Carbohydrates

General characteristics

الخصائص العامة

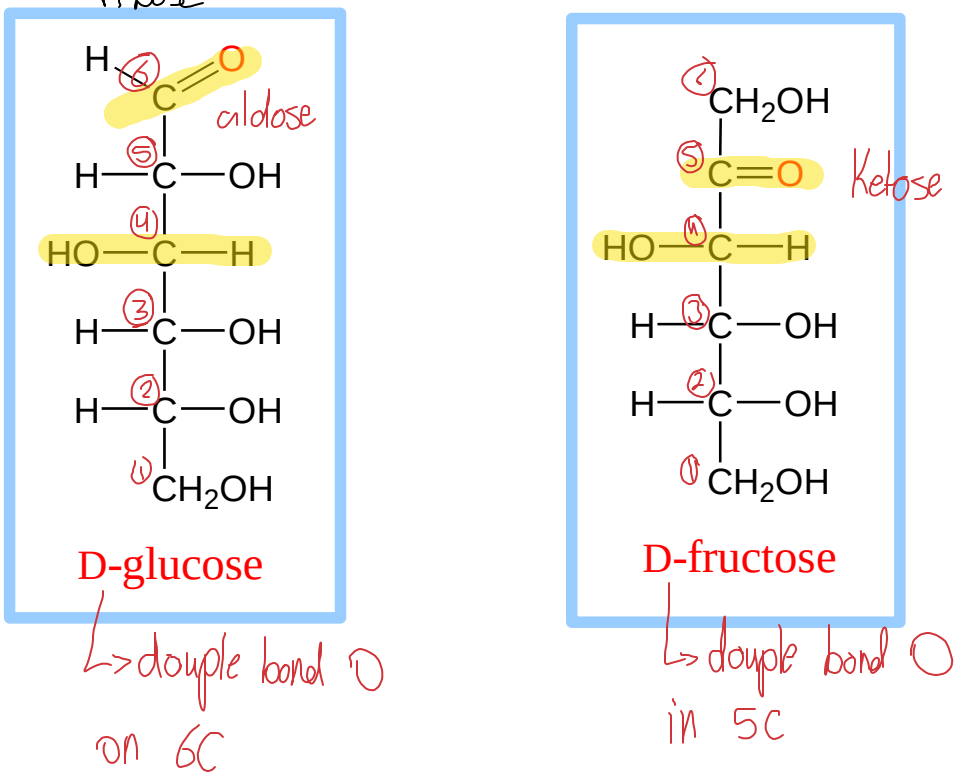
- The term came from the hydrate (H_2O) of carbon (C) → $CH_2O \rightarrow C + H_2O$
- It has the general formula $(CH_2O)_n$
- The most abundant compounds found in nature
  - أكثر وفرة ← سيليلوز في النبات
- Used as source of energy and energy storage
  - main sources is glucose (rbcs, brain)
  - as starch
- Can be converted into fats and proteins
  - from glucose
  - alanin ⇌ glucose
- Important in the formation of genes, vitamins and drugs
  - ريبوز
- Participate in biological transport
  - protein as channel [glycoprotein]
  - يشارك في النقل الحيوي
  - نقل الجلوكوز من الدم إلى خلايا الجسم لتوفير الطاقة

Classification of carbohydrates

- **Monosaccharides:**
  - Trioses, tetroses, pentoses and hexoses
  - Examples: glucose, galactose, mannose, fructose
- **Disaccharides:** 2 monosaccharides covalently linked (e.g. Sucrose, maltose, lactose)
- **Oligosaccharides:**
  - Tri, tetra, penta up to 9 or 10 units covalently linked
- **Polysaccharides or glycans**
  - Simple polysaccharides (starch, glycogen, amylopectin)
  - Complex carbohydrates (nucleic acid, glycoproteins, glycolipids, ...etc)

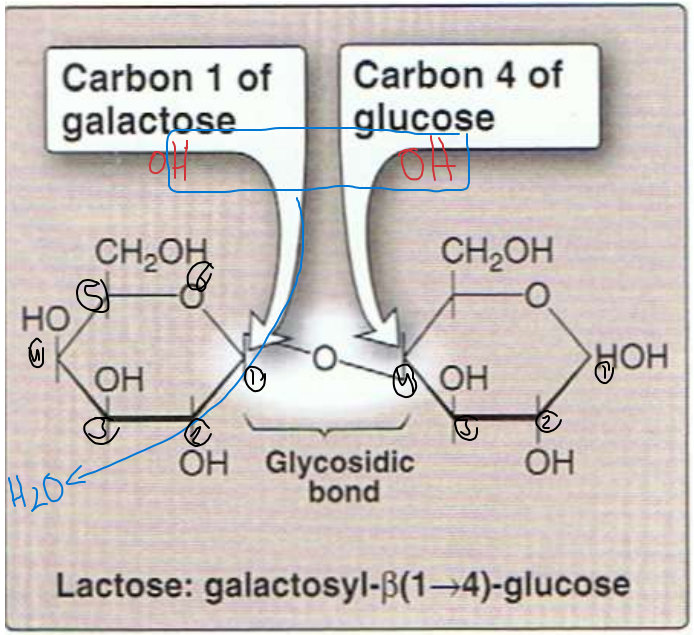
Monosaccharides

- Either aldose or ketose



Glycosidic bond

- For di- and polysaccharides
  - → between N and sugar (nucleic acid)
- Can form O- or N-glycosidic bond
  - ↳ present (OH)
  - ↳ present (N)
  - → between OH and sugar (maltose or sucrose)



β → إلى الأعلى
α → إلى الأسفل

Disaccharides → two monosaccharide

→ hydrolases for starch

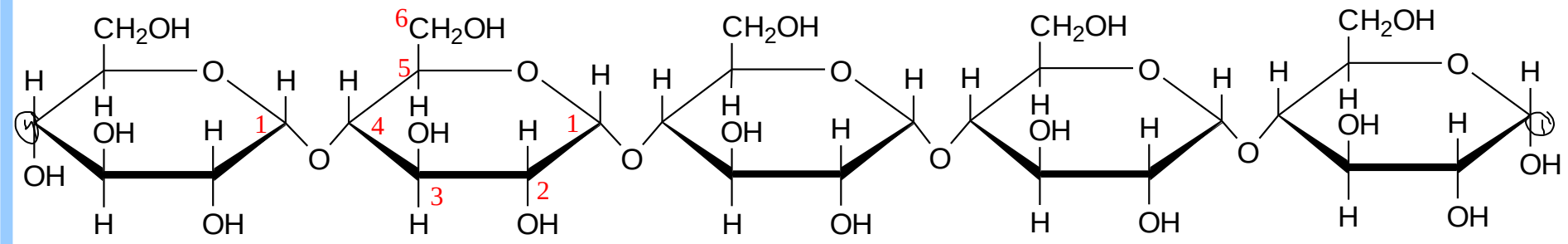
- **Maltose**: is a disaccharide with an α(1 → 4) glycosidic link between C1 - C4 OH of 2 glucoses.
  ↳ OH in 1C indicate to bellow
  → two glucose
- **Cellobiose**: is the otherwise equivalent β anomer (O on C1 points up) linked by β(1→ 4) glycosidic linkage
  ↳ OH in 1C indicate to above
- **Sucrose**, common table sugar, has a glycosidic bond linking the anomeric hydroxyls of glucose & fructose. the linkage is α(1→2)
  → No reducing ability between other sugar
- **Lactose**, milk sugar, is composed of galactose & glucose, with β(1→4) linkage from the anomeric OH of galactose.
  ↳ OH in 1C of glactose to bellow

C1 in monosacharide ability to reduces in aldehyde
C2 in monosacharide reducing ability in Ketone

Polysaccharides

→ more than two monosaccharide

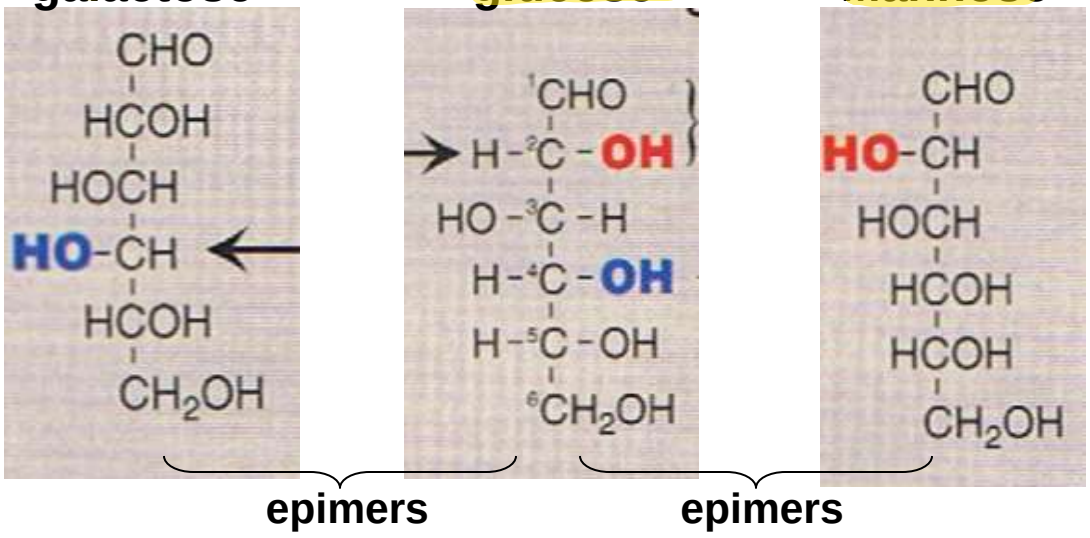
- **Plants** store glucose as **amylose** or **amylopectin**, glucose polymers collectively called starch.
  → is starch
- Glucose storage in **polymeric** form **minimizes osmotic effects**.
  تشكل الجلوكوز على شكل بوليمر يمنع التفاح وانفجار الخلايا نتيجة الضغط الأسموزي
- **Amylose** is a glucose polymer 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**.

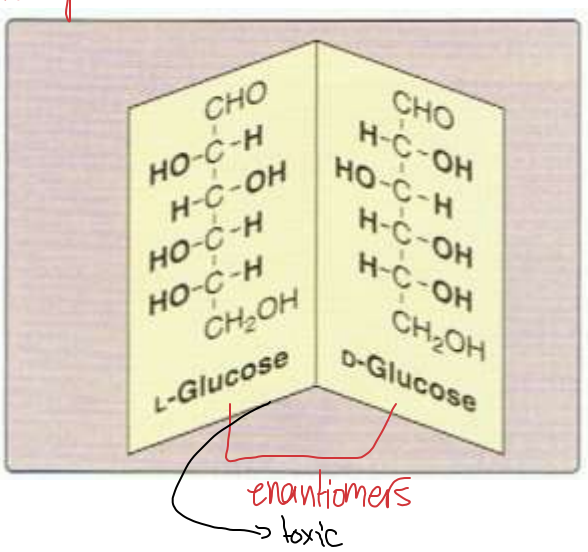


amylose

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.



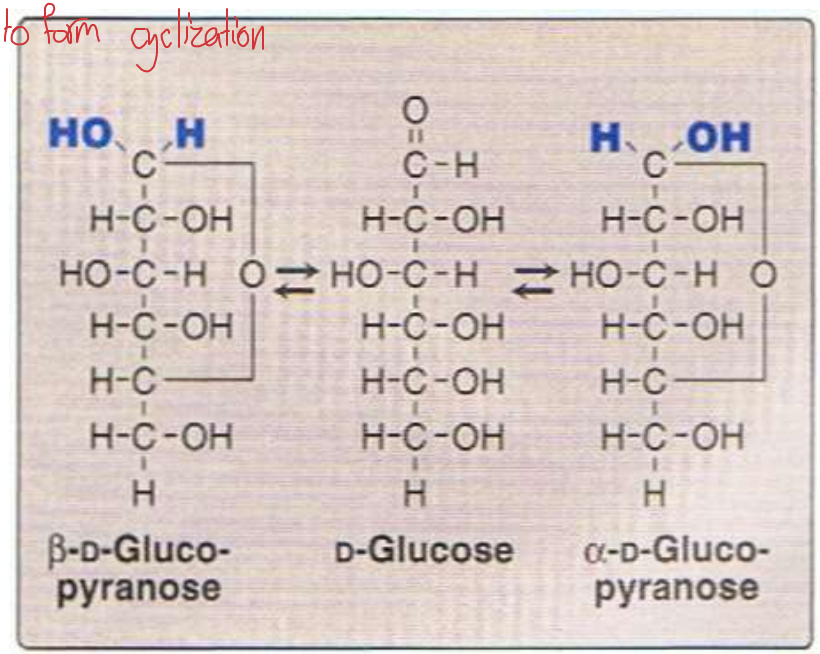


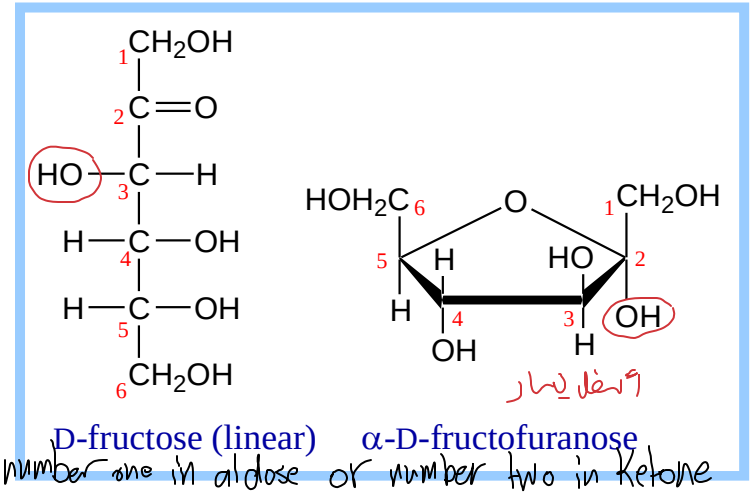
α and β sugars

interaction 1C with OH in 5C to form cyclization

- When a sugar cyclizes, an anomeric carbon is created from the aldehyde group of an aldose or keto group of a ketose.
  - anomeric carbon is 1C (glucose)
  - anomeric carbon is carbon (2)
- Glucose forms an intra-molecular hemiacetal, as the C1 aldehyde & C5 OH react, to form a 6-member pyranose ring, named after pyran
  - result on interaction carbon 1 with OH in carbon 5
- 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 → capable for interaction with another compound.
  - α (OH below the ring)
  - β (OH above the ring).

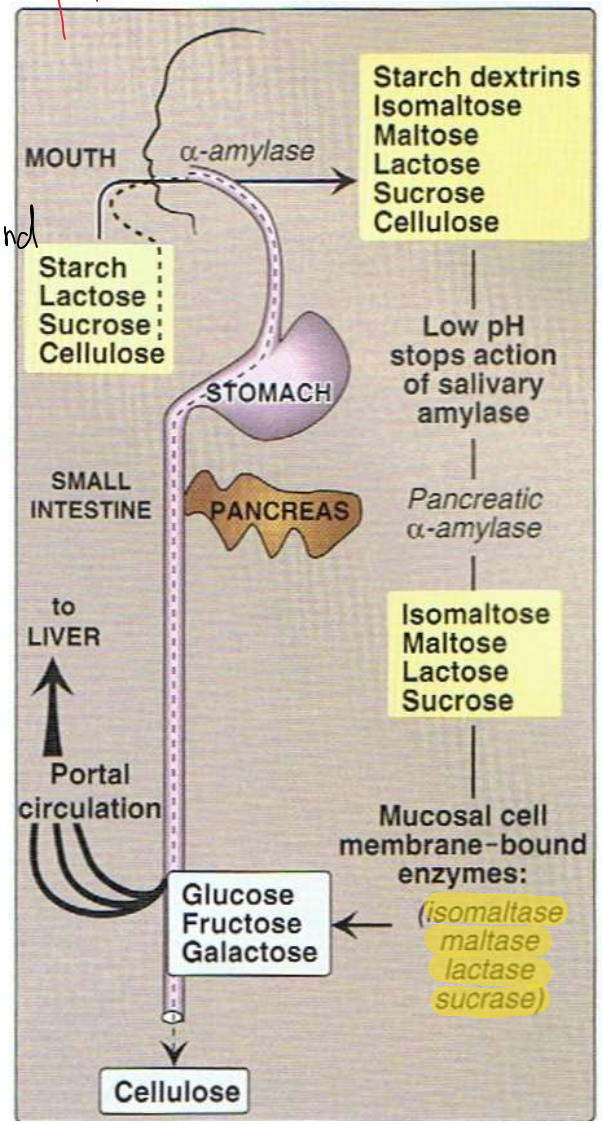
in anomeric carbon → carbon number one in aldose or number two in ketone





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

امتصاص السكريات الأحادية

- The duodenum and upper jejunum absorb the bulk of the sugars.

للجزء الأكبر

- Insulin is not required for the uptake of glucose by intestinal cells.

لا الدخول بعملية الامتصاص

glactose and glucose depend on ATP and Na^+ but fructose isn't depend on ATP and Na^+ (GLUT-5) spicific transporter

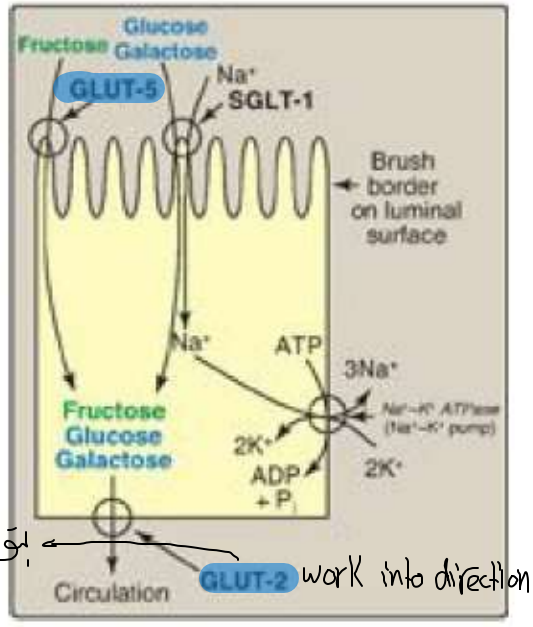
- galactose and glucose are transported to the mucosal cells by an active, energy-requiring process that involves a specific transport protein and requires a concurrent uptake of sodium ions.

في الأمعاء الدقيقة

لا امتصاص متزامن

- Fructose uptake requires a sodium-independent monosaccharide transporter (GLUT-5) for its absorption

ناقل غير معتمد على الصوديوم عكس الأعلى



يؤدي للدم ويرجع لمعان الأمعاء الدقيقة

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

Abnormal degradation of disaccharides

نقص الإنزيمات الهضمية

- Digestive enzyme deficiency

- Lactose intolerance: lactase deficiency

لعدم تحمل اللاكتوز

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

انزيمان في الجهاز الهضمي — يعانون من صعوبة هضم السكروز

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

اختبار موثوق