



Carbohydrates



Dr. Nesrin Mwafi

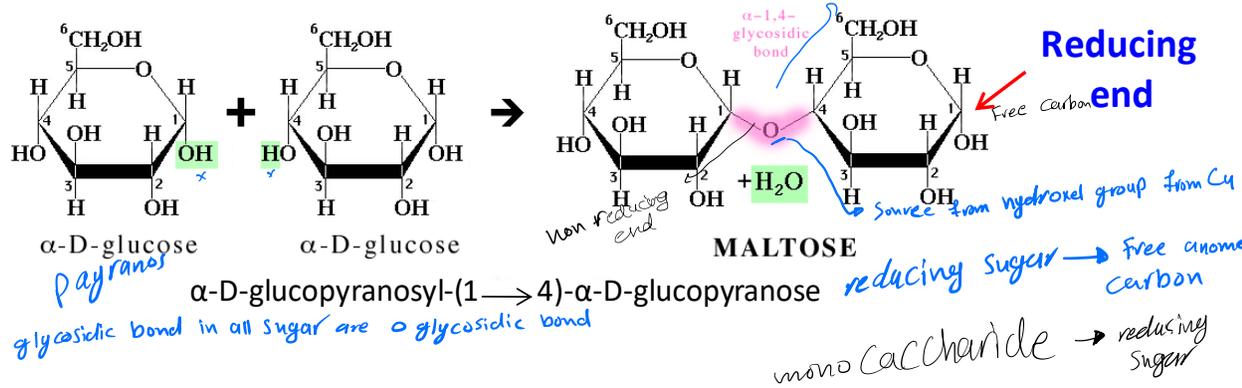
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Disaccharides

These are two monosaccharides linked together via the glycosidic bond. Three common disaccharides:

- Maltose** "malt sugar" consists of two α -glucose units, is a disaccharide released during the hydrolysis of the starch



Barely grains is used for preparation of malt beverage. During the degradation of starch, maltose sugar is produced.

starch \rightarrow maltose
 starch \rightarrow maltose
 Barily grains \rightarrow maltose



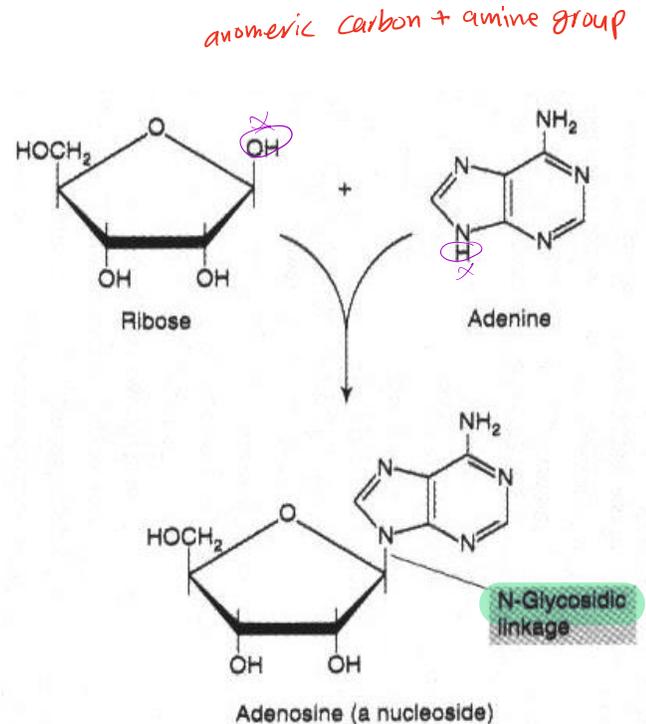
Glycosidic bond



- Glycosidic bond is a type of covalent bond where the anomeric group of a sugar can condense with an alcohol. This type of bond is called O-glycosidic bond.

- N-glycosidic bond is another type of glycosidic bond which forms between the anomeric carbon of sugar and an amine.

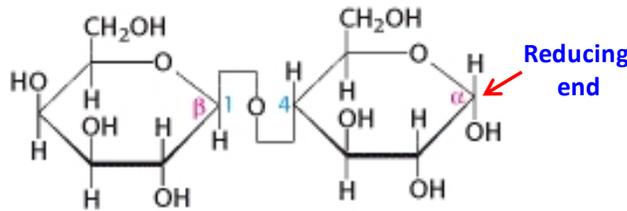
e.g. the bonds that link D-ribose and D-deoxyribose to purines and pyrimidines in the nucleic acids: RNA & DNA, respectively.





Disaccharides

- **Lactose** "milk sugar" consists of glucose & galactose, is a disaccharide occurs naturally in the milk (**dairy products**)



α -Lactose
 β -D-Galactopyranosyl-(1 \rightarrow 4)- α -D-glucopyranose

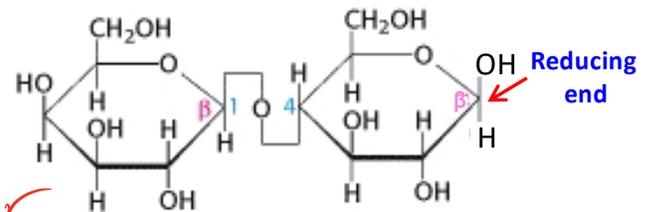
β دالة \leftarrow

α صفة \leftarrow

lactose \rightarrow reducing sugar

galactose \rightarrow دالة β pyranose
ديهي بالاول

glucose \rightarrow صفة α دالة β
ديهي الثاني
pyranose



β -Lactose
 β -D-Galactopyranosyl-(1 \rightarrow 4)- β -D-glucopyranose

دالة β



Disaccharides

- **Lactose Intolerance:** ^{حساسية هضمية} deficiency of lactase enzyme leading to **Gastrointestinal tract (GIT) disturbances** ^{اضطرابات} such as: **nausea**, ^{قيء} **bloating**, ^{انتفاخ} **abdominal cramps** and **diarrhea** ^{اسهال} due to digestion of lactose **(intact)** by bacteria found in colon



نقص في الإنزيم الذي يحلل اللاكتوز ويحول
 فالحمض الناتجة فيدهل القولون زي ما هو ديكتريا يتكفله ريسيب
 ضاى الدمراجه



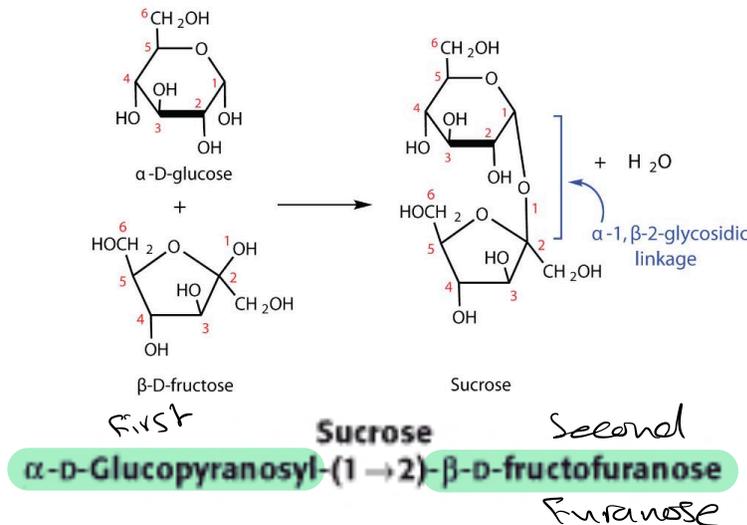
خيار رائى بيلس نادر
 لا كتر تشار عند كبر السن
 دلاضمان
 lactose free
 ممكن انه تكون مؤانحة بسبب
 التهاب امعاء بعد كعاجة برفع
 طبيعى





Disaccharides

- **Sucrose** “table sugar” consists of **glucose & fructose**, is a disaccharide obtained commercially from **cane or beet**.



Sucrose \rightarrow *di disaccharide*
non reducing
sugar
Free anomeric carbons

- Sucrose is not a reducing sugar because the anomeric carbon of the second residue (the reducing end) is not free but involved in the glycosidic bond formation.

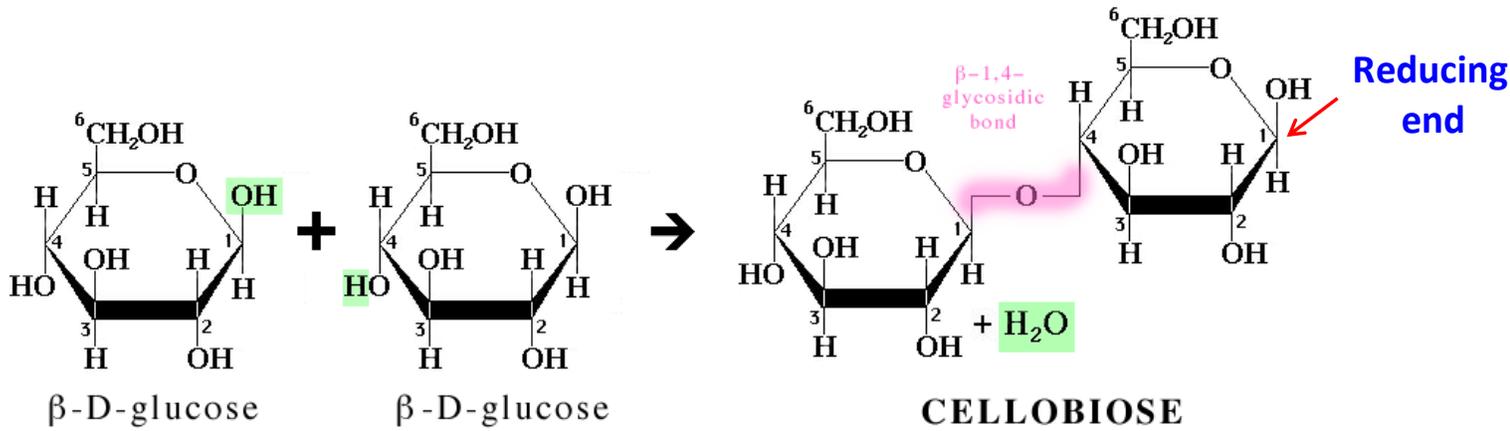


Disaccharides

Common
maltose
مaltose
مaltose
مaltose

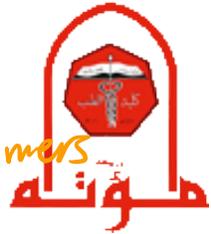
isomer of maltose

- **Cellobiose** consists of two D-glucose residues linked by the β -glycosidic bond (C1 of one residue is joined to the oxygen atom attached at C4 of the second residue). It is released during cellulose degradation



β -D-Glucopyranosyl-(1 \rightarrow 4)- β -D-glucopyranose

- Cellobiose is an isomer of maltose (stereochemistry of the glycosidic bond which is β in cellobiose and α in maltose)



Polysaccharides *Polymers of repeated monomers*

تسمى الاسم

Polysaccharides “glycans” are polymeric molecules consist of long chains of monosaccharide units bound together via the glycosidic linkages.

repeated unit

Polysaccharides composed of same type of monosaccharides are called **homopolysaccharides** “homoglycans” and those consisting of more than one type are called **heteropolysaccharides** “heteroglycans” .

*monomers
الذي يكونونهم
نفسه التي يتكرر*

*monomers
التي يتكرر*

They form branched as well as linear polymers.

*قلبي
نزي اشعم: الهماقزائل*

سلسلة مستقيمة

They are classified into:

*Function
صوب*

*تخزن السكر الزائد في الكبد وبشكل
عشاء نشوي
تخزين الطاقة*

1. Storage polysaccharides like starch and glycogen
2. Structural polysaccharides like cellulose and chitin

وطبقها لدم والقوة بالصلابة للكبد

يتكرر موجودة بالجدار الخلوي وموجودة بالخشب

*له صاي للخصبات
(الهياكل) فخر صبة تبعد
المسرة*



Storage Polysaccharides

خزن الطاقة بالسكريات البسيطة

السكر البسيط
سكر starch
ويتصل من خلال
Monomers
وهذا الذي يتم خزنه
في الخلية
بشكل
Polysaccharide

Starch: is the storage polysaccharides in plants.

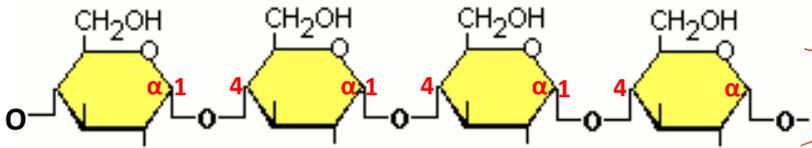
Polymer composed of glucose monomers

الجزيء المتفرع branch

a mixture of **amylose** (20%, water soluble) and **amylopectin** (80%, water insoluble) stored in plant cells as insoluble granules.

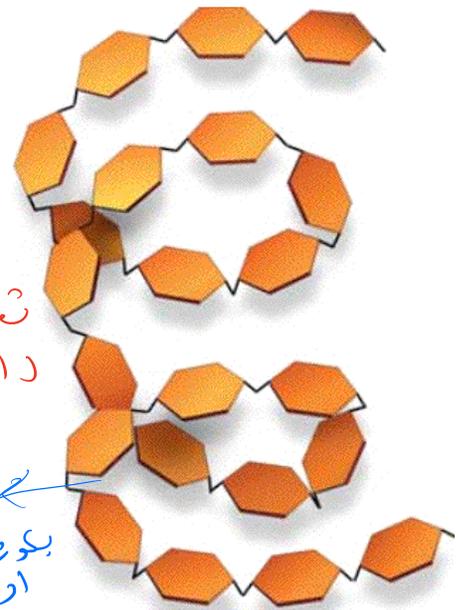
بشكل
سلسلة
من
سكرات
Starch

unbranched starch(linear)



شكلها
داخليا حلزوني

Amylose : α (1 \rightarrow 4) glycosidic bonds



بشكل حلزوني
او اجوي
بكونه حلزوني ومن جوامعها

The helical structure of amylose

يحيى جوي من الواجهه \rightarrow hollow helix

Digestion of starch



التوزيع

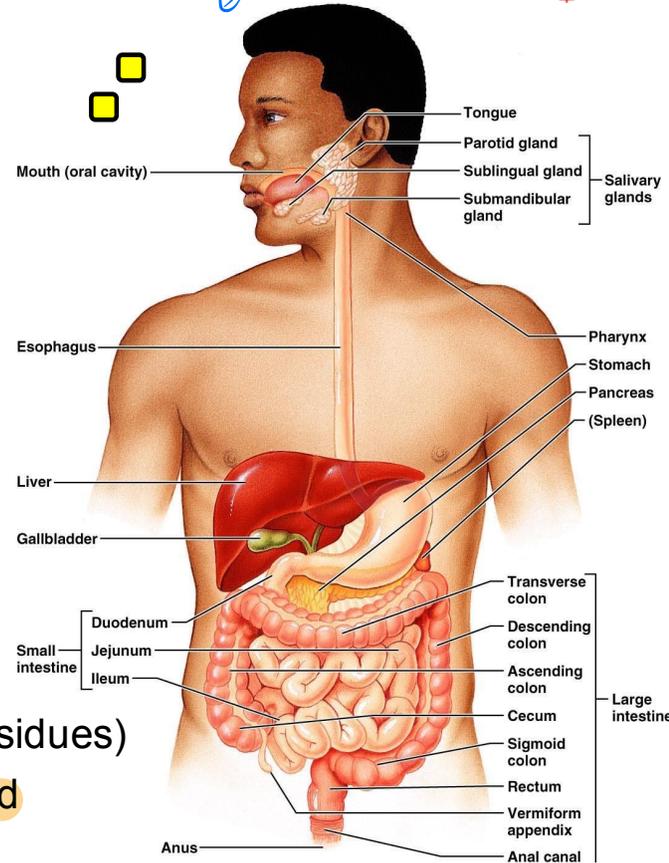
1. The salivary amylase enzyme randomly hydrolyses the α -(1 \rightarrow 4) bonds

للعبارة الطبيعية عضو البروتياز
 له وجود بالعبارة (oligosaccharide) smaller oligosaccharide
 إذا سارت في اتجاهها وهذا المثلث من السكر الزائد والسكر
 في هذه الكربون (1) في sugar
 من -- mono - (2) من

2. Starch digestion to small oligosaccharides continues in the small intestine by pancreatic amylase

3. Further hydrolysis by α -glucosidase (which remove one glucose residue at time) and by a debranching enzyme (which hydrolyzes specifically α -[1 \rightarrow 6] bond

4. The produced monosaccharides (glucose residues) are absorbed by the intestine and transported to the bloodstream





Storage Polysaccharides

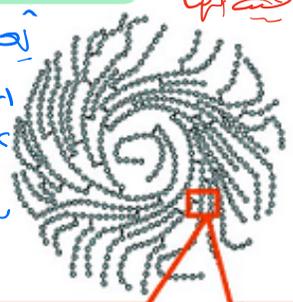
energy stores in human and animal
 بنحوه على شكل غلايكوجين

Glycogen: is the storage polysaccharide in animal & human

- Polymer composed of glucose units like amylopectin but glycogen is more highly branched with branch points occurring every 8-14 residues *α-D glucose repeated unit joined by O-glycosidic bond*
 ↳ متفرع بنحوه starch بنحوه branch أكثر
- Mainly found in skeletal muscle (up to 1-2% of muscle mass) and liver cells (up to 10% of liver mass)

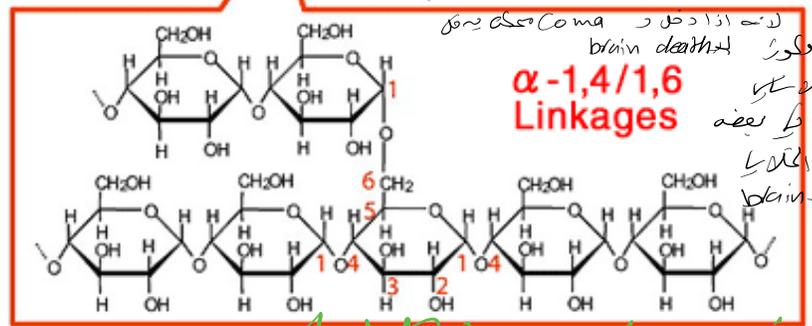
المخزن الرئيسي للـ glycogen
 أكثر من 50% على شكل جلوكوز
 المخزن في خلايا الكبد
 بنحوه glycogen كما المخزن

أيضا أدلة الخلايا
 1- خلايا وظيفتها تخزين الجلوكوجين
 كخزينة (المخزن) إذا لها شو العنصر
 2- خلايا تستقبل مصدر الطاقة
 ما كان يكوه
 3- خلايا تعتمد بشكل رئيسي على الجلوكوز
 مثل (الـ brain cells)



وحى خلايا اخرى يتفرع الجلوكوجين لها
 وحى البنوع والتمني من انكلابا هي انكلابا
 التي يستقبل مصدر الطاقة عند تحركها
 وتصلح الطاقة على تحركها
 20 ~ 50nm
 وحى خلايا مثل الـ brain cells ما يستغنى اذ
 على الجلوكوز ليعمل مرجه السكرى (الـ insulin)
 السكرية ما يات بصرفه Coma
 ●: Glucose

الرابطة الـ (1-4) linear
 الـ (1-6) branch
 رجه المتفرع الـ (1-4)

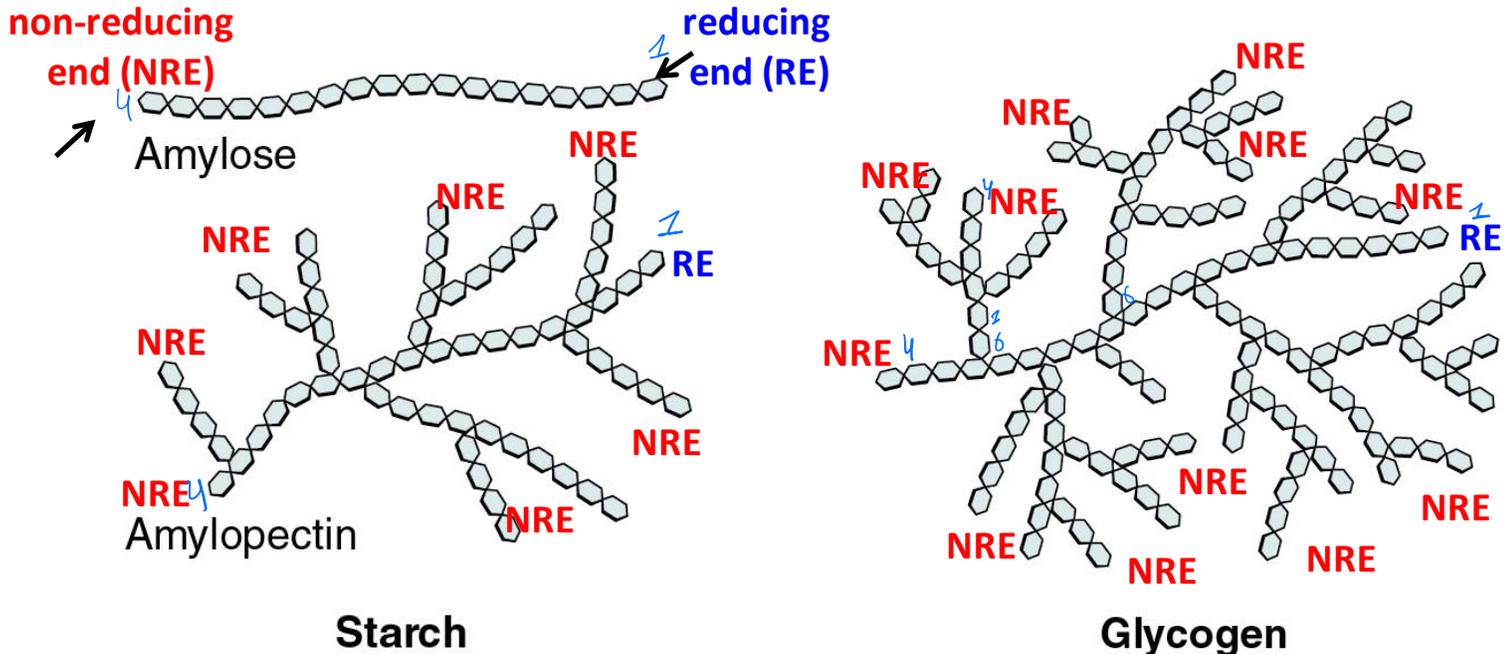


لانه اذا دخل الـ Coma صكة بنوع
 brain death
 وحى الجلوكوز
 ليعمل مرجه السكرى
 اللطاعة على بعضه
 انواعه الخلايا
 مثل الـ brain cells

Storage Polysaccharides



- Starch and glycogen have one reducing end (the molecule end containing a free anomeric carbon C1). On the other hand, the branches ends are all called non-reducing ends and being sites where enzymatic lengthening and degradation occur.



Structural Polysaccharides

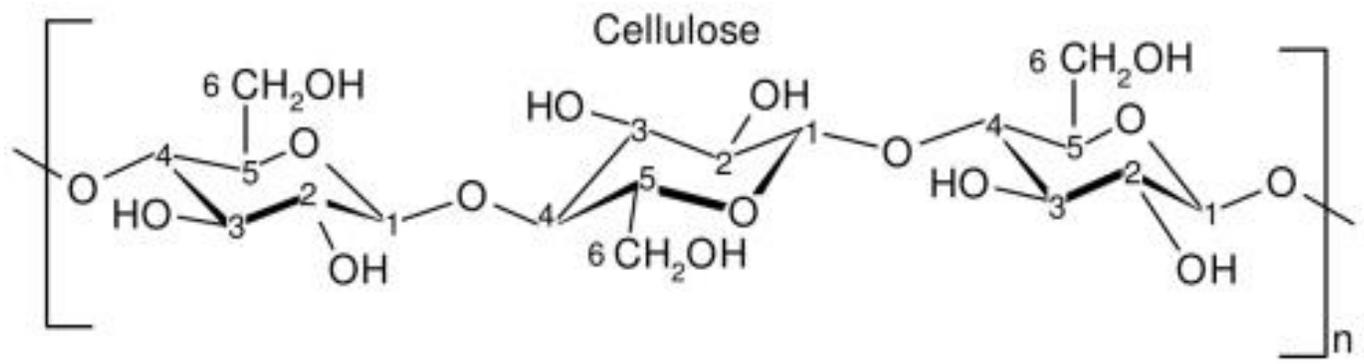


stronger than animal
→ of human cells
لذنه قالمه بلوريات
الانسان و البلاستي
مكة انه مستطوي يشكلا
به سكر ممتد
صعدا ليليلو

Cellulose: the primary structural component of plant cell walls.

- A linear polymer of D-glucose residues linked via β -(1-4) glycosidic bonds.

linear



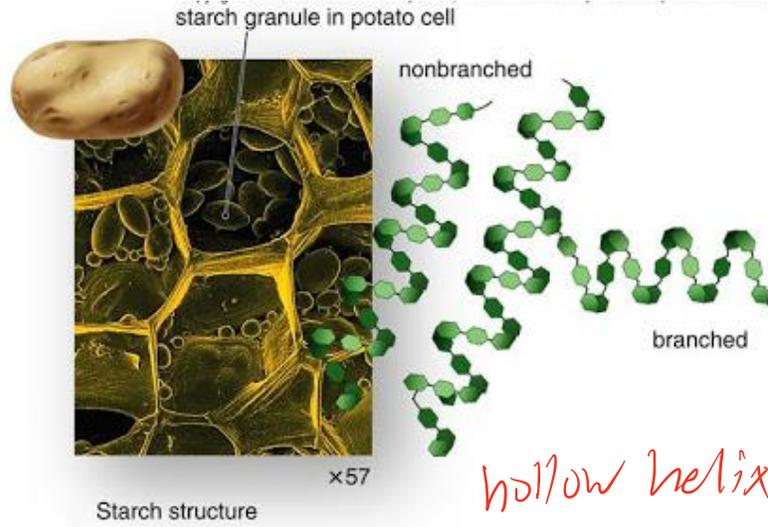
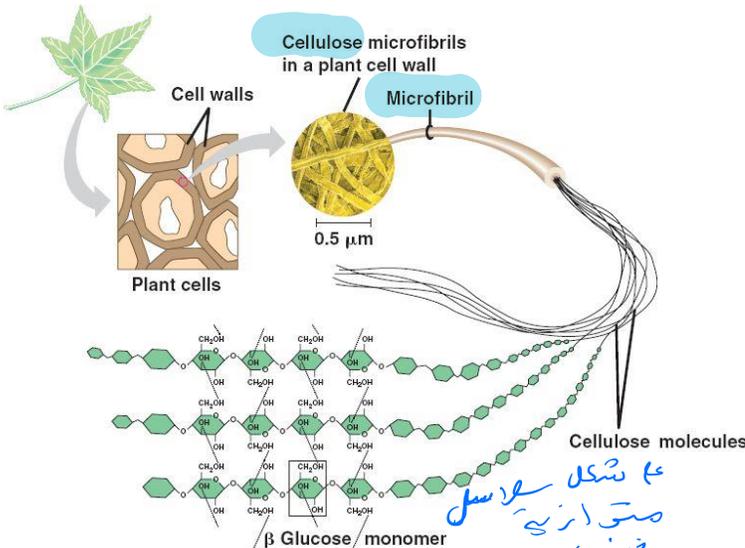
كثير / كثير

- It is the most abundant organic molecule on the earth. cellulose accounts for over half of the carbon in the biosphere.
- It adopts a very different molecular architecture from that of starch (hollow helix) due to its β -linkages.

Structural Polysaccharides



- Cellulose forms very long straight chains. The parallel chains interact with one another through H-bonds



عنا شكل سلاسل
متوازنية
وضعت كل صفا وصفا مرتبين هو بعضا برابطه
صغيره رصينه
الشكل كيه صلابه

لا نوكلا الحريميه سليلو تر يتره حركه (اصغار) وفتح الامعاء (يعني يقدر اكله عاير ما فامثلها)
بما مش ممكن الحركه مصدر للطاقة (القدرنا عليه) لانه جسمنا ما يقدر
يصنع لانه ما عنده
Cellulose enzyme
مبسر ما عنده للمعاينه فبانه زك ما هو وما عنده مبسر استصاير للجلكوز بوسيل القودون ويصنع سليلو عرقيه
الاسما تر تصعبه سايه طرايبه
القدر بالبريه

- Compared to humans, herbivores and termites can digest cellulose because they have cellulases enzymes “enzymes capable of hydrolyzing the β -(1-4) bonds of cellulose”.

منه الختم
انا بيمنا عن $\alpha(1-4)$ bond
we can eat cellulose

Structural Polysaccharides



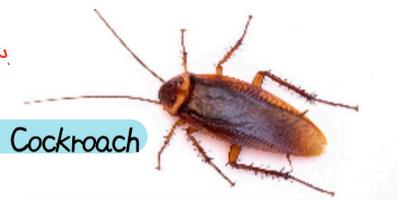
- Cellulose rich food (like vegetables) is used in patients who have constipation

Chitin:

- It is the structural component of the **exoskeletons of the invertebrates** like insects and spiders. Also, it is the main component of the **cell walls of fungi**.

الهيكل الخارجي للحيوانات

ما هي الحمار صوفية
في الكائنات اللاقحة رية
تتعلق الهيكل الخارجي بقوة والصلابة



Cockroach



Spider



Shrimp

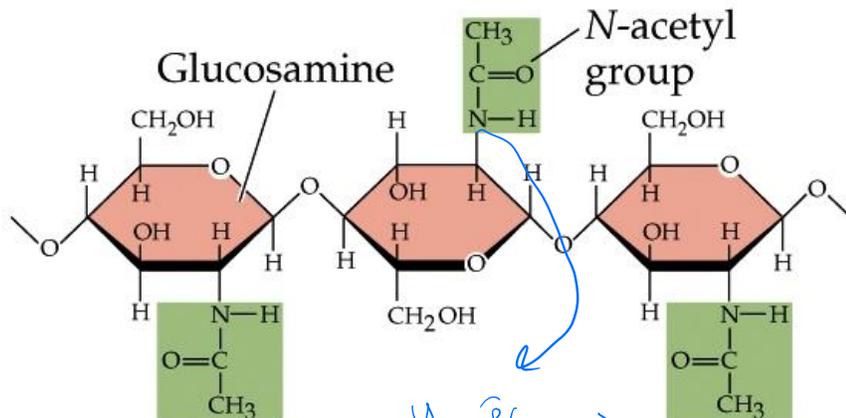
Structural Polysaccharides



- Cellulose rich food (like vegetables) is used in patients who have constipation

Chitin:

- It is the structural component of the exoskeletons of the invertebrates like insects and spiders. Also, it is the main component of the cell walls of fungi.
- A long chain polymer of N-acetyl-D-glucosamine residues joined by β -(1-4) bonds.



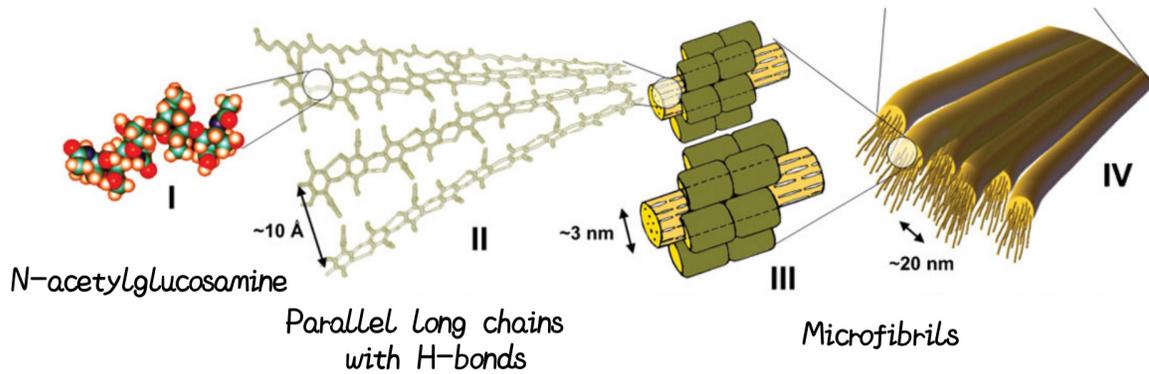
as like -
acetyl group

Structural Polysaccharides



- It has similar structure to cellulose with the only difference is the replacement of OH at C2 of each monomer with acetyl amine group

البنية الجزيئية والبنية الدقيقة



Structural Polysaccharides



- It has similar structure to cellulose with the only difference is the replacement of OH at C2 of each monomer with acetyl amine group

Chitosan is a linear polysaccharide composed of randomly distributed β -(1-4)-linked D-glucosamine (deacetylated unit) and N-acetyl-D-glucosamine (acetylated unit). It is produced **commercially** by deacetylation of chitin (e.g. by treating shrimp shells with the alkali sodium hydroxide).



شrimp من الطبيعة ببيوصها كذا (شrimp) لئلا تاكله البرية يا فتلك انما اكلها تارها ل شrimp
كطوص بمرحله كالتصوير وبتصغيرها على ما بعد كبره
بشكل ال glucose amine نبدل في مكانه كاعطيه group

Medical uses: it is useful in **weight loss** and **obesity treatment plans** because it can **reduce fat absorption**

+ it has high fiber content \rightarrow it can absorb the water \rightarrow you feel full
الاسفطه
تسبب



Heteropolysaccharides

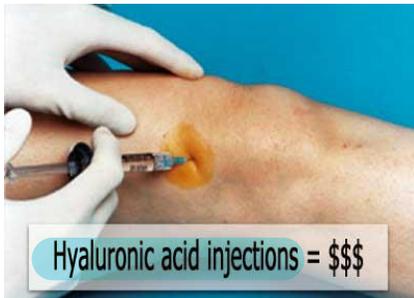


بالعامة بتكرر

- ❑ Consist of two or more different monosaccharide units and are closely associated with lipid (glycolipids) or protein (glycoproteins)
- ❑ The naturally occurring heteroglycans are mostly found in the connective tissues (such as cartilage, tendon, blood vessel walls,.....etc)

1. Hyaluronic acid (Hyaluronate)

- It is the major component of joint fluid (synovial fluid). It acts as a lubricating agent and shock absorber.
- It is also a major component of skin, where it is involved in tissue repair. Dry and scaly skin such as that caused by eczema may be treated with a prescription skin lotion containing sodium hyaluronate as its active ingredient.



Hyaluronic acid injections = \$\$\$

ع

مكونه
لها المبرضان الكمال افضل
يكونها صافي الكمال



Heteropolysaccharides

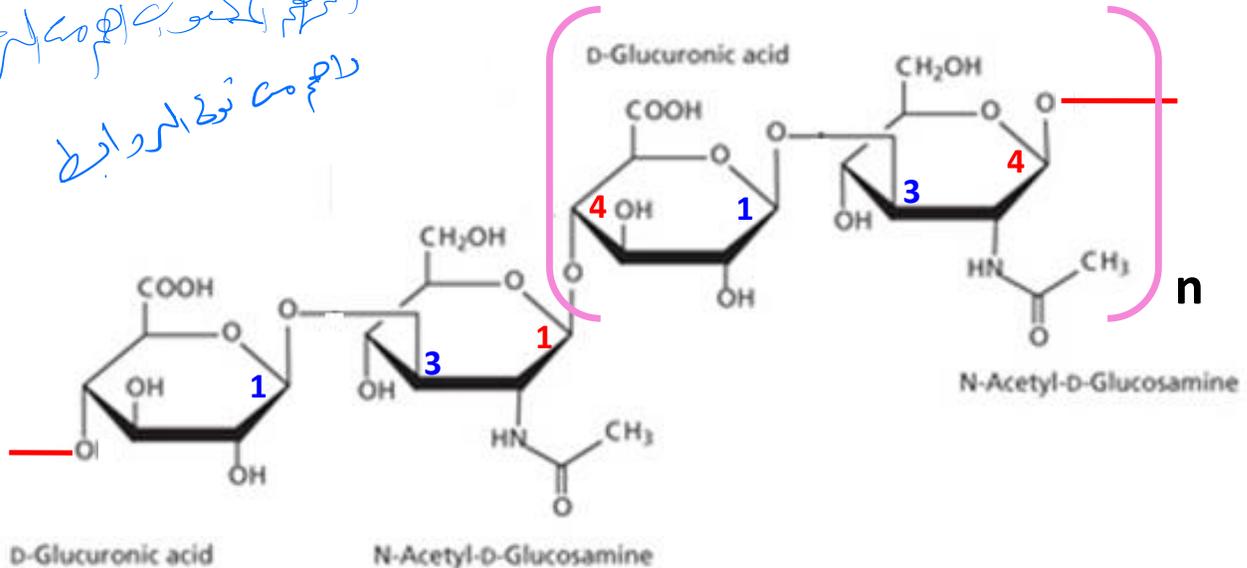


- Hyaluronic acid is a **linear** polymer of the disaccharides “ D-glucuronic acid and N-acetyl-D-glucosamine “ linked via alternating **β -1,4** and **β -1,3** glycosidic bonds.

بالتالي

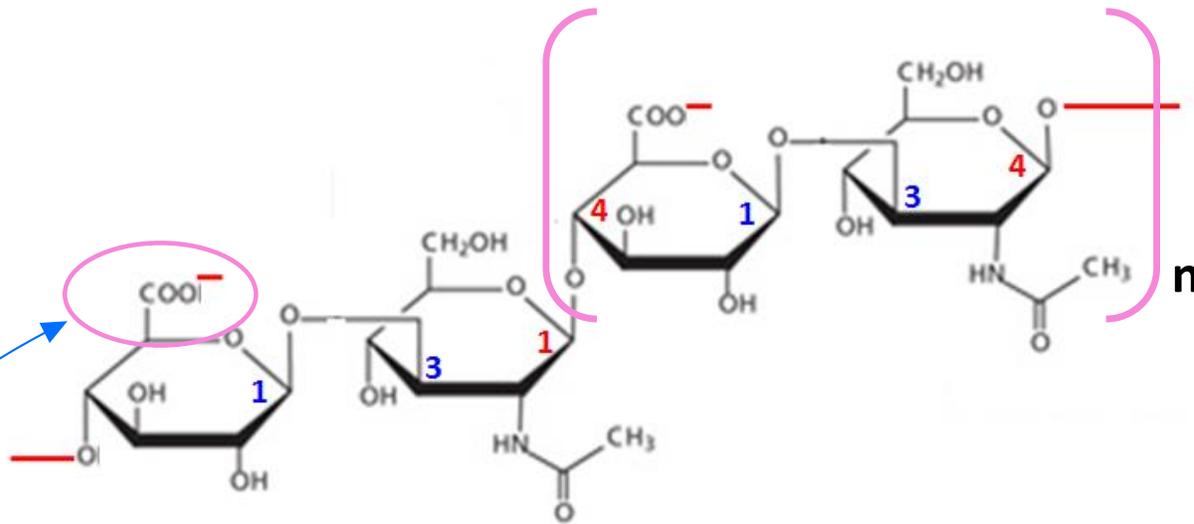
linear/natural

رابطه الخطية المهم من البروتين
لا يتم من نوع البروتين



Hyaluronic Acid

Heteropolysaccharides



D-Glucuronate
(anion)

N-Acetyl-D-Glucosamine

شعور كنه
سايه

Hyaluronate (anionic polymer)

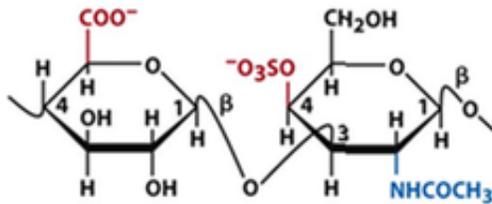
Heteropolysaccharides



باللغة العربية للهيكلية Structure تبصم كما مرآة بضميرها
Sulfate group

2. Sulfated heteroglycans these consist of sulfated disaccharide units such as: chondroitin sulfate, dermatan sulfate, keratan sulfate and heparin

- **Chondroitin-4-sulfate & Chondroitin-6-sulfate** are unbranched polymers containing the disaccharide “ D-glucuronic acid and N-acetyl-D-galactosamine ” with the N-acetyl-D-galactosamine OH groups at position 4 and 6 being sulfated, respectively.

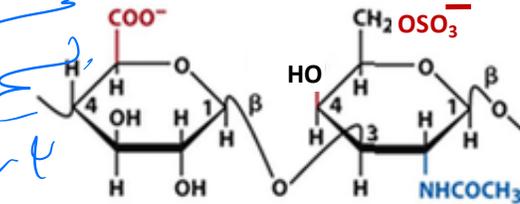


D-Glucuronate

N-acetyl-D-galactosamine-4-sulfate

Chondroitin-4-sulfate

Handwritten blue notes: "بصميرها", "الهيكلية", "باللغة العربية", "للهيكلية".



D-Glucuronate

N-acetyl-D-galactosamine-6-sulfate

Chondroitin-6-sulfate

Heteropolysaccharides



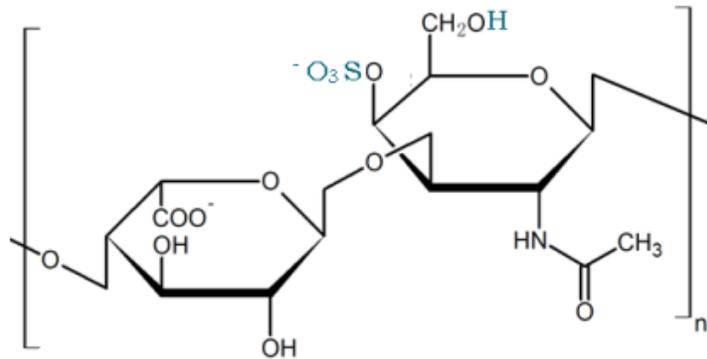
- Chondroitin sulfate is a major component of cartilages. They provide them with resistance to compression. Loss of chondroitin sulfate from the cartilage is a major cause of osteoarthritis.
- Chondroitin is used as dietary supplement to treat osteoarthritis. It is commonly sold together with glucosamine



Heteropolysaccharides



- **Dermatan sulfate**: is a natural polysaccharide found mostly in the skin. It is a linear polymer of a disaccharide containing L-Iduronic acid (modified L-Idose sugar) and N-acetyl-D-galactosamine-4-sulfate



سوزینه بی ایس ایف
Sulfate

L-Iduronate

N-acetyl-D-galactosamine-4-sulfate

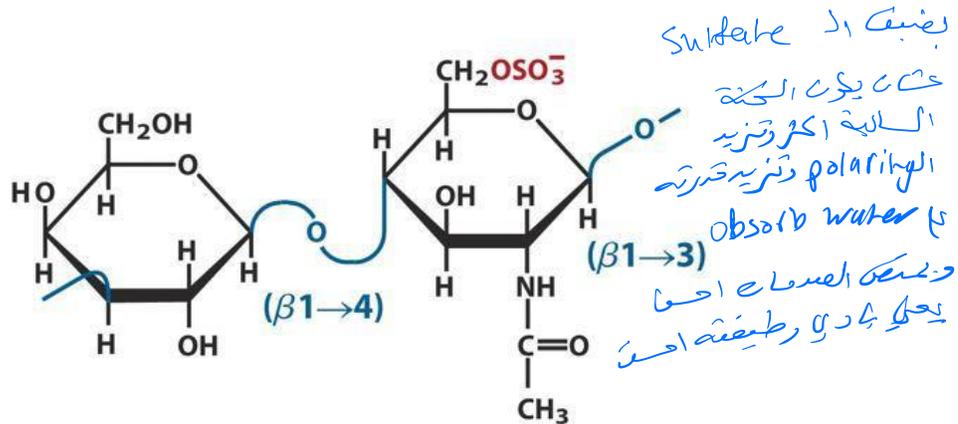
Dermatan sulfate

Heteropolysaccharides

التي مرتبها موجود اى باله كسسه connective



- **Keratan sulfate** is a natural polysaccharide mainly found in the cartilage and bone. It is highly hydrated molecules which in joints can act as a cushion to absorb mechanical shock. This linear polymer is consisting of repeating disaccharide unit containing D-galactose and N-acetyl-D-glucosamine-6-sulfate



D-galactose

N-acetyl-D-glucosamine-6-sulfate

Keratan sulfate

دراسة (أولم) عندك



Heteropolysaccharides

الدوية الكبريتية راقدة الالتهاب
Connective tissue

صغيرة

اضرابي

صبيحة

- Heparin is stored almost exclusively within the secretory granules of mast cells and it inhibits blood clotting. So, heparin is widely used as an injectable anticoagulant (e.g. postsurgical patients)

تحتوى على
الخلايا

بعد الجراحة



الاندثار الخلية المنوية
بما تقرى على الالتهاب الكيماوية
التي تمنع انهما موجودة بالفتحة
منه بال
Fissure blood