جامعة الملك سعود
King Saud University

Biochemistry team 436

# Carbohydrates

- Color Index:

- Important.
- Extra Information.
- **Doctors slides.**

436 Biochemistry team

**Revised by**

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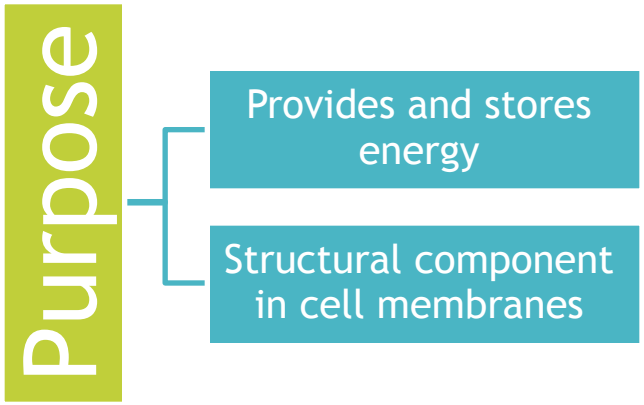
# Objectives:

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

# Carbohydrates

## “hydrates of carbon”

Are the most abundant organic molecules in nature




Empiric formula:

$(CH_2O)n$

“hydrates of carbon”

## Some carbohydrate metabolism disorders:

Diabetes mellitus : a chronic disease associated with abnormally high levels of the sugar glucose in the blood.

Galactosemia : condition in which the body cannot process or 'metabolise' the sugar galactose. Which means High galactose level in the blood

Glycogen storage disease : is the result of defects in the processing of glycogen synthesis or breakdown within muscles, liver, and other cell types

Lactose intolerance : is the inability of adults and children to digest lactose

# Classification

**Monosaccharides**
Simple sugar

**Disaccharides**
2 sugar units

**Oligosaccharides**
3-10 sugar units

**Polysaccharides**
>10 sugar units

**Homopolysaccharides**
Same sugar unit multiple copies

**Heteropolysaccharides**
Different sugar units multiple copies

**Branched**
-One chain but it has a branch on it
glycogen and starch
(a-glycosidic polymer)

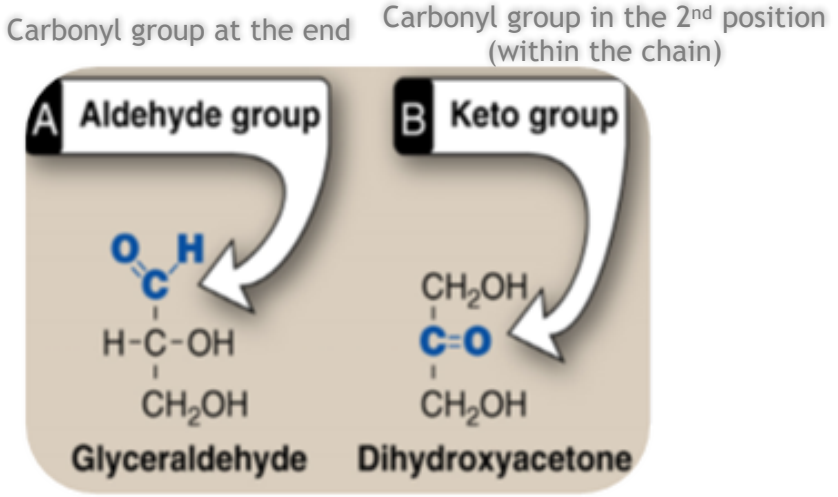
**Unbranched**
-Single chain
Cellulose
(B-glycosidic polymer)

# Monosaccharides

**Are further classified based on:**

| 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 |

## 1- No. of Carbons




## 2- Functional Sugar group ( Aldose & Ketose )

| | Aldose | Ketose |
|---|---|---|
| Triose | Glyceraldehyde | Dihydroxyacetone |
| Pentose | Ribose | Ribulose |
| Hexose | Glucose | Fructose |

- The smallest Aldehyde is Glyceraldehyde.
- Hexose is the most common functional group
- Glucose -> Aldehyde group  Fructose -> Ketone group

## Isomerism: → Compounds having same chemical formula but different structural formula

- Aldo Isomers — Glucose
- Keto Isomers — Fructose

المركبان يملكان نفس الصيغة الكيميائية لكن اختلفوا في المجموعة الوظيفية لتكون احدهما الدهايد (RCOH) وكيتون (RCOR)

## Epimers → CHO dimers that differ in configuration around only one specific carbon atom

e.g. -Glucose and galactose, C4
-Glucose and Mannose, C2

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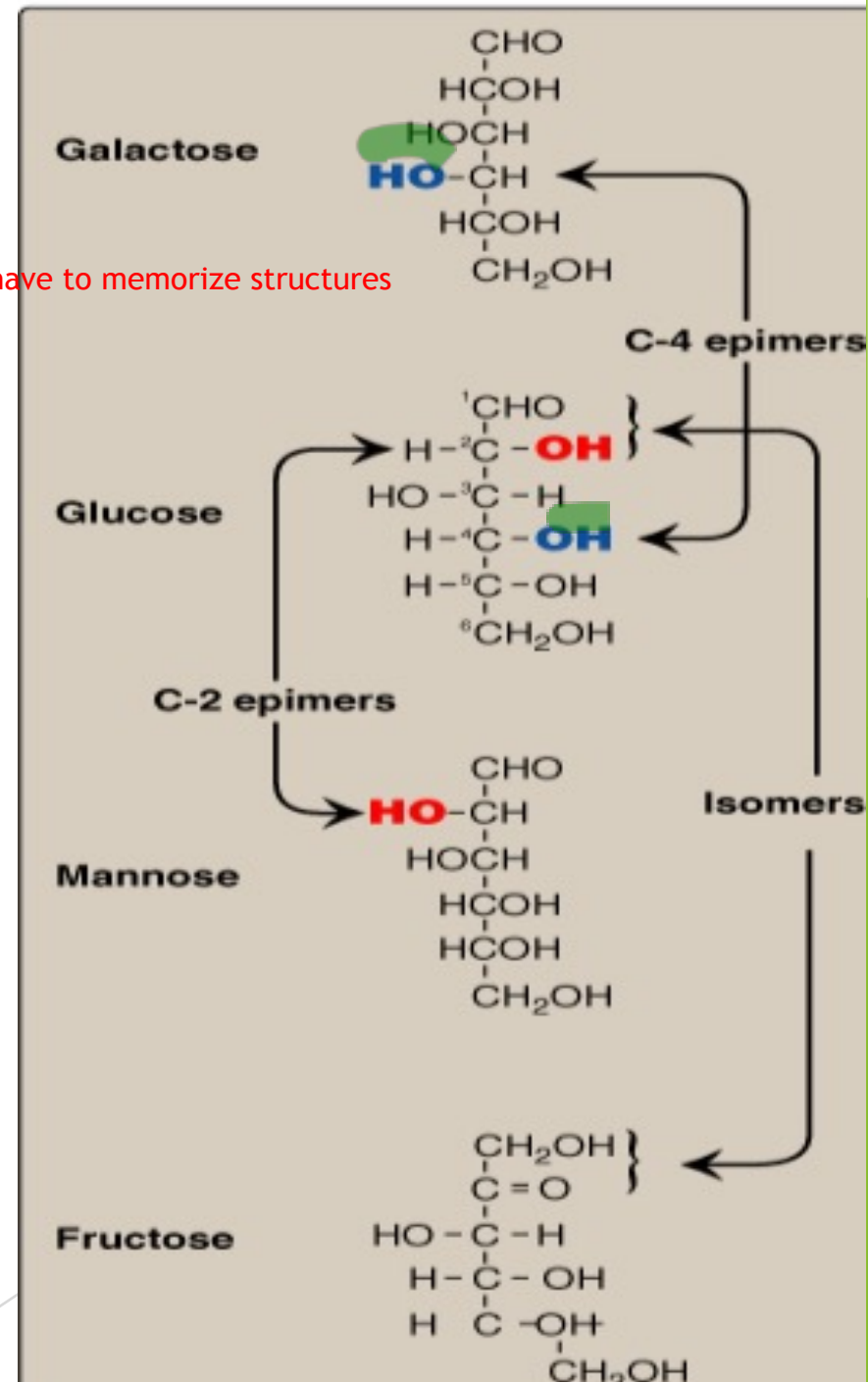
The difference is only around one molecule( as shown in the figure- only one carbon has difference in the position of OH around it).
Galactose and mannose are not epimers since their configuration differ around more than only one carbon atom

*You don't have to memorize structures



# Enantiomers (D- and L-Forms)

Structures that are **mirror images** of each other and are designated as D- and L-sugars based on the position of –OH group on the **asymmetric carbon farthest from the carbonyl carbon**

mirror images: every thing is in the oppisite site. Right will be left, left will be right.

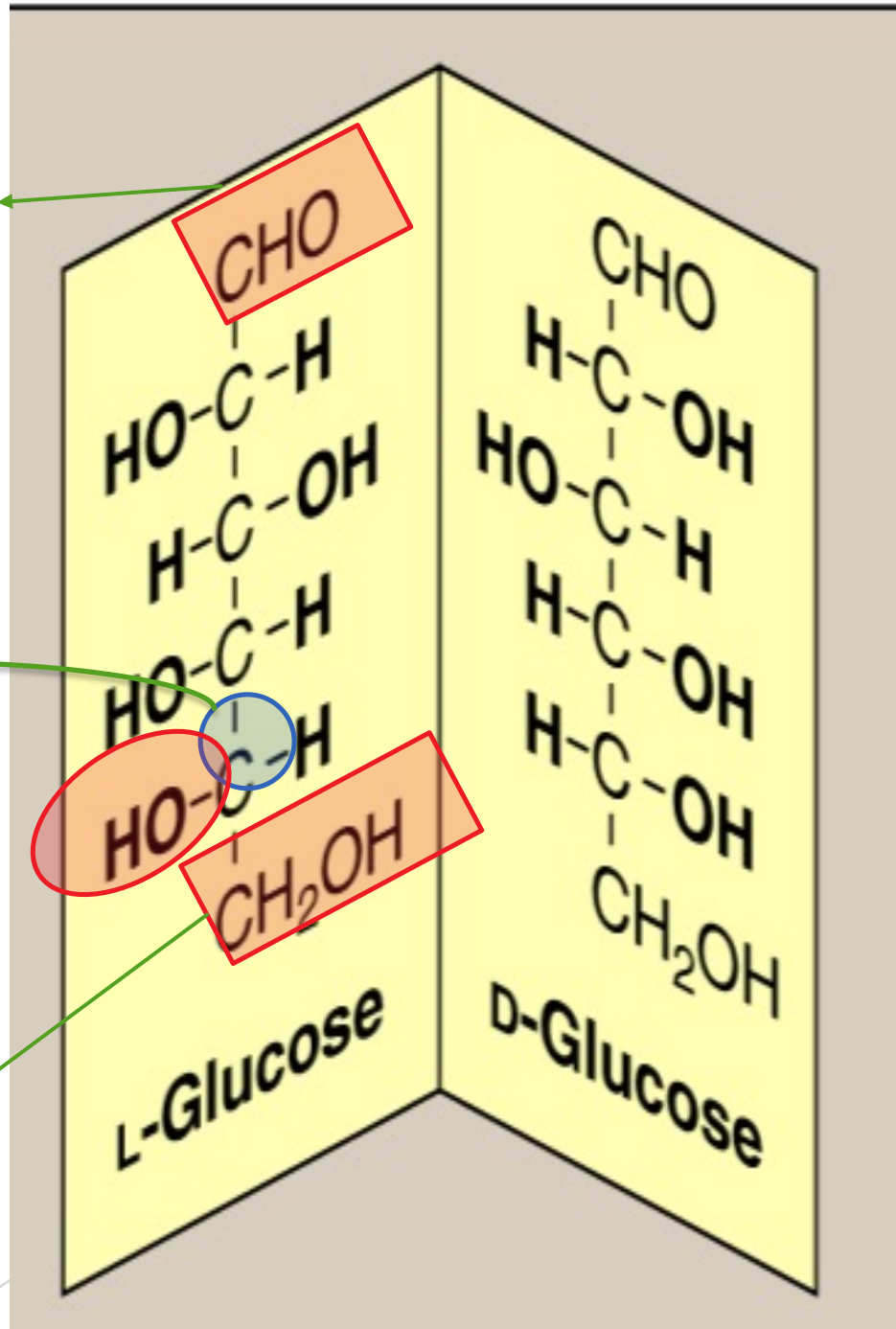
asymmetric carbon: carbon with 4 different groups.

L: stand for left
D: stand for right(Majority of sugars in humans )

NOT ASYMMETRIC- carbonyl carbon.

How to know if D or L?
1-Look for the farther asymmetric carbon from carbonyl carbon.
2-At that carbon we determain the posithion of (OH) is at the right(D) or at the left (L).

NOT ASYMMETRIC



# α- and β-Forms

❑ Cyclization of Monosaccharides with 5 or more carbon are predominantly found in the ring form

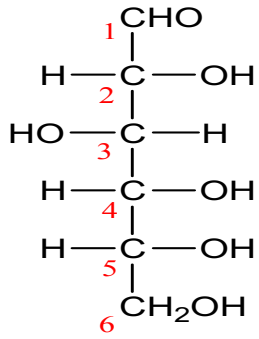
-The aldehyde or ketone gruop reacts with the -OH grp on the same sugar

-Cyclization creates an anomeric carbon (former carbonyl carbon) generating the α and β configurations.

(An anomer is a type of epimer found in carbohydrate chemistry. An anomer is a cyclic saccharides, carbohydrate)

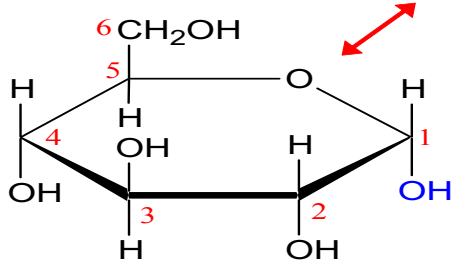
How to know if α or β? If the OH of aldehyde/ketone group was:
down: alpha
up: beta

Carbon 1 will interact with carbon 5 and make a ring

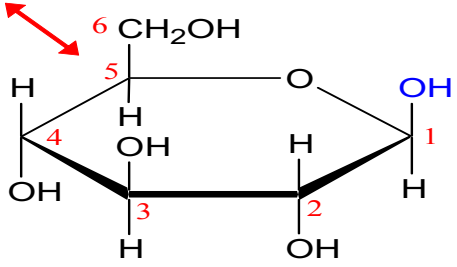



Aldehyde group

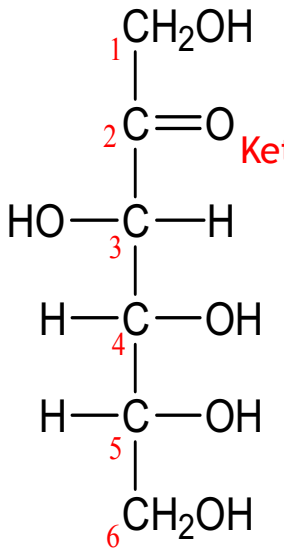
D-glucose (linear form)




-D-glucose



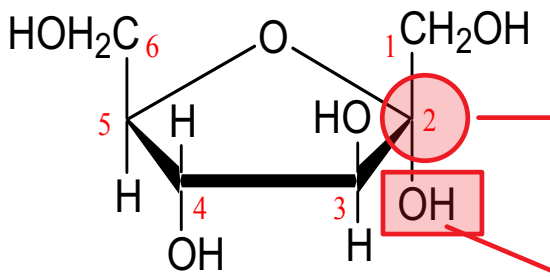

-D-glucose




Ketone group

D-fructose (linear)

2 (carbonyl carbon) will interact with 5 and make a ring




-D-fructofuranose

anomeric carbon

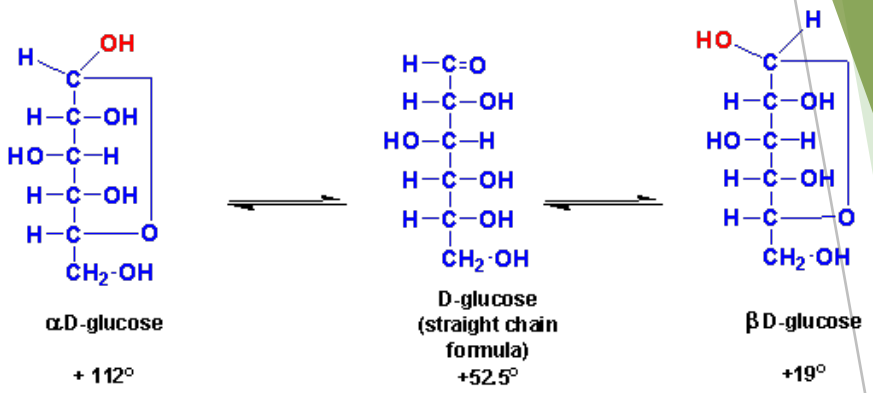
OH is down

# Mutarotation

*You don't have to memorize structures + Temperature

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

Alpha and beta are not fixed in the solution + converting from beta to alpha not required any energy or enzymes when




# Sugar Isomers:

**Aldo-Keto**
- Same : formula
- Different : functional Group

**Epimers**
- Same : formula
- Different : configuration around a *single* carbon atom

**D-and L-forms**
- Same : molecular formula
- Different : position of OH group on the *asymmetric carbon* farthest from carbonyl group

**α-and ß-anomers**
- Same : molecular formula
- Different : position of OH around anomeric carbon

# Disaccharides

*You don't have to memorize structures

- **Joining of 2 monosaccharides by O-glycosidic bond .**

**Examples :**

C1 of the first glucose

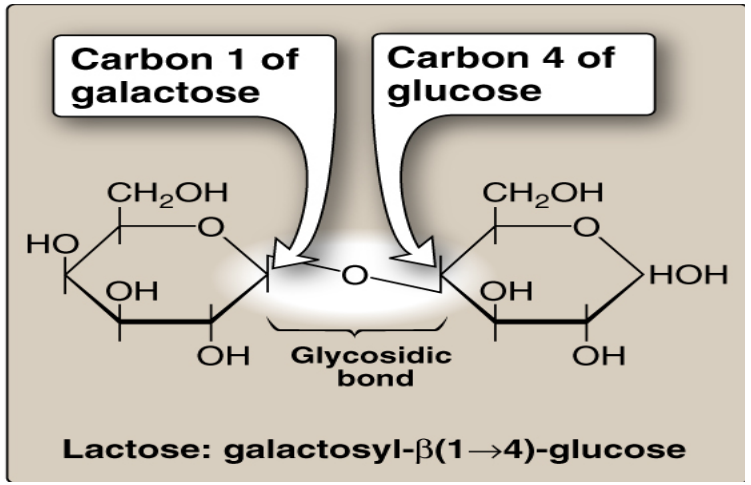
**1-Maltose(α-1, 4)= glucose + glucose**

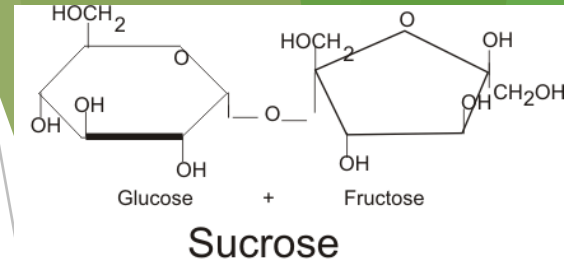
OH toward down

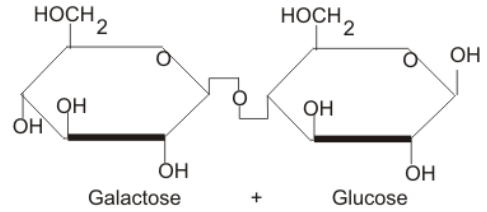
C4 of the second glucose

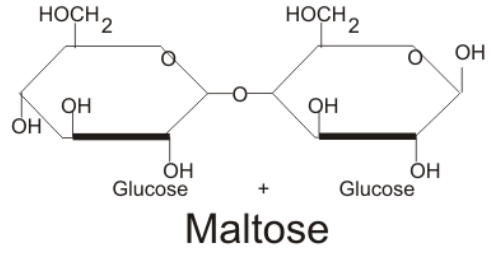
**2- Sucrose (α-1,2)= glucose + fructose**

**3- Lactose (β-1,4)= glucose + galactose**

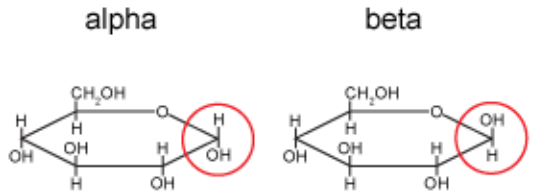


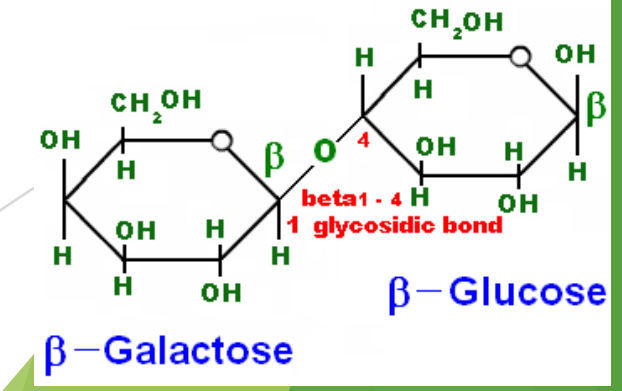



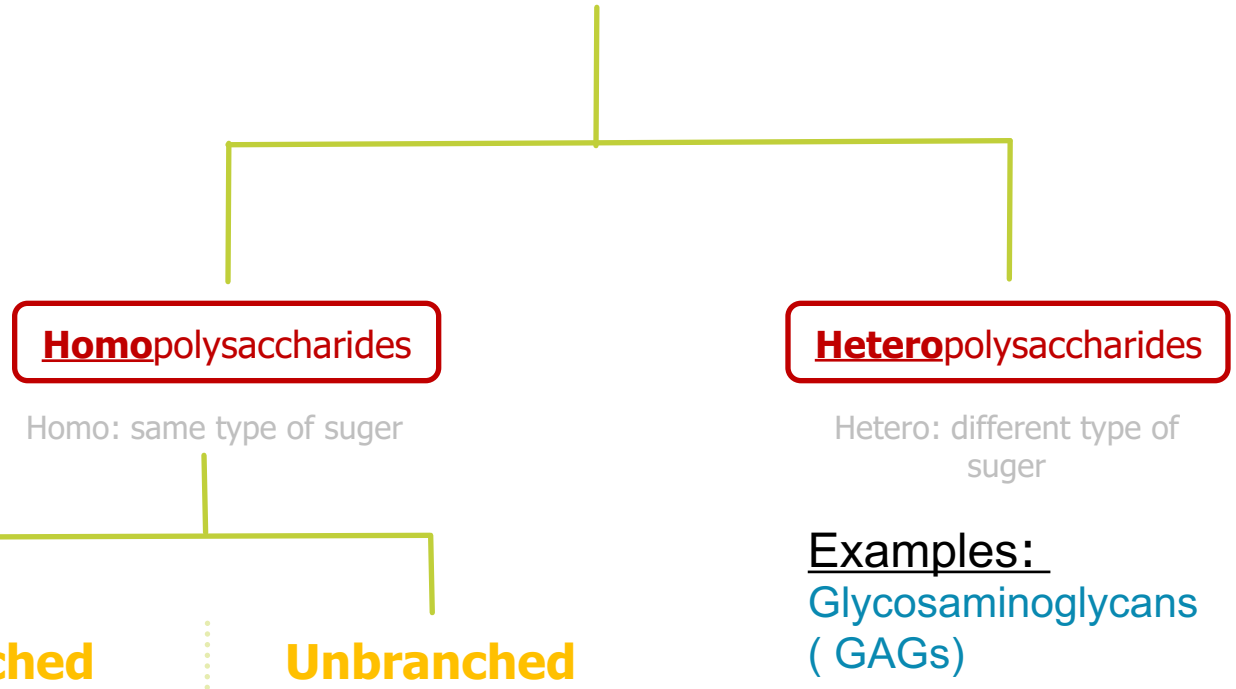




**NOTE**:
α= OH down
B= OH up



# Polysaccharides



# 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
- Reducing sugars reduce chromogenic agents like Benedict's reagent or Fehling's solution to give a colored precipitate
- Urine is tested for the presence of reducing sugars using these colorimetric tests

If the hydroxyl group on the anomeric carbon of a cyclized sugar is not linked to another compound by a glycosidic bond, the ring can open. The sugar can act as a reducing agent, and is termed a reducing sugar. Such sugars can react with chromogenic agents (for example, Benedict's reagent or Fehling's solution) causing the reagent to be reduced and colored, with the aldehyde group of the acyclic sugar becoming oxidized.

***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.

**http://www.youtube.com/watch?v=Kj15mH5zB6Y&t=7m55s**

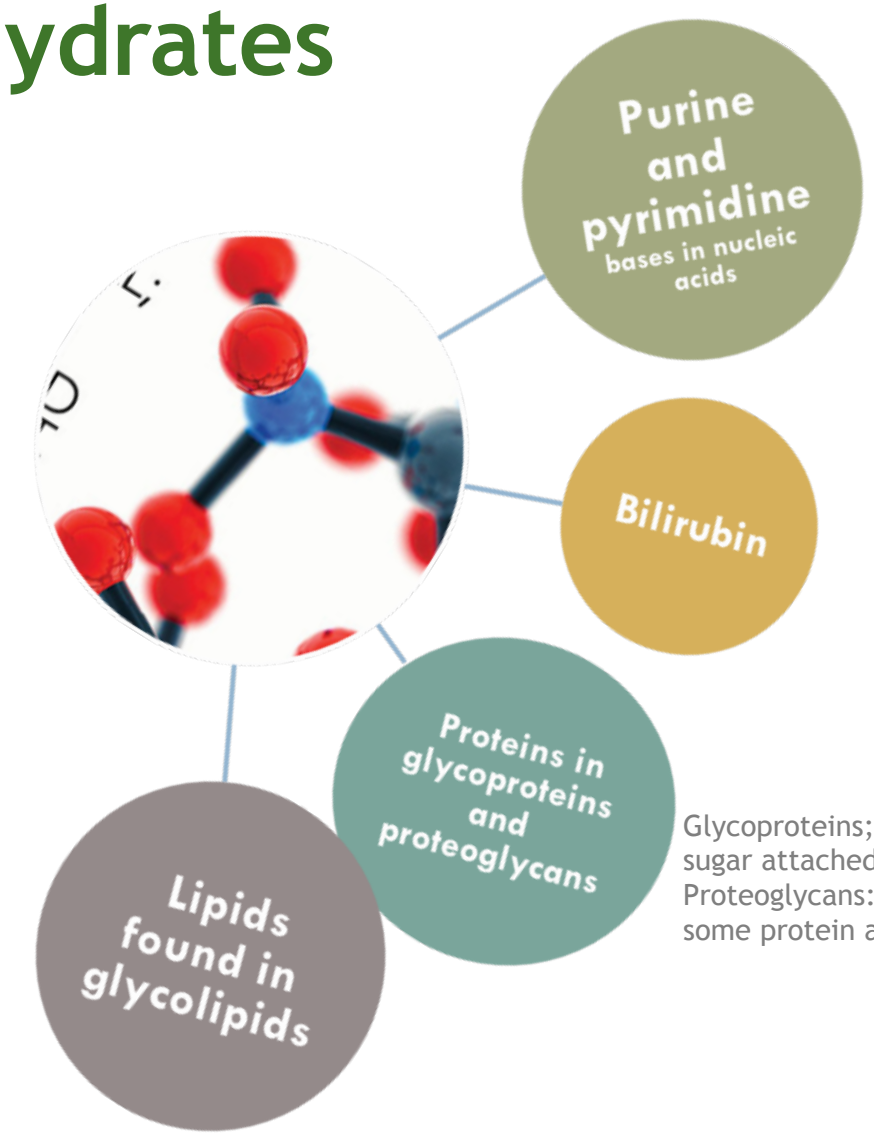
الفيديو جدا رائع يفسر بطريقة جدا مفهومة وبسيطة

Examples

- Monosaccharides
- Maltose
- Lactose

# Complex Carbohydrates

- **Carbohydrates attached to non-carbohydrate structures by glycosidic bonds (O- or N-type).**




Carbohydrates can be attached by glycosidic bonds to non-carbohydrate structures, including purine and pyrimidine bases

Glycoproteins; proteins that have some sugar attached to it.
Proteoglycans:carbohydrate having some protein attached to it.

Glycolipids: lipids that have some sugar attached to it

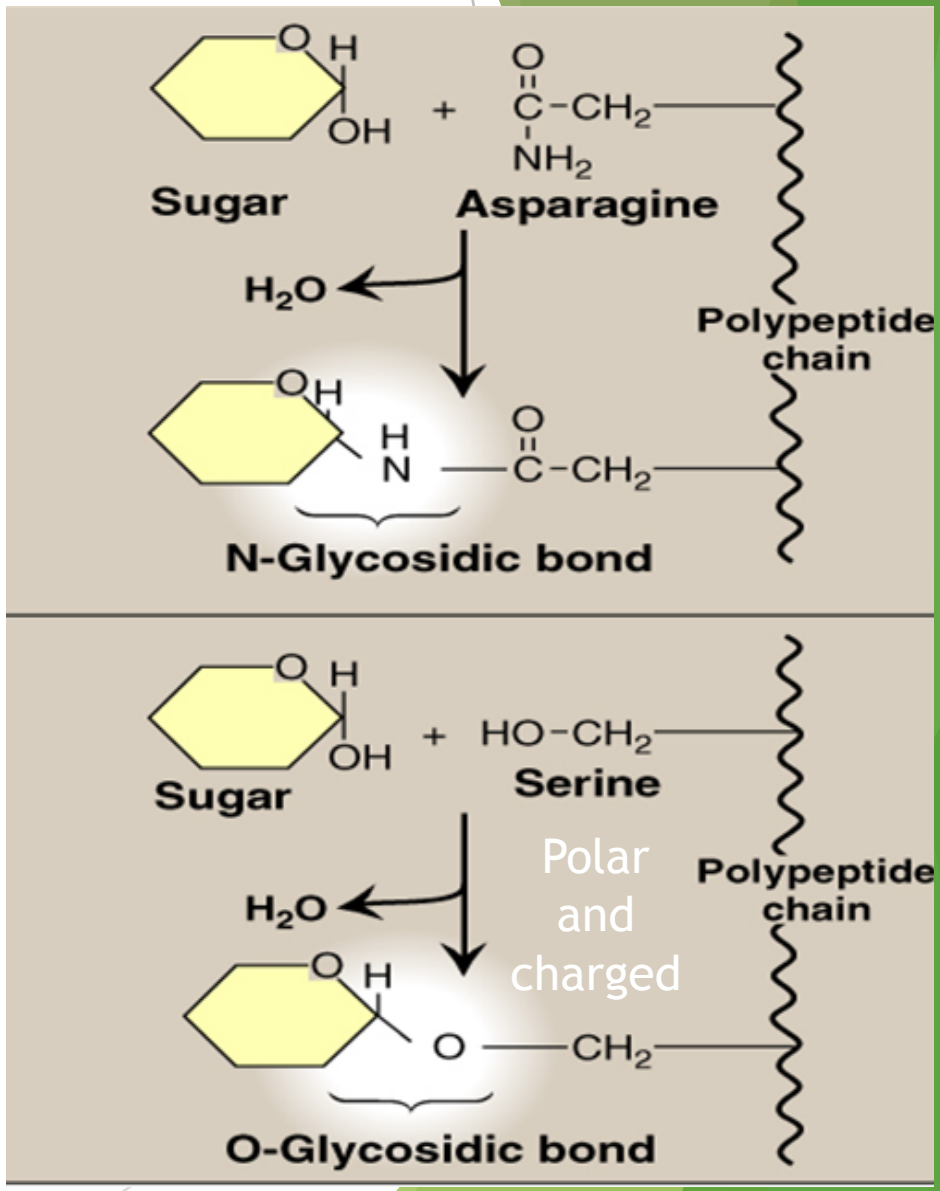
# Glycosidic Bonds

## N-Glycosidic

- If the group on the non-carbohydrate molecule to which the sugar is attached is an –NH2 group, the structure is an N-glycoside and the bond is called an N-glycosidic link.

## O-Glycosidic

- If the group is an –OH, the structure is an O-glycoside, and the bond is an O-glycosidic link



# Glycosaminoglycans

** Polysaccharide → monosaccharide is the unit*
** GAGs → disaccharide is the unit*

## GAGs

- are **linear** polymers not branched
- of repeating **disaccharide** units
- So it is large complex of negatively charged **hetropolysaccharide** chains

Formula
**[acidic sugar-amino sugar]n**

**The amino sugar**

*Usually sulfated*

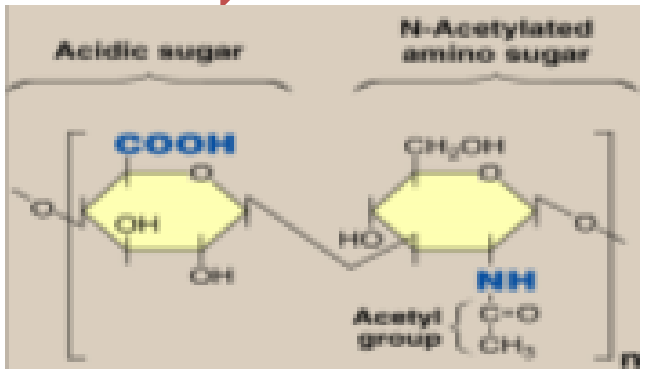
*D-glucosamine*

*D-galactosamine*

**The acidic sugar**

*D-glucuronic acid*

L-iduronic acid




- are associated or bind with

- A **small** amount of **protein**

*forming **proteoglycans** which consist of **over 95** percent **carbohydrate***

- A **large** amounts of **water**

*producing the **gel-like matrix***

*that forms the **extracellular matrix (body's ground substance)***

*Since it's negatively charged it can form bonds with water

**Anticoagulant : prevent blood from clotting**

**can use it when you have investigation**

Example of GAGs

**Chondroitin sulfates**

Most abundant like in bone,cartilage

**Keratan sulfates**

Most hetrogeneous

**Hyaluronic acid**

Compared to other ,it is unsulfated and not covalently attached to protein

**Heparin**

Unlike other GAGs that are exracellular ,heparin is intracellular and serves as an anicoagulant

# Resilience of GAGs

## GAGs

Are large complexes of strongly negatively charged
* Carboxyl group of acidic sugar
* sulfated group

Results of negatively

Resilience of synovial fluid

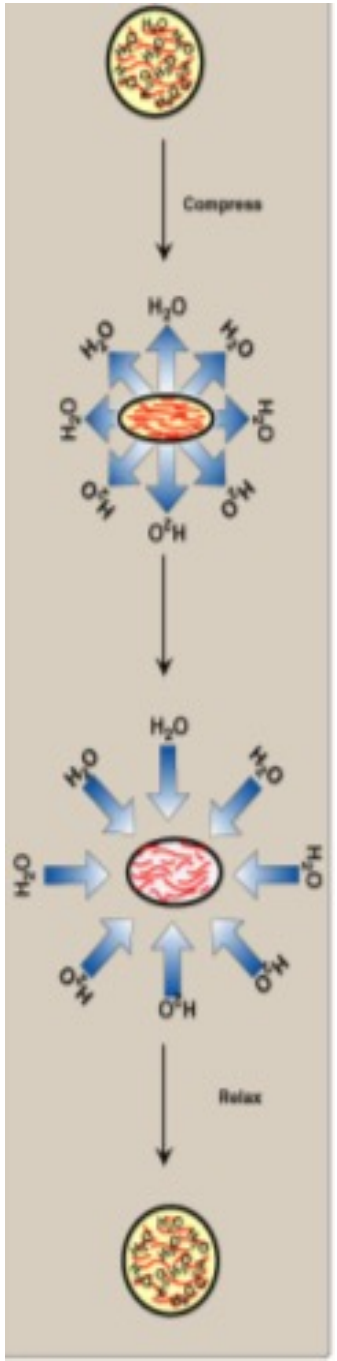
Slippery consistency

GAGs solution

**When it compressed :**
The water is ”squeezed out” then it will be (smaller volume)

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

**When the compressed is relased :**
The GAGs spring back to their original, (hydrate volume) because of the repulsion of their negative charges

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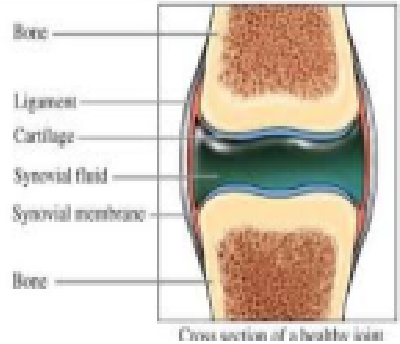


Because of negative charges, the GAGs chains tend to be extended in solution and repel each other and when brought together, they "slip" past each other
This produces the **"slippery" consistency of mucous secretions and synovial fluid**

زي السائل اللزج يكون موجود بالمفاصل عشان يقلل الاحتكاك فيها

-The viscous, lubricating properties of mucous secretions also result from GAGs
-The original naming of these compounds as **mucopolysaccharides**

# Carbohydrates ($CH_2O$)

**Monosaccharides**

Can be classified according to:

- NO.Of C atoms
- Functional gr.

**Aldoses** — **Ketoses**

- Glyceraldehyde ← Trios "3C" → Dihydroxyacetone
- Ribose ← Pentos "5C" → Ribulose
- glucose ← Hexos "6C" → fructose

**Disaccharide**

"2 Mono units"

Bond: O-glycosidic

*Sucrose= glucose+fructose

* Maltose= glucose+glucose

*Lactose= glucose+galactose

**Oligosaccharide**

(3-10) monosaccharide

**Polysaccharide**

(more than 10)

Homopolysaccharide

- **Branched**: *glycogen, *starch
- **Unbranched**: *cellulose

Heteropolysaccharide

**e.g: Glycosaminoglycan (GAG)**

*it has a negative charge

*Linear

*forms Proteoglycan, it has 95% carbohydrates

*forms a Gel-like matrix

*forms viscous and lubricating the mucos (mucopolysaccharide)

*consists of repeated disaccharide units

**Amino sugar (sulfated)**

D-glucosamine

Or D-galactosamine

**Acidic sugar**

D-glucuronic acid

L-iduronic acid

# videos

Naming and classification

Cyclic structure of carbohydrates

# Quiz

## Girls team members:

1- زينة الكاف.
2- جومانا القحطاني.
3- ريم السرجاني.
4- شذا الغيهب.
5- سارة الشمراني.
6- لجين الزيد.
7- روان الوادعي.
8- هيفاء الوعيل.
9- روان القحطاني.
10- لمى الفوزان.
11- بثينة الماجد.

## -Team leaders:

نوره السهلي.
عبدالله المانع.

## -Contact us:

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