

BCM 210 LECTURE
SALEMCITY, A.J

CARBOHYDRATE CHEMISTRY

- Carbohydrates (saccharides) are a large family of naturally occurring compounds including sugars, starches, and cellulose, as well as materials found in bacterial cell walls and insect exoskeletons.
- Carbohydrates, in general, contain a C-C skeletal monomers bearing C=O and OH (and sometimes NH₂) functional groups.

SUGAR DERIVATIVES OF BIOLOGICAL IMPORTANCE

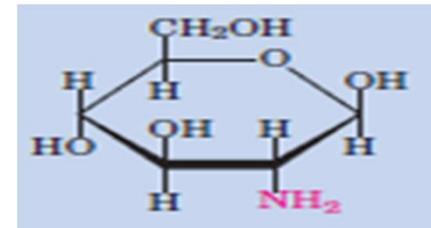
- Monosaccharides undergo various reactions to form biologically important derivatives.
- The important functional groups present in monosaccharides are hydroxyl and carbonyl groups.
- The hydroxyl group forms phosphodiester bond, usually with phosphoric acid or is replaced by a hydrogen or amino group.
- The carbonyl group undergoes reduction or oxidation to produce number of derived monosaccharides.

- These derivatives include amino sugar, sugar acids, sugar phosphates, deoxy sugars, and sugar amides etc.

➤ **Amino Sugars and N-acetylated sugars**

- The hydroxyl group, usually at C-2, is replaced by an amino group to produce amino sugars such as glucosamine, galactosamine and mannosamine.
- The amino group may be condensed with acetic acid to produce N-acetyl amino sugars, for example, N-acetyl glucosamine.
- This glucosamine derivative is important constituent of many structural polymers (chitin, bacterial cell wall polysaccharides etc.).

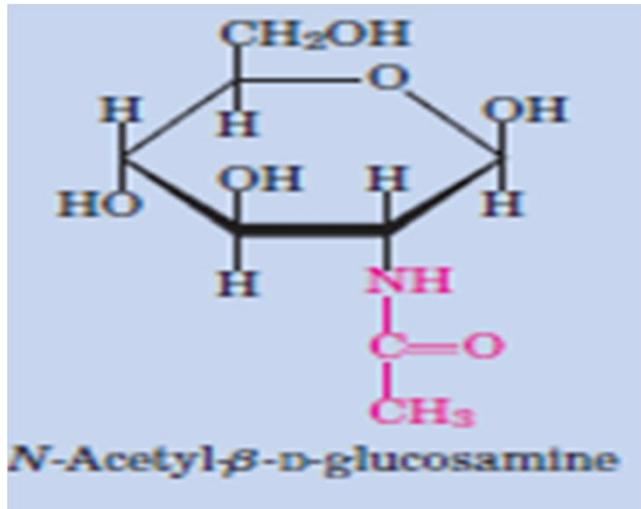
- **Glucosamine:** the systemic name is 2-Amino-2-deoxy-D-glucose.
- Glucosamine is an amino sugar derived from glucose, produced in the body from the sugar glucose and the amino acid glutamine through the action of the enzyme glucosamine synthetase.
 - Glucosamine stimulates the synthesis of proteoglycans, glycosaminoglycans (also called mucopolysaccharides), and collagen.
 - Glycosaminoglycans are a major component of joint cartilage, supplemental glucosamine may help to rebuild cartilage and treat arthritis.



- It therefore plays a role in the formation of cartilage and the cushioning synovial fluid between the joints
- Glucosamine has been shown to help repair the mucosal-lining defensive barrier called the glycosaminoglycan layer (GAG).
- Defects in the GAG layer have been implicated in Crohn's disease, ulcerative colitis, and interstitial cystitis.

➤ **N-Acetylglucosamine (GlcNAc)**

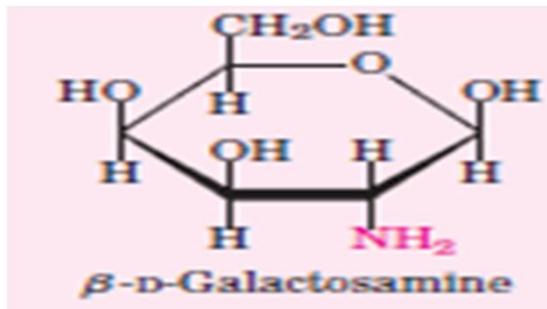
- GlcNAc is a crucial biopolymer component of the bacterial cell wall which alternates between monomeric chains of GlcNAc and N-acetyl muramic acid, cross-linked with oligopeptides at the lactic acid residue of MurNAc. This is called peptidoglycan.



- GlcNAc is the monomeric unit of the polymer chitin found in insects and crustaceans.
- In bacteria, GlcNAc induces components that are important for colonization of human hosts, including fimbriins that mediate adhesion to host cells, multidrug exporter genes and Curli fibers that promote biofilm formation.
- In mammals, GlcNAc is a key sensor of nutrient status that is involved in insulin signaling, cell cycle control, and other essential processes.
- N-acetylglucosamine also play role in limiting cholesterol absorption and decreasing insulin secretion.

➤ Galactosamine

Galactosamine is a hexosamine derived from galactose. This amino sugar is a constituent of some glycoprotein hormones such as follicle-stimulating hormone (FSH) and luteinizing hormone (LH).



➤ **N-Acetylgalactosamine**

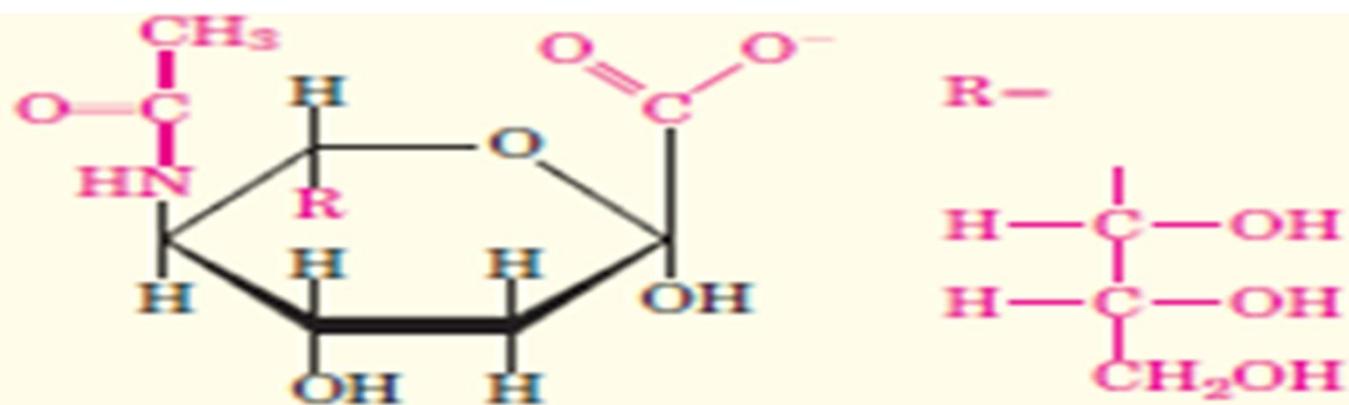
- Chemically, it is an amide between galactosamine and acetic acid.
- N-Acetylgalactosamine is necessary for intercellular communication, and is concentrated in sensory nerve structures of both humans and animals.

- N-acetylgalactosamine is also concentrated in other sensory nerve structures especially in the retina, photoreceptors, optic nerve, and the epithelial pigment of the eyes of both humans and animals.
- Thus, suggesting it may be extremely important for optimal vision.

➤ **Neuraminic acid and Sialic acid**

- Neuraminic acid ($\text{C}_9\text{H}_{17}\text{NO}_8$) is a nine carbon monosaccharide. It may be theoretically visualized as the aldol-condensation product of pyruvic acid and D-mannosamine .
- The N- or O-substituted derivatives of neuraminic acid are collectively and commonly known as sialic acids, with N-acetylneuraminic acid as the predominant .

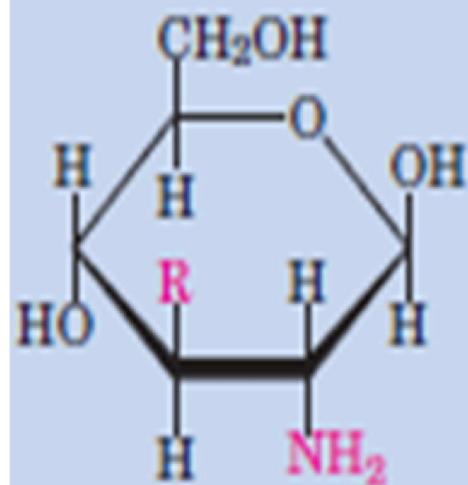
- Neuraminic acid does not occur naturally, but its derivatives are widely distributed in animals tissues such as brain, heart etc and in the body fluids like amniotic fluid, saliva and breast milk.
- It is important for brain development, learning, memory and cognitive performance.
- N-acetylneuraminic acid is important for cellular communication and is an immune system modulator.
- As an immune modulator, N-acetylneuraminic acid affects the viscosity of mucus, which in turn repels viruses, bacteria and other pathogens.



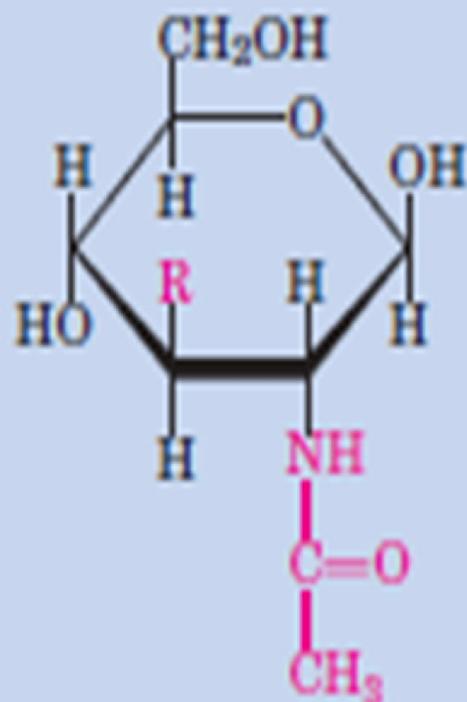
N-Acetylneuraminic acid
(a sialic acid)

➤ **N-Acetylmuramic acid, or MurNAc**

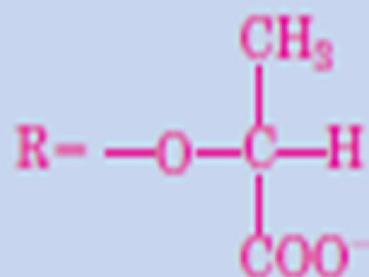
- Molecular formula: **C₁₁H₁₉NO₈**
- It is the ether of lactic acid and N-acetylglucosamine.
- It is part of a biopolymer in the bacterial cell wall, built from alternating units of N-acetylglucosamine (GlcNAc) and N-acetylmuramic acid (MurNAc) linked by $\beta(1\rightarrow4)$ glycosidic bonds, cross-linked with oligopeptides at the lactic acid residue of MurNAc.
- This layered structure is called peptidoglycan.



Muramic acid



N-Acetylmuramic acid



➤ **Polyols**

- Both aldoses and ketoses are reduced to polyhydric alcohols (polyols) when treated with enzymes, sodium amalgam, and hydrogen under high pressure with catalyst or sodium borohydride.

➤ **Ethylene glycol**

- In its pure form, it is an odourless, colourless, syrupy liquid with a sweet taste.
- Ethylene glycol is toxic, and its ingestion should be considered a medical emergency.

- Glucose
- Fructose
- Mannose
- Glyceraldehyde
- Erythrose
- Ribose
- Galactose

Sorbitol
Sorbitol and mannitol
Mannitol
Glycerol
Erythritol
Ribitol
Dulcitol

➤ **Glycerol**

- Glycerol is a precursor for synthesis of triacylglycerols and of phospholipids in the liver and adipose tissue.
- The glycerol component can be converted to glucose by the liver and provides energy for cellular metabolism.

➤ **Erythritol**

- Erythritol is a natural sugar alcohol. It occurs naturally in fruits and fermented foods.

➤ **Xylitol**

- It naturally occurs in the fibers of many fruits and vegetables, including various berries, cornhusks, oats, and mushrooms. Xylitol is roughly as sweet as sucrose but with only two-thirds the food energy.

- Xylitol is a low-calorie alternative to table sugar.

➤ **Mannitol**

- Mannitol is used clinically to reduce acutely raised intracranial pressure, until more definitive treatment can be given, and to treat patients with oliguric renal failure.
- Mannitol can also be used to open the blood-brain barrier by temporarily shrinking the tightly coupled endothelial cells that make up the barrier.
- This makes mannitol indispensable for delivering various drugs directly to the brain (e.g. in the treatment of Alzheimer's disease)

➤ **Sorbitol**

- As a food additive it is categorized as a sweetener, emulsifier and humectant.
- Ingesting excess sorbitol can lead to some abdominal pain, gas, and mild to severe diarrhea.
- Diabetic retinopathy and neuropathy may be related to excess sorbitol in the cells of the eyes and nerves.

➤ **Carboxylic acid sugars**

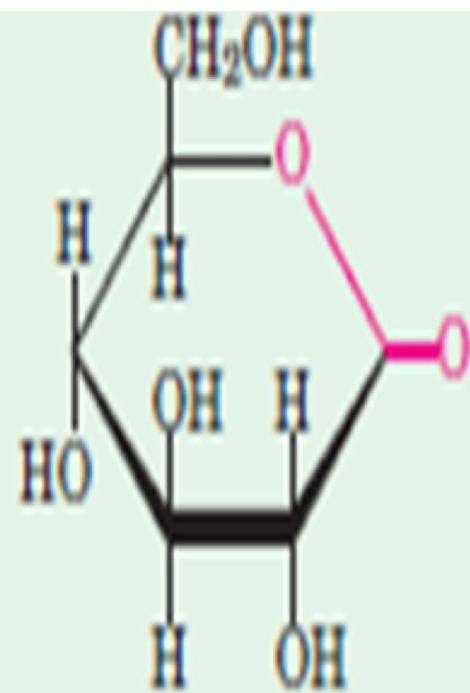
- The carbonyl group at C1 of monosaccharides may be oxidized to generate aldonic acids while C-6 oxidation results in uronic acids.

❖ **Glucuronic acid**

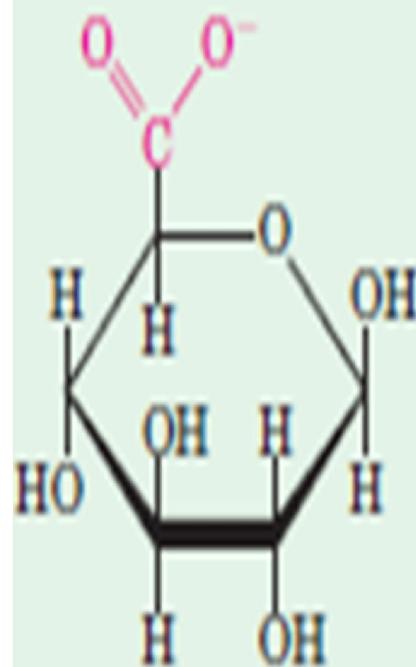
- Glucuronic acid is a carboxylic acid. It occurs by C-6 oxidation.
- In the animal body, glucuronic acid is often linked to poisonous substances, mainly in the liver, to allow for subsequent elimination, and to hormones to allow for easier transport.
- These linkages involve O-glycosidic bonds. The process is known as glucuronidation.

➤ **Gluconic acid**

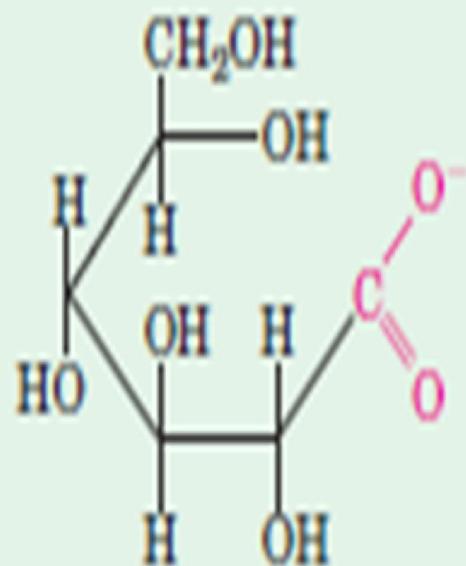
- Gluconic acid is the carboxylic acid formed by the oxidation of the C-1 of glucose.
- In aqueous solution, some gluconic acid molecules will convert to the cyclic ester Glucono delta lactone, and the two exist in equilibrium.
- Gluconic acid occurs naturally in fruit, honey, and wine; and is used as a food additive, an acidity regulator. It is a strong chelating agent, especially in alkaline solution.



D-Glucono- δ -lactone



β -D-Glucuronate



D-Gluconate