434 | Biochemistry Team

Carbohydrates: structure and Function

“foundation block”

Objectives:

- The structure of carbohydrates of physiological significance
- The main role of carbohydrates in providing and storing of energy
- The structure and function of glycosaminoglycans

Color index: red=important note
orange=further explanation

Learning About Carbohydrates

They are the most abundant organic molecules in nature

The empiric formula is $(CH_2O)n$ ("n" should be 3 or more ,n>= 3)

The other name of carbohydrate is "hydrates of carbon"

	
Carbohydrates: provide important part of energy in diet Act as the storage form of energy in the body are structural component of cell membranes	Many diseases associated with disorders of carbohydrate metabolism including: Diabetes mellitus Galactosemia Glycogen storage diseases Lactose intolerance

CLASSIFICATION

Consist of	Monosaccharides	Disaccharides	Oligosaccharides	Polysaccharides
	One monosaccharide unit (simple sugar)	Two monosaccharide units	3-10 monosaccharide units	more than 10 sugar units

Polysaccharides:

- **Homopolysaccharides**: Contains of one type of monosaccharides
- **heteropolysaccharides**: Contains of more than one type of monosaccharide

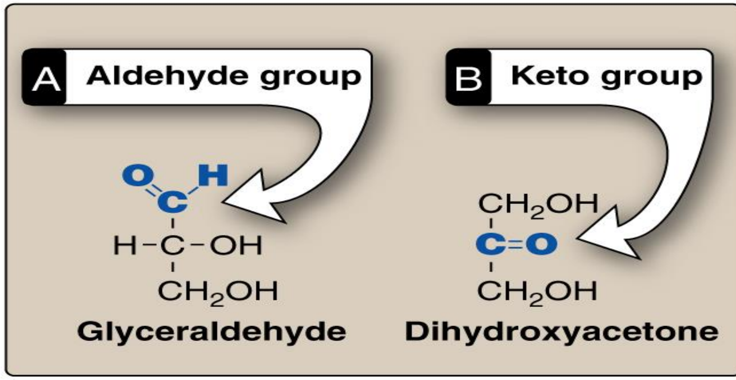
CLASSIFICATION OF MONOSACCHRIDES

Based on:

1) Number of carbon atom:

Generic names		Examples
3 carbons:	trioses	Glyceraldehyde
4 carbons:	tetroses	Erythrose
5 carbons:	pentoses	Ribose
6 carbons:	hexoses	Glucose
7 carbons:	heptoses	Sedoheptulose
9 carbons:	nonoses	Neuraminic acid

2) Functional sugar group:
if the Monosaccharide has **Aldehyde group –** we call it **aldoses**
but if the Monosaccharide has **Keton group –** we call it **ketoses**



Examples

	Aldose	Ketose
Triose	Glyceraldehyde	Dihydroxyacetone
Pentose	Ribose	Ribulose
Hexose	Glucose	Fructose

ISOMERISM

Definition: compounds having the same molecular formula but different structural formula.

Sugar isomers

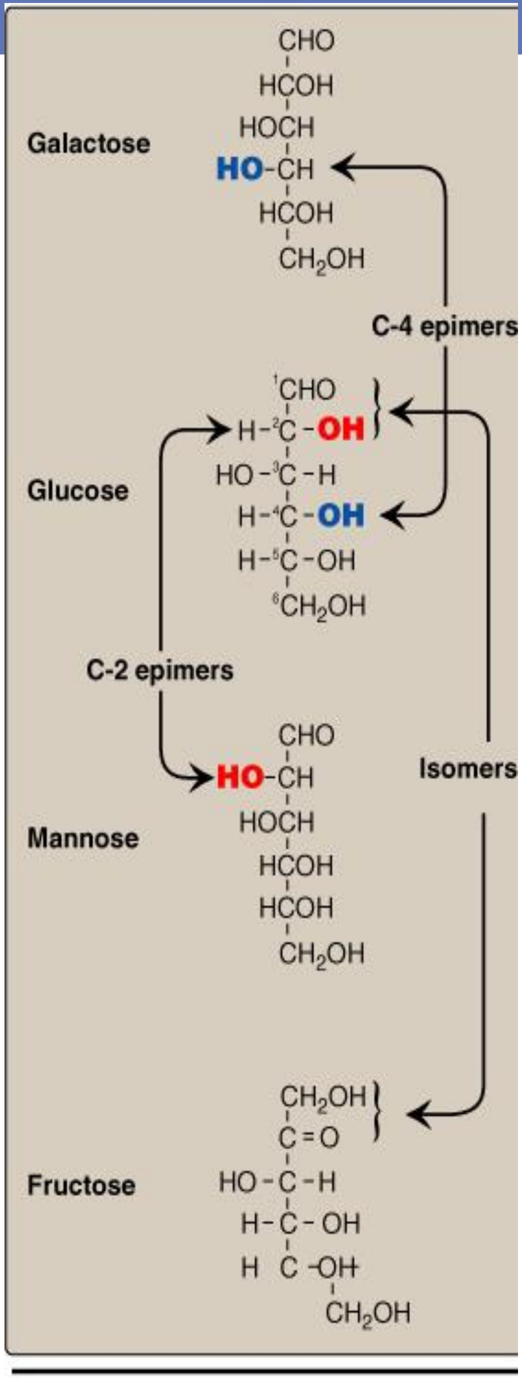
- Aldo-keto
- epimers
- D-and L-forms
- **α- and β-anomers**

Aldo-Keto isomers

Location of the carbonyl group is different.
Aldehyde- C1
Ketone- within the chain R-CO-R
E.g
Glucose(aldose) and Fructose(ketose)

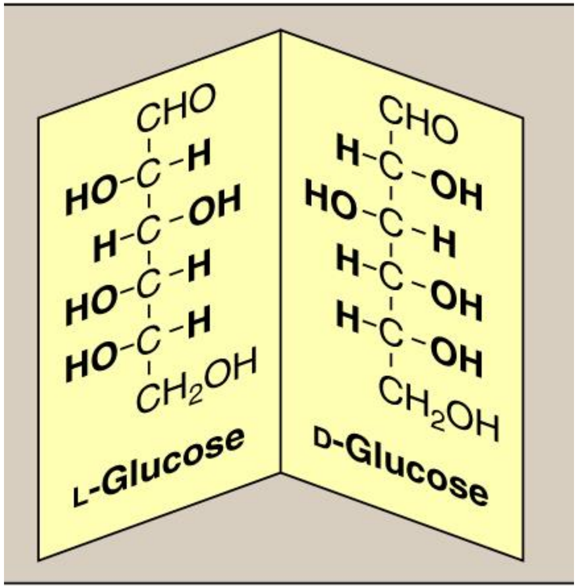
Epimers

CHO dimers that differ in configuration around only <u>one specific</u> carbon atom.
E.G
Glucose and **galactose C4**
Glucose and mannose C2
Glactose and mannose are not epimers, they differ around carbon no. C2&C4.



ENANTIOMERS

Structures that are mirror images of each other. Designated as D-L Sugars based on the position of (OH-Hydroxyl grp) on the **asymmetric carbon(Carbon attached to four chemically different grps) farthest from the carbonyl carbon**
Majority of sugars in humans are **D-sugars**



α- and β-Forms

Mutarotation

<u>Cyclization of Monosaccharides</u>

Monosacchrides with five or more carbon atoms are found in the ring form

↓

The carbonyl group reacts with the hydroxyl group (OH) on the same sugar.

↓

This gives rise to an anomeric carbon (former carbonyl group) generating the α and β configurations.

↓

Aldehyde-C2 Ketone-C2

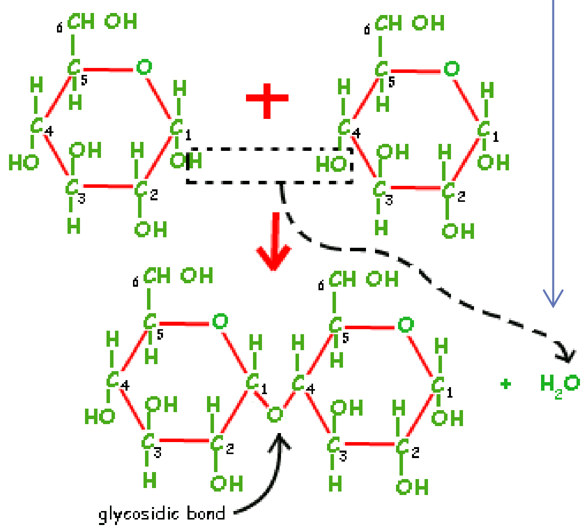
In solution the cyclic α and β anomers of a sugar are in equilibrium with each other and can be interconverted spontaneously

DISACCHARIDES

Joining of 2 monosaccharide's by **o-glycosidic bond**

dehydration

Examples:



Maltose (α-1, 4)= glucose + glucose

Sucrose (α-1,2)=glucose + fructose

Lactose(β-1,4)=glucose + galactose

So what (α-1, 4) or (α-1,2) mean??

Let's have (Maltose) as an example..

Name

OH (hydroxyl group) toward down

Maltose (α-1, 4)= glucose + glucose

C4 of the second glucose

C1 of the first glucose

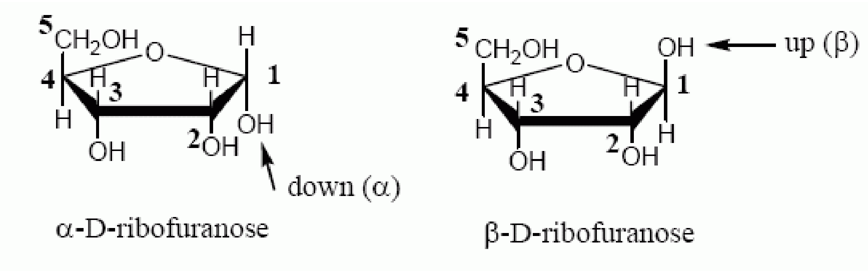
α= OH down

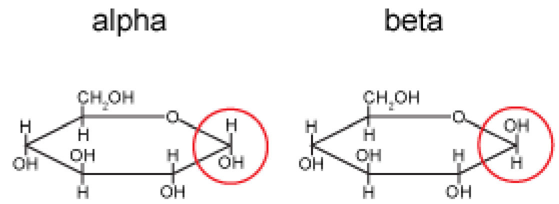
B= OH up

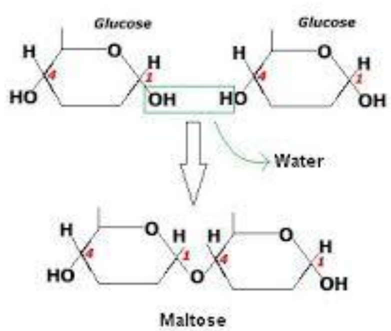
D= most OH on the right

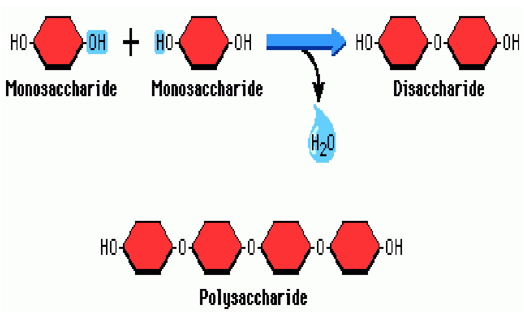
L= most OH on the left

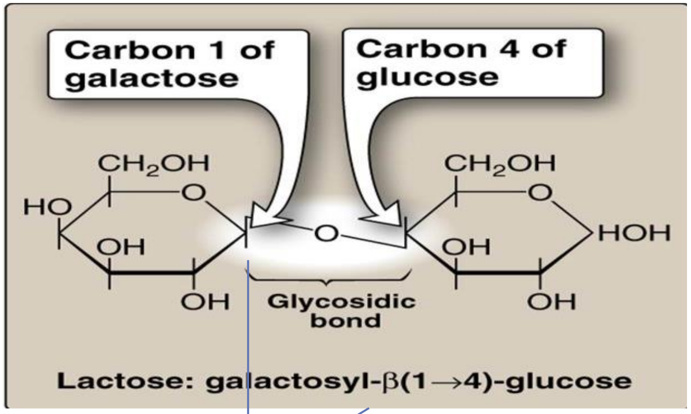
Important pictures to understand disaccharides :











β= up

polysaccharides

(Homo)polysaccharides

Homo= same type of sugar

Branched

-One chain but it has a branch on it

Examples:

Glycogen and starch (α-glycosidic polymer)

unBranched

-Single chain

Example:

Cellulose (β-glycosidic polymer)

(Hetero)polysaccharides

Hetero= different types of sugars

-Example:

glycosaminoglycans (GAGs)

Reducing Sugars

-If the O on the anomeric C of a sugar is not attached to any other structure **(Free),** that sugar can act as a reducing agent

(مولد اللون)

-Reducing sugars reduce (chromogenic agents) like(رواسب ملونة) Benedict's reagent or Fehling's solution to give a (colored precipitate)

العامل المختزل: المادة التي تتأكسد وتسبب اختزالاً لمادة اخرى
العامل المؤكسد: المادة التي تُختزل وتسبب تأكسداً لغيرها

Example: urine don't have any sugar on it, we add a reducing agent to a sample of urine, if it's get (colored) then we know that the patients have diabetes

Reducing agent

Examples:

Monosaccharides

Maltose and Lactose

Sucrose is non-reducing, Why?

Sucrose is the combination of cyclic structures of Glucose and Fructose and therefore does not have a free aldehyde or ketone group.

Important thing:
Density of the color on the urine sample depends on the amount of sugar (**Monosaccharides, Maltose and Lactose)**

Complex carbohydrate

(CHO + non-CHO) structure Attached by Glycosidic bonds (O- or N-) Type

Purine and pyrimidine

In nucleic acids

Bilirubin

Proteins

Lipids

Glycolipids

Proteoglycans

Long chains of CHO (95%) with small amount of protein, consist of a core protein to which up to 100 linear GAGs chains covalently attached

Glycoproteins

Short chains of CHO with larger amount of protein

Glycosaminoglycans"GAGs"

Bind with large amount of water , producing the gel-like matrix that forms body's grounds substance and cause the viscosity of mucous secretions (Mucopolysacchrides)

Heteropolysacchrides composed of **repeating disacchrides unit** [acidic sugar – amino sugar]

Acidic sugar

D- Glucuronic acid or L- iduronic acid

Amino sugar

D- glucosamine or D-galactosamine

Acidic sugars give GAGs their strongly negative nature by their –ve carboxyl group "sulfate group "

• Resilience of GAGs

Relationship between glycosaminoglycan structure and function .

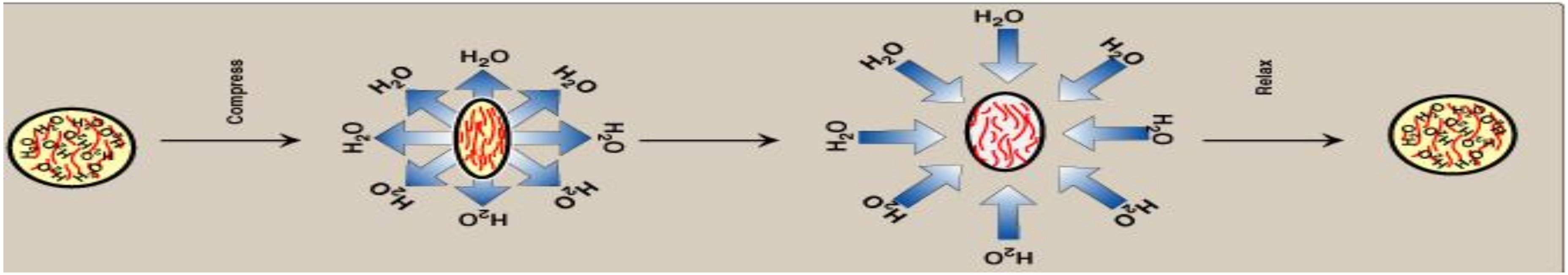
Because of -ve charges(Due to COOH in sugar)
The GAG chains tend to be extended(متمددة)in solution and repel (تنافر) each other. (like Magnets). This produces the "**slippery" consistency of mucous secretions and synovial fluid.**
*They're are associated with a large amount of water.

synovial fluid=
Prevents the friction of the joints

GAGs are like sponge:

When a solution of GAGs are compressed,
The water will be squeezed out and the GAGs will be forced to occupy a smaller volume.
Because of the -ve charge after the compression is released,
GAGs will come back to its original+hydrated volume.

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



Members of GAGs

- **Chondroitin sulfates**
  - Most **abundant** GAGs
- **Keratan sulfates**
  - Most **heterogeneous** GAGs
- **Hyaluronic acid**
  - **unsulfated** and **not** covalently attached to protein
- **Heparin**
  - Unlike other GAGs that are extracellular, heparin is **intracellular** * serves as an anticoagulant

Helping videos:

Carbohydrates: YouTube

Disaccharides: YouTube

quiz your self: [Quiz]

Made by biochemistry team : bio

لينة الجرف
سارة المبرك
ارياف السلمة
شيخة الدوسري
نهى القويز
مشاعل امين
جمانة فطاني
اميرة بن زعير

محمد المعشوق
محمد الخراز
أنس الزهراني
محمد الدماس
أسامة عبد القادر
محمد الصبيح
عبدالعزيزالسعود

نوف العريني
رنا الجنيدل
ريما الرشيد
حنان عبدالمنعم
لمى القحطاني
نجود الرشيد
رنا البراك
فتون المطيري