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. O-glucose; O-fructose)

2. Oligosaccharides (≥ 2 monosaccharide units)
   Disaccharides (e.g. Sucrose)

3. Polysaccharides (≥ 20 monosaccharide units)
   (e.g. cellulose, glycogen)
Monosaccharides \((CH_2O)_n; \ n \geq 3\)

- Aldehydes
- Ketones

\[
\begin{align*}
\text{(aldehyde group)} & & \text{(keto group)} \\
\text{O} & \equiv & \text{H} \quad & \quad C = O \\
| & & | \\
C & & | \\
\end{align*}
\]

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
(CH$_2$O)$_n$  

$n = 3$  

Trioses

\begin{align*}
\text{D-Glyceraldehyde} & : \\
\text{L-Glyceraldehyde} & :
\end{align*}

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 \( 2^n \) steroisomers

- 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
Figure 18-3, page 465

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Figure 18-4, page 466
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**Reducing group**

1. H
2. CH₃OH
3. HO
4. HO
5. CO
6. CH₂OH

**d-Glucose**
(Open-chain form)

**α-β-D-Glucopyranose**

**β-D-Glucopyranose**

**d-Fructose**

**α-d-Fructofuranose**
(A ring form of fructose)

Top and bottom figures, page 467

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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 ($\alpha 1 \rightarrow 2 \beta$)
- Invertase hydrolytic enzyme
Lactose (found in milk)

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

Maltose (hydrolytic product of starch)

- Glucose unit + glucose unit ($\alpha\ 1 \rightarrow 4$)
- Maltase
Sucrose
\((\alpha-D-Glucopyranosyl-1\rightarrow2)-\beta-D-fructofuranoside)\)

Lactose
\((\beta-D-Galactopyranosyl-1\rightarrow4)-\alpha-D-glucopyranoside)\)

Maltose
\((\alpha-D-Glucopyranosyl-1\rightarrow4)-\alpha-D-glucopyranose)\)
POLYSACCHARIDES

Glycogen:

• The main storage polysaccharide of animal cells

• A polymer of \((\alpha 1 \rightarrow 4)\) — linked subunits of glucose, with \((\alpha 1 \rightarrow 6)\) — 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 \(\alpha 1 \rightarrow 4\)

  • Amylopectin (the branched form) - glucose units \(\alpha 1 \rightarrow 4\), with branches every 30 units, \(\alpha 1 \rightarrow 6\)
'They’re the controls — potato-free potatoes!'
Dextran:

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

Cellulose:

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

Cellulose
(\(\beta-1,4\) linkages)