



# CARBOHYDRATE CHEMISTRY

## Mucopolysaccharides

by

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# MUCOPOLYSACCHARIDES (Glycosaminoglycans GAGs)

## I. Neutral mucopolysaccharides:

- Formed of protein & polysaccharides.
- Contain acetyl hexosamines but no uronic acid.
- Present in mucous secretion.

## II. Acidic mucopolysaccharides:

A. Non-sulfated

B. Sulfated



## Heterogeneous (mucopolysaccharides GAGs)

I. Neutral	II. Acidic	
NANA in tissue of vertebrate & bacteria	A. Non-sulfated	Hyaluronic a.
Bl. gp subs. ( <u>L-fucose</u> is important constituent)	B. sulfated	Heparin
Gonadotrophins & thyrotrophic H		Heparan sulphate
$\alpha 1$ & $\alpha 2$ globulins		Chondroitin sulfate
Ovalbumin		Keratan sulphate
Fibrinogen		Dermatan sulphate



**N.B. L-fucose is deoxyhexose at C6 (C<sub>6</sub>H<sub>12</sub>O<sub>5</sub>)**

**NANA: Pyruvate + mannosamine**

# Mucopolysaccharides (negatively-charged)

- Most GAG are present extracellular except heparin
- They act as lubricant and cushion for other tissues as they absorb large amount of water
- On compression of GAG; water is squeezed out and they occupy smaller volume. When the compression is released they return to their original volume. This property is called **resilience** of synovial fluid and vitrous humor of the eye.

## Acidic MPS

Formed of (repeated disaccharide units):

1- amino-sugar acids OR amino- sugars

2- Uronic acid (glucuronic or iduronic) OR

monosaccharide Linked by glycosidic bond



# II. Acidic mucopolysaccharides

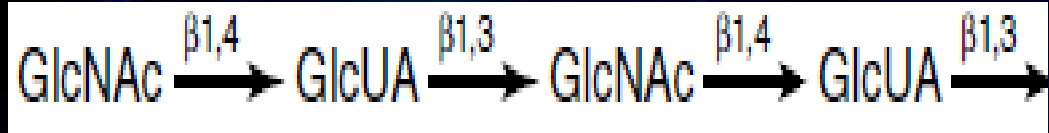
## A. Non-sulfated mucopolysaccharides:

### 1. Hyaluronic acid

- Repeating units of N-acetyl glucosamine & B-glucuronic a.

#### Functions:

- Forms the cement substance between tissues.
- Present in synovial fluid (lubricant facilitates joint movement)
- Makes cartilage compressible.
- Makes ECM loose (by the ability to attract H<sub>2</sub>O).
- Permits cell migration during wound repair & morphogenesis.



## (N.B.)

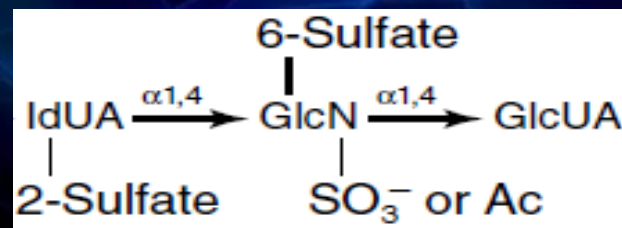
- It facilitates cell migration; being produced in increased amount by tumor cells; so facilitates migration through ECM & spread of tumor.
- Hyaluronidase secreted by certain bacteria causes destruction of this cement subs. (hyaluronic a) so help spread of infection (spreading factor).
- Hyaluronidase is present in acrosomal cap of sperm & invades the tissues of the ova causing destruction of hyaluronic a. & its fertilization.
- Morphogenesis: cell differentiation into tissues & organs in the embryo



# A. Sulfated mucopolysaccharides:

**1-Heparin:** repeating units of:

- **Sulfated glucosamine & Sulfated glucuronic a. (or L-iduronic a.)**
- linked by  **$\alpha$ -1,4 glycosidic bond.**
- Formed by **mast cells (intracellular), located along the blood vessel wall** in many tissues like heart, lung, liver, kidney, skin & spleen.
- Its concentration in blood is very low.



**N.B. Iduronic acid is C5 epimer of glucouronic acid (differ in the position of  $-\text{OH}$  at C5)**



# Functions of heparin

## 1. Anticoagulant:

It activates antithrombin III &

It Inhibits blood clotting factors II, VII, IX & X.

## 2. Plasma clearance from lipids:

It activates lipoprotein lipase that digests  
plasma lipids.

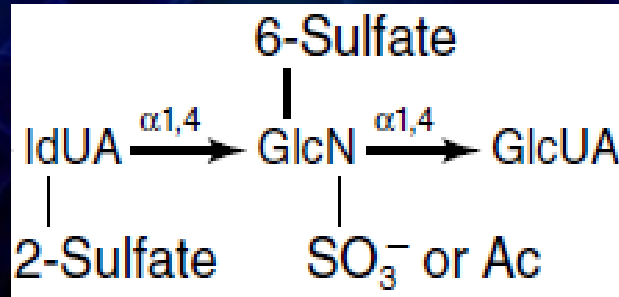
(heparin & lipoprotein lipase are clearing factors)





## 2- Heparan sulphate:

- It differs from heparin in the amount of **uronic a.** & the sulphate attached to glucosamine  
**(more glucuronic a. but less sulphated glucosamine)**.
- It is a component of ECM in the form of proteoglycans. It has a role in:
  1. **Cell-cell interaction &**
  2. **Cell membrane receptors.**



### 3- Chondroitin sulfate: repeating units of:

- N- acetyl galactosamine &  $\beta$ -glucuronic a. linked by B-1,3 bond. Types: 3 (A, B & C)

#### 1- Chondroitin sulfate A:

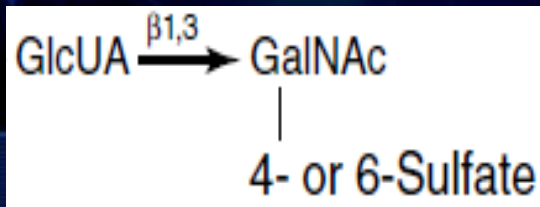
sulfate ester gp of N- acetyl galactosamine

at C4 → *Chondroitin-4-sulfate A*

at C6 → *Chondroitin-6-sulfate C*

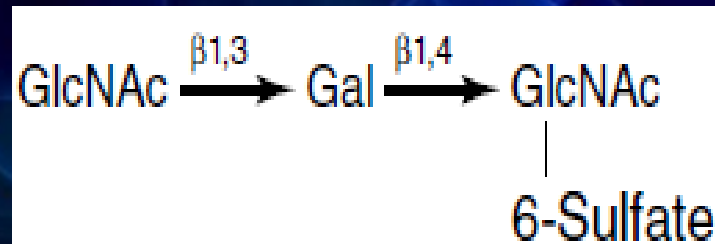
Chondroitin itself is a minor component of ECM but its sulfate ester (A & C) are major component of cartilage, bone, cornea & other connective tissues.

**2- Chondroitin sulfate B:** It yields upon hydrolysis L-iduronic a. instead of D-glucuronic a.



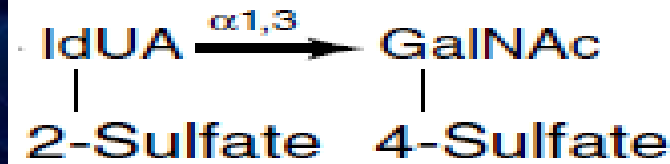
## 4- Keratan sulphate: repeating units of:

- Galactose and N-acetyl glucosamine linked together by  $\beta$ - bond.
- No uronic acid.
- Present in cornea (to make it transparent), cartilage and tendons.



## 5- Dermatan sulphate: repeating units of:

- L-iduronic acid and N-acetyl galactosamine linked together by  $\alpha$ -1,3 bond.
- Present in blood vessels, heart, cornea, sclera & skin. It maintains the shape of sclera



Points	Hyaluronic a	Heparin	Heparan S	Chondroitin S	Keratan S	Dermatan S
Amino S.	Glucosamine	Glucosamine	Glucosamine	Galactosamine	Glucosamine	Galactosamine
Uronic a	Glucuronic a	Glucuronic + <b>Iduronic</b>	<b>Glucuronic</b> + Iduronic	Glucuronic + Iduronic	<b>Galactose</b> (No uronic a)	Iduronic a
Sulfate	<b>Absent</b>	Present	Present	Present	Present	Present
Bonds	<b><math>\beta</math>-1,3 &amp; <math>\beta</math>- 1,4</b>	<b><math>\alpha</math>-1,4</b>	<b><math>\alpha</math>-1,4</b>	<b><math>\beta</math>-1,3</b>	<b><math>\beta</math>-1,3 &amp; <math>\beta</math>- 1,4</b>	<b><math>\alpha</math>-1,3</b>
Sites	- S.C. tissues - Ovum Wall -Synovial fluid	-CT <u>Mast cells</u> (liver, spleen, kidney, bone marrow) but least conc. in blood.	EXTRA- CELLULAR Matrix (ECM)	- Matrix of cartilage - Tendons - Ligaments - Bone	- <u>Cornea</u> . -Cartilage -Tendons	-Blood vessels -Heart. - <b>Cornea</b> , - <b>Sclera</b> - Skin.
Function	Protective for tissues	Anticoagulant Lipid clearance from plasma	-Cell-cell interaction -Cell membrane receptors	Supportive	Supportive Transparency of cornea	Supportive Maintains the shape of sclera

**N.B. When proteins are connected to acidic mucopolysaccharides →→ proteoglycans**





**Thank you**