

CHAPTER 18. CARBOHYDRATES

Carbohydrates are:

- **The most abundant biomolecules on earth**
 - **One the four major classes of biomolecules (proteins, carbohydrates, nucleic acids, lipids)**
-

Major biological roles of carbohydrates:

- **Energy storage, fuels, metabolic intermediates**
- **Part of DNA & RNA**
- **Structural elements of cells**
- **Components of many proteins & lipids**
- **Cell- cell recognition**

Major classes of carbohydrates:

1. Monosaccharides

(e.g. D- glucose; D- fructose)

2. Oligosaccharides (≥ 2 monosaccharide units)

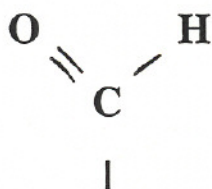
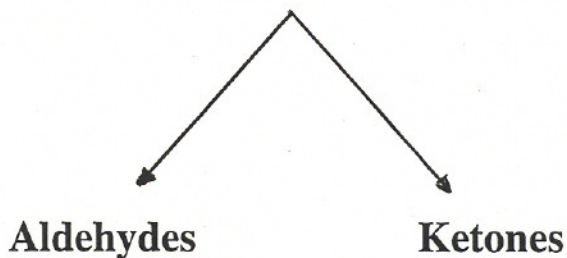
Disaccharides (e.g. Sucrose)

3. Polysaccharides (≥ 20 monosaccharide units)

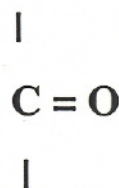
(e.g. cellulose, glycogen)

MONOSACCHARIDES

Monosaccharides $(\text{CH}_2\text{O})_n$; $n \geq 3$



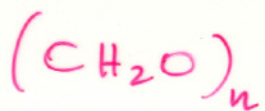
(aldehyde group)



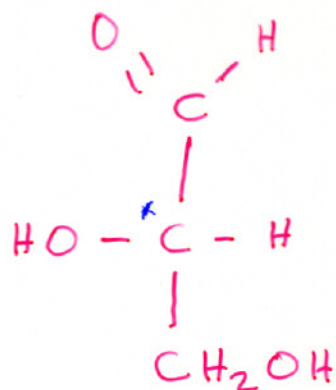
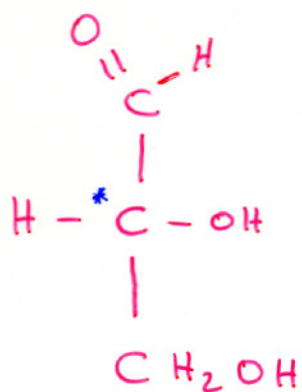
(keto group)

If the aldehyde group is at the end of the carbon chain \Rightarrow
aldose

If the keto group is at the end of the carbon chain \Rightarrow ketose

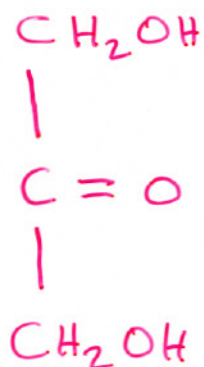


$n = 3$ trioses



D-Glyceraldehyde

L-Glyceraldehyde



Dihydroxyacetone

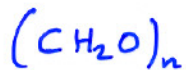
Physical Properties of Monosaccharides:

- **Colorless**
- **Crystalline solids**
- **Soluble in water**
- **Insoluble in nonpolar solvents**
- **Sweet taste**

Monosaccharides have asymmetric centers

- **D& L isomers**
- **A molecule with n asymmetric carbons can have 2^n stereoisomers**
- **In monosaccharides, the D and L isomers refer to the asymmetric carbon which is most distant from the carbonyl carbon (aldehyde or keto group)**
- **Two groups that differ only in the configuration around one carbon atom are called EPIMERS**

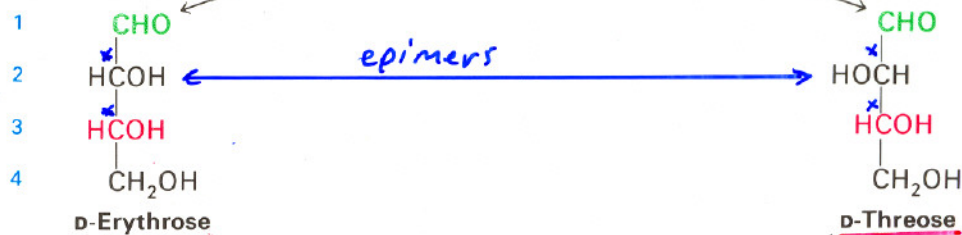
The common monosaccharides have cyclic structures



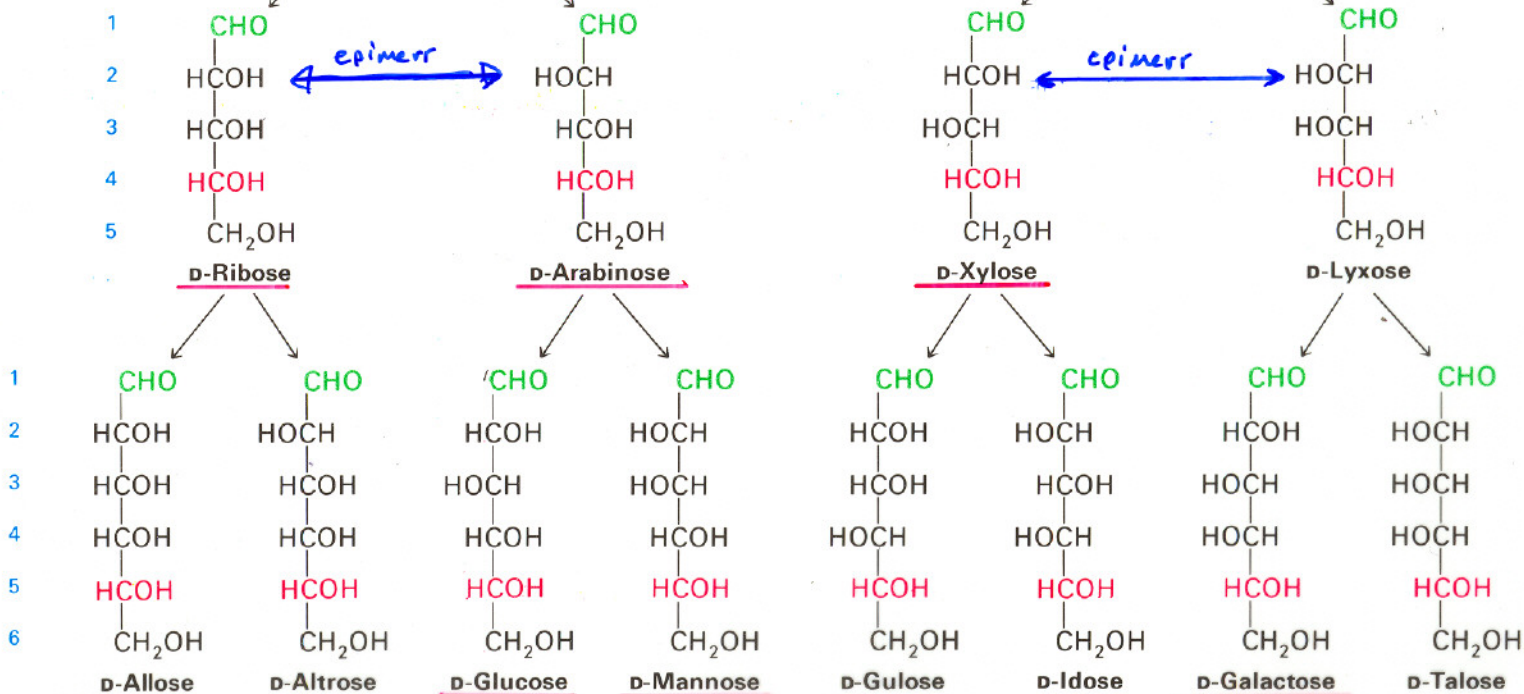
n = 3



n = 4



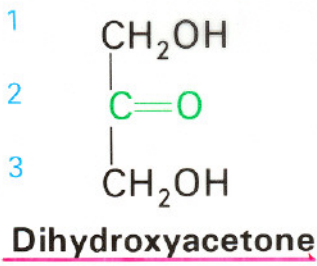
n = 5



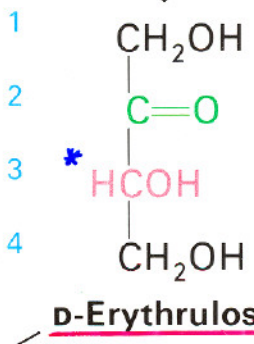
n = 6

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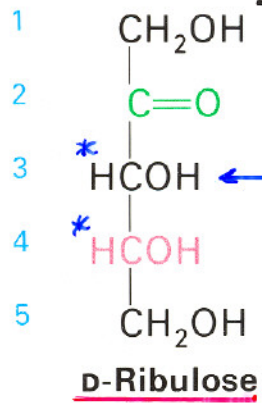
n=3



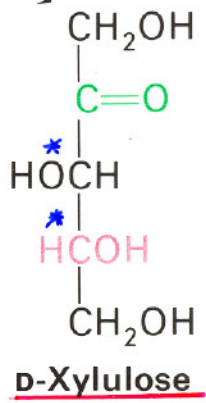
n=4



n=5



epimer



n=6

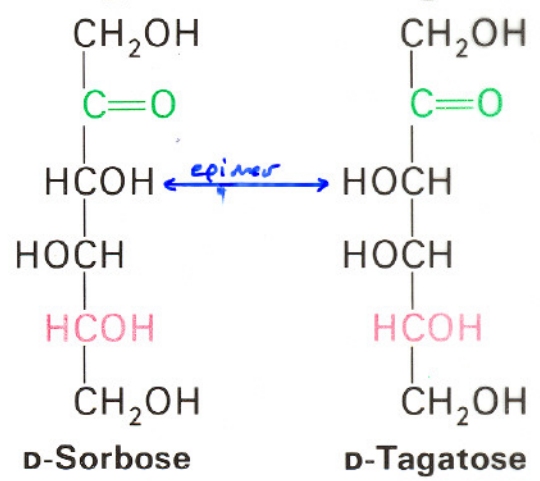
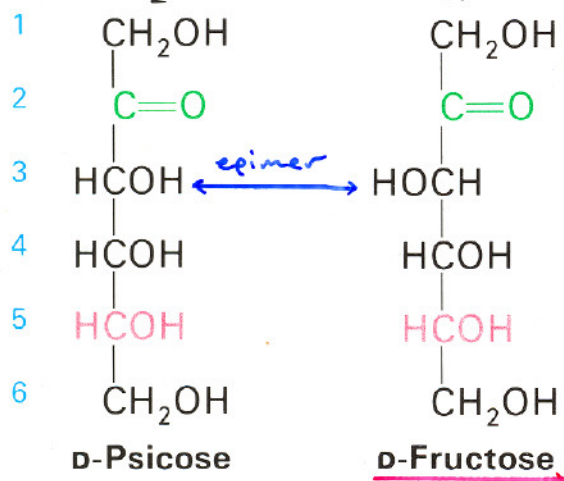
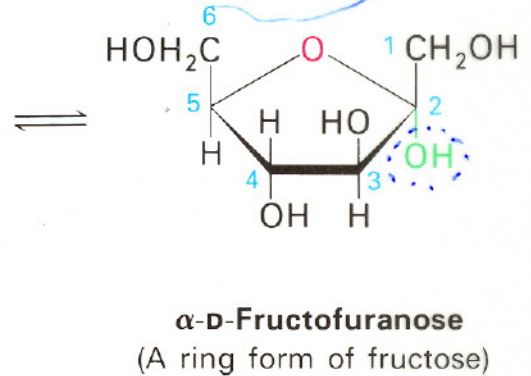
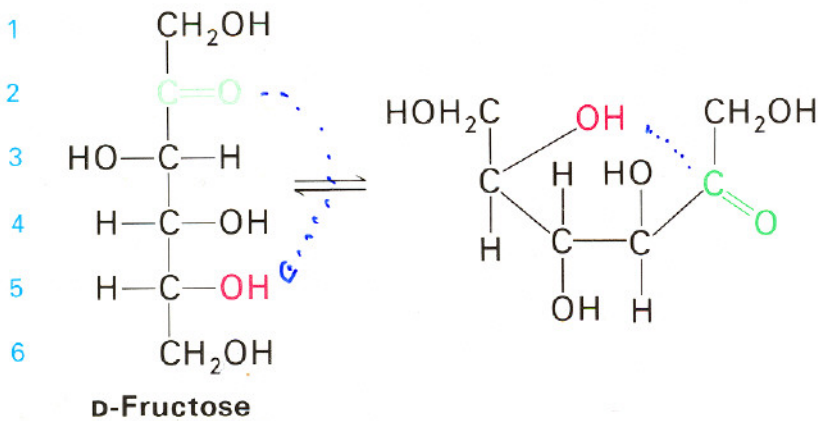
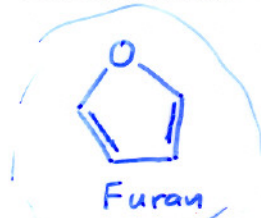
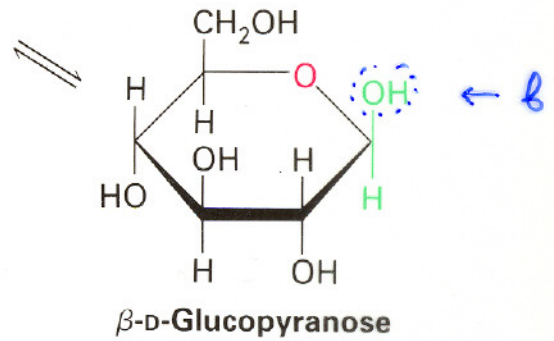
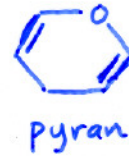
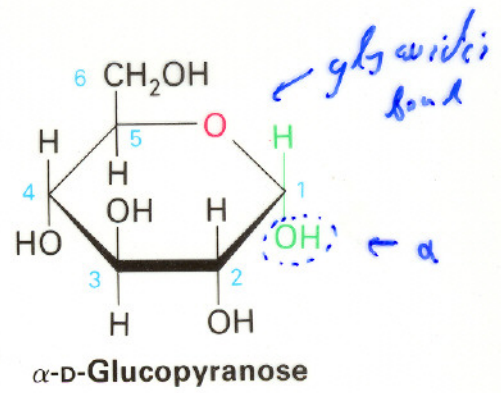
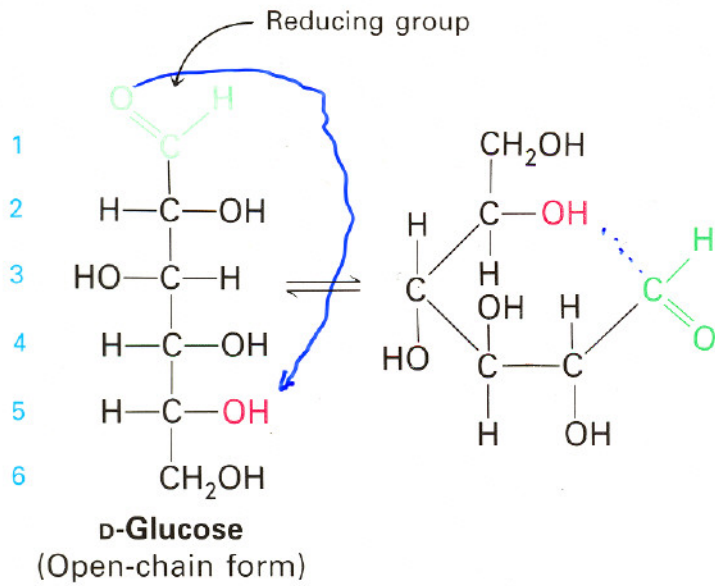


Figure 18-4, page 466



DISACCHARIDES

Disaccharides (such as sucrose, lactose, and maltose) consist of two monosaccharides joined covalently by an O- glycosidic bond

Sucrose (common table sugar)

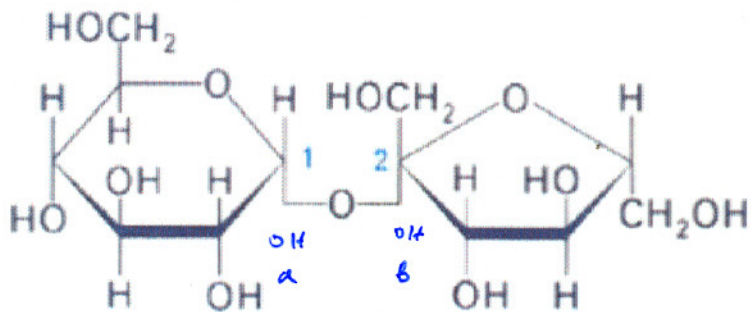
- Glucose unit + fructose unit (α 1 \rightarrow 2 β)
- Invertase hydrolytic enzyme

Lactose (found in milk)

- Galactose unit + glucose unit (β 1 \rightarrow 4)
- Lactase, β -galactosidase
- Most adults are intolerant of milk because they are deficient in lactase

Maltose (hydrolytic product of starch)

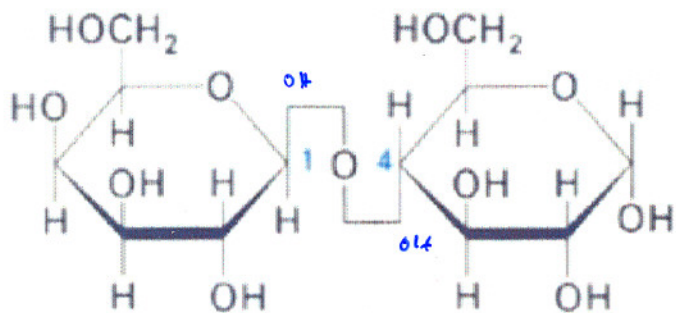
- Glucose unit + glucose unit (α 1 \rightarrow 4)
- Maltase



glucose
+
fructose
a 1 → 2 b
↓ b
c

Sucrose

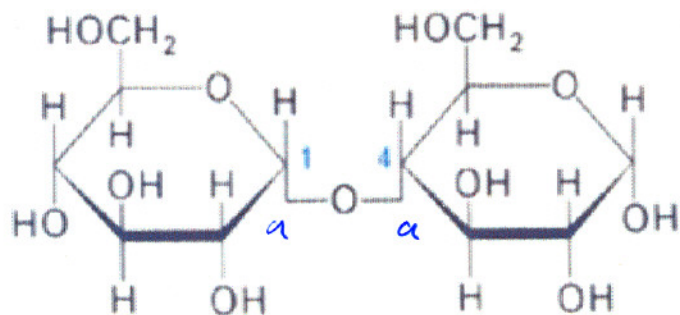
(α -D-Glucopyranosyl-(1→2)- β -D-fructofuranoside)



galactose
+
glucose
b 1 → 4 a

Lactose

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



glucose
+
glucose
a 1 → 4

Maltose

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

POLYSACCHARIDES

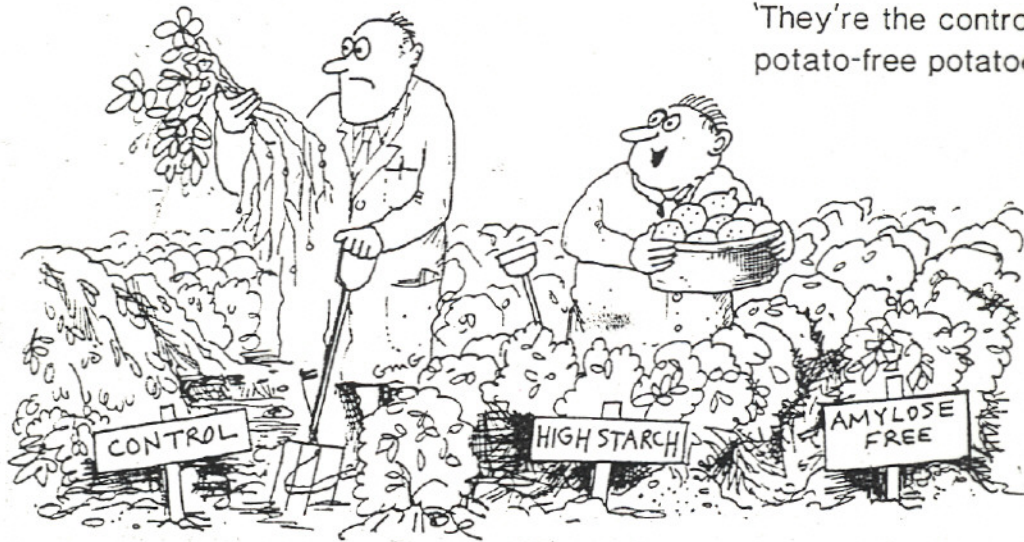
Glycogen:

- The main storage polysaccharide of animal cells
- A polymer of (α 1 \rightarrow 4) — linked subunits of glucose, with (α 1 \rightarrow 6) — branches which occur about once in ten units
- Glycogen is especially abundant in the liver

Starch:

- The main storage polysaccharides in plants
- It exists in two forms:
- Amylose (the unbranched form)- glucose units α 1 \rightarrow 4
- Amylopectin (the branched form)- glucose units α 1 \rightarrow 4, with branches every 30 units, α 1 \rightarrow 6

'They're the controls –
potato-free potatoes !'



Dextran:

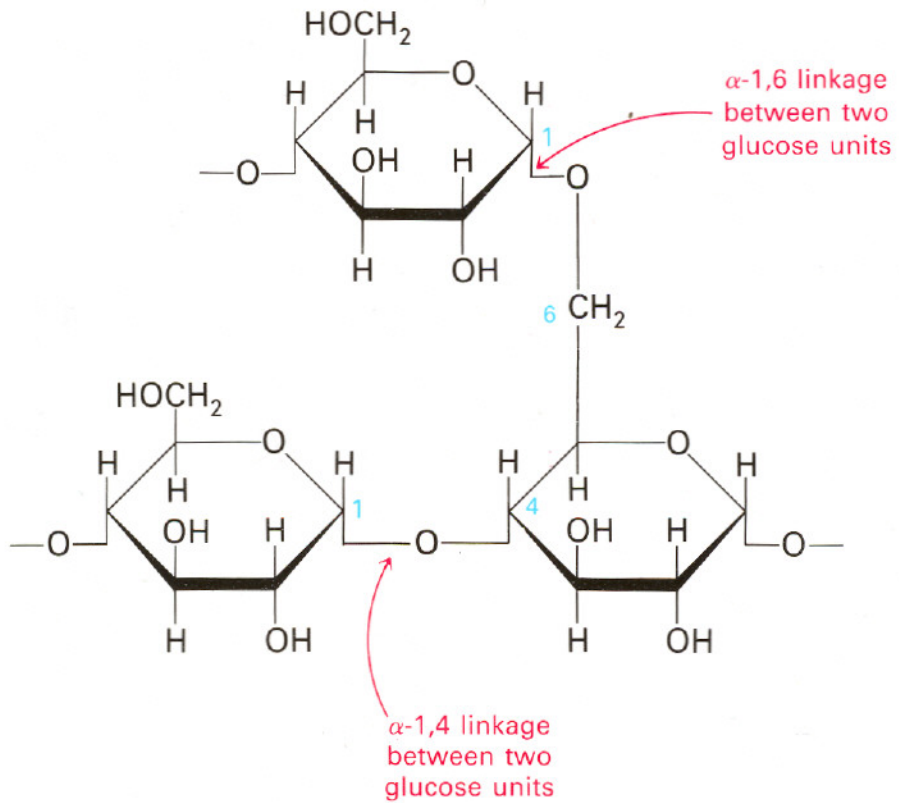
- A storage polysaccharide in yeasts and bacteria
- Glucose units, α 1 \rightarrow 6, with occasional branches

Cellulose:

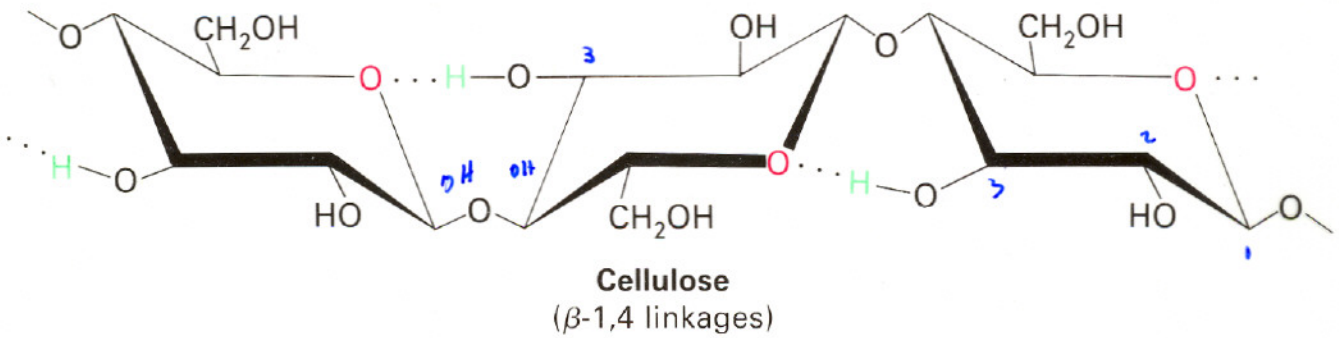
- The most abundant organic compounds in the biosphere
- Structural component of the cell wall of plants
- Glucose units, α 1 \rightarrow 4

$\alpha \rightarrow 4 \alpha$

$\alpha - 1, 4$



Glycogen



Figures 18-13 and 18-14, page 473