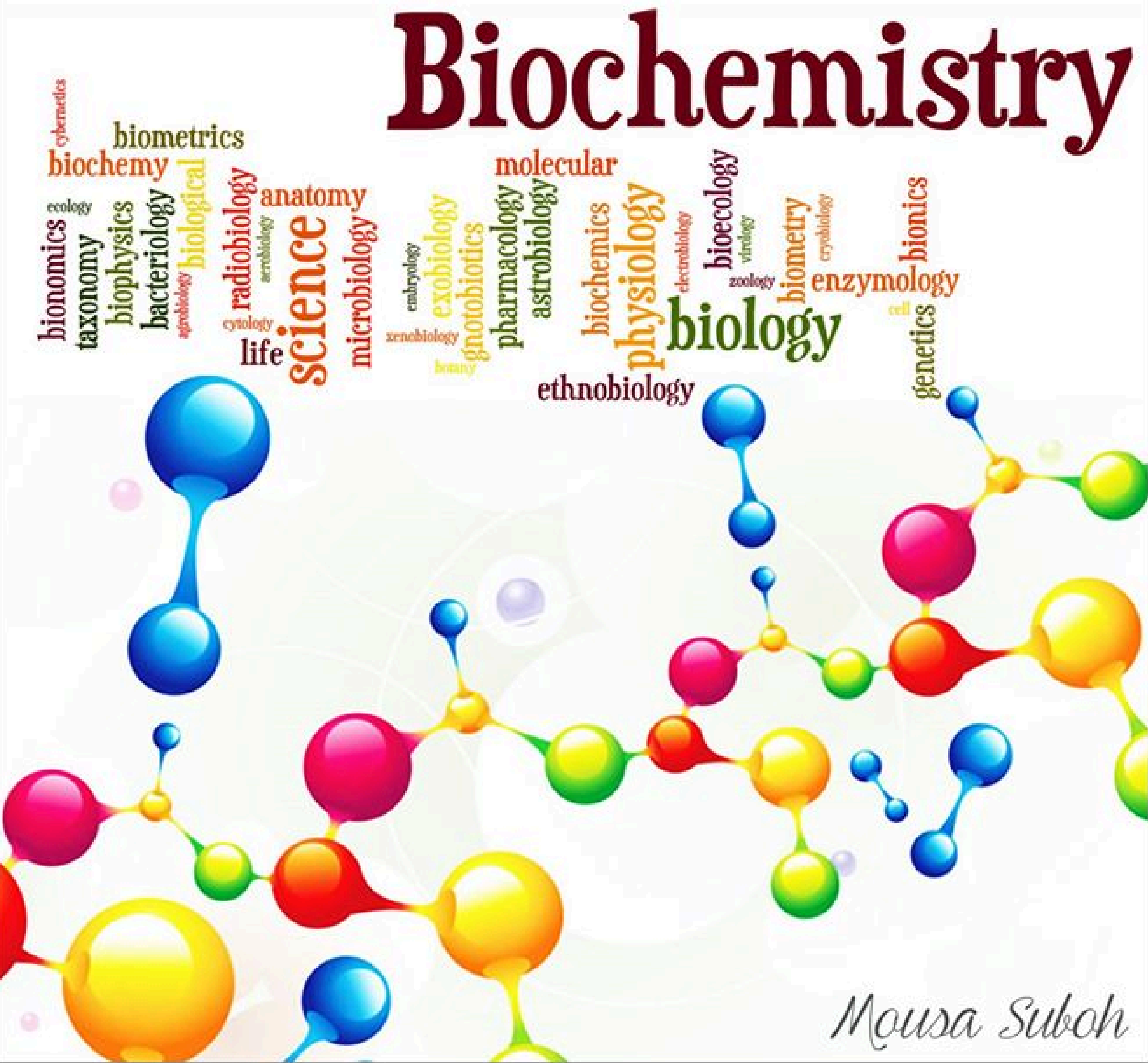
Lecture : #11- Sections 1,2,3

Dr. Name : Dr. Mamoun Ahram

Done By : Raya Majali

☐ Slide ■ Sheet

Medical Committee
The University of Jordan



Carbohydrates ➔ (Also called: saccharides)

-can be classified by the number of sugars that constitute the molecules:

1- monosaccharides:

-General formula: $(CH_2O)_n$

-Contain one sugar molecule

-Contain two or more hydroxyl group

-e.g. Glucose, galactose, fructose

-how to differentiate between glucose and galactose?

They are epimers at C-4

-NOTE: some books may draw the structure of the sugar flipped

So make sure before deciding whether it's alpha or beta that it's not drawn flipped (normal structure: C-6 extending upward , flipped: C-6 extending downward)

2-Disaccharides:

-contain two specific sugar molecules

-carbons involved in the glycosidic linkages are (C-1,C-2,C-4,C-6)

e.g. :

A) Maltose:

-may present in malt (شعير)

-made up of two α-glucose molecules

-Glycosidic linkage: α:1-4

B) Lactose:

-made up of β-galactose and glucose (glucose is in the α conformation and galactose is in the β conformation)

-glycosidic linkge: β-1:4

-Lactose can be present in different conformations, for example you can have α: 1-4 glycosidic bond and α: 1-6 (different type of linkages between sugars)

c) Sucrose:

-Made up of α-glucose and β-fructose

3-Oligosaccharides:

Saccharide polymer made up of small number of simple

sugars (3-9)

One e.g. is given that is: Raffinose

-trisaccharide mainly present in beans and peas

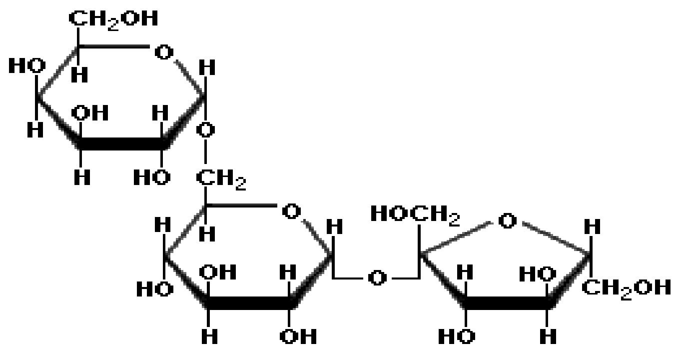
-it can't be digested in our digestive system. It's instead digested by a bacteria present in the intestine that's why our body produces too much gases when eating beans and peas.

-it's made up of three sugars: galactose, glucose, fructose

-glucose and galactose linkage: α-1:6

Glucose and fructose linkage : α-1:2 (sucrose disaccharide)

Note: fructose is in β conformation.



-note:

Oligosaccharides or saccharides in general can be used in manufacturing processes by being used as a part of the overall structure of drugs like:

1)Digoxin: used for cardiovascular diseases

2) Erythromycin: antibiotic (contains monosaccharides in its structure)

3)streptomycine: antibiotic (it's composed of an oligosaccharide)

4)doxorubicin : cancer chemotherapy (contains monosaccharides in its structure)

Note: sugars can be used as part of the overall structure of drugs.

4- Polysaccharides

-saccharide polymer made up of more than 10 monosaccharides

-it can be homopolysaccharide (one type of monosaccharides) or heteropolysaccharide (made up of more than one type of monosacharides)

-things we care about when we study a polysaccharide:

1) What type of monosaccharides can form the polysaccharide? Is it one type or multiple? (Homo or hetero)

2) The length of the polysaccharide?

3) Branching: it saves space.

4) Function: storage purposes (energy) or structural purposes (tissues)

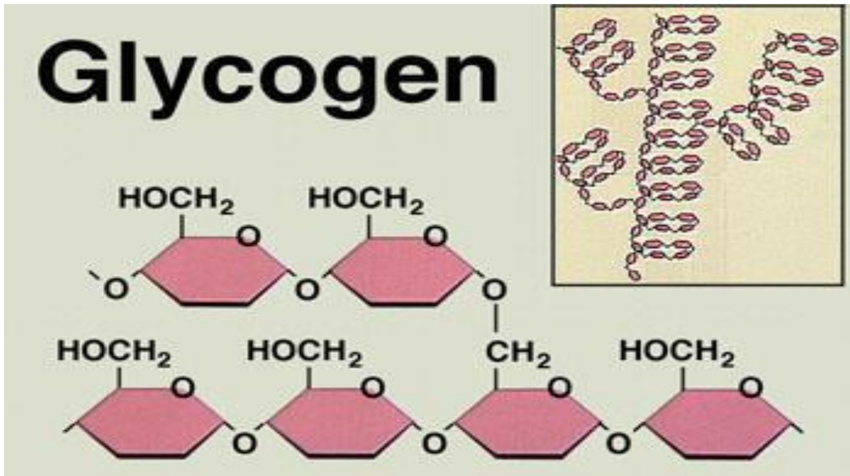
-What's the difference in structure between storage and structural polysaccharides?

Storage polysaccharides are flexible and bonds can rotate

Structural polysaccharides are rigid and tough, they mustn't be flexible.

A) Storage: store glucose molecules so whenever we need energy we take glucose molecules out of this polysaccharides and generate energy (e.g. glycogen, starch, dextran)

*Glycogen :



-it's the storage molecule in animal cells

-homopolysaccharide

-made up of glucose molecules

-found in liver cells as granules, each granule is made up of glucose monomers that are bonded to each other and rotating on each other to store as many glucose monomers as they can in a small space that's why it's also branched.

-linkage:

In the linear structure (inside the chains): α: 1-4

At the branching point, the linkage is: α-1:6 (but in the chain itself: α: 1-4)

-it gives a branch every 10 glucose residues (glycogen a is very highly branched molecule)

*Starch:

-storage molecule in plant cells

-homopolysaccharid

-found in two forms : Amilose and amilopectin

Amilose which is less abundance (10%-20%), not branched (chain structure), the glycosidic linkage: α-1:4.

Amilopectin which is more abundant (80%-90%), branched,The glycosidic linkage in the linear structure is α-1:4 and at the branching point α-1:6, it gives a branch every 25 glucose residue (less branched than glycogen).

When starch or glycogen (like meat) are digested they can give either free glucose units or Maltose disaccharide.

*Dextran:

-storage molecule in yeast and bacteria

-branched

-glycosidic linkages are variable (1-2, 1-3, or 1-4)

-homopolysascharide

-all are made up of α-glucose molecules

B) Structural: form the structure of a tissue, organ or body (e.g. cellulose, Actin, Pectin)

*Cellulose:

-homopolysaccharide, made up of β-glucose monomers (The importance of the β conformation is that bonds can't rotate)

-when lining up chains top to each other they form a hydrogen bonds and the result is a large, rigid and tough structure made up of chains linked by Hydrogen bonds (these chains are rigid structures).

-when digested it gives a disaccharide called: cellobiose.

-there're no enzymes to digest it in the human body.

-importance of eating cellulose or fibers:

1) It helps in solving the problem of constipation (امساك) which happens because of not having enough water in the intestine. so when we eat fibers (they're bulky) they go to the intestine and the intestine try to get rid of them and force the body to absorb water in the intestine to get rid of these bulky fibers then the problem is solved.

2) Help in getting rid of poisons and reduce the risk of having cancer. (long-term benefit)

*Chitin:

-found in insects, it forms exoskeleton.

-homopolysaccharide, made up of N-Acetyl-β-D-Glucosamine which is a glucose molecule has an acetylated amine group.

-glycosidic linkage: β-1:4

*Pectin: structural molecule

-goes along with cellulose (found in plants)

-homopolysaccharide, made up of modified acidic form of galactose (galactonic acid) {replacement of C-6 with carboxylic group}

Note : Are polysaccharides reducing sugars? (Like glycogen or chitin)?

Remember: to call a molecule a reducing sugar, it should have a free anomeric carbon, but in polysaccharides only terminal points have free anomeric carbon and it forms only a too small portion of the molecule. So it’s not enough to call the whole molecule a reducing sugar.

-Some other structural types of polysaccharides

A-GLYCOSAMINOGLYCANS (GAG) (glycans indicates sugars, amino indicates that these sugar molecules are modified (amino sugars).

-heteropolysaccharides, made up of repeated disaccharides (these disaccharides are characterized by being charged –they have a negative charge by having polar groups like carboxylic group or sulfur groups).

-contain modified aminosugars, either glucosamine or galactosamine

Why they are negatively charged?

1-To interact with water.

2- Because they form the ECM in connective tissues (including blood) ,e.g: in cartilage found in the knee for example; when we jump and release the pressure and the negative charges create repulsion and the tissue extends so it forms a caution to protect our joints.

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

B-PROTEOGLYCANS

-They have lots of sugars connected to some proteins:

-importance:

1-they are lubricants

2-they are structural components in connective tissue.

3-mediate adhesion of cells to the ECM: bind two cells to each other.

4- sometimes cell receives growth factors and such things that the cell doesn't need at the present time so they can be stored by binding to the proteoglycans.

5-Bind factors that stimulate cell proliferation and cell growth.

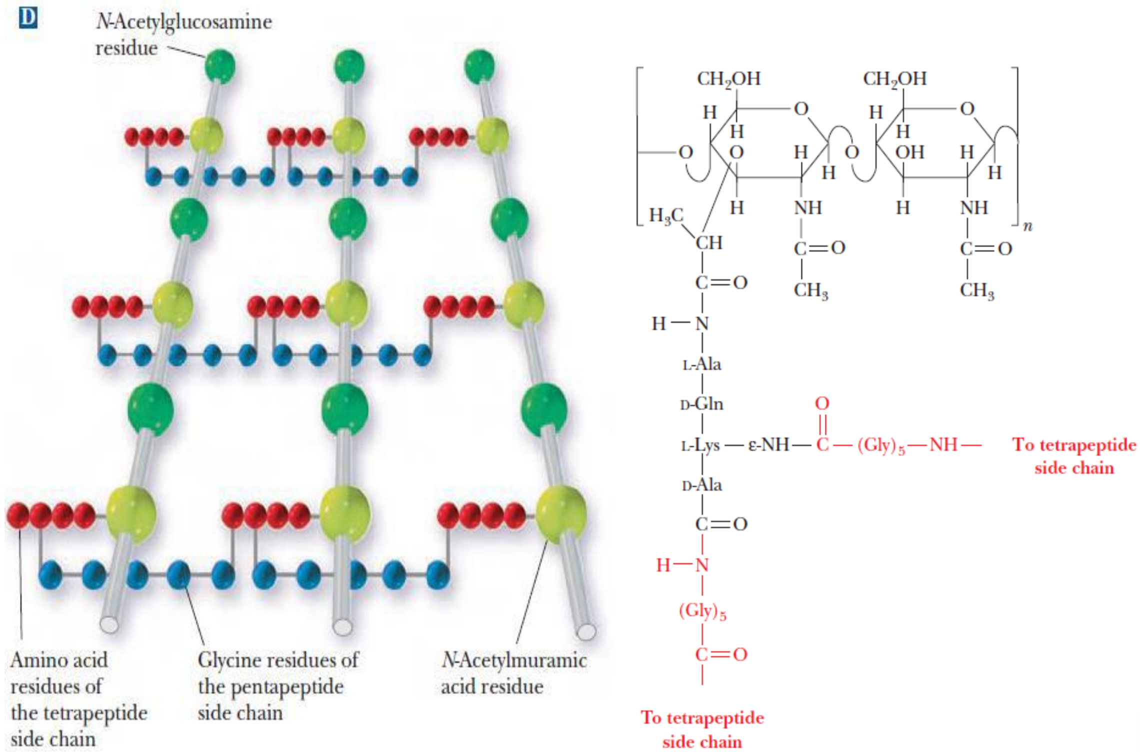
6- Make up the bacterial cell wall:

-made of: repeated disaccharides which are NAG N-acetylglucosamine and NAM N-acetylmuramic acid (a glucose molecule that has Lactic acid linked to it).

-You have different chains of these disaccharides, these chains are connected to each other by peptides extending from them and those peptides can have D as well as L amino acids, one of these amino acids is L-lysine, and from this amino acid you can have an extending pentaglycine peptide which is connected to another amino acid which is alanine which is the terminal point of this peptide.

Overall, this structure is known as Peptidoglycan

D



-GLYCOPROTEINS:

-lots of proteins connected to them some sugars

-carbohydrates (sugars) can be connected to proteins either to:

1)The nitrogen if Aspargine (N-glycosidic linkage through the amide group of asparagine)

2)The hydroxyl group of serine, threonine or sometimes hydroxylisne (O-glycosidic linkage is to the hydroxyl of serine, threonine, or hydroxylysine).

-note: Significance of protein-linked sugars:

1) Determine protein folding: presence of sugar can create additional noncovalent interactions between different groups of

proteins (it creates repulsion) so their presence influences protein folding

2)It also determines protein targeting: when protein is synthesized in a cell they can have many sugars linked to them, and trhese specific types of sugar can tell where this protein should go (plasma membrane, outside cell, stay inside, etc…)

3) They also prolong protein's half-life: one example is Albumin .Its half life is 19 days ,without glycosylating its half life would be an hour and a half.

4- Signaling

5-Cell-cell communication: An example is Blood typing: where we have a fatty acid known as singolipid modified by a number of sugars (backbone) and they can be connected to :

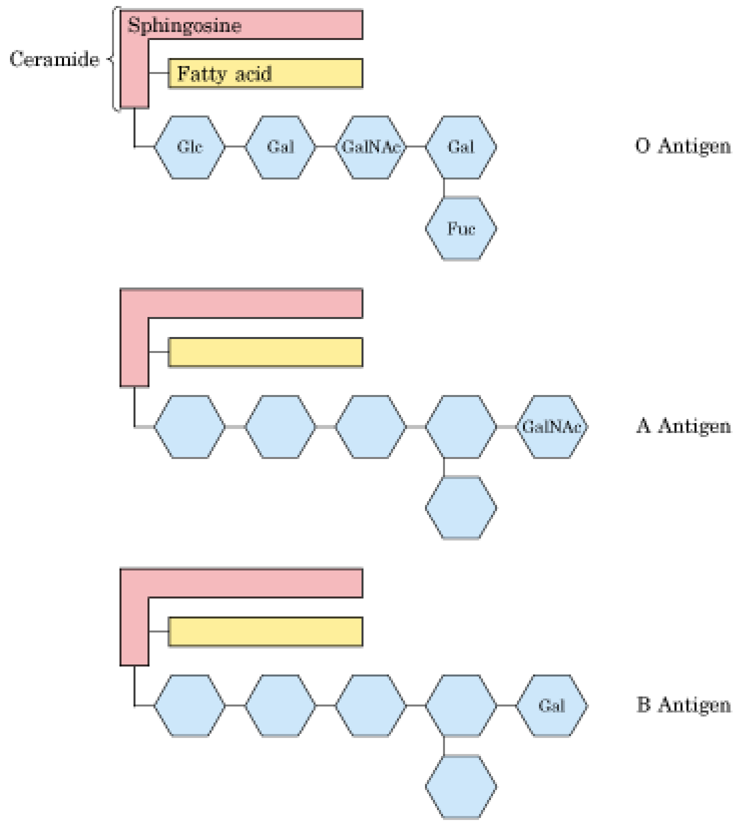
1)nothing → O type

2) Galactose→ B type

3) N-acetylgalactosamine → A type

That's why we can transfer blood from O to all other blood types, because the immune system can recognize the whole backbone but if we transfer from A to B , cell can't recognize the N-acetylgalactosamine for example; and so on.

Note: a person with a blood type AB can get blood from any other type of blood, because the immune system of that person will recognize all antigens, it'll also recognize A antigens as well .as B antigens



-SIALIC ACID / N-acetylneuraminate

A modified sugar

-made up of the amino sugar: neuraminic acid

-found in terminal points of oligosaccharides and glycoproteins.

- present in the nervous system.