بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

BioChemistry

﴿وَلَقَدۡ خَلَقۡنَا ٱلۡإِنسَٰنَ وَنَعۡلَمُ مَا تُوَسۡوِسُ بِهِۦ نَفۡسُهُۥۖ وَنَحۡنُ أَقۡرَبُ إِلَيۡهِ مِنۡ حَبۡلِ ٱلۡوَرِيدِ﴾

MID | Lecture 8

Carbohydrates Pt.3

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Color coding used in the modified:

- *Black: the original slides*
- *Navy Blue: the doctor's explanation/words*
- *Gray: additional information and explanation*
- *Red: important information*

- Revision from the previous lecture:
- glycogen and starch both are examples of homopolysaccharides. They are made of glucose residues only connected to each other by glycosidic bonds (one if the carbons involved in the bond is the anomeric carbon that determines if the sugar is alpha or beta “anomers”). They are storage polysaccharides meaning they are used for the generation of energy in metabolism . Glycogen exist in animal cells and human cells, starch which has two types amylose (not branched) and amylopectin (branched) exist in plant cells. The branching point is alpha 1-6 , the chain elongation point is alpha 1-4.

- The advantage of having alpha glycosidic bond in the orientation : it makes the polysaccharide more water soluble and makes the molecule bent (flexible) so you can a lot of glycogen as a small sized molecule in a small volume and that is why we have a lot of glycogen in the liver (90% of glycogen exist in liver & 10% exist in skeletal muscle cells) , muscle cells needs energy so it uses its storage and when it almost done it sends a signal just like other tissues in the body for the liver to give it glucose.

The completion of Revision from the previous lecture:

- The cells go to the glycogen molecules that they own snd they start removing the terminal glucose residues and that's why branched glycogen is better because it has more terminal residues.

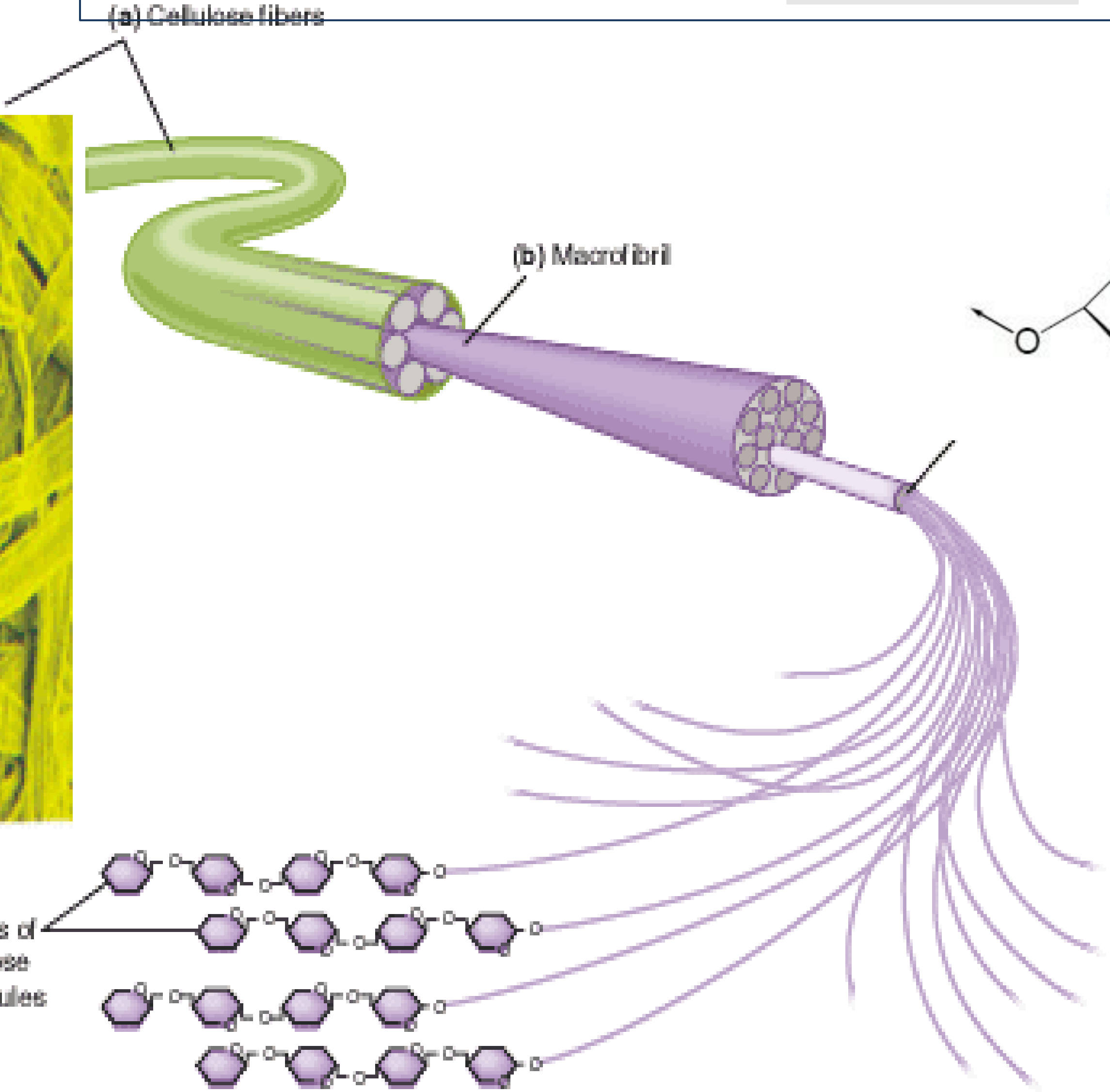
- The two major functions of liver: 1-to provide peripheral tissues with glucose whether by glycogen or gluconeogenesis (will be discussed later) , 2- to remove toxic materials from the body by the enzymes it contain

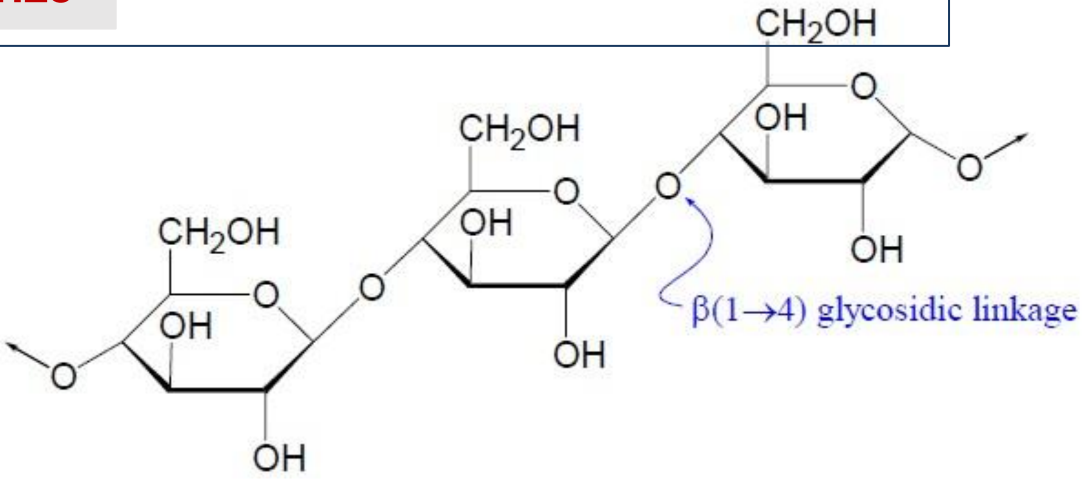
- In plant cells it has a lot of water inside it relatively to the hepatic cells or liver cells so the starch is less branched than glycogen

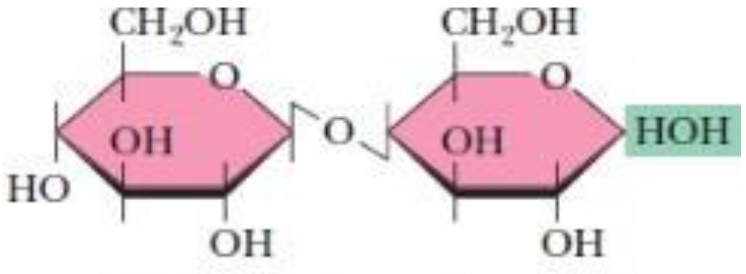
Cellulose

It is a structural polysaccharide the biological assistant doesn‘t use cellulose as storage for glucose ,it is also homopolysaccharides like starch &glycogen

Memorize







Cellobiose (glucose-β-1,4-glucose)

There is different ways for drawing molecules

- Cellulose is a homo polysaccharide it is made of glucose residues just like glycogen and starch, except that the residues are connected with each other by beta 1-4 glycosidic bond.

- Why beta ? Because the alpha is used to make the molecule more flexible but the beta for some chemical reasons cannot be bent (it is not a flexible molecule it stays as a chain) , it is not branched.

- So we have multiple straight chains of glucose residues, all of them are connected to each other as beta 1-4 glycosidic bonds. Rigid molecules and this indicates that the structure fits the function, its function is to provide strength, structure and rigidity for the stem of the plant to keep it straight and stable. (It's right that it can be bent but it is not as flexible as in glycogen).

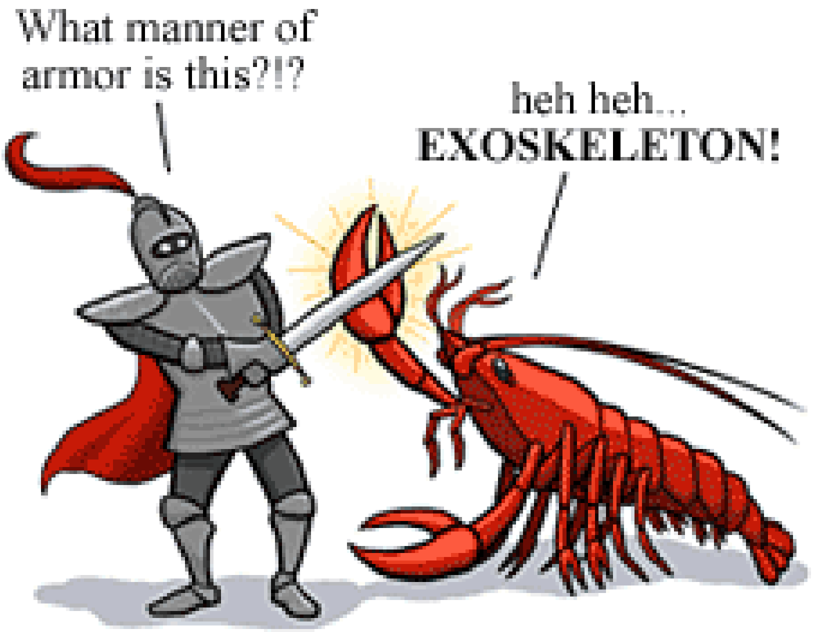
- We can’t digest the cellulose it a fiber so people who has Constipation uses duphalac and lactose or anything that contains fibers because it helps to moisten the stool as they can‘t be digested so in large intestines we will have drowning of water from the the body to the large intestines.

- Because we have straight chains above each other we‘ll have hydrogen bonds between the different glucose residues (between the chains)

Chitin

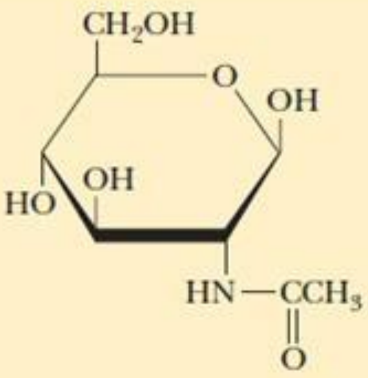
It is made of chains acetyl glucose amine.
It is a homo polysaccharide but it is made of modified glucose

- What is the precursor?
- Where does it exist?

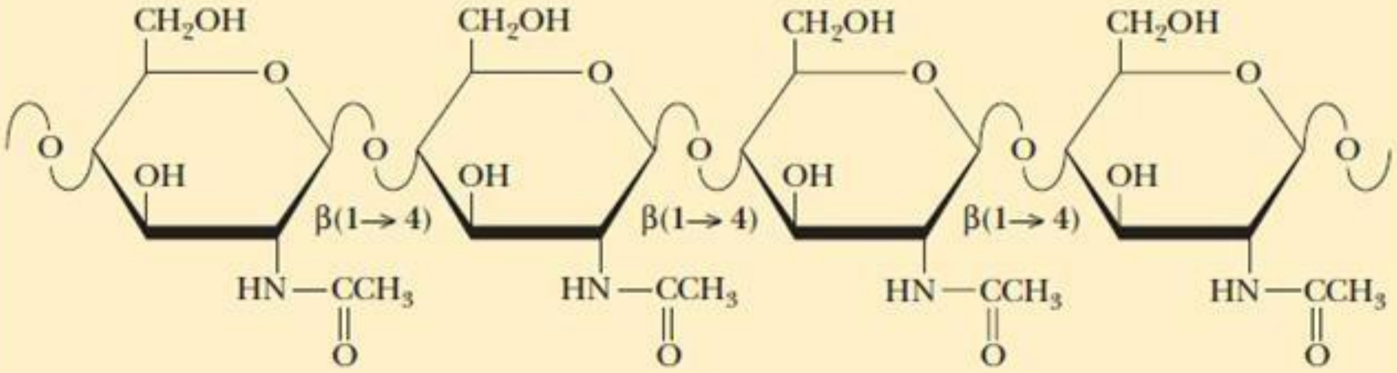


of insects

The N because the acetyl group is on the nitrogen group. Bate because of the anomeric carbon



N-Acetyl-β-D-glucosamine



Do not memorize but study the structures.

The presence of n acetyl group gives me even more hydrogen bonds

Pectin

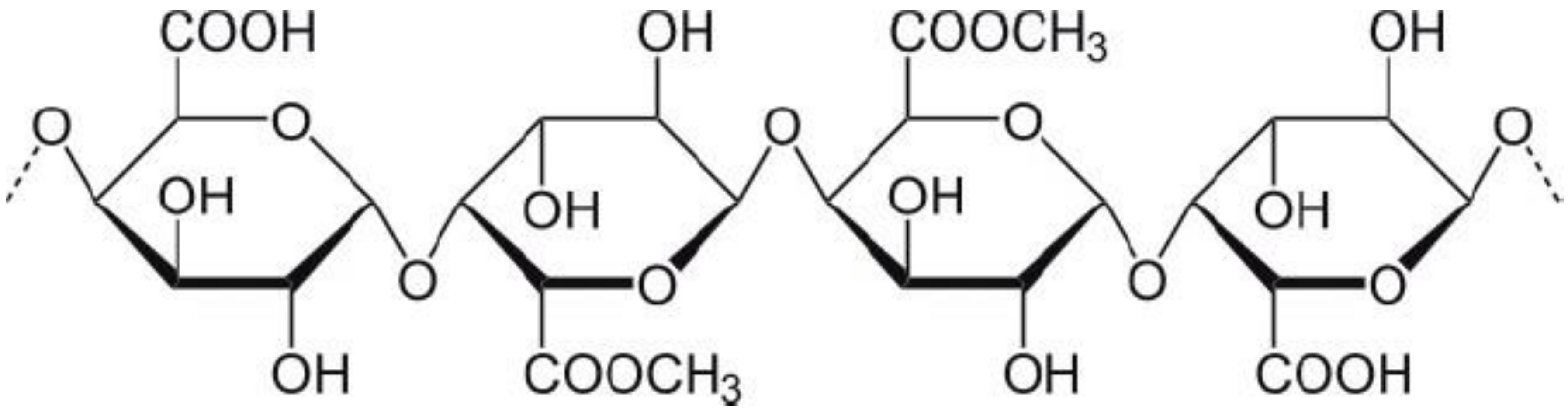
- What is the precursor?
- Where does it exist? In plants

We have sugar acids inside the molecule itself (also glucose) connected to each other

The bond is alpha 1-4 it is a flexible molecule

It can also be used in industry

It is made of galactose



Do not memorize but study the structures.

Are polysaccharides reducing?

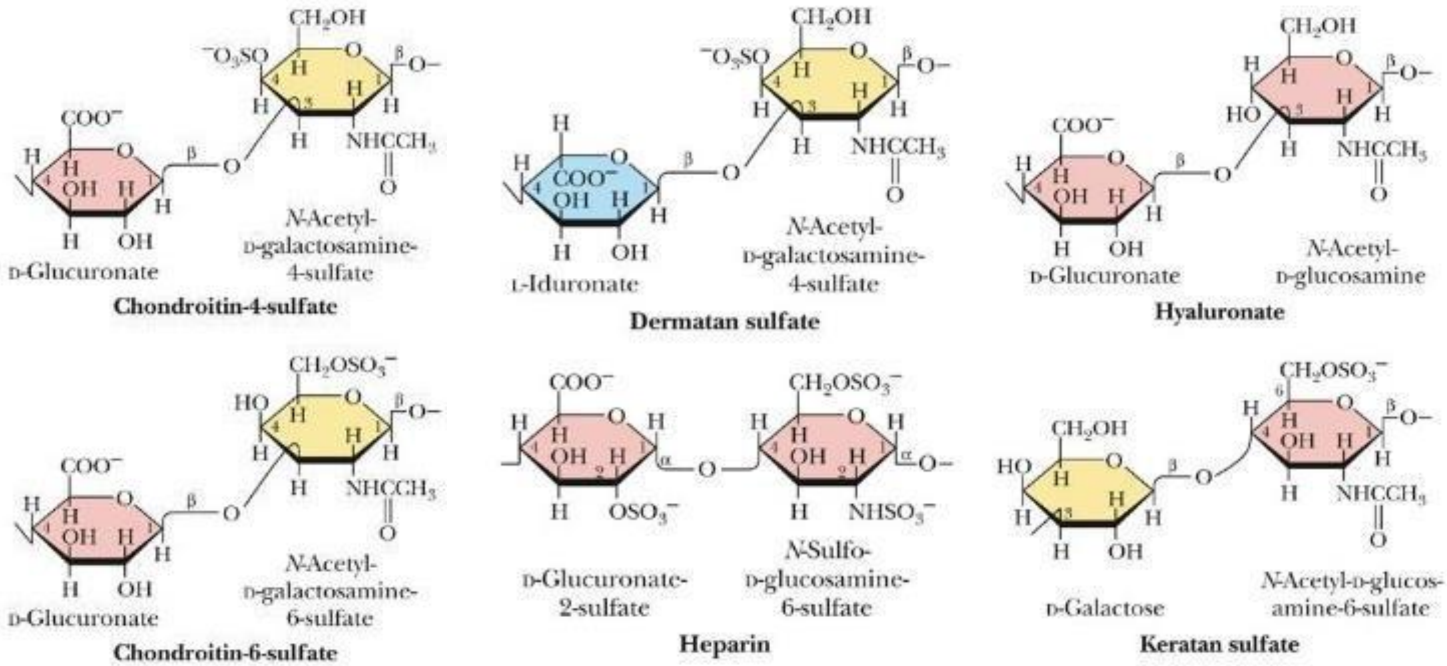
- A sample that contains only a few molecules of a large polysaccharide, each molecule with a single reducing end, might well produce a negative test because there are not enough reducing ends to detect.

Even though glycogen and starch each have one reducing end containing a terminal glucose residue with a free anomeric carbon, they are generally not considered reducing sugars. This is because only one glucose residue per molecule has a free anomeric carbon, while the vast majority of glucose residues are involved in glycosidic bonds. Therefore, the reducing activity of the entire glycogen or starch molecule is negligible

Glycosaminoglycans

- What are they? Where are they located?
- Derivatives of an amino sugar, either glucosamine or galactosamine
- At least one of the sugars in the repeating unit has a negatively charged carboxylate or sulfate group.

Do not memorize but study the structures.



Glycosaminoglycans

- These are structural molecules (they are not storage molecules).
- They are made of repeating units of disaccharides by connecting them via β glycosidic bonds (most of them are beta but heparin is alpha-linked for example)
- Starch, glycogen and Pppllulose are repeated glucose molecules (repeated monosaccharide units).
- Each disaccharide unit connected within the molecule via β glycosidic bonds.
- These disaccharides are aminosugars (amino group is not attached on the anomeric carbon, usually carbon 2).
- Extracellular molecules (outside the cell).
- Rigid structures (support the structure).
- Negatively charged (negative carboxylate group or sulfate group) and they are highly interacting with each other by non -covalent interactions

- Dermatan sulfate:
- Derma from the skin and the skin must be rigid (so it can be a solid tissue)
- Heparin (natural anticoagulant):
- Exists in blood, responsible for preventing blood clotting (coagulation) which gives blood some sort of viscosity.
- For example: when we put some blood in a tube and leave it for 5 minutes it solidifies because the Heparin is deactivated(I confirmed this info from the doc himself).
- Hyaluronate: Exists in tissues all over (synovial fluid, vitreous humor, extracellular fluid for loose CT) which gives rigidity. It is also a lubrican fluid (in cartilage)
- Keratan sulfate: exists in tissues, like bone and cartilage (to give rigidity to the structure).
- Chondroitin sulfate: in cartilage (after compressing, the cartilage relaxes due to the negative charged "repulsion"). Most abundant glycosaminoglcan in cartilage.

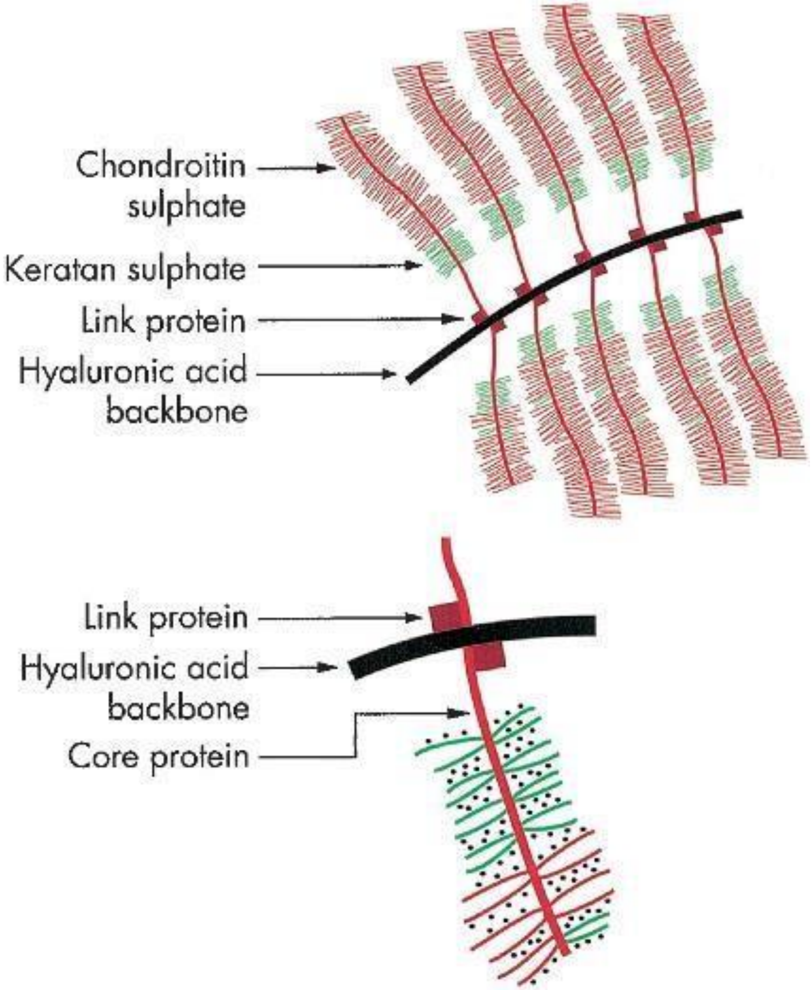
Localization and function of GAG

GAG	Localization	Comments
Hyaluronate	synovial fluid, **vitreous humor, ECM of loose connective tissue**	**the lubricant fluid , shock absorbing** As many as 25,000 disaccharide units
Chondroitin sulfate	**cartilage**, bone, heart valves	**most abundant GAG**
Heparan sulfate	basement membranes, components of cell surfaces	contains higher acetylated glucosamine than heparin
Heparin	component of intracellular granules of mast cells lining the arteries of the lungs, liver and skin	**A natural anticoagulant**
Dermatan sulfate	skin, blood vessels, heart valves	
Keratan sulfate	cornea, bone, cartilage aggregated with chondroitin sulfates	Only one not having uronic acid

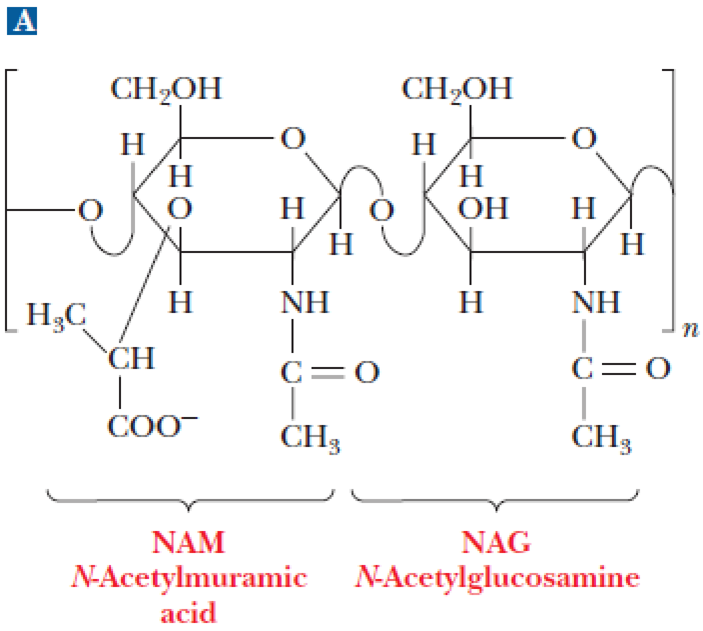
Proteoglycans

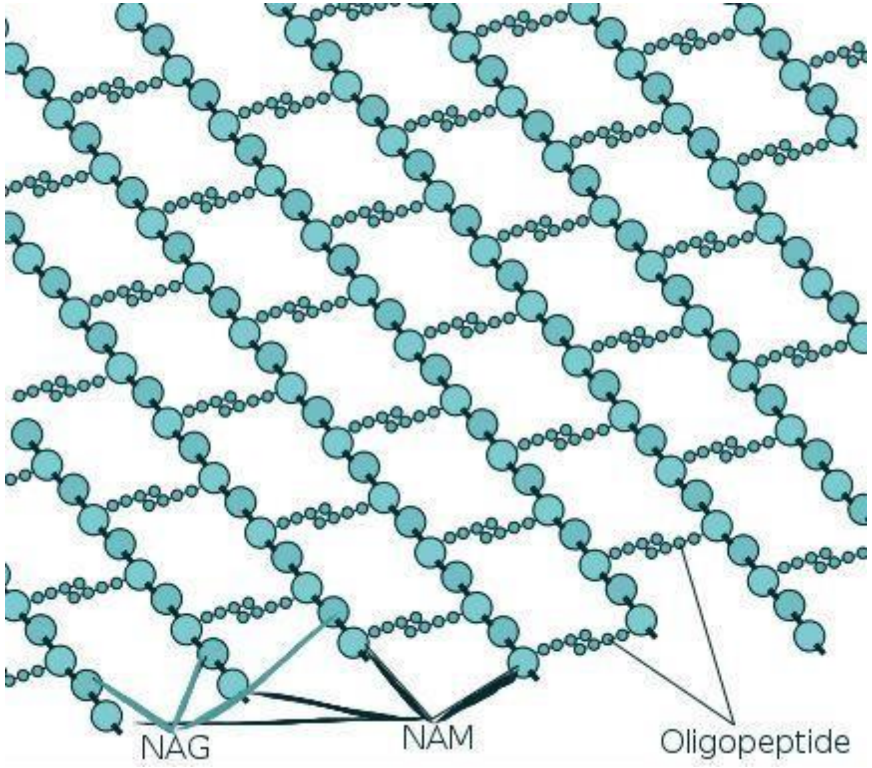
- Lubricants
- Structural components in connective tissue
- Mediate adhesion of cells to the extracellular matrix
- Bind factors that stimulate cell proliferation

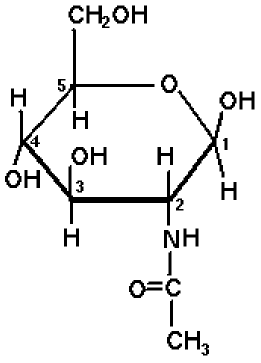
Large glycosaminoglycans+ large sugars with some proteins.
Main structure: sugar. Minor component: protein.



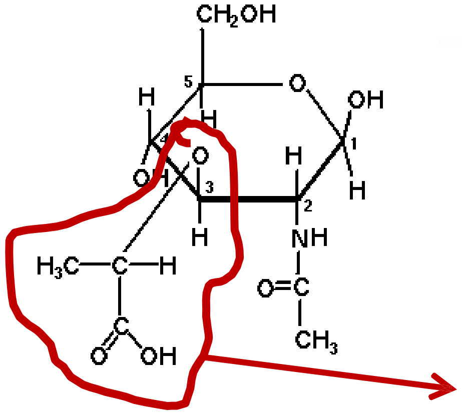
Bacterial cell wall







N-acetylglucosamine (NAG)



N-acetylmuramic acid (NAM)

Lactic acid

Acetyl groups create a lot of non-covalent interactions (hydrogen bonds)

Do not memorize or study the structures.

Bacterial cell wall:

Some bacteria have two membrane systems:

1. Plasma membrane (flexible)
2. Cell wall (gives rigidity to the surface of the bacteria)

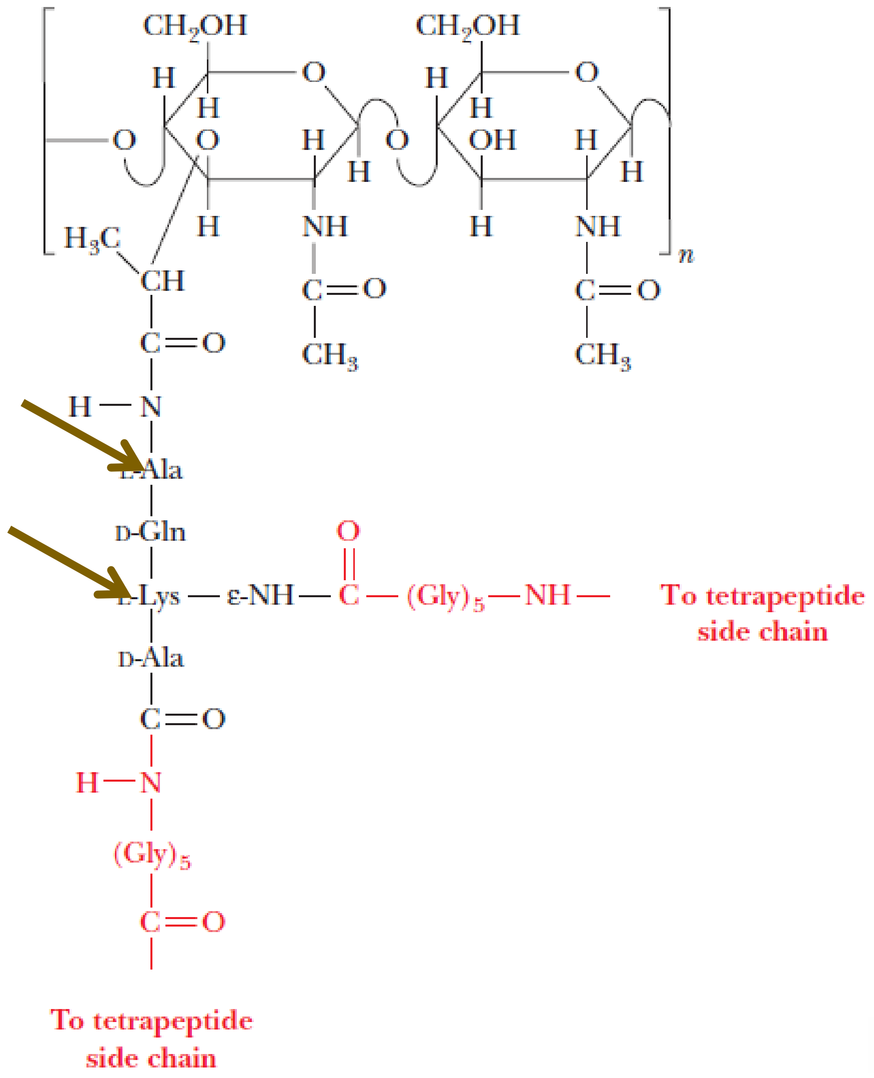
*this bacterial cell wall consists of repeated disaccharides (acetyl muramic acid with acetyl glucosamine).

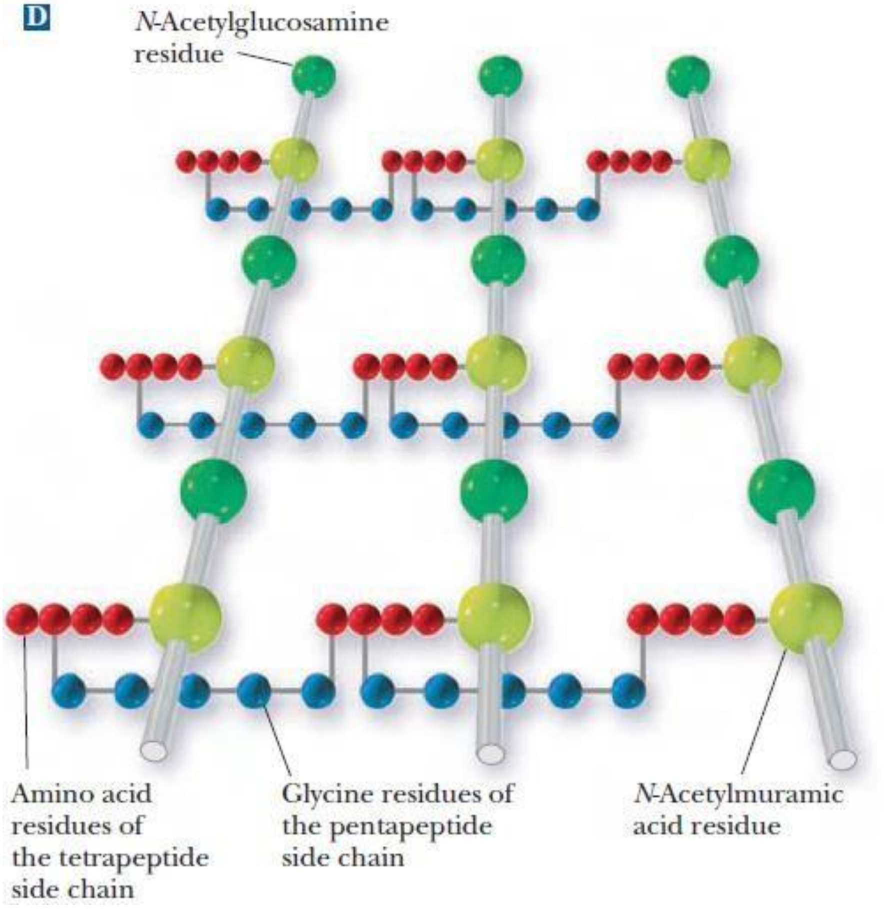
*notice too that the glycosidic bond is β (rigidity)

*we notice between disaccharides short aminoacids(peptides)

Connecting the chains of glycoaminoglycans (creating rigid structure).

Peptidoglycan





Proteins with some sugars
While proteoglycans : sugars with some proteins

Glycoproteins

- The carbohydrates of glycoproteins are linked to the protein component through either O-glycosidic or N-glycosidic bonds
  - The N-glycosidic linkage is through the amide group of asparagine (Asn)
  - The O-glycosidic linkage is to the hydroxyl group of serine (Ser), threonine (Thr) or hydroxylysine (hLys)

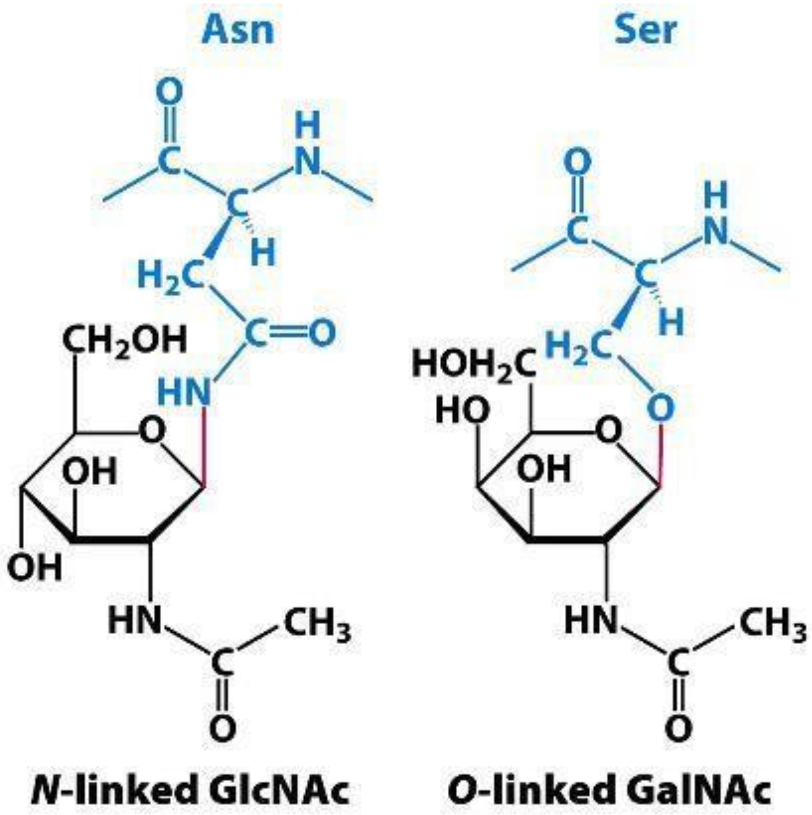


Figure 11.15
Biochemistry, Seventh Edition

Do not memorize or study the structures.

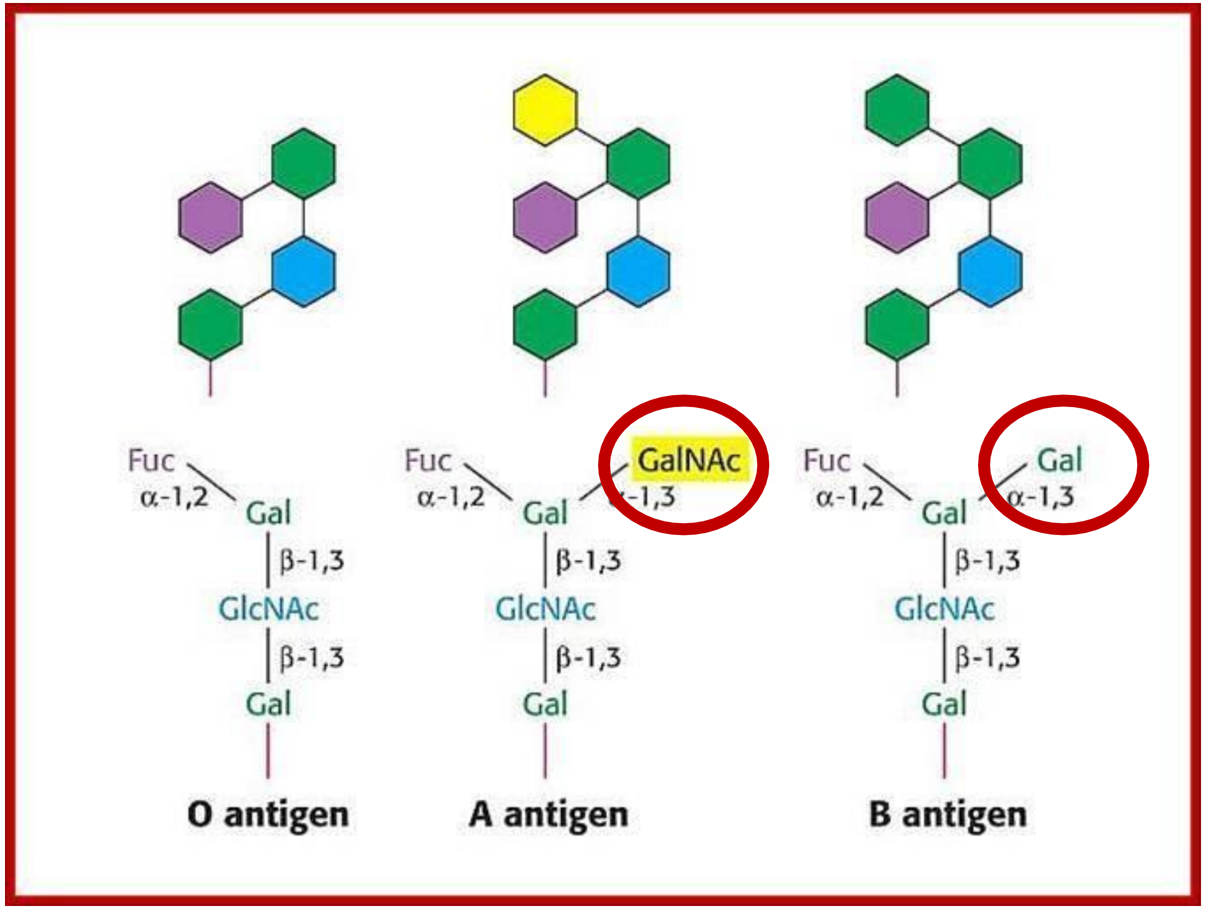
Significance of protein-linked sugars

- Soluble proteins as well as membrane proteins
- Purpose:
  - Protein folding (formation of 3D structure)
  - Protein targeting inside the cell (sugars act as a tag for the protein).
  - Prolonging protein half-life.
  - Cell-cell communication.
  - Signaling

Blood typing and glycoproteins

Sugars on RBCs surface

- Three different structures:
  - A, B, and O
- The difference:
  - N-acetylgalactosamine (for A)
  - Galactose (for B)
  - None (for O)

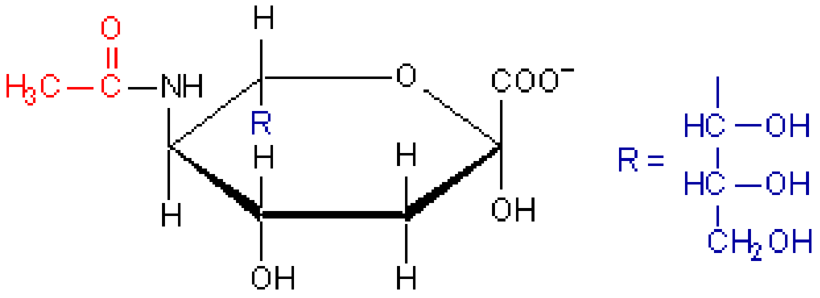


Individuals with blood type A or B can receive type O blood because type O has a basic sugar structure that the immune system naturally recognizes. However, people with type O cannot receive type A or B blood. Types A and B have extra sugar molecules (N-acetylgalactosamine for A, and galactose for B) that the immune system of a type O person sees as foreign, causing an immune reaction. People with type AB blood can receive blood from any group because they possess both A and B sugar structures, so their immune system doesn't reject any of them.

Sialic acid

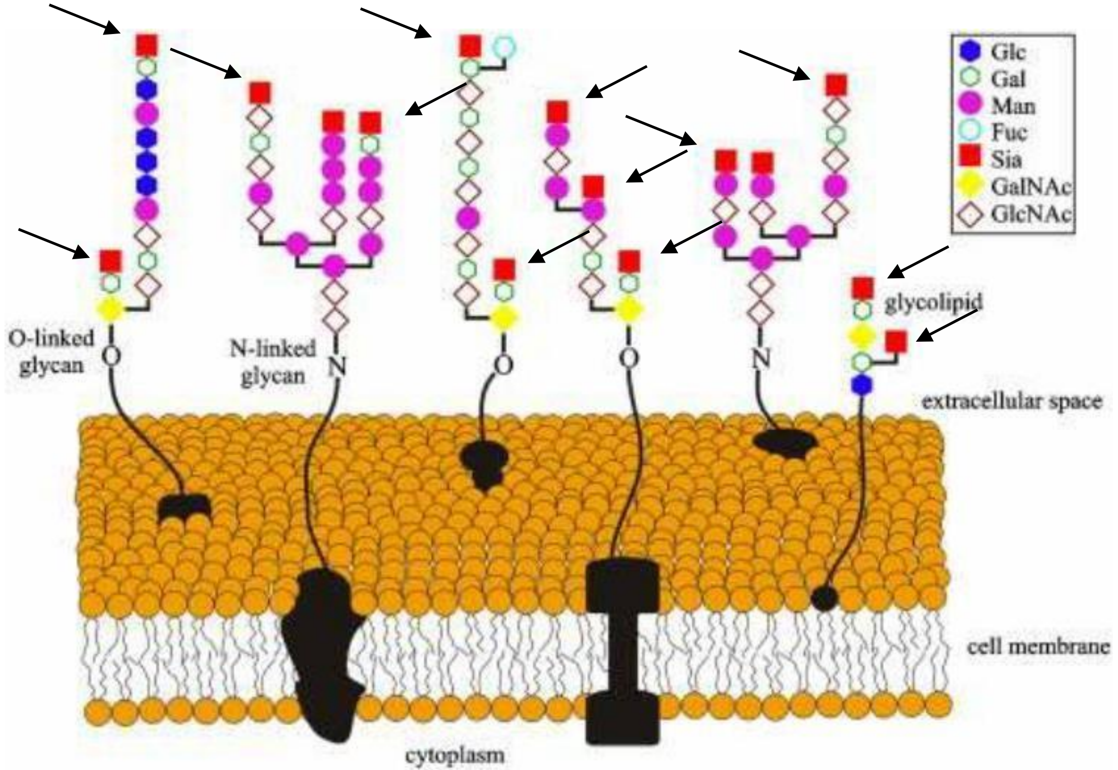
On the cell surface, usually the terminal sugar is known as sialic acid. It is a type of modification of sugars.
Amino group is on carbon number 5.
(the doctor said c6 but corrected it after the lecture)

- N-acetylneuraminate
- Precursor: the amino sugar, neuraminic acid
- Location: a terminal residue of oligosaccharide chains of glycoproteins and glycolipids.



N-acetylneuraminate (sialic acid)

Do not memorize or study the structures.



Quiz!

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	Slide 12		note added (most of them are beta but heparin is alpha-linked for example)
V1 → V2			

Additional Resources:

Reference Used:

1. Dr. Mamoun lecture 2026

https://youtu.be/fUkVyzcBvy0?si=FCob87zY6cMWzCuD

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تعلم عيوبنا فاسترها وتعلم حاجاتنا فاقضها وكفى بك
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