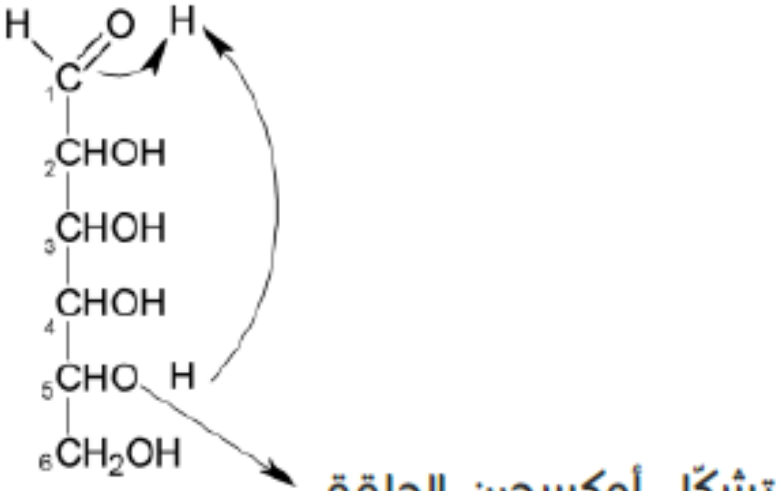
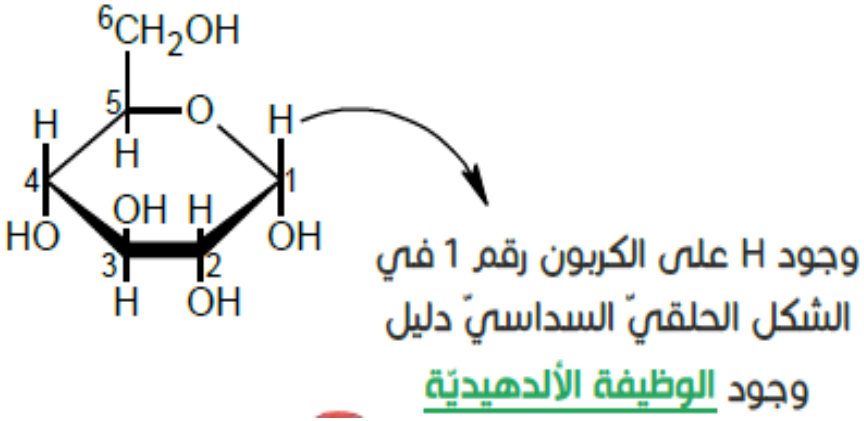
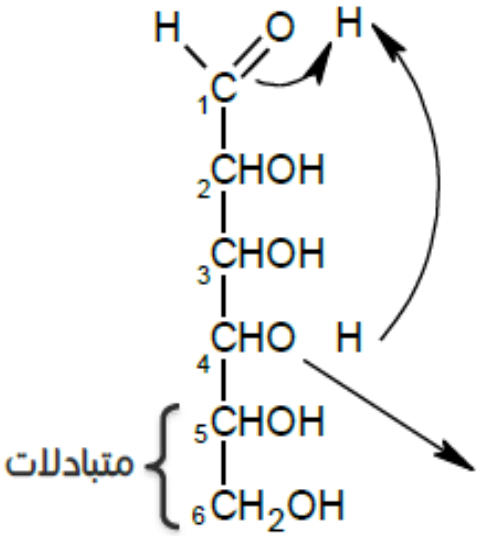
Glucose



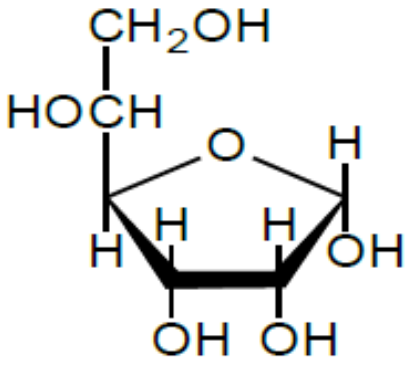
تشكّل أوكسجين الحلقة



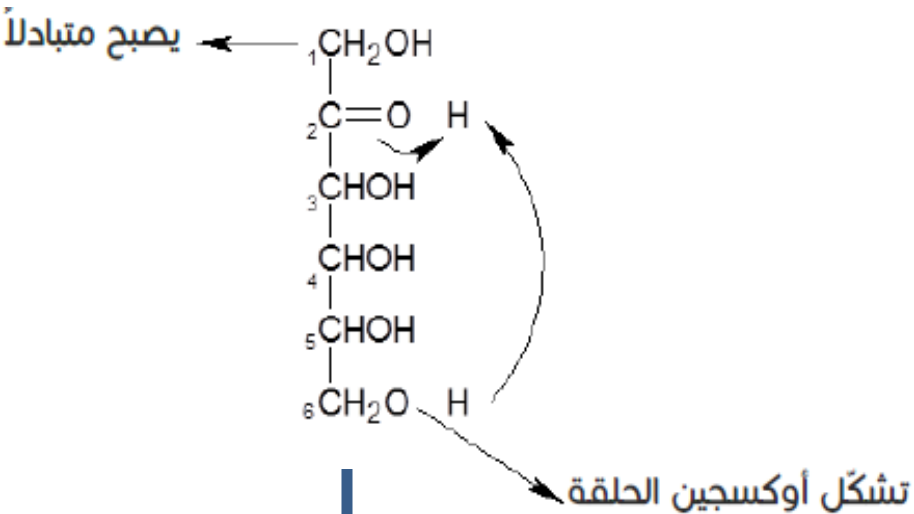
وجود H على الكربون رقم 1 في
الشكل الحلقيّ السداسيّ دليل
وجود الوظيفة الألدهيديّة

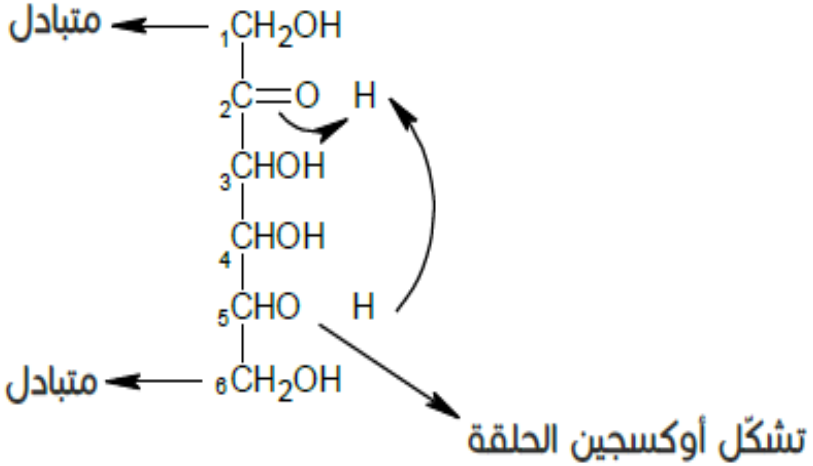


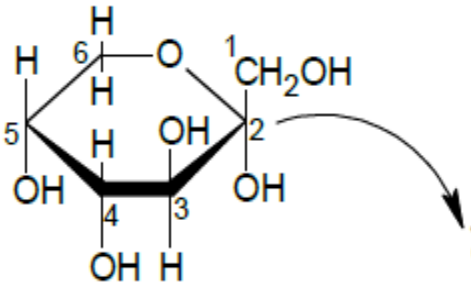
تشكّل أوكسجين الحلقة



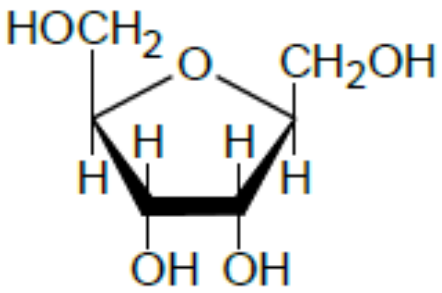
Fructose





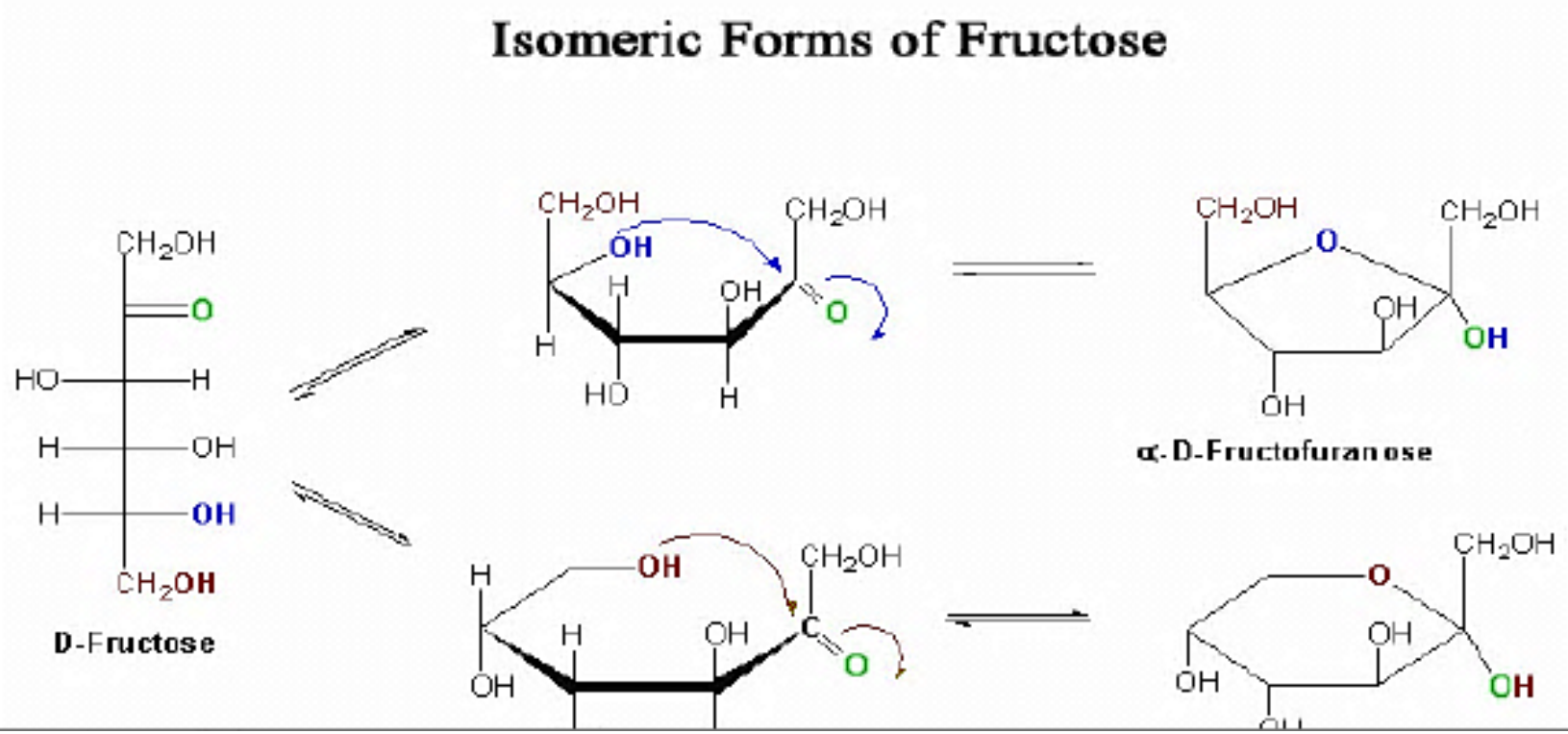


عدم وجود H على الكربون رقم 2 في الشكل الحلقيّ السداسيّ دليل وجود الوظيفة الكيتونيّة.



الفركتوز سكر كيتوني (كيتوز):

- فإذا ارتبطت زمرة الكيتون (الموجودة على الكربون رقم ٢) مع مجموعة الهيدروكسيل (الموجودة على الكربون رقم ٦) حصلنا على فركتوز سداسي الحلقة (فركتوبيرانوز).
- وإذا ارتبطت زمرة الكيتون (الموجودة على الكربون رقم ٢) مع مجموعة الهيدروكسيل (الموجودة على الكربون رقم ٥) حصلنا على فركتوز خماسي الحلقة (فركتوفورانوز).



Reactions of Monosaccharides:

Five important reactions of monosaccharides:

- Oxidation to acidic sugars
- Reduction to sugar alcohols
- Phosphate ester formation
- Amino sugar formation
- Glycoside formation

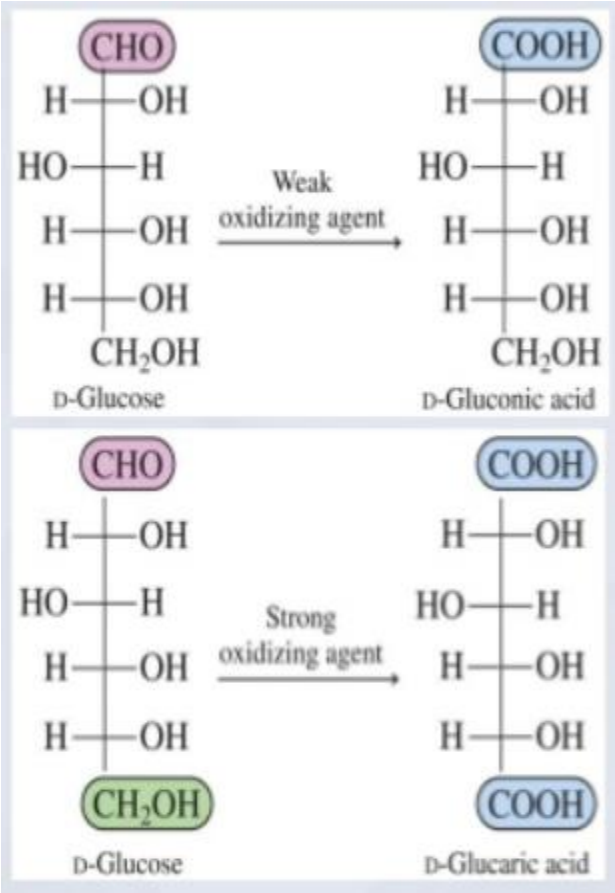
1- Oxidation

• Gives three different types of acidic sugars depending on the type of oxidizing agent used:

– Weak oxidizing agents like Tollens and Benedict's solutions oxidize the aldehyde end to give an *aldonic acid*.

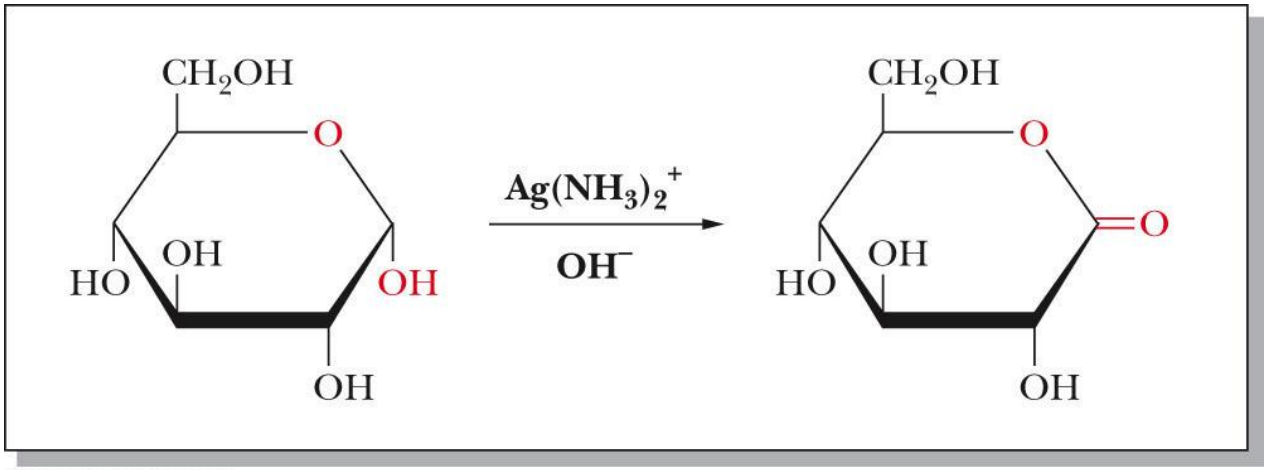
– Strong oxidizing agents can oxidize both ends of a monosaccharide at the same time to produce *aldaric acid*.

– In biochemical systems enzymes can oxidize the primary alcohol end of an aldose such as glucose, without oxidation of the aldehyde group, to produce an *alduronic acid*.



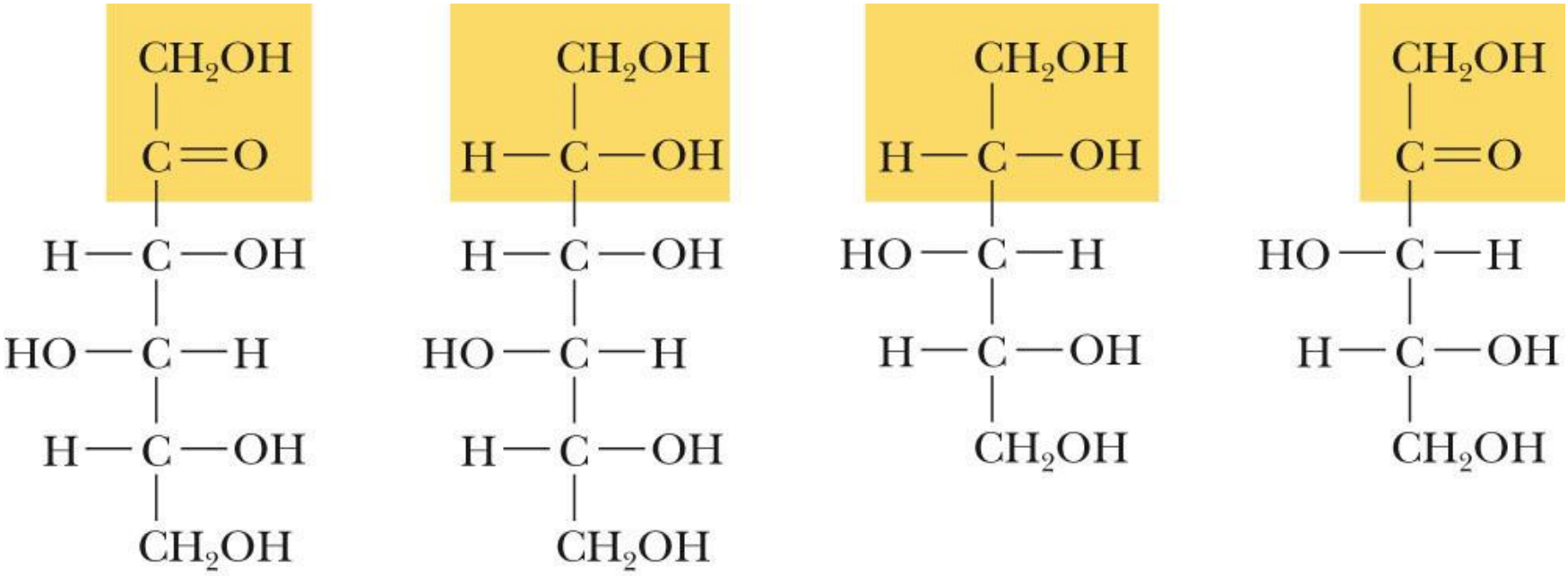
Reactions of Monosaccharides

- **A reducing sugar:** one that reduces an oxidizing agent
  - When the oxidizing agent is Tollens solution (نترات الفضة والأمونيا), silver precipitates as a silver mirror



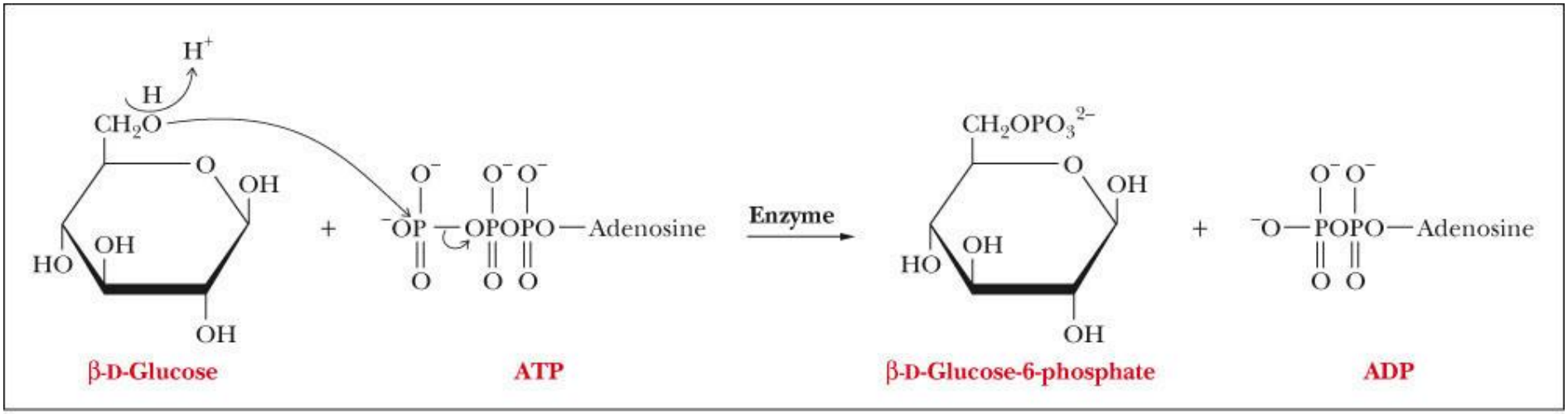
2- Reduction

- The carbonyl group of a monosaccharide can be reduced to an hydroxyl group by a variety of reducing agents (as $NaBH_4$), the corresponding polyhydroxy alcohol, sugar alcohol is produced



3- Phosphoric Esters Formation

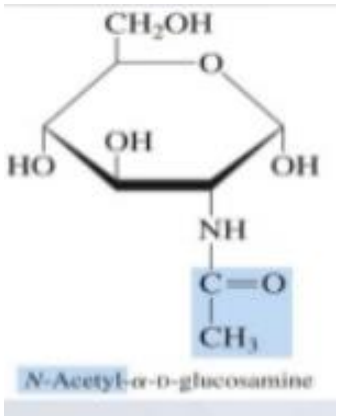
- Phosphoric esters are particularly important in the metabolism of sugars to provide energy
  - phosphoric esters are frequently formed by transfer of a phosphate group from ATP



4- Amino acids

One of the hydroxyl groups of a monosaccharide is replaced with an amino group

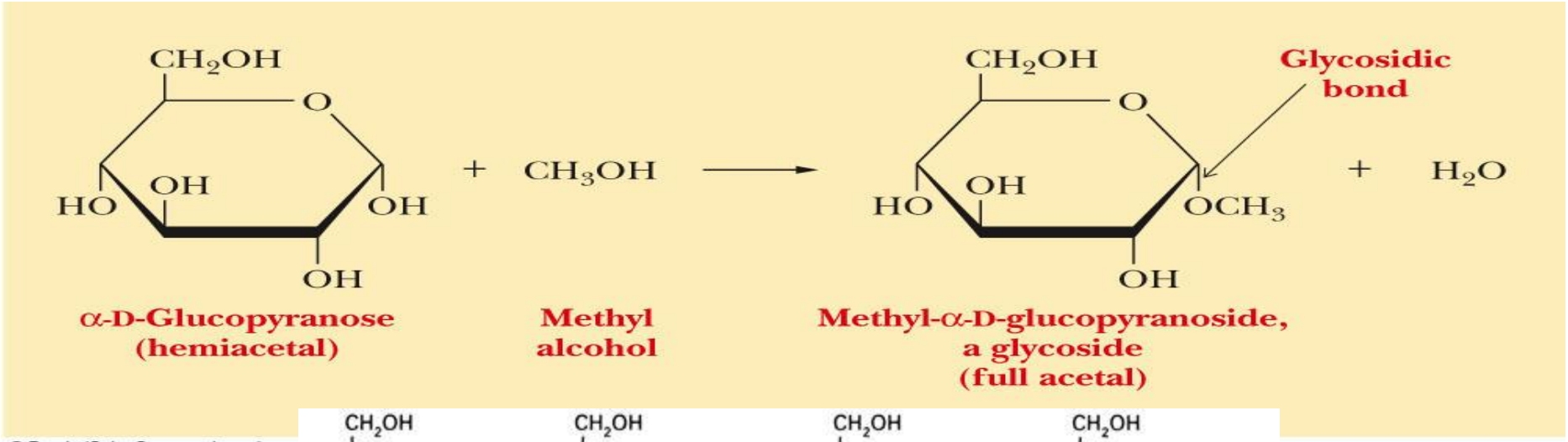
- In naturally occurring amino sugars carbon 2 hydroxyl group is replaced by an amino group
- Amino sugars and their N- acetyl derivatives are important building blocks of polysaccharides such as chitin and hyaluronic acid

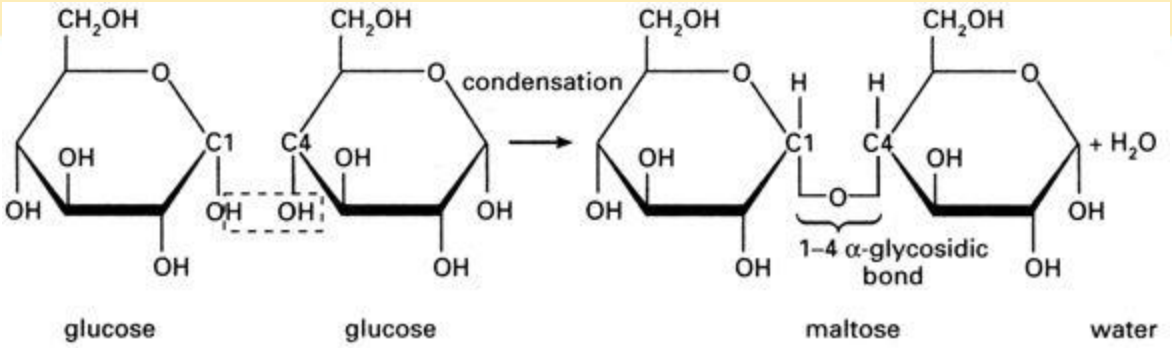


N-Acetyl-α-D-glucosamine

5- Glycosidic Bond Formation

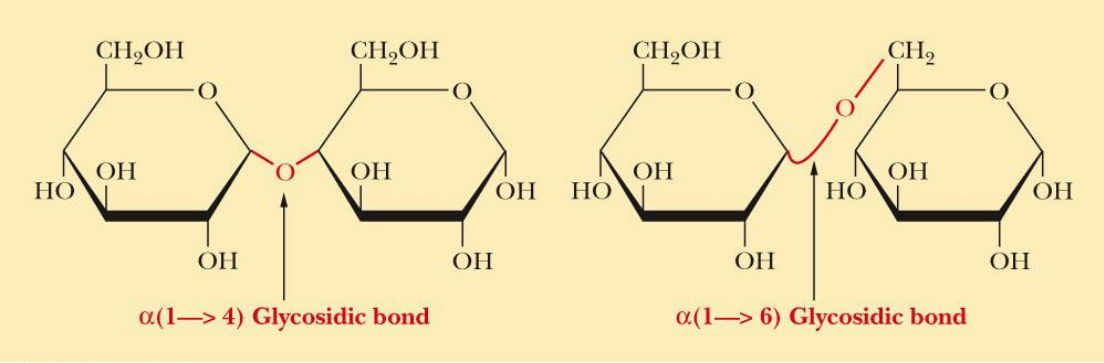
***Glycoside**: a carbohydrate in which the -OH of the anomeric carbon is replaced by -OR*

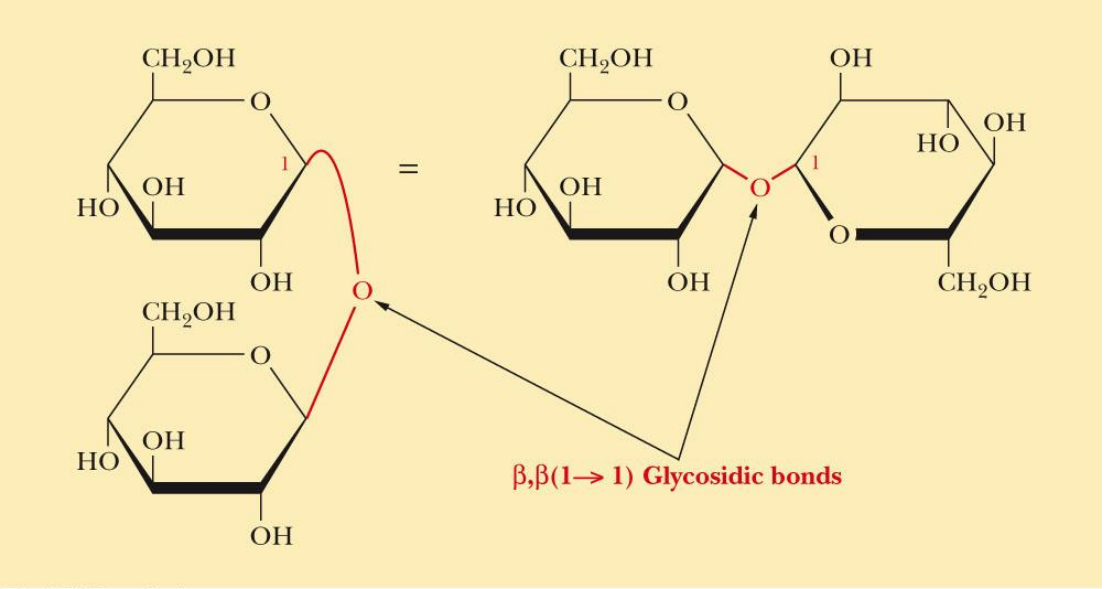




Two Different Disaccharides of α-D-Glucose

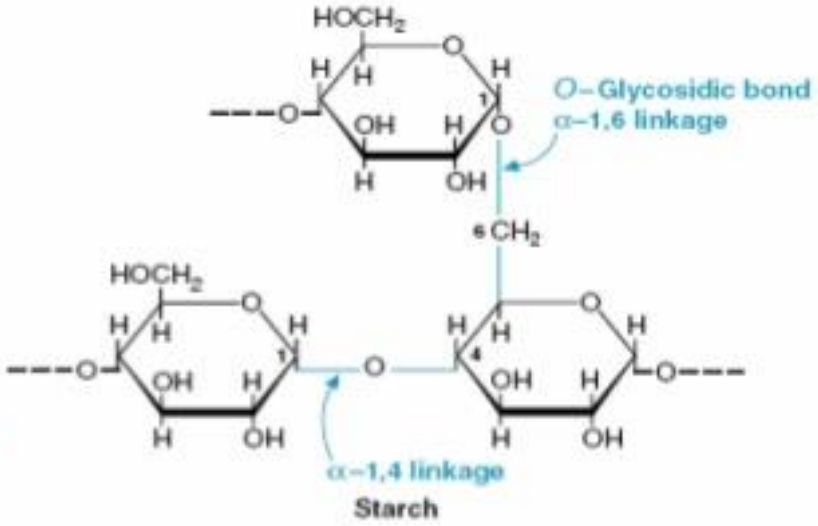
- Glycosidic linkages can take various forms; the anomeric carbon of one sugar to any of the -OH groups of another sugar to forma an α- or β-glycosidic linkage

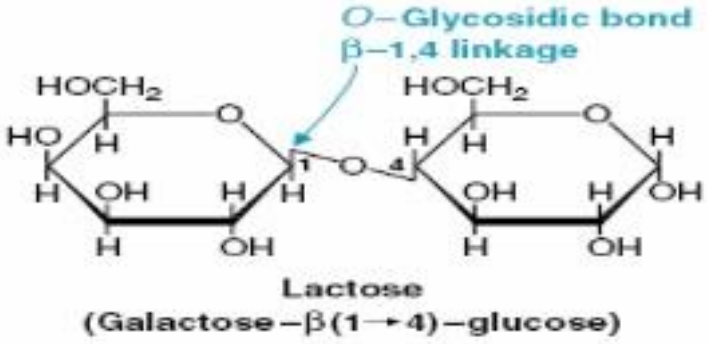




Naming glycosidic bonds

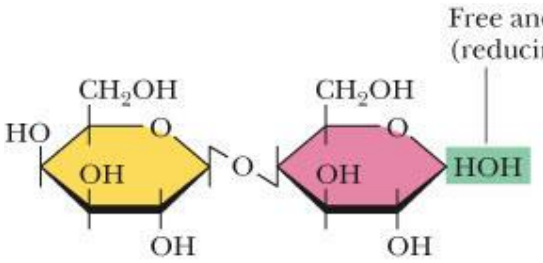
- Glycosidic bonds between sugars are named according to
  - numbers of the connected carbons (1-4, 1-6), and
  - position of the anomeric hydroxyl group of the sugar involved in the bond.



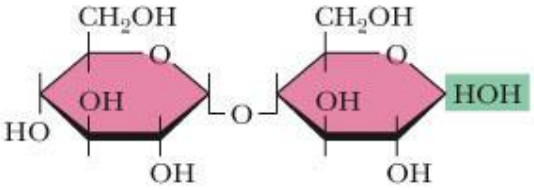


Disaccharides

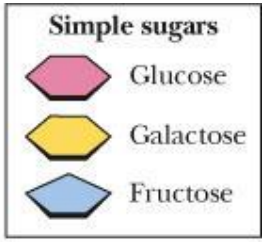
- **Sucrose**
  - Table sugar; obtained from the juice of sugar cane and sugar beet
  - One unit of D-glucose and one unit of D-fructose joined by an α-1,2-glycosidic bond
- **Lactose**
  - Made up of D-galactose and one unit of D-glucose joined by a β-1,4-glycosidic bond
  - Galactose is a C-4 epimer of glucose
- **Maltose**
  - Two units of D-glucose joined by an α-1,4-glycosidic bond
  - Formed from the hydrolysis of starch

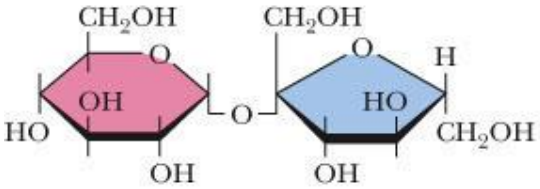


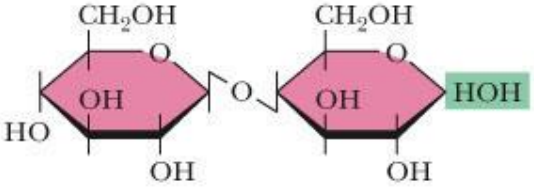
Lactose (galactose-β-1,4-glucose)



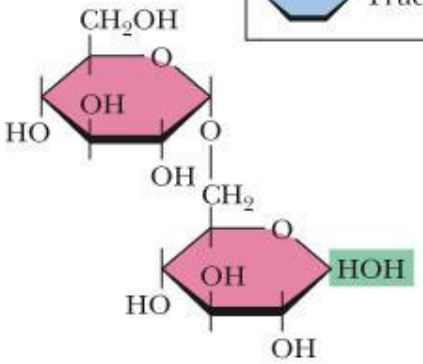
Maltose (glucose-α-1,4-glucose)




Sucrose (glucose-α-1,2-fructose)



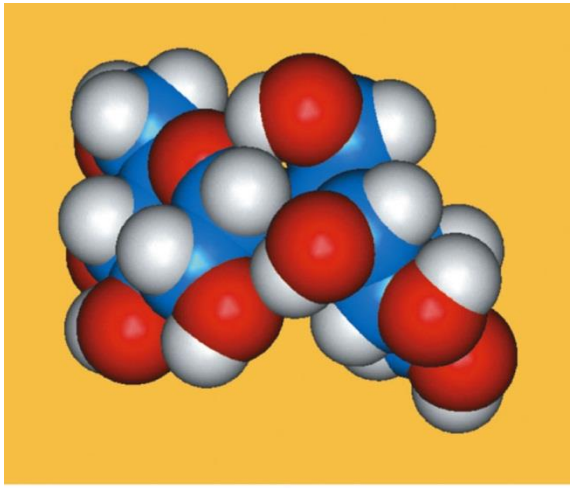
Cellobiose (glucose-β-1,4-glucose)



Isomaltose (glucose-α-1,6-glucose)

Milk sugar – human - 7%–8% lactose
cow's milk - 4%–5% lactose

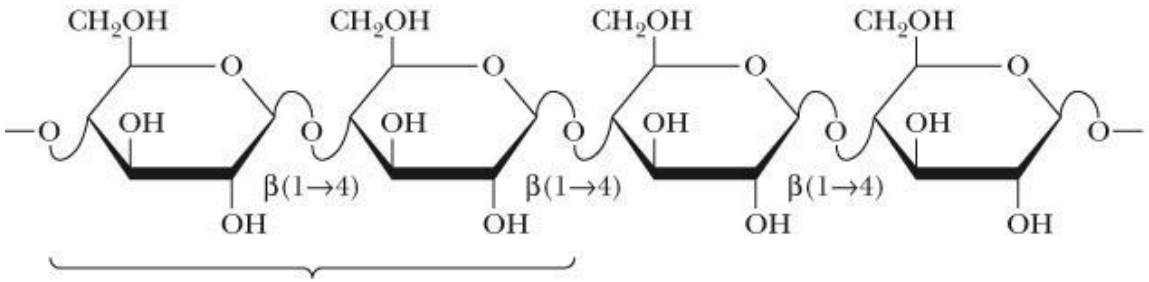
- ***Lactose intolerance: a condition in which people lack the enzyme lactase needed to hydrolyze lactose to galactose and glucose***

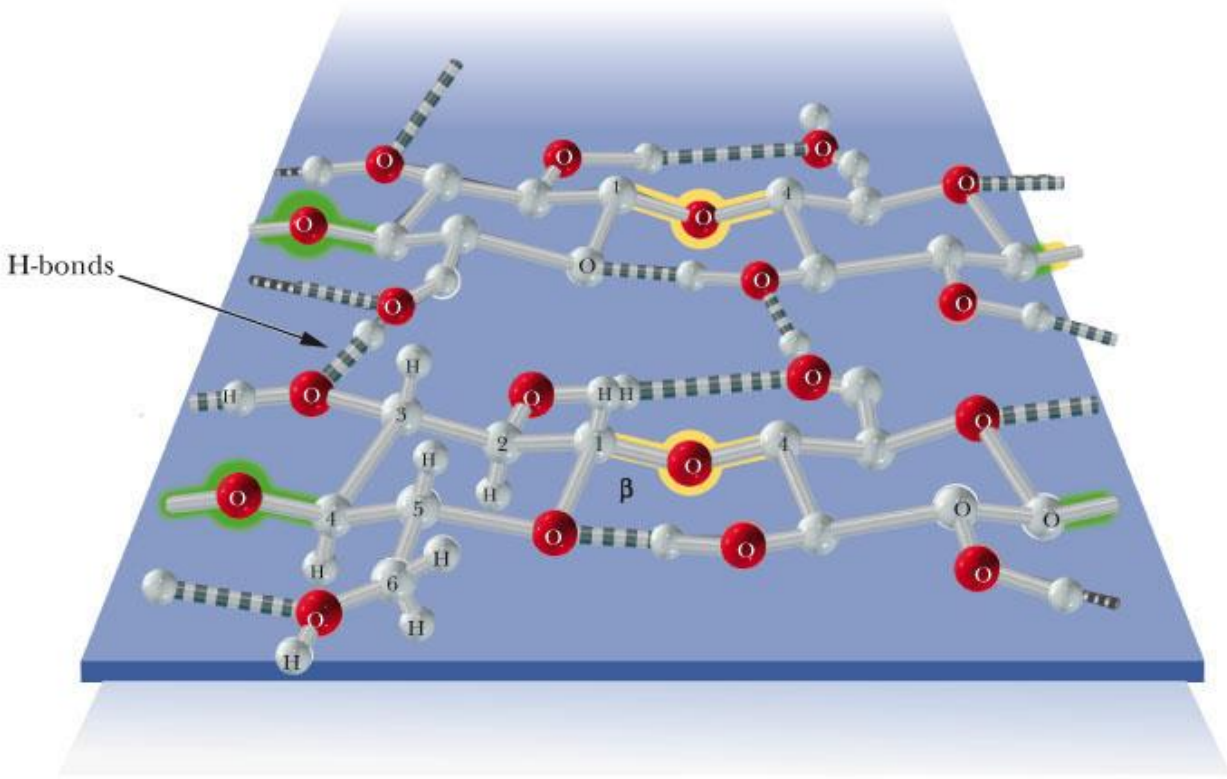

Sucrose

Structures and Function of Polysaccharides

Polysaccharide- When many monosaccharides are linked together:

- **Cellulose:** the major structural component of plants, especially wood and plant fibers
  - a linear polymer of approximately 2800 D-glucose units per molecule joined by β-1,4-glycosidic bonds
  - extensive intra- and intermolecular hydrogen bonding between chains





- **Starch** is used for energy storage in plants

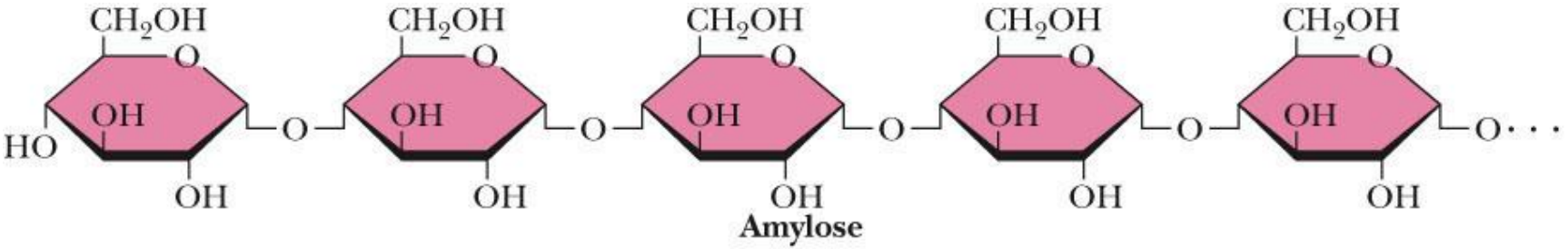
  a polymers of α-D-glucose units:

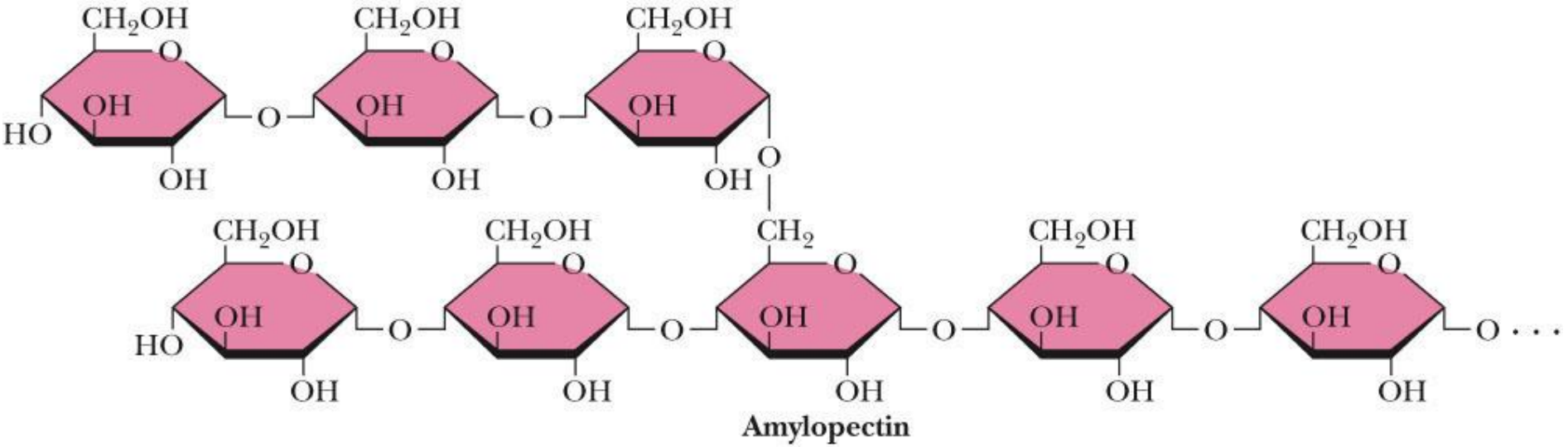
  - **amylose:** continuous, unbranched chains of up to 4000 α-D-glucose units joined by α-1,4-glycosidic bonds
  - **amylopectin:** a highly branched polymer consisting of 24-30 units of D-glucose joined by α-1,4-glycosidic bonds and branches created by α-1,6-glycosidic bonds
  - **amylases catalyze hydrolysis of α-1,4-glycosidic bonds**

  – β-amylase is an exoglycosidase

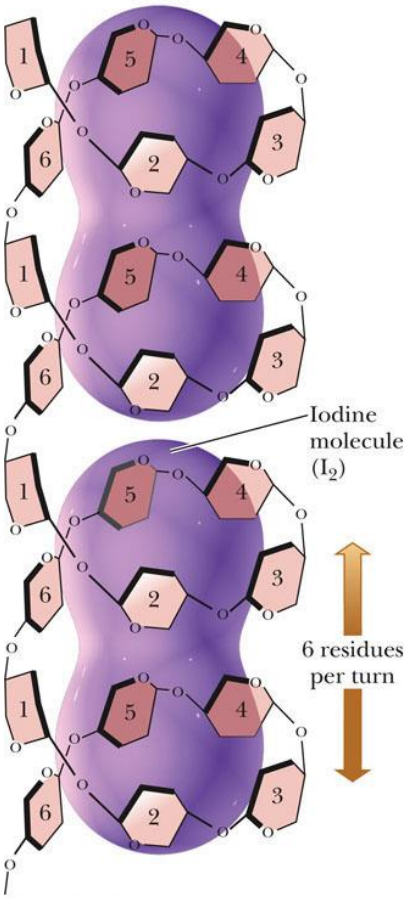
  – α-amylase is an endoglycosidase (glucose and maltose)

  - Debranching enzymes catalyze the hydrolysis of α-1,6-glycosidic bonds



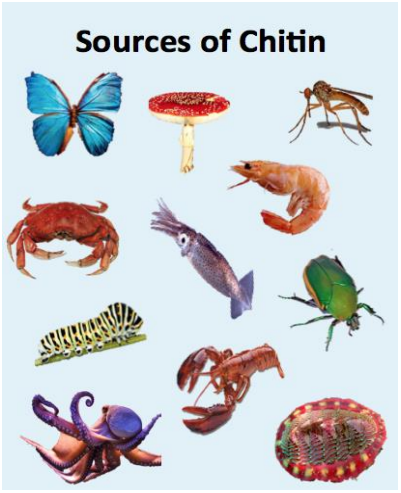


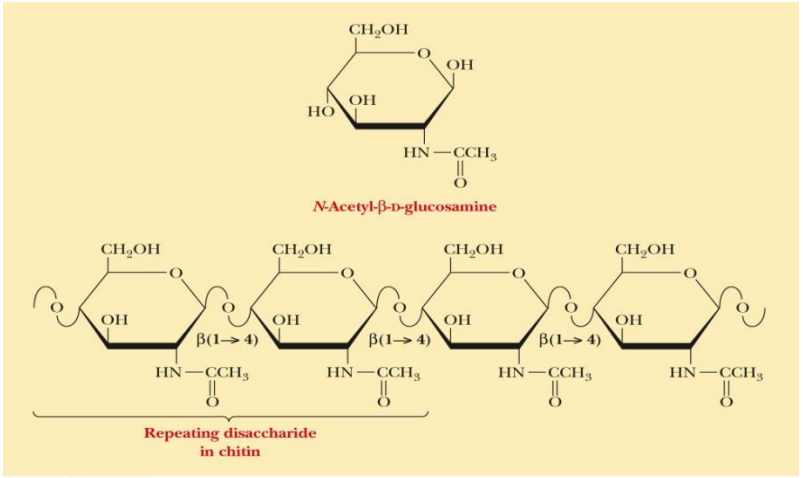
Iodine can Fit Inside Amylose to Form Starch-Iodine Complex

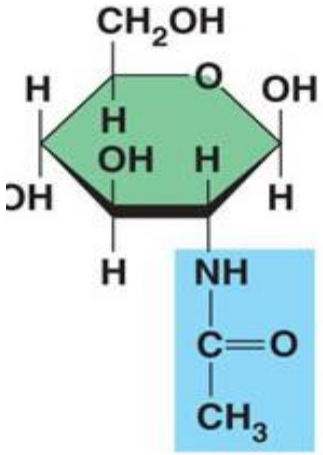


Chitin

- **Chitin:** the major structural component of the exoskeletons of invertebrates اللافقاريات, such as insects and crustaceans; also occurs in cell walls of algae, fungi, and yeasts
  - composed of units of N-acetyl-β-D-glucosamine joined by β-1,4-glycosidic bonds

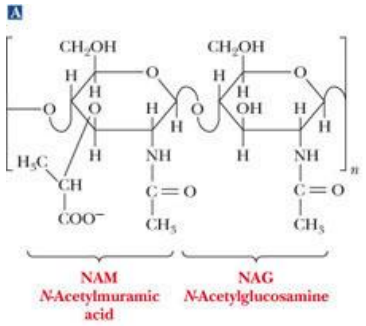


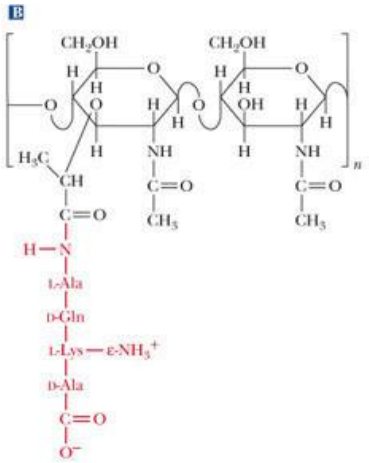


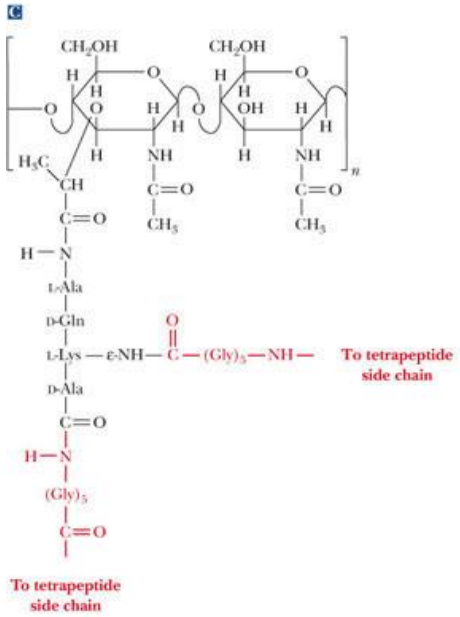


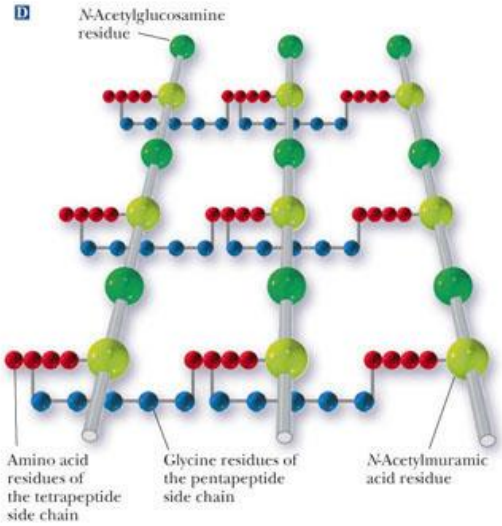
Polysaccharides

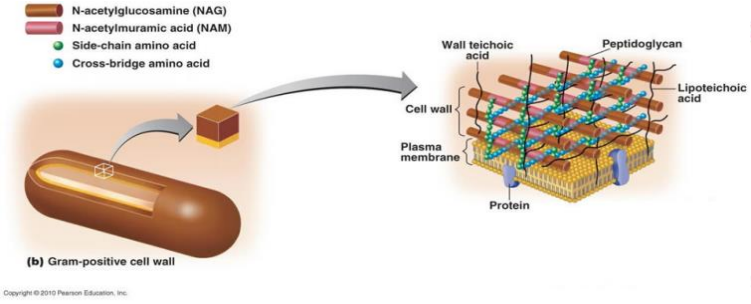
- **Bacterial cell walls:** prokaryotic cell walls are constructed on the framework of the repeating unit NAM-NAG joined by β-1,4-glycosidic bonds



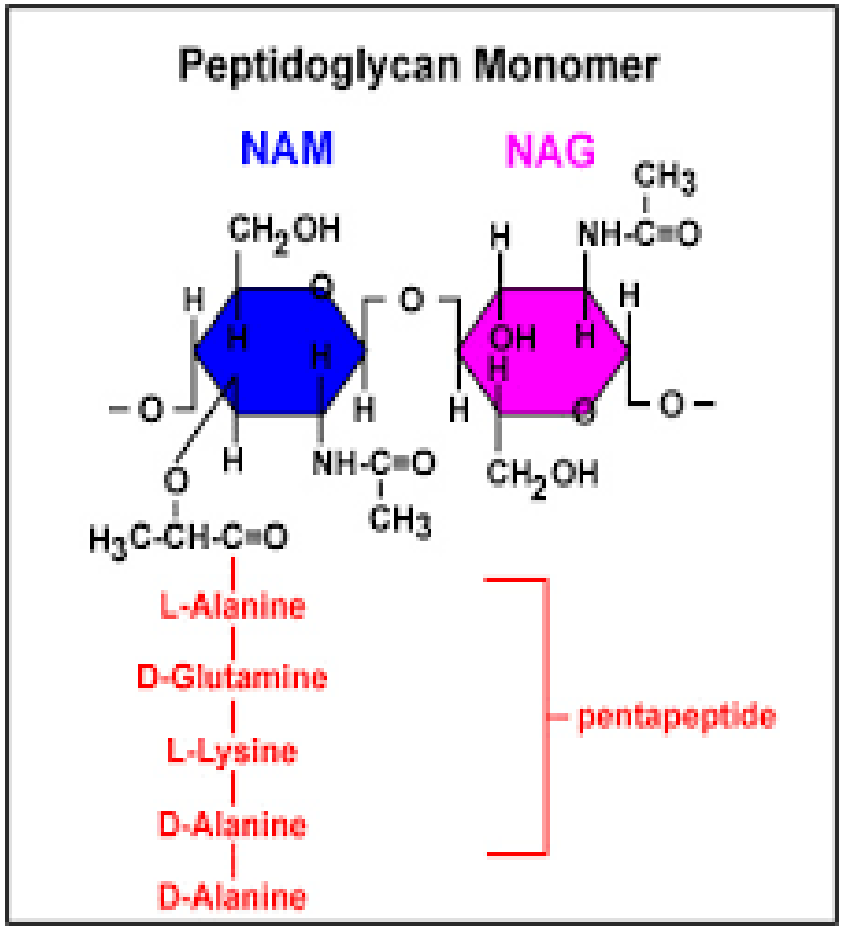


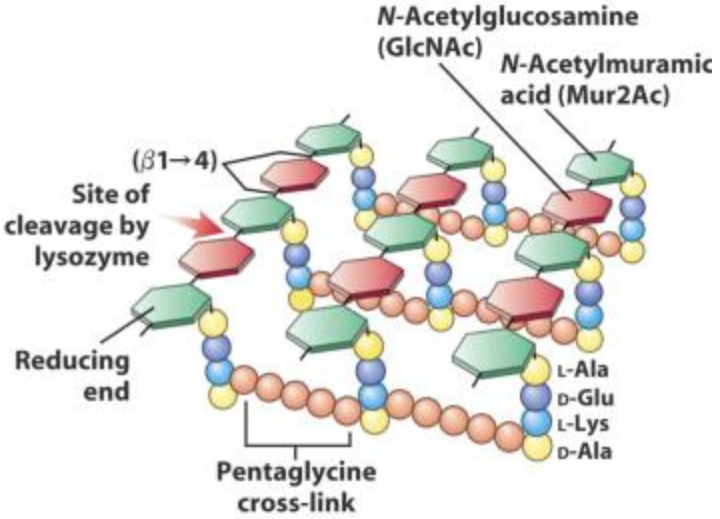


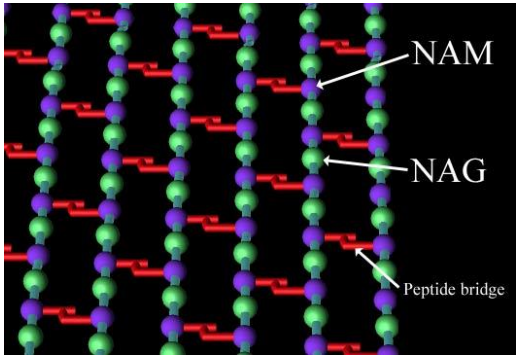




Peptidoglycan is made of chains of alternating molecules called N-acetylglucosamine (NAG), and N-acetylmuramic acid (NAM)

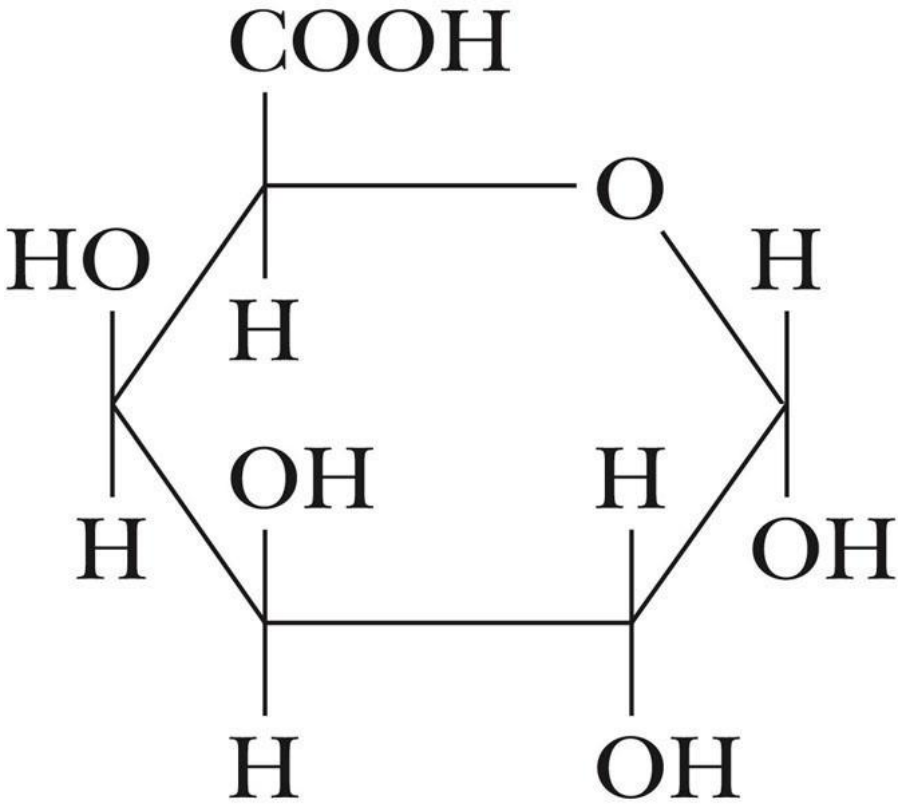






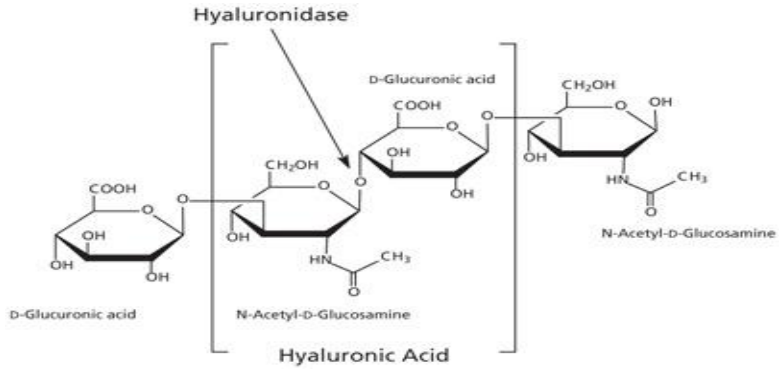
Plant Cell Walls

- consist largely of **cellulose**
- also contain pectin which functions as an intercellular cementing material
- **pectin** is a polymer of D-galacturonic acid joined by α-1,4-glycosidic bonds



Glycosaminoglycans

- **Glycosaminoglycans:** polysaccharides based on a repeating disaccharide where one of the monomers is an amino sugar and the other has a negative charge due to a sulfate or carboxylate group
  - **Heparin:** natural anticoagulant
  - **Hyaluronic acid:** a component of the vitreous humor of the eye and the lubricating fluid of joints
  - **keratan sulfate:** components of connective tissue



Hyaluronic Ac.

Glycoproteins

- **Glycoproteins** contain *carbohydrate* units covalently bonded to a polypeptide chain
  - **antibodies** are glycoproteins
  - Oligosaccharide portion of glycoproteins act as antigenic determinants
  - Among the first antigenic determinants discovered were the blood group substances
  - In the ABO system, individuals are classified according to four blood types: A, B, AB, and O
  - At the cellular level, the biochemical basis for this classification is a group of relatively small membrane-bound carbohydrates

Structures of Blood-Group Antigenic Determinants

β-*N*-Acetylgalactosamine (1→3) β-Galactose (1→3) β-*N*-Acetylgalactosamine

2
↑
1

α-L-Fucose

Nonreducing end

Type-A blood-group antigen

α- Galactose (1→3) β-Galactose (1→3) β-*N*-Acetylgalactosamine

2
↑
1

α-L-Fucose

Nonreducing end

Type-B blood-group antigen