Carbohydrates

Carbohydrates are composed of C, H, O

\[ \text{CH}_2\text{O} \xrightarrow{(\text{CH}_2\text{O})_x} \text{C}_6\text{H}_{12}\text{O}_6 \]

Function:
- fast energy
- energy storage
- raw materials
- structural materials

Monomer: sugars
- ex: sugars, starches, cellulose

Sugars
Most names for sugars end in -ose

Classified by number of carbons
- 6C = hexose (glucose)
- 5C = pentose (ribose)
- 3C = triose (glyceraldehyde)

Monosaccharides
- Single Sugars
- Dissolve easily in water
- Sweet taste
- 3 forms: Sugars all end in “ose”
  - Triose \((3\text{C})\ C_3\text{H}_6\text{O}_3\)
    (Glyceraldehyde)
  - Pentose \((5\text{C})\ C_5\text{H}_{10}\text{O}_5\)
    (Ribose, Deoxyribose = components of nucleic acids)
  - Hexose \((6\text{C})\ C_6\text{H}_{12}\text{O}_6\)
    (Glucose, Fructose, Galactose)

3-carbon sugar
- Glyceraldehyde

5-carbon sugars
- Ribose
- Deoxyribose

6-carbon sugars
- Glucose
- Fructose
- Galactose

Fig. 3.23b (TE Art)
A. Molecular Formula
(empirical formula) i.e. \( \text{C}_6\text{H}_{12}\text{O}_6 \)

B. Structural Formula
Diagram showing the arrangement of atoms.
- Glucose, fructose & galactose all have the same empirical formula, but have different structural formulae.

### Structural Forms
- **Chain Form**: Carbon backbone with oxygen & hydrogen forming side bonds.
- **Ring Form**: In aqueous solution, the molecule closes upon itself to form a more stable ring form.

### Numbered carbons
- These will become important!
- **energy stored in C-C bonds harvested in cellular respiration**

### Isomers
Molecules with the same empirical formula but different structural formulae (arrangement of atoms determines functional differences)
There are 2 types of isomers

**Structural Isomers:** different arrangement of bonds.
- eg glucose & fructose (See O=C Bonds)
- Your taste buds can tell the difference → fructose much sweeter
- Form different polymers (repeating subunits)

**Stereoisomers:** Same bond structure but different orientations of molecule groups.
- eg. Glucose & galactose: Hydroxyl groups are mirror images of one another
- α glucose (OH above the plane)
- β glucose (OH below the plane)

**Roles of Monosaccharides**

Source of energy in respiration.
- C-H bonds release lots of energy when broken → used to convert ADP to ATP.
- Glucose is the most important, metabolically

Building blocks of larger molecules.
- glucose → starch, glycogen, cellulose
- ribose → RNA (ribonucleic acid) & ATP
- deoxyribose → DNA (deoxyribonucleic acid)

**Disaccharides**
- Two monosaccharides joined by a covalent bond
Bond formation: Condensation

Condensation: The name for the bonding process by which two monosaccharides form a disaccharide. AKA dehydration synthesis.

2 hydroxyl (-OH) groups line up with one another
- One combines with a hydrogen from the other to form a water molecule: HENCE, CONDENSATION
- Forms an oxygen bridge "glycosidic bond"
- Any two hydroxyl groups can line up & bond
- Large variety of possible disaccharides

Breaking Bonds: Hydrolysis

- Hydrolysis: When polysaccharides break apart to form smaller molecules.
- Hydro = water
- Lysis = breaking apart
- Breaking a molecule apart by adding water
- Both Condensation & hydrolysis are controlled by enzymes.

Transport Disaccharides

- In humans, glucose can circulate in the blood
- In plants & many other organisms, glucose must be converted for transport to keep glucose from being "used up" while in transport
- The bond breaking enzymes are only located in tissue where glucose is meant to be used.
- Glucose + fructose = sucrose
- Glucose + galactose = lactose
- Glucose + glucose = maltose
Polysaccharides

- Formed by joining long chains of monosaccharides through condensation.
- Each successive monosaccharide is joined by a glycosidic bond.
- Polysaccharides are not sugars.
- Most important: Starch, cellulose & glycogen

Storage Polysaccharides

- Transport disaccharides may be linked together as polysaccharides for storage within cells.
- Plant polysaccharides = starches.
- Animal polysaccharides = glycogen

Starches: Amylose

- Amylose = simplest starch, hundreds / thousands of linked, unbranched alpha glucose molecules.
- #1 carbon links to #4 of next molecule = long chains of maltose.
- Long chains coil up in water making it insoluble in water
- Potato starch ~ 20% amylose
Starch: Amylopectin
- Most plant starch is amylopectin.
- Also made of many 1,4 linked glucose, but also have 1,6 branching linkages (2.6 IF)
- Only 20-30 glucose subunits.
- Mixtures of amylose & amylopectin build up as starch grains in chloroplasts & storage vacuoles.

Glycogen
- "Animal version of starch."
- Insoluble polsaccharide of branched amylose chains
- Average chain much longer and greater # of branches than plant starch.
- Animal form of energy storage.

Structural Carbohydrates: Cellulose
- Unbranched chains of beta glucose
- Several chains are crosslinked by H-bonding to form fibrils
- Several fibrils crosslink to form fibres
- Forms cell walls of plants
Fig. 3.28b (TE Art)

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Cellulose: chain of \( \beta \)-glucose subunits

\[
\text{Cellulose: chain of } \beta-\text{glucose subunits}
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