Doctor 022

Biochemistry

Sheet no. 8

Writer: Al-Razi Node team

Corrector: Al-Razi Node team

Doctor: Dr.Diala, Dr.Mamoun

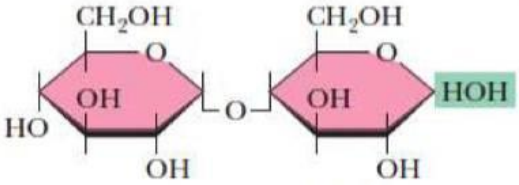
2.starch

-A plant polysaccharide (it is a storage polysaccharide in plants), it is important for us in food.

-We can obtain starch from food such as: corn, potatoes, rice etc.

-Starch is a mixture (it has two compounds; these two compounds are found together but do not interact)

-Those two compounds are amylose and amylopectin.

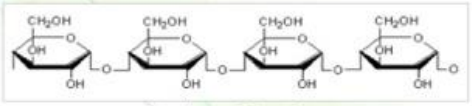


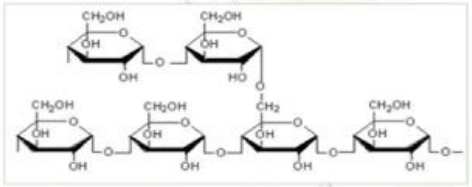
Maltose (glucose-α-1,4-glucose)

1. Amylose (10-20%)

2. Amylopectin (80-90%)

-Amylose and Amylopectin are both polysaccharides composed of a long chain of glucose linked together by an **alpha 1-4 linkage** and they are non-reducing sugars.


Amylose Structure


Amylopection Structure

-Amylose has no branching, but at the same time it will not be linear; it will wind as a helix.

-Amylopectin is branched, it branches every 25 residues, the branching occurs on carbon number 6, meaning the **linkage is an alpha 1-6** (Just like glycogen).

-It is broken down by amylase. This enzyme is found in the mouth (salivary amylase) and in the small intestines, they shatter (cleave or break) the starch in a random way until they reach very simple molecules that are ready for absorption.

Amylopectin vs. Glycogen

-They are very similar in structure

- Both are made from the same monomer, and both are branched.

- Glycogen exists in animals and amylopectin in plants.

- Glycogen is more highly branched (Branching points occur about every 10 residues in glycogen and about every 25 residues in amylopectin).

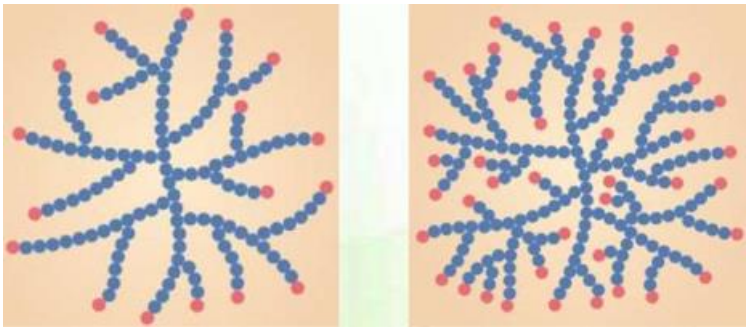
- **Why is branching important?**

- It makes it more water-soluble and prevents crystallization.

- It provides Easy access to glucose residues (it makes it easier for the enzymes to digest it)

-Branching increases solubility, because it increases the surface area for interaction or formation of hydrogen bond between glycogen or amylopectin with water molecules.

-Look at the picture below:



-The red dots are non-reducing ends, because carbon 4 is the free one, and C4 cannot be reduced.

-There is only one free anomeric carbon which is at the end of the free chain.

-The point of branching is the only alpha 1-6.

-Starch is made up of repeating units of disaccharide (mostly maltose), in addition to branching.

-Starch isn't synthesized in our cells, starch enters our body by food.

-On each red ball (each end) we have an enzyme that attacks and breaks it down to glucose monomers, so we can release several glucose residues at the same time.

-It is considered as a quick source of glucose, and thus a quick source of energy.

-starch is digested by fragmentation to small pieces, and then into smaller pieces until we get:

-Maltose disaccharide ——> broken down by maltase(enzyme).

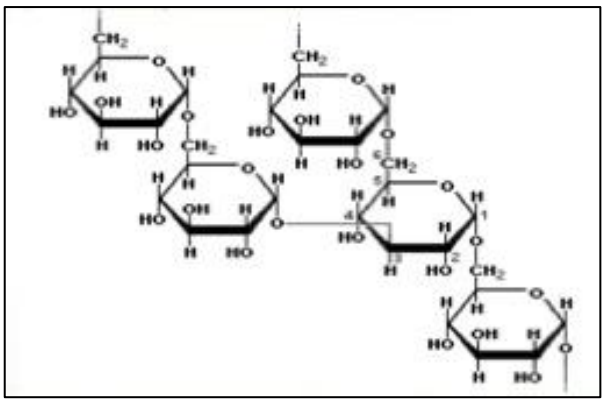
-Single Glucose residue (free sugars) ——> absorption.

3.Dextran

-It is a storage polysaccharide, Yeast and bacteria utilize (use) it.

-Made of alpha (1-6)-D-glucose with branched chains.

-Those Branches can be: 1-2, 1-3, or 1-4. It is extensively branched because it has more than one type of branching. so, it forms a large network.



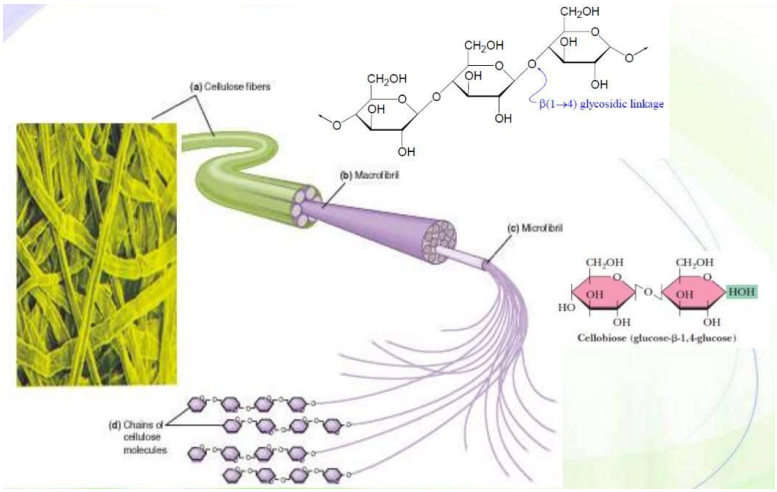
-it is found in abundance in plaque layer that covers the teeth, if we don't brush our teeth.

-It is abundantly found in oral cavity.

-Bacteria in the mouth produces dextran and builds a complicated network.

-You can remove this layer by using the correct way to brush your teeth. When you brush your teeth, don't use water on the toothbrush, because it will dissolve the active ingredient of the toothpaste, whose mechanical function is to scrape this layer.

4.Cellulose



-It is a structural polysaccharide which provides support, especially in the stalks of different plants, it is made of glucose monomers connected through beta (1-4) linkages.

-It is a long fiber, because when it is a linear fiber, you can compact them to each other then they can form more hydrogen bonds, noncovalent interactions, so it adds to the mechanical properties of this molecule making it stronger.

-Our bodies are unable to digest cellulose fibers, because we don't have an enzyme that can break down beta (1-4) linkages.

-We can find this **cellulase** enzyme in the intestine of herbivores (آكلات الأعشاب).

-Cellulose doesn't get digested in our bodies, meaning that instead of getting absorbed, it will remain in our digestive system until it's excreted.

Osmotic pressure increases in the GI tract because of the fact that cellulose remains in the digestive system and that it can create a lot of hydrogen bonds with water, which will attract water from surrounding cells and into the GI tract in order to nullify the increase of osmotic pressure.

-Cellulose gives the feeling of fullness because it makes hydrogen bonds with water, so it becomes larger(بينفش) giving the feeling of fullness, because as it becomes larger it puts pressure on the walls of the intestines so, it causes stretching in the smooth muscles causing a signal of fullness.

-Activates **peristaltic movements**: which are contractions in the stomach that push the ingredients out.

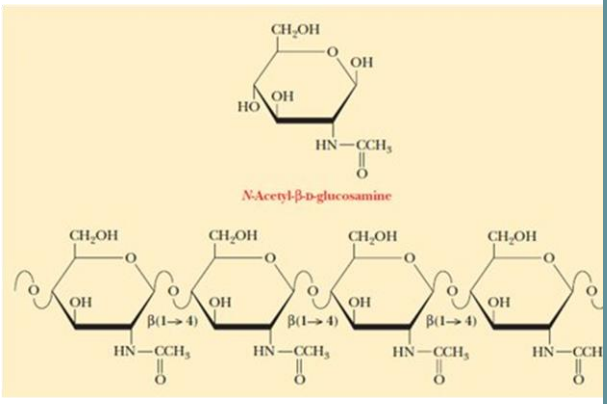
-Cellulose is considered a solution for decreasing constipation.

-Cellulose is like threads which become knotted and form a net (like a fisherman's net) that catches the compounds that enter with it. So, for example, if you eat something greasy with vegetables (plants) it will catch some of the cholesterol molecules, also it could catch toxic compounds.

-This unit(disaccharide), which is made up of 2 glucose molecules connected via beta 1,4 linkage is called **cellobiose**.

5.chitin: chitin is a structural polysaccharide, it's mainly found in the exoskeleton of animals (ex: insects, lobsters and some fish), which acts as a hard cover(shell).

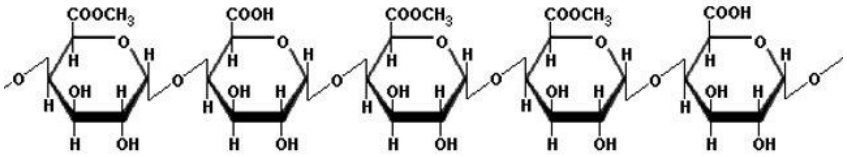
Chitin is a homo-polysaccharide (consists of a repeat of the same monomers), the building unite(monomer) of this polysaccharide is a modified sugar known as **N-acetylglucosamine** (N-Acetyl-B-D-glucosamine), the presence of nitrogen and acetyl group (as we studied earlier) provides more **H-bond donors** and **H-bond acceptors** which gives this monomer the ability to make more hydrogen bonds between those residues and chains, and increase the non-covalent interactions between them, providing the mechanical properties that are needed for chitin to do its function which is structural support.



(Chitin monomers and chains)

6.Pectin: pectin is found mainly in plant cells and bacteria, it is used as a gelling agent (once added to a substance, it turns it into gel- like state).

-It can be used as a replacement for gelatine as a gelling agent.



-Pectin is a **hetero-polysaccharide** (consists of different repeats of monomers), those monomers are modified sugars with the same basic monosaccharide **galactose**, this modification is oxidation.

-The first modification is the oxidation of galactose to **D-galacturonate** (not glucuronate) which represents the monomer bearing the (COOH, the second monomer in the figure above).

-Further modification of D-galacturonate by the addition of (CH3) gives us an ester known as **Methyl-D-galacturonate**, which represents the monomers bearing the (COOCH3, the first monomer in the figure above).

-So, by repeating those two monomers we get a hetero-polysaccharide known as **Pectin**.

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.

-Overall if we look at the structure of those polysaccharides, they are mainly non-reducing.

-If you remember, in glycogen and starch, there was only one free end that was able to be oxidized (there is only one free anomeric carbon able to be oxidized which is located at the end of the main chain only), now in a polysaccharide we can have several hundreds to several thousands of monomers. Therefore, the ability of one monomer to be oxidized compared to other thousands of monomers unable to be oxidized would be unsignificant and barely noticeable.

-This principle applies to other polysaccharides so; overall polysaccharides are non-reducing.

7. Glycosaminoglycans (GAGs): GAGs are **hetero polysaccharides**, made of repeated disaccharide unites.

-They are connected to a core protein. This structure consisting of GAGs and a core protein is known as Proteoglycans (we will study it next).

-What sets GAGs apart from other polysaccharides is their high polarity.

-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.

-GAGs consist of modified sugars (mainly modified glucose and galactose)

-This modification can be the addition of **amino groups** (amination, ex: N-acetyl-glucosamine, N-acetyl-galactosamine etc), **Sulfate groups** (sulfation) and **oxidation** (forming glucuronate or galacturonate, etc…), and all those modifications add a negative charge to the sugar increasing its polarity. That's why GAGs are highly negative.

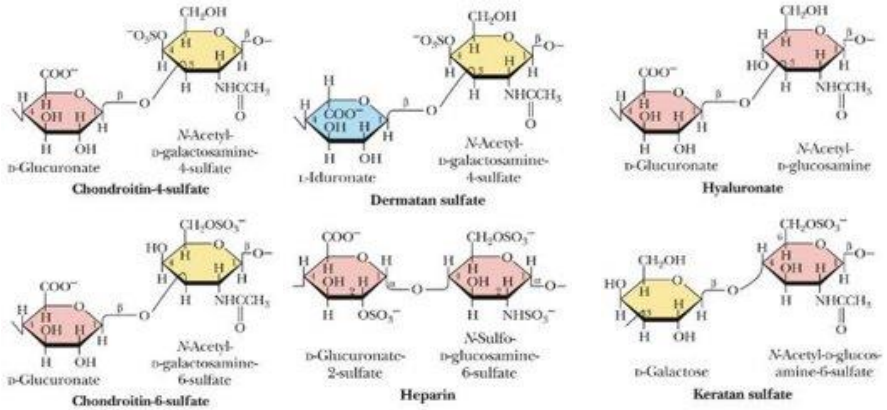
-Those negative charges attract water molecules, recruiting them and giving the Extra Cellular Matrix gelatinous properties, so GAGs are shock absorbent.

-GAGs are dynamic structures, they interact with the surrounding environment, and any changes inside it (like pressure) will influence the number of GAGs on the core protein (increase or decrease the number depends on the stimulus).

-An example of this type of regulation is the Intraocular pressure, this pressure is subject to frequent changes (morning and night, head movement and many other factors). So, when the pressure increase, the number of GAGs inside the eye will decrease; giving more space to the fluid and reducing the pressure, and when the pressure decreases the number of GAGs increases; giving less space to the fluid and increasing the Intraocular pressure.

-before diving into the figures, note that the yellow rings are modified galactose, the pink rings are modified glucose, and the only blue ring is an Iduronate.

-You are not required to know the modifications in each GAG, just know the common names (not the systematic) that are written in bold below.



Localization and function of GAG:

-Some notes about the table:

-GAGs are variable in their locations and functions.

-The vitreous humour: it is the gel substance that fills and inflates the eye hole.
-Why is there Synovial fluid? Because its lubricant that prevents friction between bones.
-Heparin is an anticoagulant (مضاد للتجلط) substance.

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

-GAGs must link to core protein in order to
make structures that are called Proteoglycans.
-Proteoglycan can have more than one type of GAGs.
-The importance of proteoglycans:

1.Lubricants

2.Structural component in connective tissue.

3.Mediate adhesion of cells to the extracellular matrix.

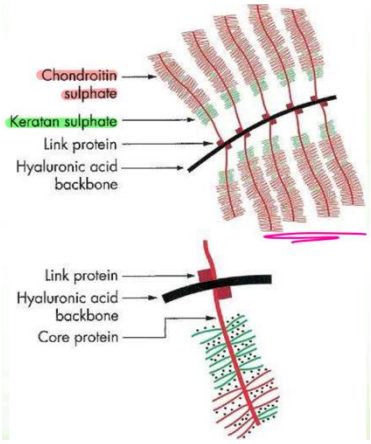
4.Bind factors that stimulate cell proliferation.

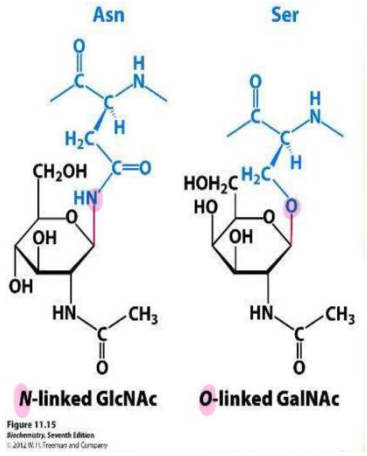
Glycoproteins

-How are carbohydrates linked to proteins?
The carbohydrates of glycoproteins are linked to the protein component through either O-glycosidic or N-glycosidic bonds.
-what is the responsible component for the type of linkage? the type of amino acid that will create a bond between the protein and the oligosaccharide.
-The N-glycosidic linkage is through the amide group (NH2) of **Asparagine (Asn,N).**
-The O-glycosidic linkage is to the hydroxyl group (OH) of **Serine (ser, S), threonine (Thr, T) or hydroxylysine (hLys)**.
-Significance of protein-linked sugars:
-Soluble proteins as well as membrane proteins.
-Purpose: Protein folding, Protein targeting, prolonging protein half-life, Cell-cell communication and Signalling.

Proteoglycans. Glycoproteins.

Anas Alhmadat



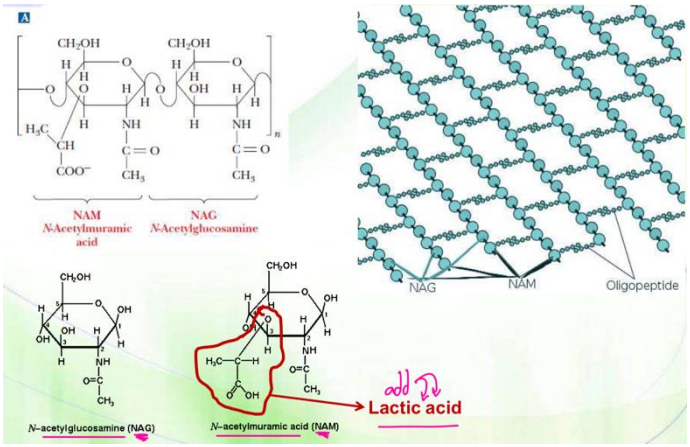


Bacterial cell wall

-Another place that we can find polysaccharide is [Bacterial wall].

-Because of its rigidity, there is a strong mechanism of binding that makes this structure.

-Bacterial cell wall: it is a heteropolysaccharide which is made of two types of sugar (monosaccharide) are:

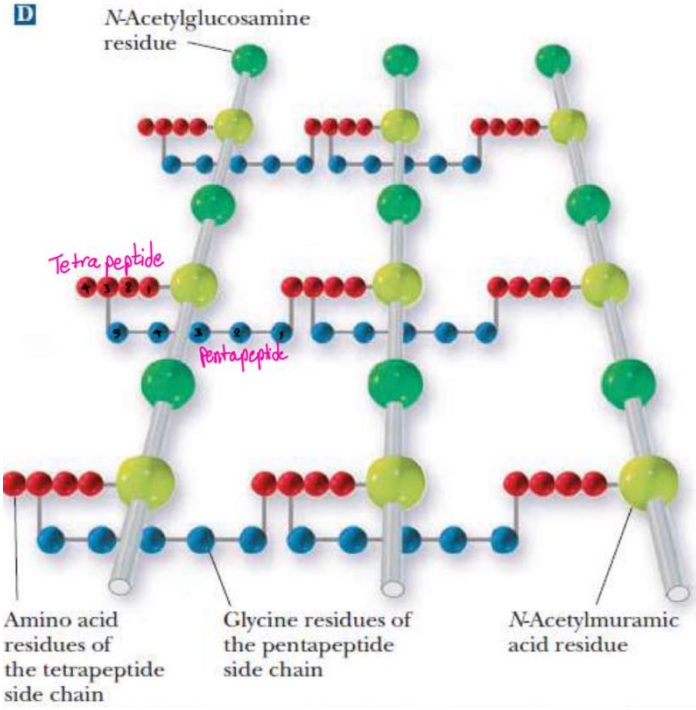


1.N-acetylglucosamine (NAG).

2.N-acetylmuramic acid (NAM).

-The chains of polysaccharide bind together by: H bonds and Covalent bonds by oligopeptides (amino acids) from (NAM) sugar to (NAM) sugar in other chain.

-You are not required to memorize the amino acids here.



Blood typing and glycoproteins (ABO system):

-Three different structures: A, B and O

-The difference is:

1.N-acetylgalactosamine (for A type).

2.Galactose (for B type).

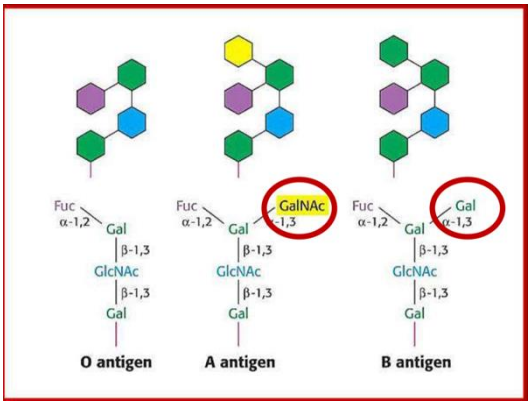
3.Both structures (for AB type)

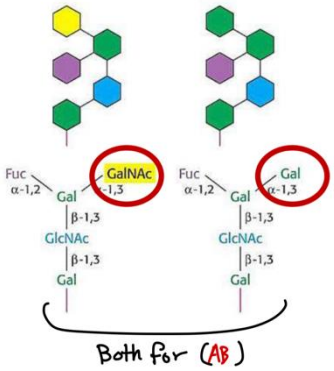
4.non for (O type)

-So, the difference between the four blood groups is the sugar component.

- The common of antigen structure:

-Galactose then N-acetylgalactosamine the galactose then frucose.





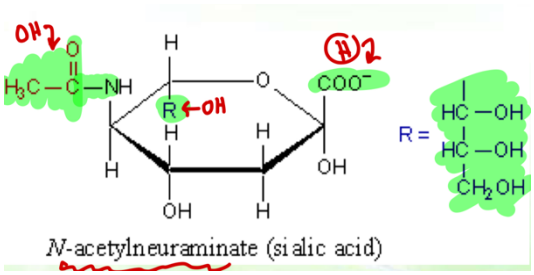
Sialic acid

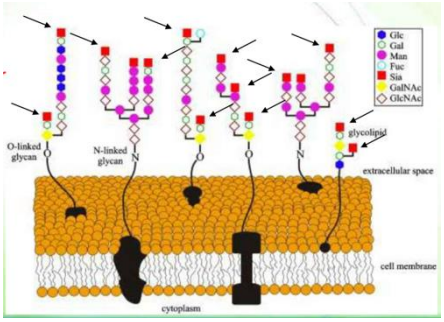
-sialic acid is a modified sugar (galactose) = N-acetylneuraminate.

-precursor: the amino sugar, neuraminic acid.

-Location: a terminal residue of oligosaccharide chains of glycoproteins and glycolipids.

-sialic acid is common in glycoproteins and glycolipids (will be discussed later)





V2

-Fixed some grammatical and spelling mistakes, united the font colours and sizes and fixed the design.

-The paragraph (The endings of these branches have carbon number 4, they are non reducing ends ..) at page 3 is removed because it is explained later in the sheet in a better sequence and context.

-The paragraph (, it will not broken down like the degradation of glycogen the branching process of glycogen is very extensive, because this allows fast degradation) at page 3 is removed.

-The paragraph (in the beginning, a transparent protein layer will form on teeth (the formation of this layer begins after seven hours, even if we don't eat) so if we don't brush our teeth for a period of ….etc) at page 4 is removed.

-Rewritten the paragraph (It is made up of a polar molecule which is glucose, so it will attract water molecules and make hydrogen bonds with them. First because it changed the osmotic pressure…so it will move water towards the intestines,) at page 5.