Carbohydrates

General characteristics

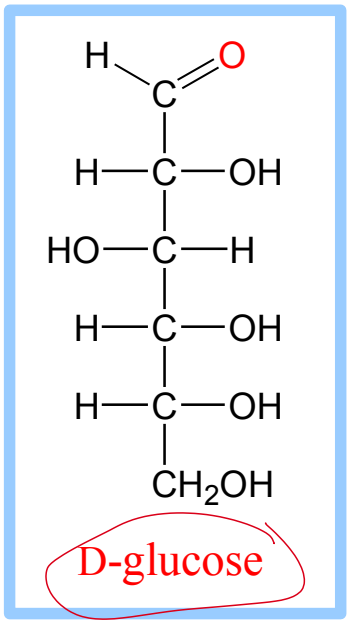
- The term came from the hydrate (H_2O) of carbon (C)
- It has the general formula $(CH_2O)_n$
- The most abundant compounds found in nature
- Used as source of energy and energy storage
- Can be converted into fats and proteins
- Important in the formation of genes, vitamins and drugs
- Participate in biological transport

What are the Classification of carbohydrates?

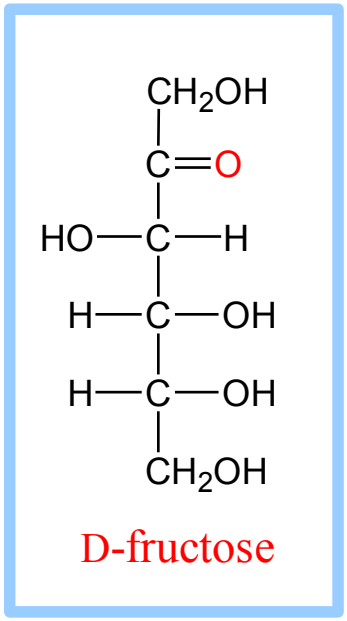
- Monosaccharides: سكريات أحادية
  - Trioses (3C), tetroses (4C), pentoses (5C) and hexoses (6C)
  - Examples: glucose, galactose, mannose, fructose مهم حفظ
- Disaccharides: 2 monosaccharides covalently linked بروابط تساهمية ثنائية (e.g. Sucrose, maltose, lactose)
- Oligosaccharides: من 3C الى 10C
  - Tri, tetra, penta up to 9 or 10 units covalently linked
- Polysaccharides متعددة or glycans باسم ثاني
  - Simple polysaccharides (starch, glycogen, amylopectin)
  - Complex carbohydrates (nucleic acid, glycoproteins, glycolipids, ...etc)

Monosaccharides

- Either aldose or ketose



D-glucose



D-fructose

Glycosidic bond

هي الرابطة التي تربط السكريات ببعض

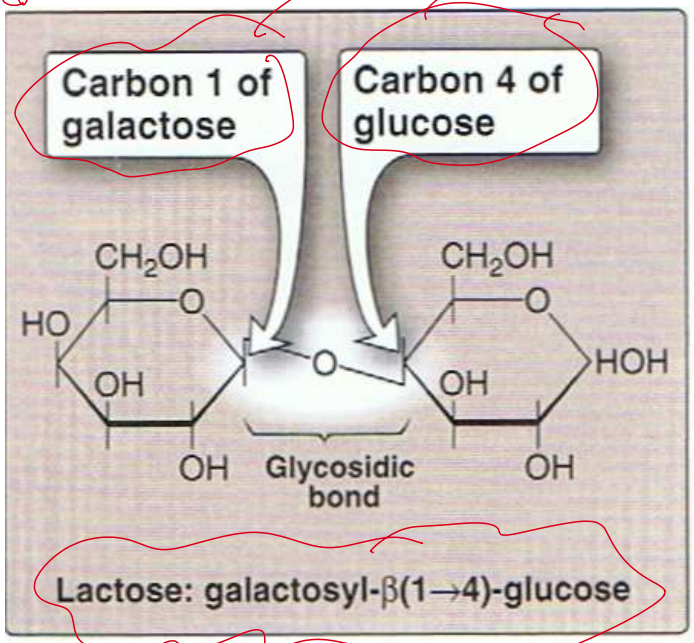
بس على الثنائية والمتعددة

- For di- and polysaccharides

- Can form O- or N-glycosidic bond

حسب مكان الارتباط

- O-glycosidic bond
- N-glycosidic bond

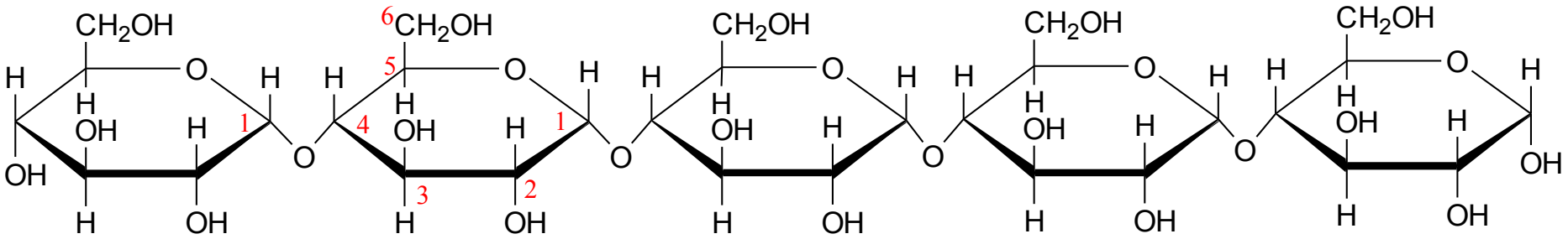


Disaccharides

- **Maltose**: is a disaccharide with an $\alpha(1 \rightarrow 4)$ glycosidic link between C1 - C4 OH of 2 glucoses.
- **Cellobiose**: is the otherwise equivalent β anomer (O on C1 points up) linked by $\beta(1 \rightarrow 4)$ glycosidic linkage
- **Sucrose**, common table sugar, has a glycosidic bond linking the anomeric hydroxyls of glucose & fructose. the linkage is $\alpha(1 \rightarrow 2)$
- **Lactose**, milk sugar, is composed of galactose & glucose, with $\beta(1 \rightarrow 4)$ linkage from the anomeric OH of galactose.

Polysaccharides

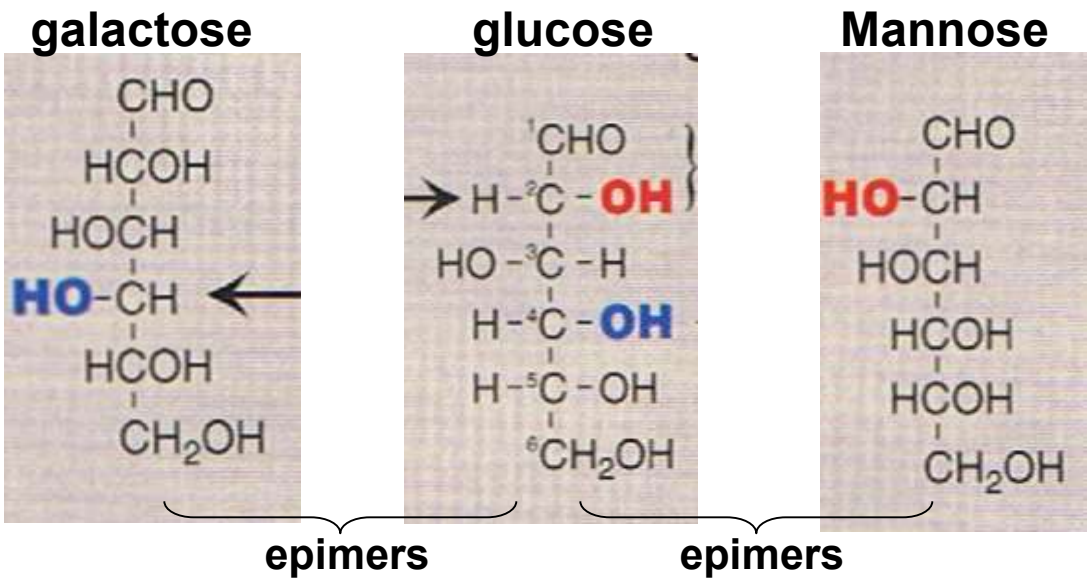
- **Plants** store glucose as **amylose** or **amylopectin**, glucose polymers collectively called starch.
- Glucose storage in **polymeric** form **minimizes osmotic effects**.
- **Amylose** is a glucose polymer with **α(1→4)** linkages.
- The end of the polysaccharide with an anomeric C1 not involved in a glycosidic bond is called the **reducing end**.

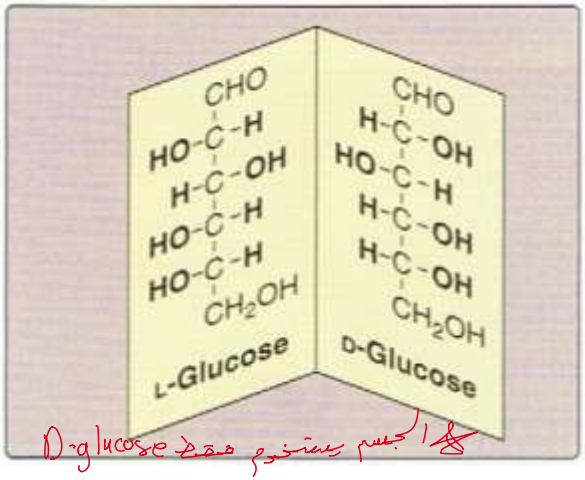


amylose

Sugar isomers

- Compounds with the same chemical formula are called isomers.
- **Epimers**: If two monosaccharide isomers differ in configuration around one specific carbon atom (with the exception of the carbonyl carbon), they are defined as epimers of each other.
- If a pair of sugars are mirror images of each other (enantiomers), the two members of the pair are designated as D- and L-sugars.



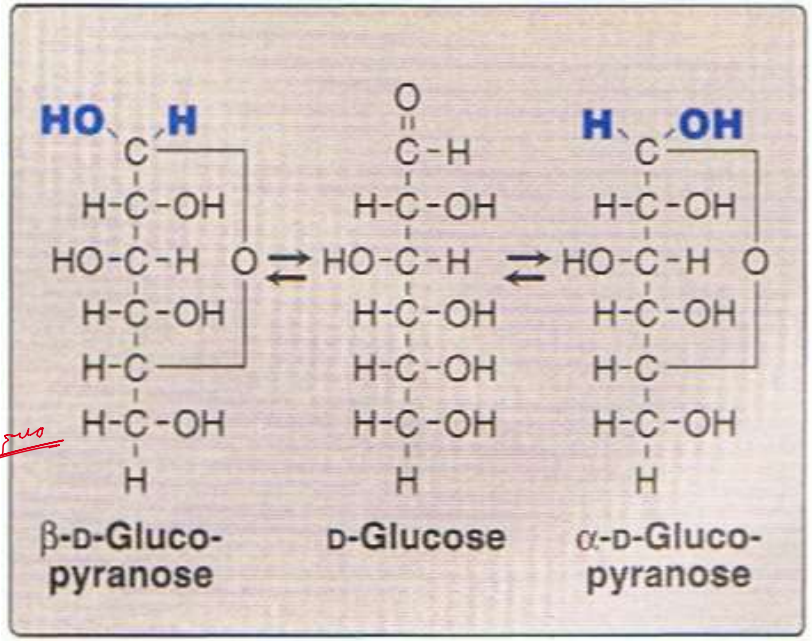


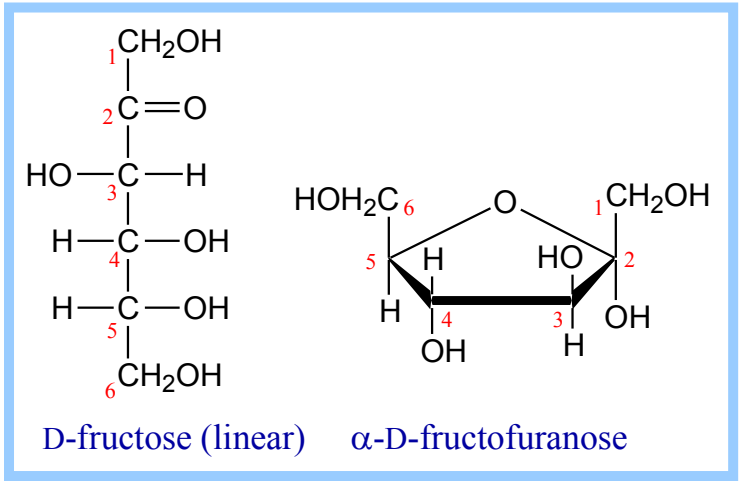
α and β sugars

- When a sugar cyclizes, an anomeric carbon is created from the aldehyde group of an aldose or keto group of a ketose.

- Glucose forms an intra-molecular hemiacetal, as the C1 aldehyde & C5 OH react, to form a 6-member pyranose ring, named after pyran

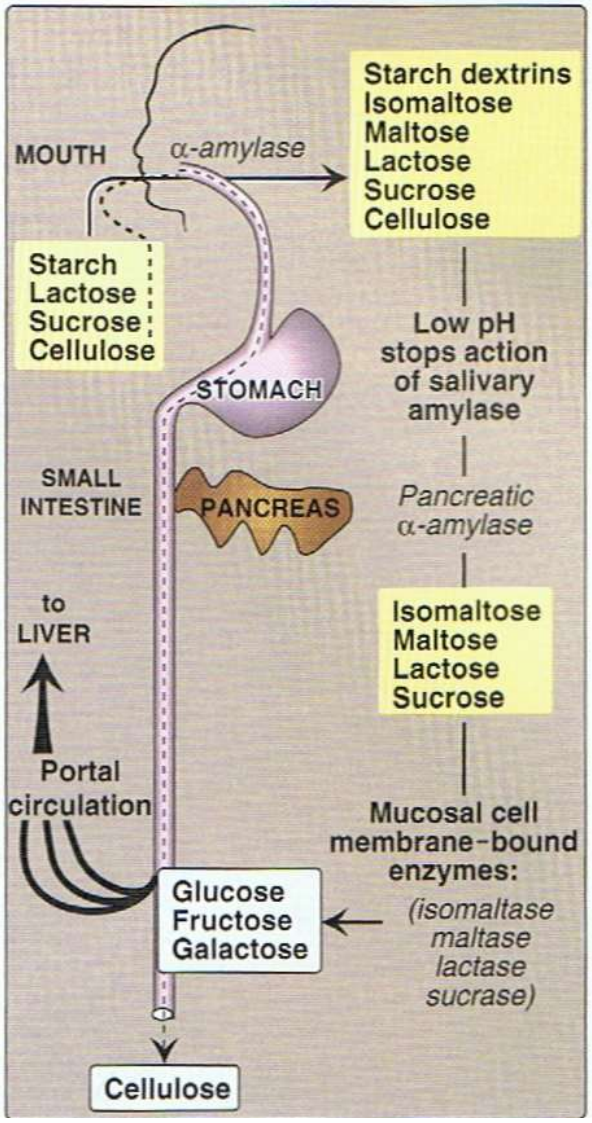
- This carbon can have two configuation, α or β. If the oxygen on the anomeric carbon is not attached to any other structure, that sugar is a reducing sugar
  - α (OH below the ring)
  - β (OH above the ring).





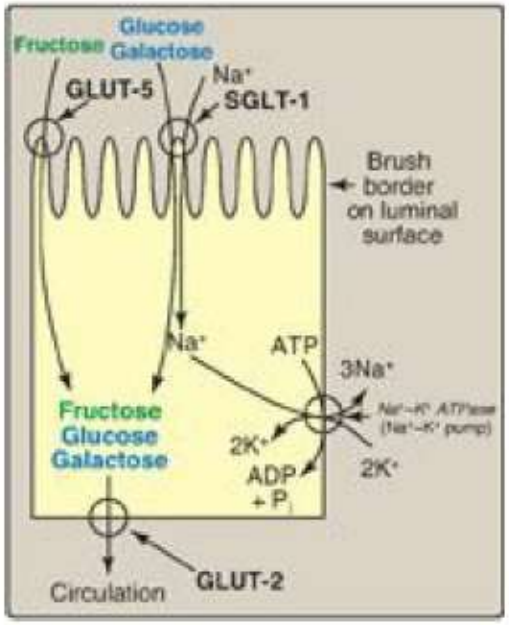
Digestion of carbohydrates

- Digestion of carbohydrates begins in the mouth by salivary α-amylase enzyme which breaks α-1,4 glycosidic bond
- The digestion stops in the stomach because the amylase is inactivated by the high acidity
- further digestion of carbohydrates by pancreatic enzymes occurs in the small intestine by pancreatic amylase



Absorption of monosaccharides

- The duodenum and upper jejunum absorb the bulk of the sugars.
- Insulin is not required for the uptake of glucose by intestinal cells.
- galactose and glucose are transported to the mucosal cells by an active, energy-requiring process that involves a specific transport protein and requires a concurrent uptake of sodium ions.
- Fructose uptake requires a sodium-independent monosaccharide transporter (GLUT-5) for its absorption



Abnormal degradation of disaccharides

- Because predominantly monosaccharides are absorbed, any defect in a specific disaccharidase activity of the intestinal mucosa causes the passage of undigested carbohydrates into the large intestine.

(osmotic diarrhea) إسهال ← تسحب ماء ← تروح للقولون ← إذا ما إنهضمت ..

- As a consequence of the presence of this osmotically active material, water is drawn from the mucosa into the large intestine, causing osmotic diarrhea.

- This is reinforced by the bacterial fermentation of the remaining carbohydrate to two- and three-carbon compounds (which are also osmotically active) producing large volumes of CO_2 and H_2 gas, causing abdominal cramps, diarrhea, and flatulence,

البكتيريا تخمرها ينتج ← H_2 / CO_2 ← ويسبب غازات وتشنجات

(Diseases)

Abnormal degradation of disaccharides

1. Digestive enzyme deficiency

2. Lactose intolerance: lactase deficiency

حساسية من اللاكتوز

3. Isomaltase-sucrase deficiency: defect in sucrose degradation (10% of eskimos)

مشكلة في sucrose

- Measurement of hydrogen gas in the breath is a reliable test for determining the amount of ingested carbohydrate not absorbed by the body

Breath hydrogen test التشخيص و

هذا: اطلع H_2 كلي ⇐ في سوء إمتصاص