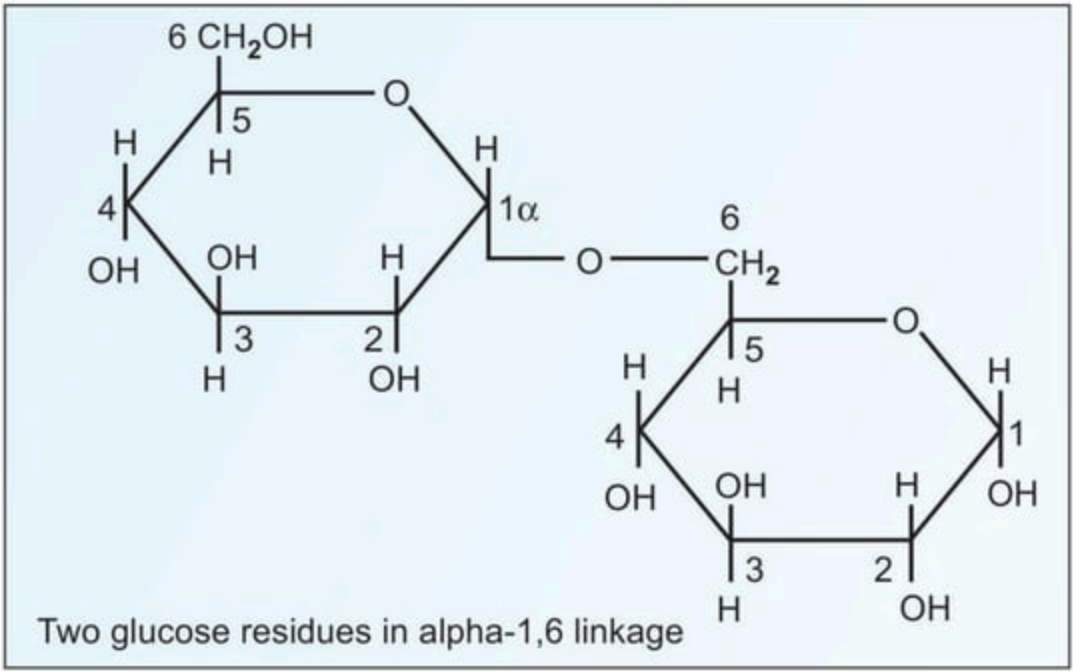


It is the sugar present in milk

Maltose


6 CH2OH
H
5
O
H
H
4
1
OH
H
OH
3
2
α
O
H
OH
Glucose component
6 CH2OH
H
5
O
H
H
4
1 α
OH
H
3
2
OH
H
OH
Glucose component
Glucosyl-alpha-1,4-glucose

Isomaltose



Two glucose residues in alpha-1,6 linkage

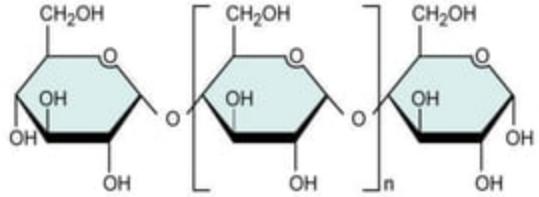
Homopolysaccharides

- Starch
- Glycogen
- Cellulose
- Inulin
- Dextrans
- Chitin

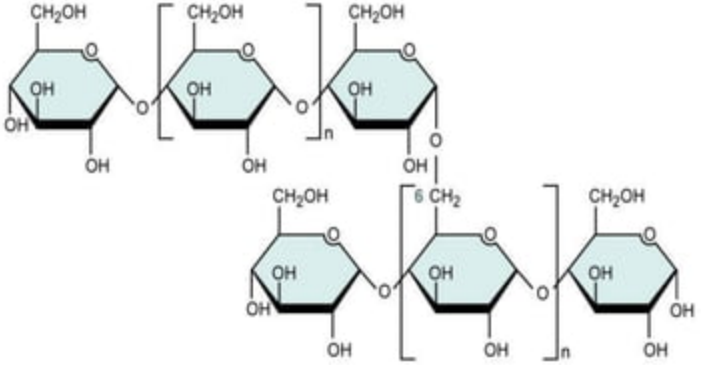
Starch

- It is the reserve carbohydrate of **plant kingdom**
- **Sources: Potatoes, cereals (rice, wheat) and** other food grains.
- Starch is composed of amylose and amylopectin.

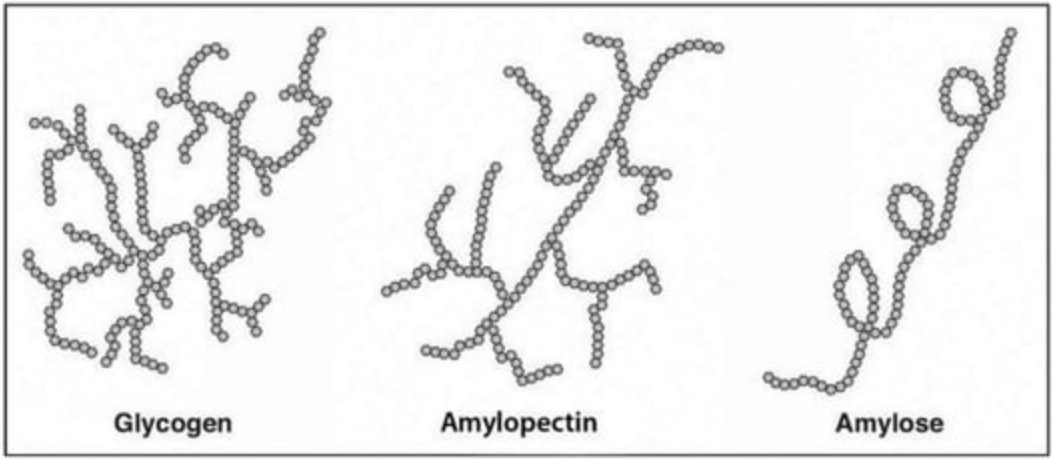
Amylose



Amylopectin



Glycogen



It is the reserve carbohydrate in animals. It is stored in liver and muscle. About 5% of weight of liver is made up by glycogen. Excess carbohydrates are deposited as glycogen.

Cellulose

- It is made up of glucose units combined with **beta-1,4 linkages**. It has a straight line structure, with no branching points.
- Beta-1,4 bridges are hydrolyzed by the enzyme **cellobiase**. But this enzyme is **absent in animal and human** digestive system, and hence cellulose cannot be digested.

Importance

- Cellulose, though not digested, has great importance in human nutrition.
- It is a major constituent of fiber, the non-digestable carbohydrate.
- The functions of dietary fiber
  - Increasing the bulk of feces so reduces constipation.
  - Decreasing the absorption of cholesterol from the intestine.

Inulin

- It is a long chain homoglycan composed of D-fructose units with repeating beta-1,2 linkages.
- It is the reserve carbohydrate present in various bulbs and tubers, such as onion, garlic.
- It is clinically used to find renal clearance value and glomerular filtration rate.

Dextrans

- These are highly branched homopolymers of glucose units with 1-6, 1-4 and 1-3 linkages. They are produced by micro-organisms.
- Since they will not easily go out of vascular compartment, they are used for intravenous infusion as plasma volume expander for **treatment of hypovolemic shock**

Dextrose, Dextrin and Dextran are different

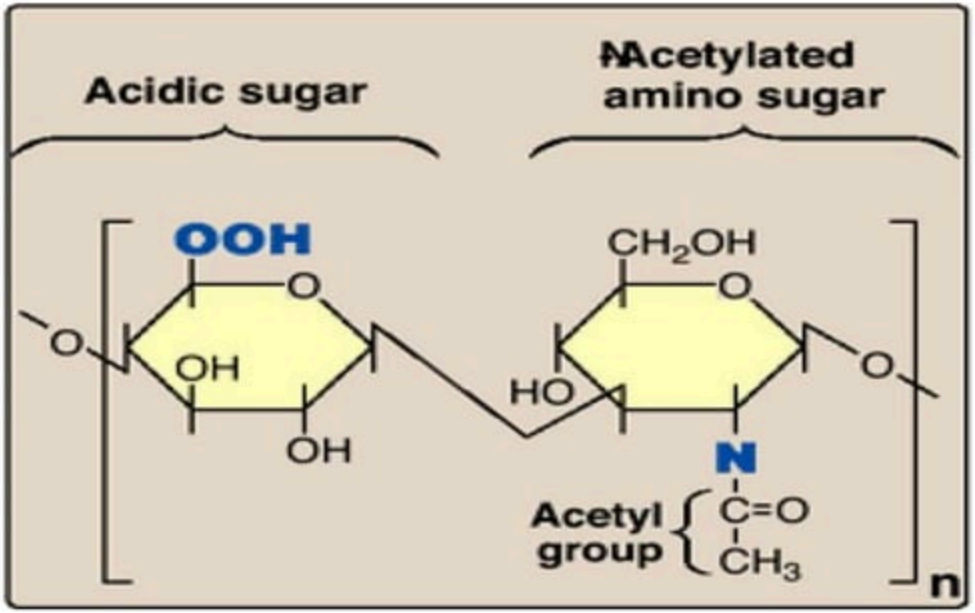
- D-glucose is otherwise called Dextrose, a term often used in bed-side medicine, e.g. dextrose drip.
- Dextrin is the partially digested product of starch.
- Dextran is high molecular weight carbohydrate, synthesized by bacteria.

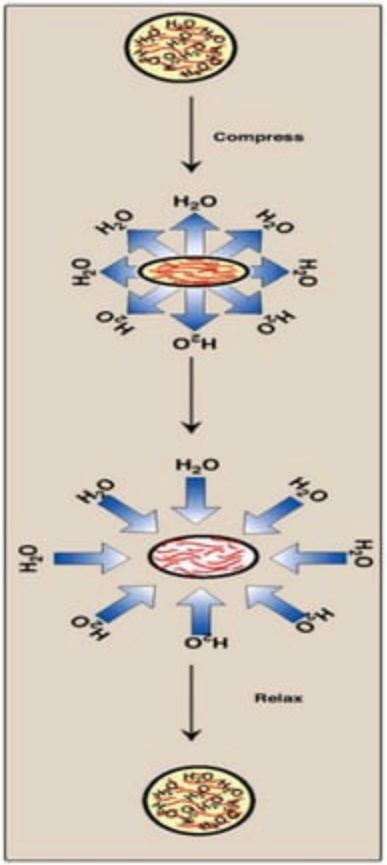
Chitin

- It is present in exoskeletons of crustacea and insects.
- It is composed of units of N-acetyl-glucosamine with beta-1,4 glycosidic linkages.

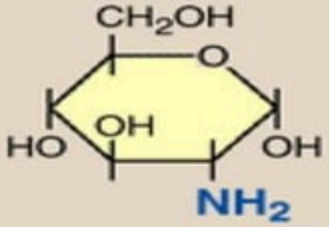
Heteropolysaccharides

Glycosaminoglycans

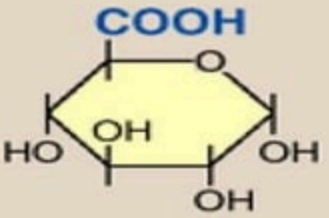




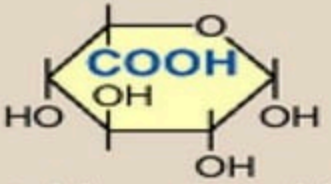
This property contributes to the resilience of synovial fluid and the vitreous humor of the eye



Glucosamine



D-Glucuronic acid



L-Iduronic acid

GAGs	Composition (Repeating units of)	Tissue distribution	Functions
Hyaluronic acid	D-glucuronic acid and N-acetyl D-glucosamine	Connective tissue Synovial fluid Vitreous humor Gel around ovum	lubricant and shock absorbant in joints
Chondroitin sulphate	D-glucuronic acid and N-acetyl D-galactosamine 4-sulfate	bone, cartilage, Tendons,heart valves and skin	Helps to maintain the structure And shapes of tissues
Dermatan sulfate	D-Iduronic acid and N-acetyl D-galactosamine 4 –sulfate	Skin	Helps to maintain shapes of tissues
Keratan sulphate	galactose and N-acetyl glucosamine	cornea tendons	Keeps cornea Transparent
Heparin	sulphated glucosamine and glucuronic acid or iduronic acid	blood, lung, liver ,kidney, spleen	Anticoagulant Clearing factor

Glycoproteins

Proteoglycans: When carbohydrate chains are attached to a polypeptide chain.

Glycoproteins: Carbohydrate content ≤ 10%.

Any questions?

Thank you