Carbohydrates

- Biological molecule (macromolecule)
- Consisting of C, H and O
- General formula: $C_x(H_2O)_y$

Classification

- Number of sugar units

- **Monosaccharides:** simple sugars with multiple OH groups.
- **Disaccharides:** 2 monosaccharide covalently linked.
- **Polysaccharides:** chains of monosaccharide units covalently linked.

Monosaccharides

Classifications
(based on number of carbon atom)

Triose=3, Tetrose=4, Pentose=5, Hexose=6

Monosaccharides with eight or more carbons are rarely observed as they are quite unstable.

Aldoses with an aldehyde group at one end

Hexose=6 (no of carbon atom)
Glucose: $C_6H_{12}O_6$

Glucose: Most important sugar in our diet

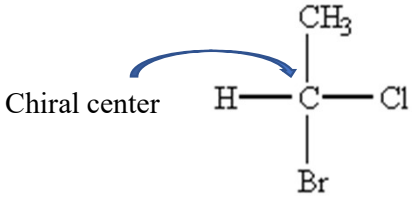
Ketoses with a keto group, usually at C2

Hexose=6 (no of carbon atom)
Fructose : $C_6H_{12}O_6$

Fructose: It is sweetest of all sugars

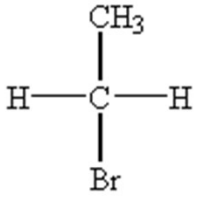
Chiral center/carbon

Chiral carbon Asymmetric carbon - 4 different groups are attached to it



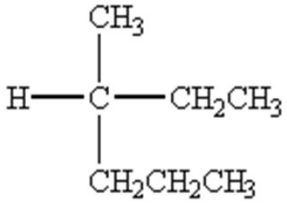
chiral

Has 4 different atoms bonded to the carbon



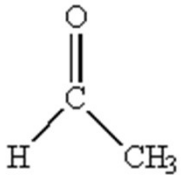
achiral

Does not have 4 different atoms or groups bonded to the carbon (2 hydrogens)



chiral

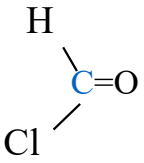
Has 4 different groups bonded to the carbon

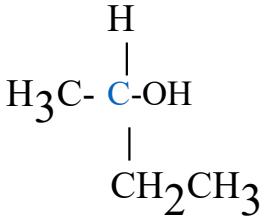


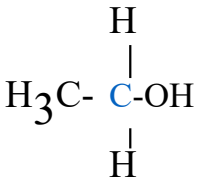
achiral

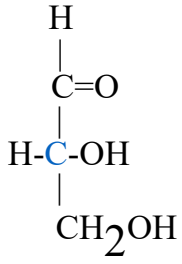
Only has 3 atoms bonded to the carbon

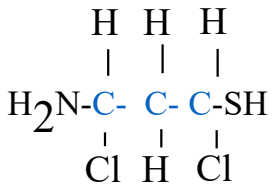
Is the 'blue' carbon chiral?











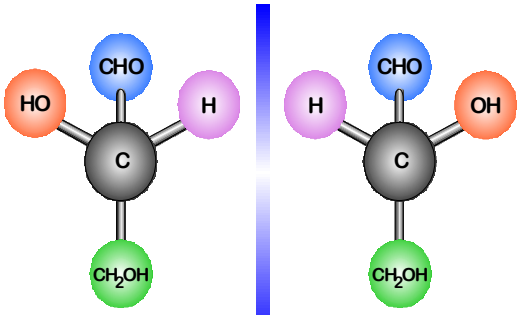
Stereoisomers

Carbohydrate exists as stereoisomers.
Stereoisomers are isomers that have the **same composition but differ in the spatial orientation**

- ✓ Same molecular formula and the same structural formula
- ✓ The same order and types of bonds
- ✓ Having at least one chiral carbon
- ✓ Differ in the spatial arrangement of the atoms in the molecule.

L- and D- glyceraldehyde (Triose monosaccharide)

Two compounds that are stereoisomers of each other have the same physical properties but differ in the optical properties.



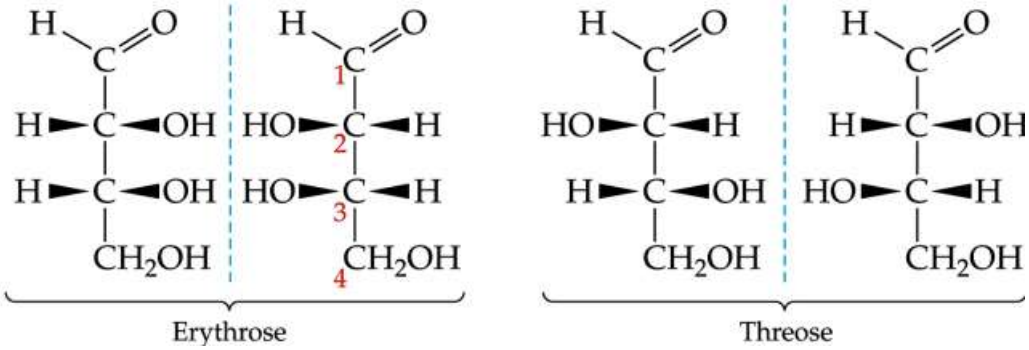
L-form **D-form**

Latin words dexter (on the right) and laevus (on the left)

Hydroxyl (-OH) group
right: **D** sugar
left: **L** sugar

Pairs of stereoisomers or enantiomers are mirror images of one another.

The number of stereoisomers is **2^n**, where n is the number of asymmetric centers.

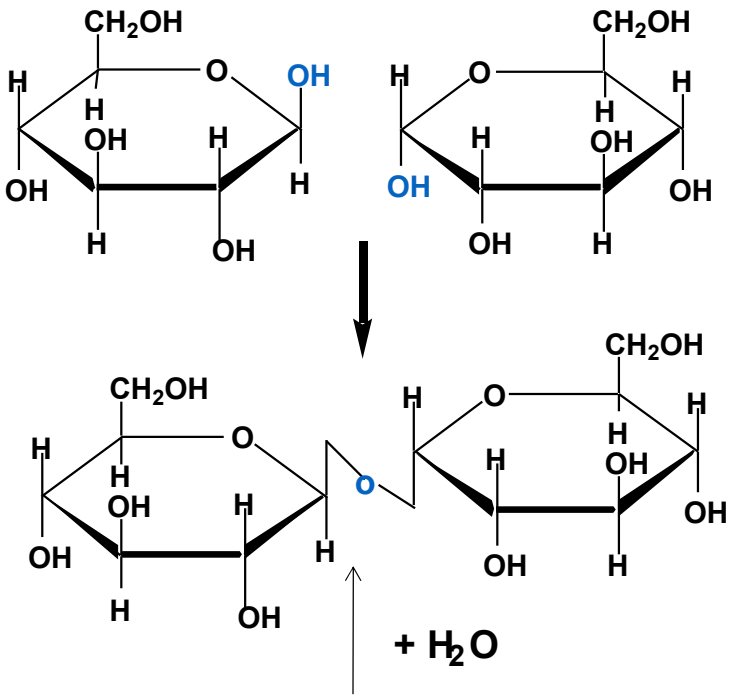


This aldotetrosose, has 2 chiral carbon atoms and a total of $2^2 = 4$ possible stereoisomers

Glycoside formation

- Cyclic monosaccharide can form link with another one (or more).

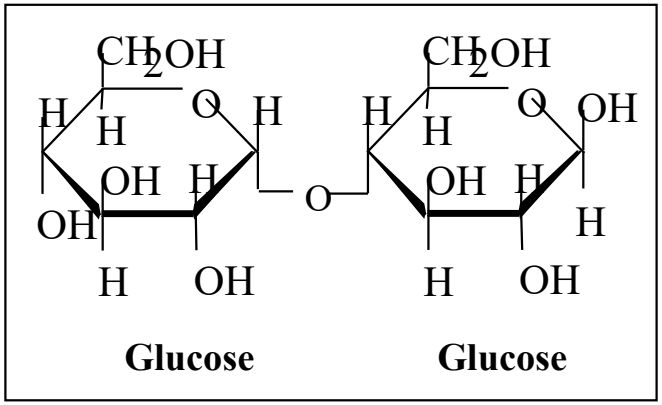
$C_6H_{12}O_6$



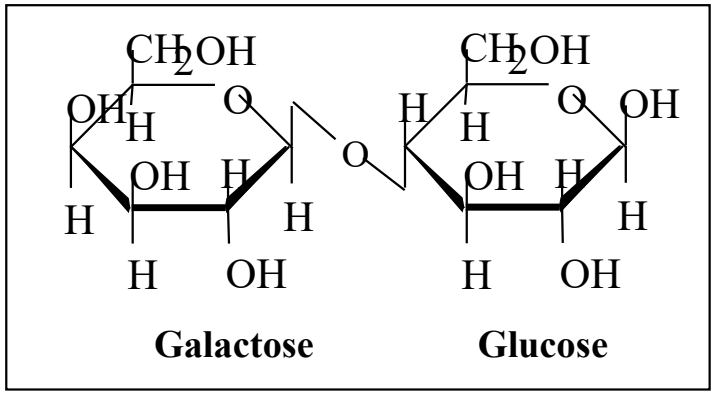
Glycosidic bond

Disaccharides

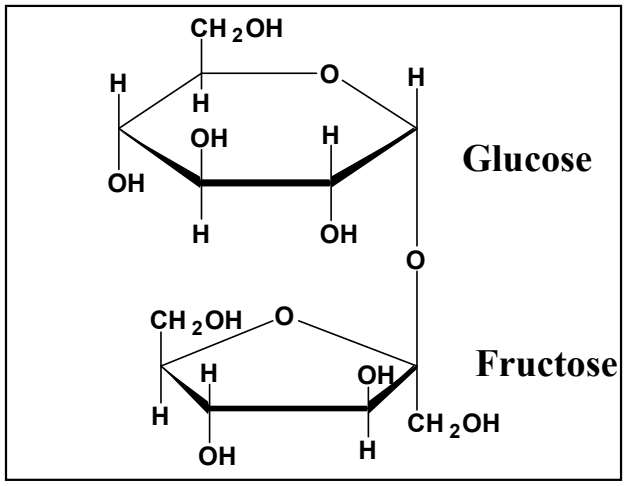
Maltose



Lactose (Milk sugar)



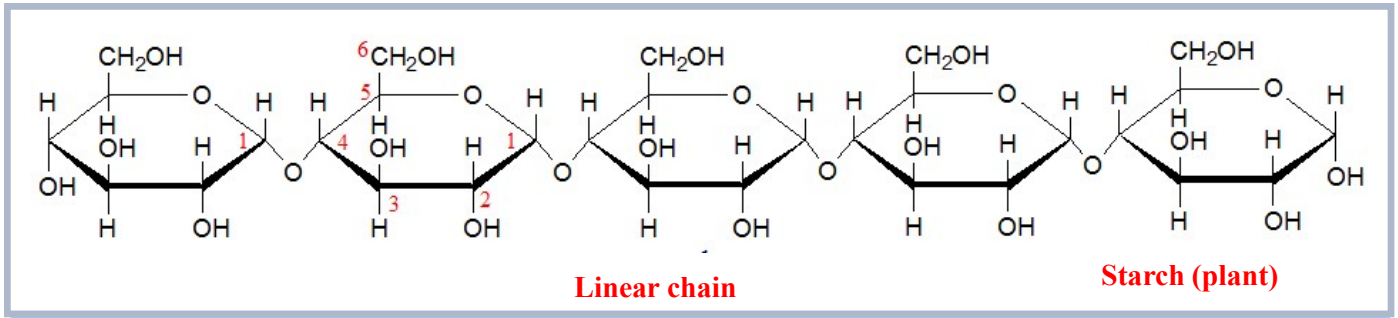
Sucrose (Plants)

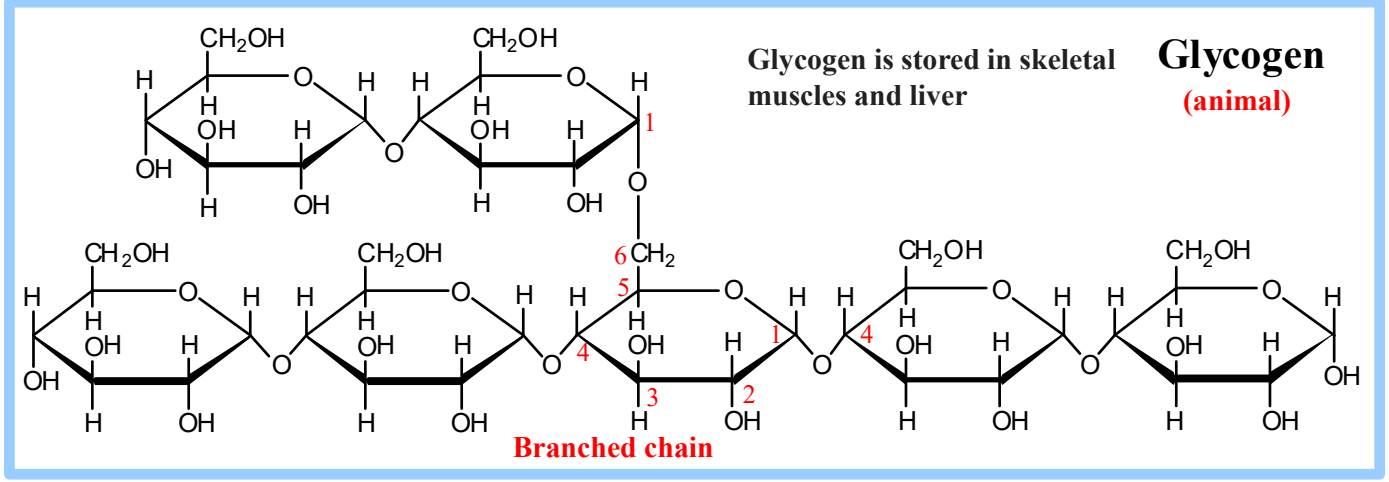


Polysaccharides

They are long chain polymeric carbohydrates composed of monosaccharide units bound together by glycosidic linkages.

- Energy storage





Lipids

1. Naturally occurring macromolecules
2. Includes fatty acids, fats and oils, phospholipids
3. Functions:

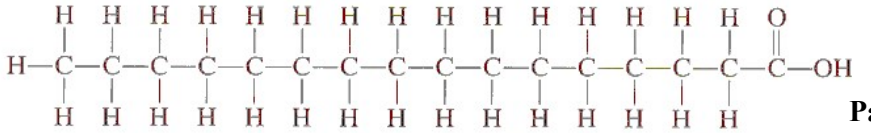
Signaling
Storing energy
Formation of structural components of cell membranes

Fatty acids

Fatty acids are naturally occurring carboxylic acids with an unbranched carbon chain and an even number of carbon atoms.

Saturated fatty acid

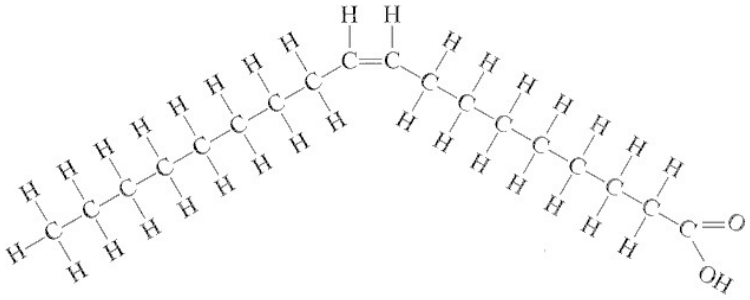
Only carbon-carbon single bonds



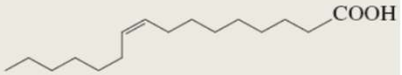
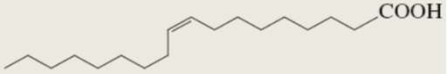
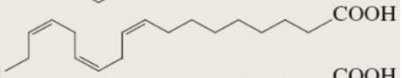
Palmitic acid (16 carbon)

Unsaturated fatty acid

- Those molecules that contain one or more double bonds are said to be unsaturated.
- There are mono- and polyunsaturated fatty acids.

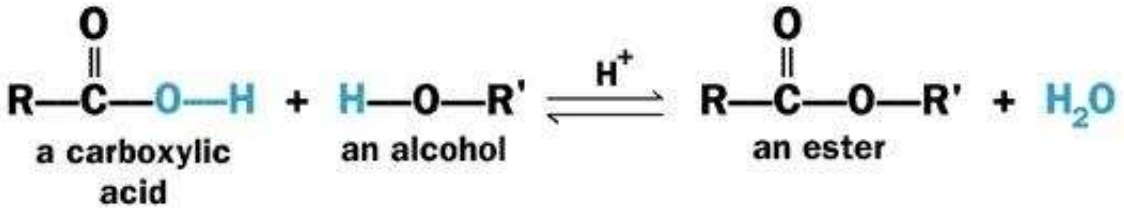


Oleic acid (18 carbon)

Number of carbons	Common name	Systematic name	Structure
Saturated			
12	lauric acid	dodecanoic acid	
14	myristic acid	tetradecanoic acid	
16	palmitic acid	hexadecanoic acid	
18	stearic acid	octadecanoic acid	
20	arachidic acid	eicosanoic acid	
Unsaturated			
16	palmitoleic acid	(9*Z*)-hexadecenoic acid	
18	oleic acid	(9*Z*)-octadecenoic acid	
18	linoleic acid	(9*Z*,12*Z*)-octadecadienoic acid	
18	linolenic acid	(9*Z*,12*Z*,15*Z*)-octadecatrienoic acid	
20	arachidonic acid	(5*Z*,8*Z*,11*Z*,14*Z*)-eicosatetraenoic acid	
20	EPA	(5*Z*,8*Z*,11*Z*,14*Z*,17*Z*)-eicosapentaenoic acid	

Ester formation

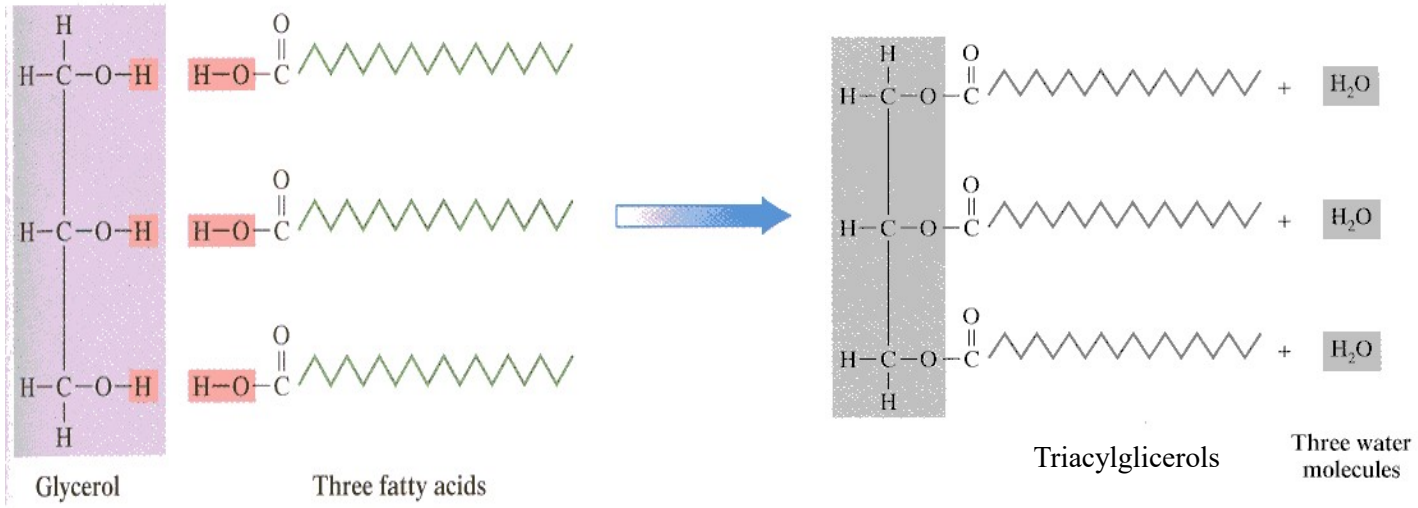
Esters are formed when the **carboxylic** acid is heated with the **alcohol** in the presence of a catalyst.



(Where R and R' are general hydrocarbon groups)

Oils and fats

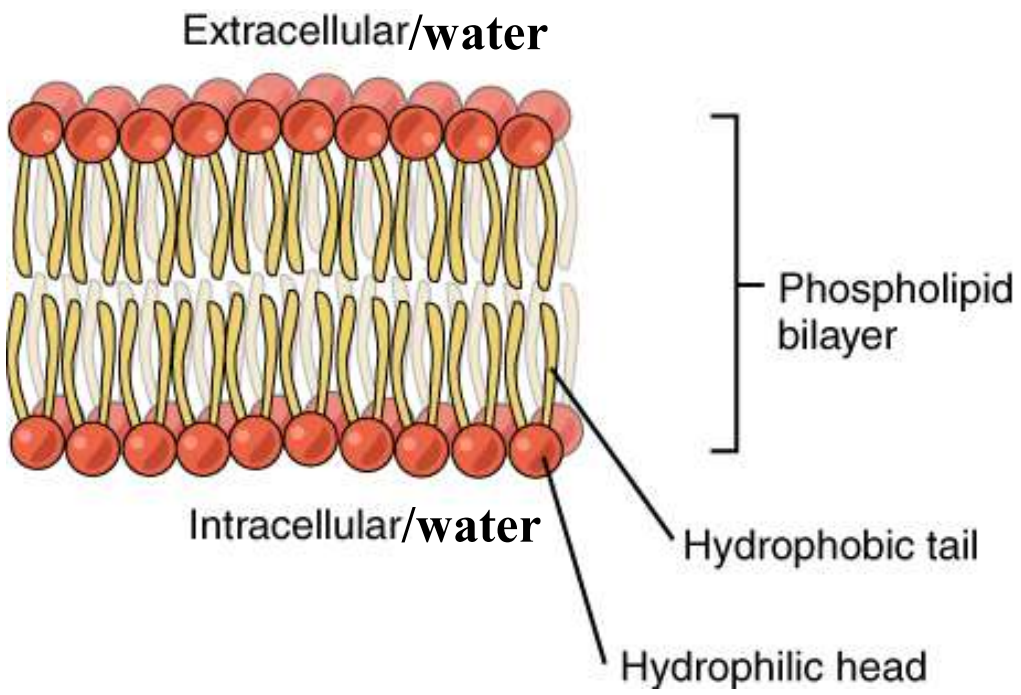
These are the esters of Fatty acid and trihydric alcohol (eg. Glycerol) are called triacylglycerols



(Trihydric alcohol)

Reaction formation of triacylglicerols

Phospholipid bilayer of cell membrane



Phospholipids

There are the triesters of glycerol:

2 -OH groups are esterified with fatty acids

1 is esterified with phosphoric acid, which in turn is esterified to an alcohol.