Biochemistry I

Carbohydrates

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Biomedical important

Glucose is the most important carbohydrate; most dietary carbohydrate is absorbed into the bloodstream as glucose, and other sugars are converted into glucose in the liver.
It is the precursor for synthesis of all the other carbohydrates in the body, including
glycogen for storage;
ribose and deoxyribosein nucleic acids; and galactose in lactose of milk, in glycolipids, and
in combination with protein in glycoproteins and proteoglycans. Diseases associated with carbohydrate metabolism include <u>diabetes mellitus, galactosemia, glycogen storage diseases,and lactose intolerance</u>.

Classification of carbohydrates

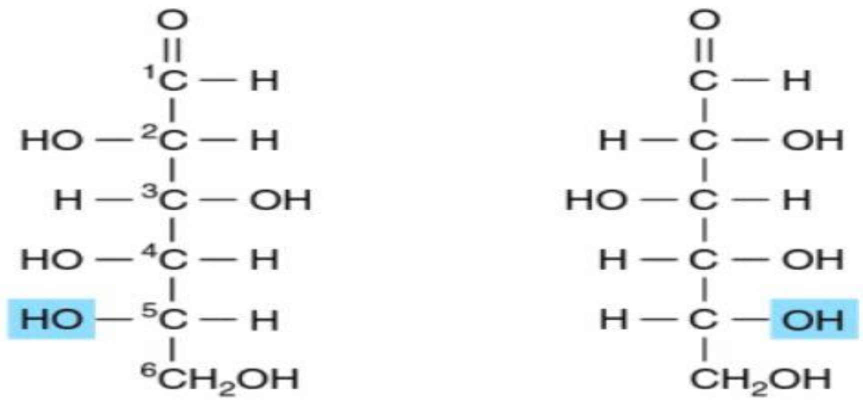
1)Monosaccharides are those carbohydrates that cannot be hydrolyzed into simpler carbohydrates: classified as trioses, tetroses, pentoses, hexoses, or heptoses, depending upon the number of carbon atoms; and as aldoses or ketoses. Examples are listed in Table 13–1.

(2)Disaccharides are condensation products of two monosaccharide units. Examples are maltose and sucrose.

(3)Oligosaccharides are condensation products of three to ten monosaccharides; maltotriose is an example.

4)Polysaccharides are condensation products of more than ten monosaccharide units; examples are the starches and dextrins, which may be linear or branched polymers. Polysaccharides are sometimes classified as hexosans or pentosans, depending upon the identity of the constituent monosaccharides.

L-Glycerose (L-glyceraldehyde) | D-Glycerose (D-glyceraldehyde)



L-Glucose | D-Glucose

Figure 13–2. D- and L-isomerism of glycerose and glucose.

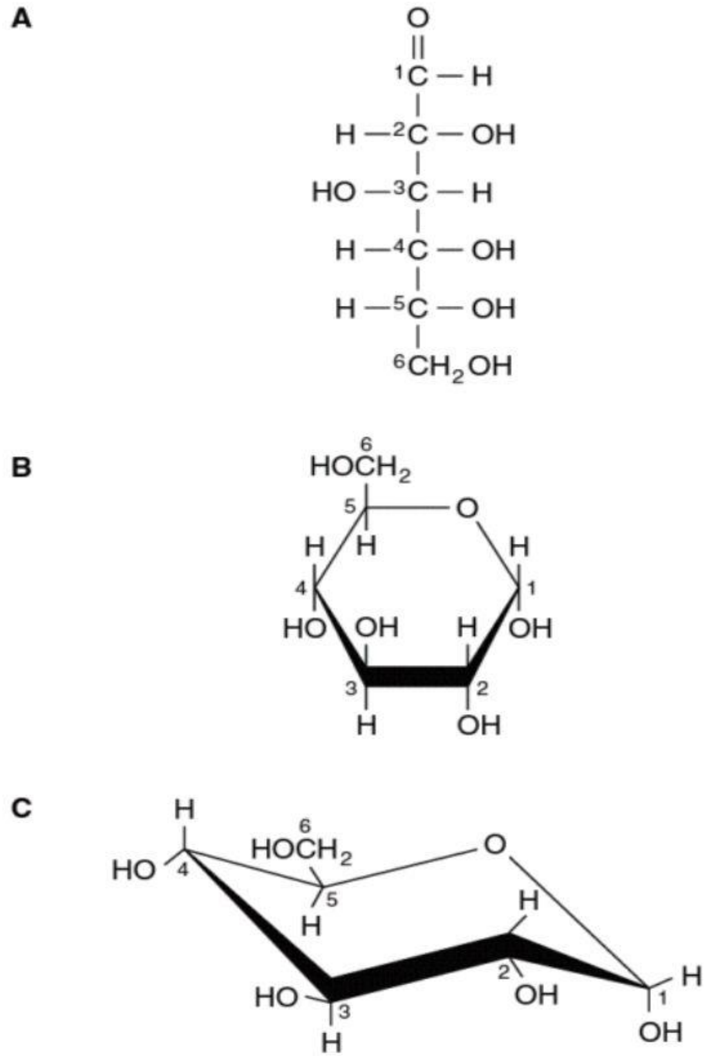


Figure 13–1. D-Glucose. A: straight chain form. B: α-D-glucose; Haworth projection. C: α-D-glucose; chair form.

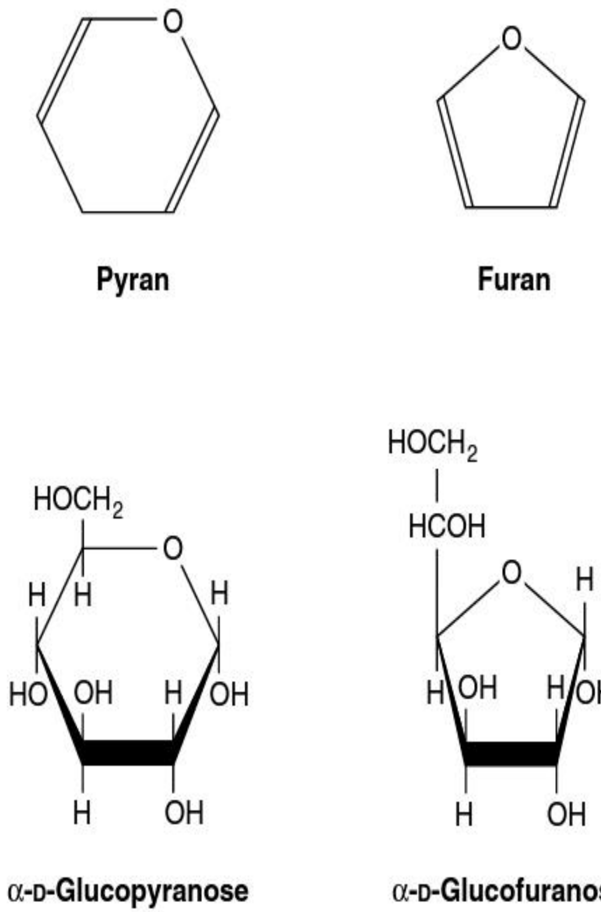


Figure 13–3. Pyranose and furanose forms of glucose.

Aldoses sugars

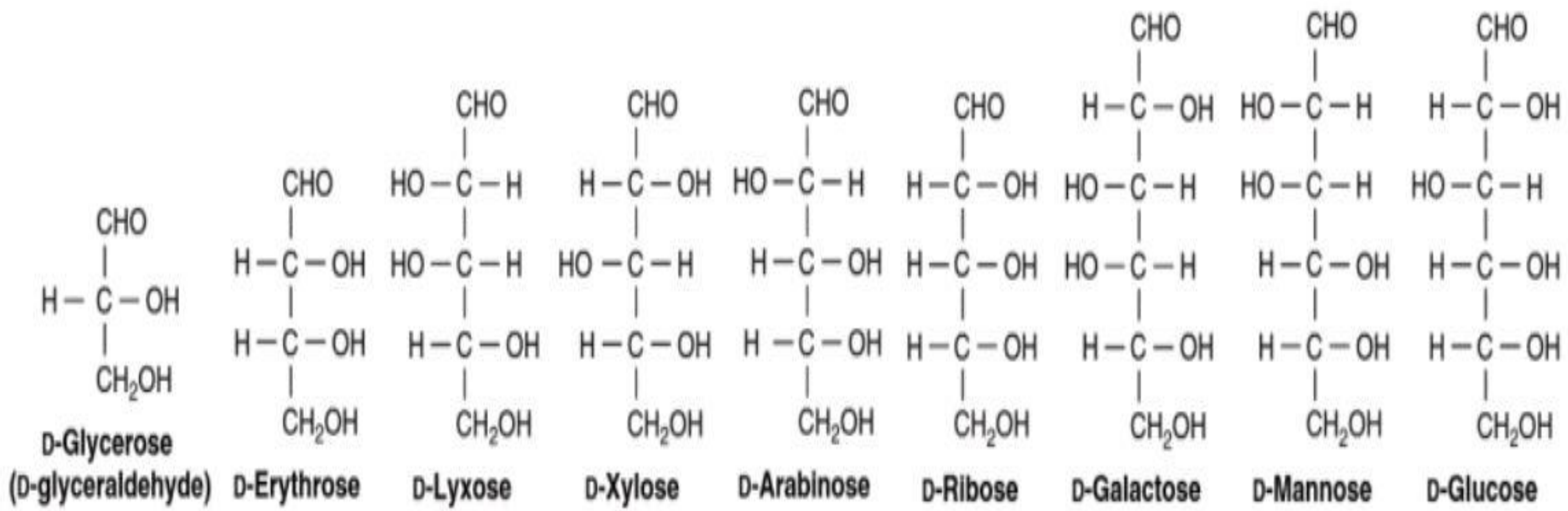
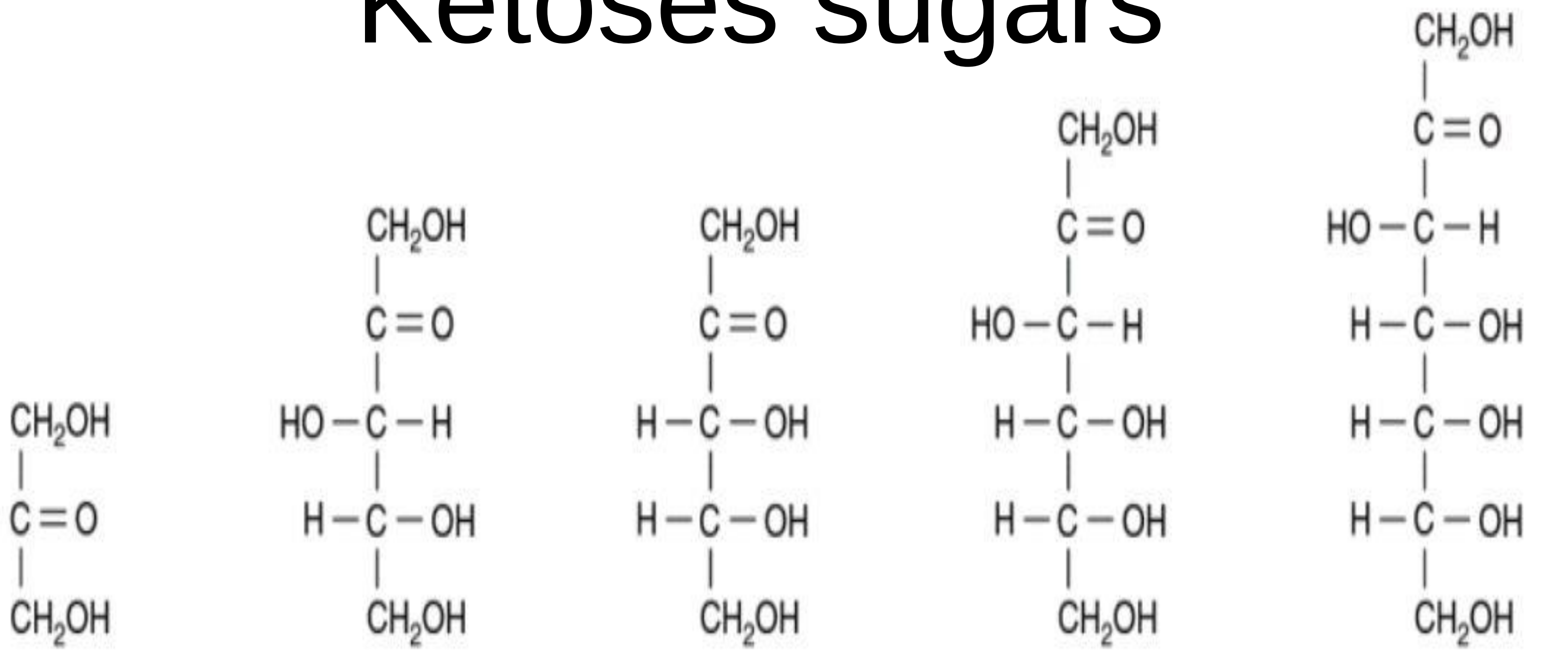


Figure 13–6. Examples of aldoses of physiologic significance.

Ketoses sugars



Dihydroxyacetone | D-Xylulose | D-Ribulose | D-Fructose | D-Sedoheptulose

Figure 13–7. Examples of ketoses of physiologic significance.

Table 13–2. Pentoses of physiologic importance.

Sugar	Where Found	Biochemical Importance
D-Ribose	Nucleic acids.	Structural elements of nucleic acids and coenzymes, eg, ATP, NAD, NADP, flavoproteins. Ribose phosphates are intermediates in pentose phosphate pathway.
D-Ribulose	Formed in metabolic processes.	Ribulose phosphate is an intermediate in pentose phosphate pathway.
D-Arabinose	Gum arabic. Plum and cherry gums.	Constituent of glycoproteins.
D-Xylose	Wood gums, proteoglycans, glycosaminoglycans.	Constituent of glycoproteins.
D-Lyxose	Heart muscle.	A constituent of a lyxoflavin isolated from human heart muscle.
L-Xylulose	Intermediate in uronic acid pathway.	

Table 13–3. Hexoses of physiologic importance.

Sugar	Source	Importance	Clinical Significance
D-Glucose	Fruit juices. Hydrolysis of starch, cane sugar, maltose, and lactose.	The "sugar" of the body. The sugar carried by the blood, and the principal one used by the tissues.	Present in the urine (glycosuria) in diabetes mellitus owing to raised blood glucose (hyperglycemia).
D-Fructose	Fruit juices. Honey. Hydrolysis of cane sugar and of inulin (from the Jerusalem artichoke).	Can be changed to glucose in the liver and so used in the body.	Hereditary fructose intolerance leads to fructose accumulation and hypoglycemia.
D-Galactose	Hydrolysis of lactose.	Can be changed to glucose in the liver and metabolized. Synthesized in the mammary gland to make the lactose of milk. A constituent of glycolipids and glycoproteins.	Failure to metabolize leads to galactosemia and cataract.
D-Mannose	Hydrolysis of plant mannans and gums.	A constituent of many glycoproteins.	

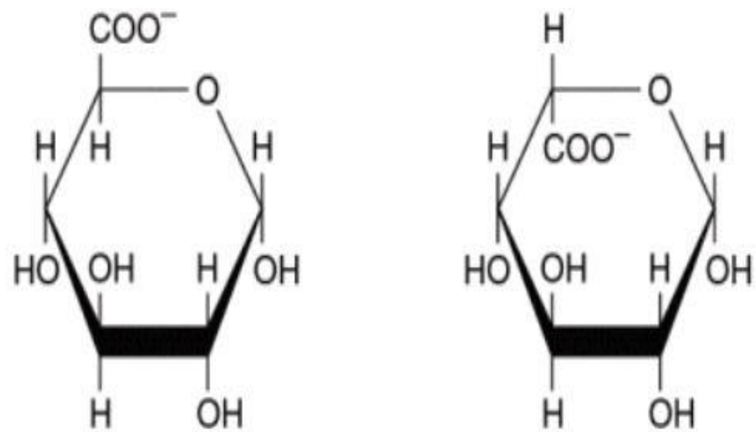


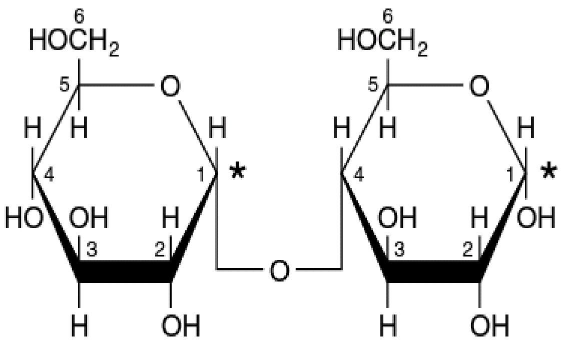
Figure 13–8. α-D-Glucuronate (left) and β-L-iduronate (right).

Disaccharides

MALTOSE, SUCROSE, & LACTOSE AREIMPORTANT DISACCHARIDES

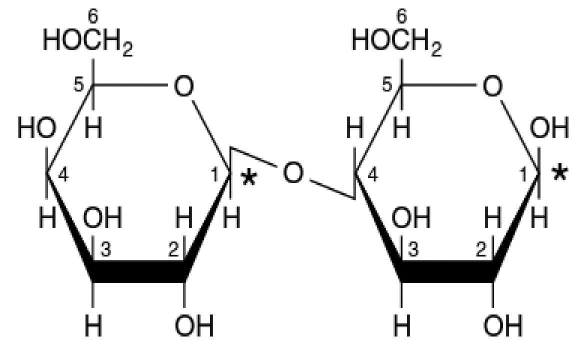
The physiologically important disaccharides are maltose, sucrose, and lactose (Table 13–4; Figure 13–11).Hydrolysis of sucrose yields a mixture of glucose and fructose.

Maltose



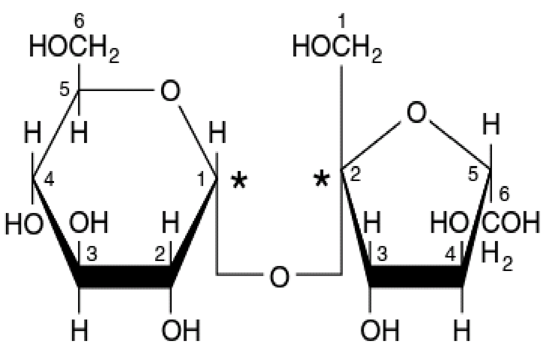
O-α-D-Glucopyranosyl-(1 → 4)-α-D-glucopyranose

Lactose



O-β-D-Galactopyranosyl-(1 → 4)-β-D-glucopyranose

Sucrose



O-α-D-Glucopyranosyl-(1 → 2)-β-D-fructofuranoside

Figure 13–11. Structures of important disaccharides. The α and β refer to the configuration at the anomeric carbon atom (asterisk). When the anomeric carbon of the second residue takes part in the formation of the glycosidic bond, as in sucrose, the residue becomes a glycoside known as a furanoside or pyranoside. As the disaccharide no longer has an anomeric carbon with a free potential aldehyde or ketone group, it no longer exhibits reducing properties. The configuration of the β-fructofuranose residue in sucrose results from turning the β-fructofuranose molecule depicted in Figure 13–4 through 180 degrees and inverting it.

Table 13–4. Disaccharides.

Sugar	Source	Clinical Significance
Maltose	Digestion by amylase or hydrolysis of starch. Germinating cereals and malt.	
Lactose	Milk. May occur in urine during pregnancy.	In lactase deficiency, malabsorption leads to diarrhea and flatulence.
Sucrose	Cane and beet sugar. Sorghum. Pineapple. Carrot roots.	In sucrase deficiency, malabsorption leads to diarrhea and flatulence.
Trehalose[1]	Fungi and yeasts. The major sugar of insect hemolymph.	

[1] *O*-α-D-Glucopyranosyl-(1 → 1)-α-D-glucopyranoside.

Polysaccharide

POLYSACCHARIDES SERVE STORAGE & STRUCTURAL FUNCTIONS

Starch is a homopolymer of glucose forming an α-glucosidic chain, called a glucosan or glucan. It is the most abundant dietary carbohydrate in cereals, potatoes, legumes, and other vegetables. The two main con-stituents are amylose(15–20%), which has a non-branching helical structure; and amy-lopectin(80–85%), which consists of branched chainscomposed of 24–30 glucose residues united by 1 →4linkages in the chains and by 1 →6 linkages at the branch points. Glycogen is the storage polysaccharide in animals. It is a more highly branched structurethan amylopectin, with chains of 12–14 α-D-glucopyranose residues (in α[1 →4]-glucosidic linkage), with branching by means of α(1 →6)-glucosidic bonds

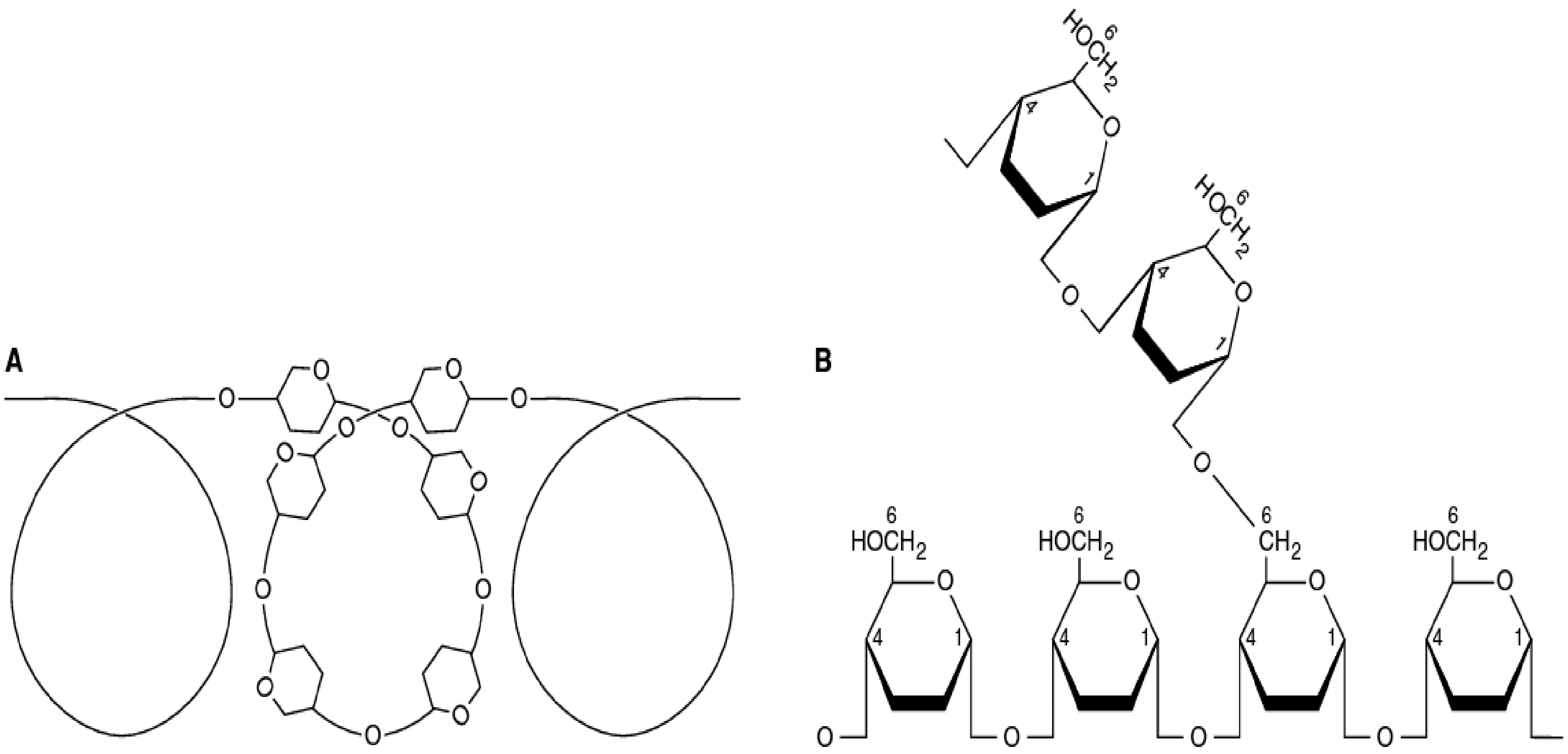
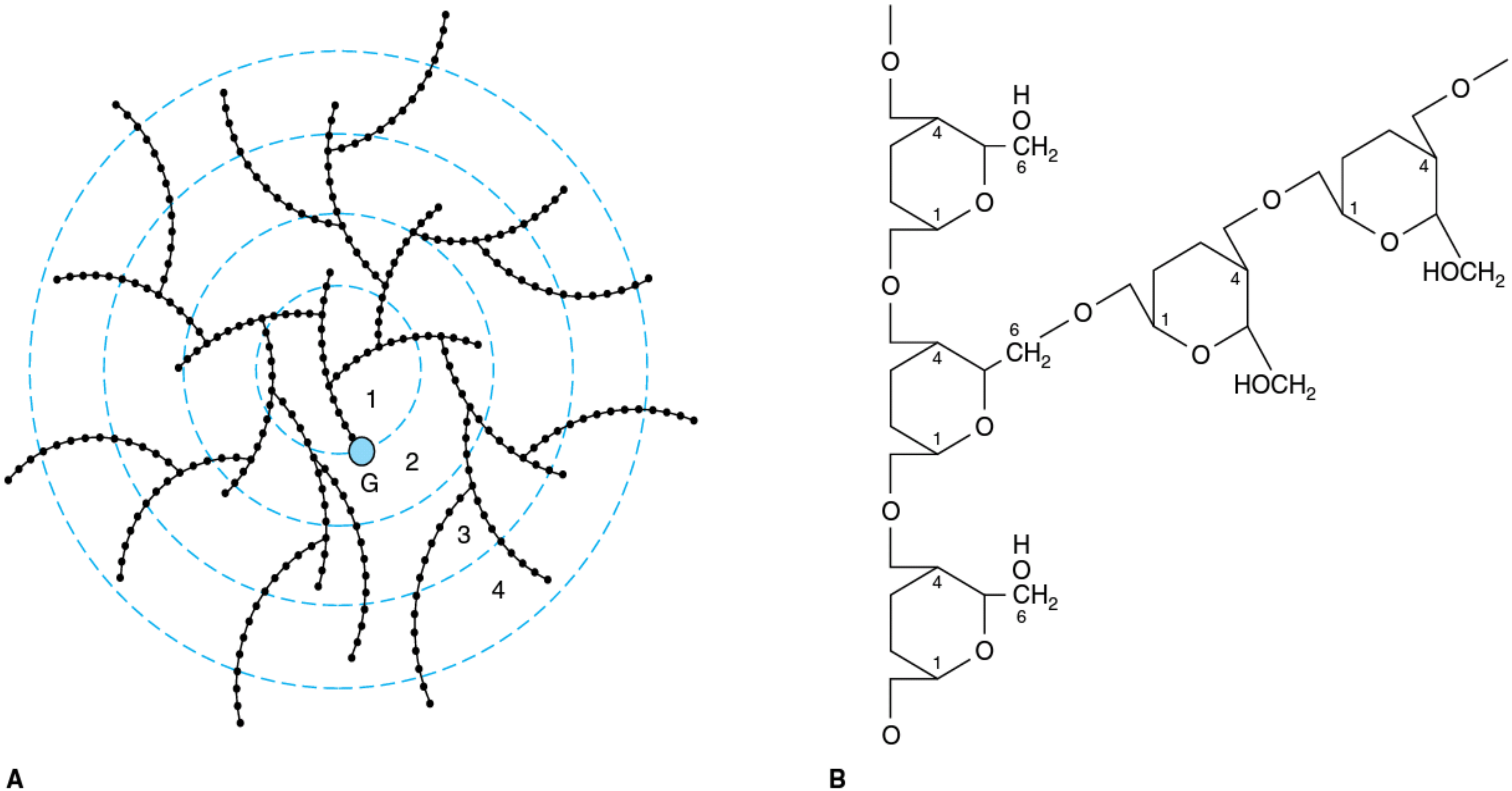


Figure 13–12. Structure of starch. **A:** Amylose, showing helical coil structure. **B:** Amylopectin, showing 1 → 6 branch point.



A **B**

Figure 13–13. The glycogen molecule. **A:** General structure. **B:** Enlargement of structure at a branch point. The

Inulin is a polysaccharide of fructose (fructosan) found in tubers and roots of dahlias, artichokes,and dandelions. It is readily soluble in water and is usedto determine the glomerular filtration rate.

Dextrins are intermediates in the hydrolysis of starch.

Cellulose is the chief constituent of the framework of plants. It is in-soluble and consists of β-D-glucopyranose units linked by β(1 →4) bonds to form long, straight chains strengthened by cross-linked hydrogen bonds. Cellulose cannot be digested by mammals because of the absence of an enzyme that hydrolyzes the βlinkage. It is an important source of “bulk” in the diet. Microorganisms in the gut of ruminants and other herbivores can hydrolyze the β-linkage and ferment the products to short-chain fatty acids as a major energy source. There is limited bacterial metabolism of cellulose in the human colon.

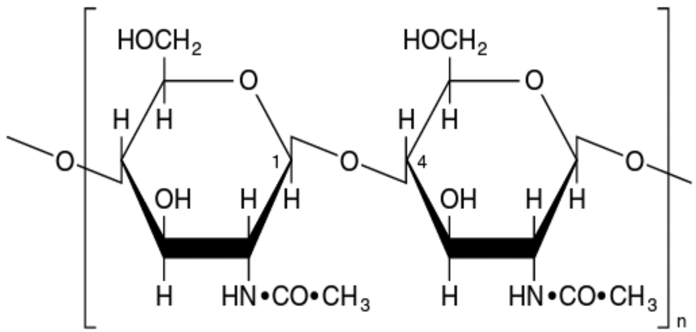
Chitin is a structural polysaccharide in the exoskeleton of crustaceans and insects and also in mushrooms. It consists of N-acetyl-D-glucosamine units joined by β (1 →4)-glycosidic linkages

Glycosaminoglycans (mucopolysaccharides) are complex carbohydrates characterized by their content of amino sugars and uronic acids.When these chainsare attached to a protein molecule, the result is a proteoglycan. Proteoglycans provide the ground or packing substance of connective tissues. Their property ofholding large quantities of water and occupying space,thus cushioning or lubricating other structures, is due to the large number of -OH groups and negative charges on the molecules, which, by repulsion, keep the carbohydrate chains apart. Examples are hyaluronicacid, chondroitin sulfate, and heparin. Glycoproteins(mucoproteins) occur in many different situations in fluids and tissues, including the cell membranes.

Glycoproteins

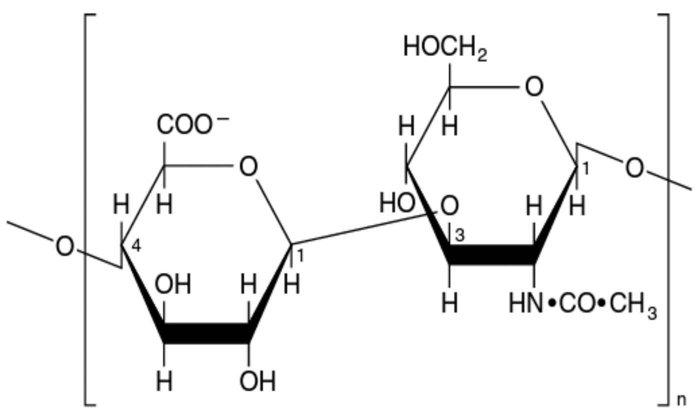
They are proteins containing branched or unbranched oligosaccharide chains see Table below. The sialic acidsare N- or O-acyl derivatives of neuraminic acid (Figure below). Neuraminic acid is a nine-carbon sugar derived from mannosamine (an epimer of glucosamine) and pyruvate. Sialic acids are constituents of both glycoproteins and gangliosides

Chitin



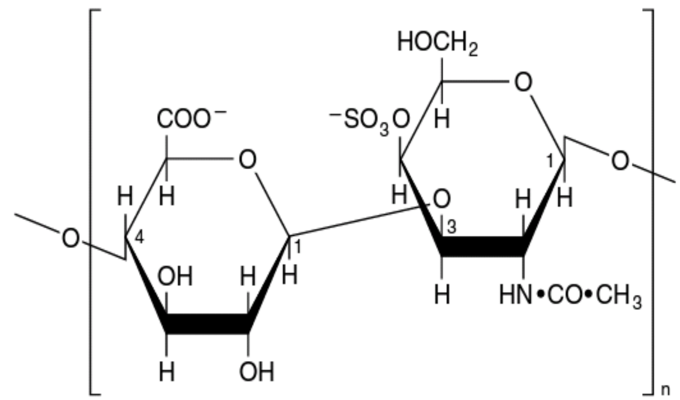
N-Acetylglucosamine *N*-Acetylglucosamine

Hyaluronic acid



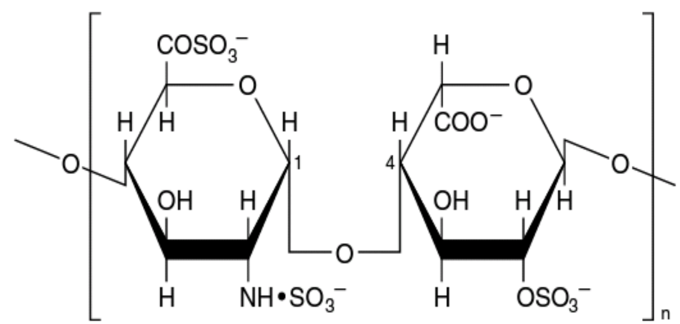
β-Glucuronic acid *N*-Acetylglucosamine

Chondroitin 4-sulfate
(Note: There is also a 6-sulfate)



β-Glucuronic acid *N*-Acetylgalactosamine sulfate

Heparin



Sulfated glucosamine Sulfated iduronic acid

Table 13–5. Carbohydrates found in glycoproteins.

Hexoses	Mannose (Man) Galactose (Gal)
Acetyl hexosamines	*N*-Acetylglucosamine (GlcNAc) *N*-Acetylgalactosamine (GalNAc)
Pentoses	Arabinose (Ara) Xylose (Xyl)
Methyl pentose	L-Fucose (Fuc; see Figure 13–15)
Sialic acids	N-Acyl derivatives of neuraminic acid, eg, *N*-acetylneuraminic acid (NeuAc; see Figure 13–16), the predominant sialic acid.

Thanks

- Any Questions ?
- Reference