

Lecture 10

Discipline: Bioorganic Chemistry

Lecturer: Associate Professor, Dr. Gulnaz Seitimova

Title: Di-, oligo- and polysaccharides. Classification, structure, preparation, chemical properties, physiological role.

Objective: The aim of this lecture is to provide a comprehensive understanding of the classification, structural diversity, methods of preparation, chemical reactivity, and biological functions of di-, oligo-, and polysaccharides in living organisms.

Main Questions: Classification of di-, oligo-, and polysaccharides. Structural features and glycosidic linkages. Methods of preparation and biosynthesis. Chemical properties and reactions. Physiological and biological roles of saccharides. Examples of biologically important saccharides.

Key Notes and Theses

General Overview

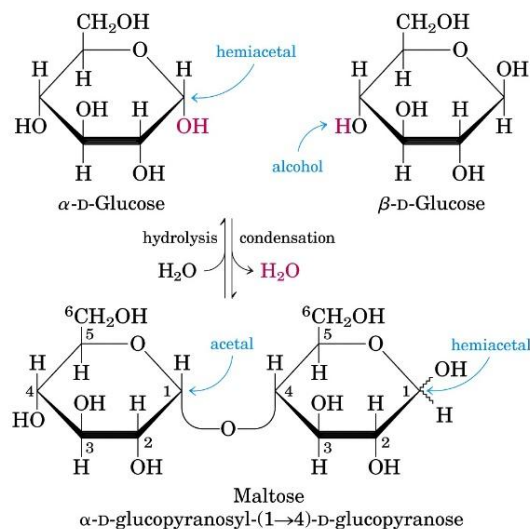
Carbohydrates are polyhydroxy aldehydes, ketones, or their derivatives that play essential roles in energy metabolism, structural organization, and signaling in biological systems. Depending on the number of monosaccharide units, they are divided into di-, oligo-, and polysaccharides.

Disaccharides

Definition: Carbohydrates composed of two monosaccharide units linked by a glycosidic bond.

Common examples and linkages:

- Sucrose (glucose + fructose) — $\alpha(1\rightarrow2)\beta$ linkage
- Lactose (glucose + galactose) — $\beta(1\rightarrow4)$ linkage
- Maltose (glucose + glucose) — $\alpha(1\rightarrow4)$ linkage
- Cellobiose — $\beta(1\rightarrow4)$ glucose dimer



Preparation:

- Enzymatic or chemical condensation of two monosaccharides
- Hydrolysis of polysaccharides (e.g., starch → maltose)

Chemical Properties:

- Reducing disaccharides: maltose, lactose
- Non-reducing disaccharides: sucrose
- Hydrolysis catalyzed by acids or specific enzymes (maltase, lactase)

Physiological Role:

- Rapid energy sources
- Intermediates of carbohydrate digestion

Oligosaccharides

Definition: Carbohydrates containing 3–10 monosaccharide residues.

Types:

- Homooligosaccharides: one type of monosaccharide
- Heterooligosaccharides: different monosaccharides

Examples:

- Raffinose (trisaccharide)
- Stachyose (tetrasaccharide)
- Fructo-oligosaccharides (FOS)
- Glycoprotein/glycolipid oligosaccharides

Preparation:

- Partial hydrolysis of polysaccharides
- Enzymatic synthesis using glycosyltransferases

Chemical Properties:

- Soluble in water, often sweet
- Participate in glycosylation reactions
- Can form specific molecular recognition motifs

Physiological Role:

- Prebiotics that stimulate beneficial gut microbiota
- Components of glycoproteins and glycolipids
- Involved in immune recognition and cell signaling

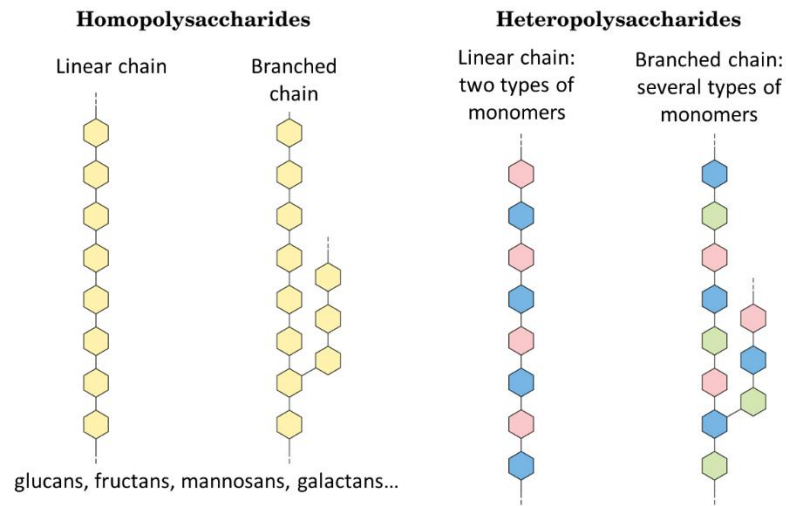
Polysaccharides

Definition: High-molecular-weight polymers of monosaccharides linked by glycosidic bonds (typically >10 units).

Classification:

- Homopolysaccharides: composed of one type of monomer
 - Starch (glucose)
 - Glycogen (glucose)

- Cellulose (glucose)
- Chitin (N-acetylglucosamine)
- Heteropolysaccharides: diverse monomers
- Hyaluronic acid
- Heparin
- Chondroitin sulfates



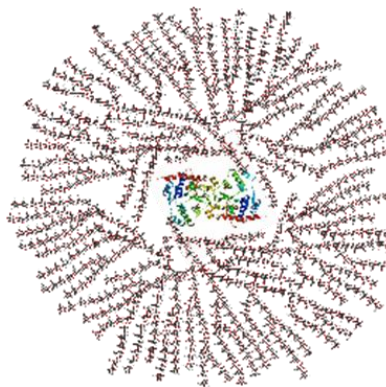
Structure and Examples

Starch

- Mixture of amylose ($\alpha 1 \rightarrow 4$) and amylopectin ($\alpha 1 \rightarrow 4$, $\alpha 1 \rightarrow 6$)
- Plant storage carbohydrate

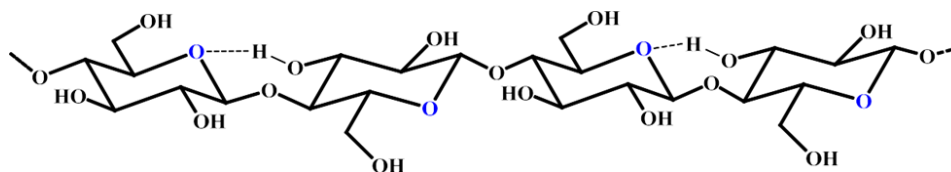
Glycogen

- Highly branched ($\alpha 1 \rightarrow 4$, $\alpha 1 \rightarrow 6$)
- Primary glucose reservoir in animals



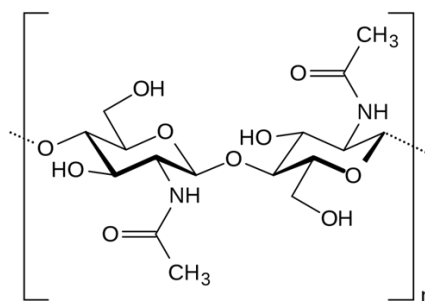
Cellulose

- $\beta(1 \rightarrow 4)$ -linked glucose
- Linear, rigid polymer
- Major structural component in plants



Chitin

- $\beta(1\rightarrow4)$ -linked N-acetylglucosamine
- Component of fungal cell walls and exoskeletons of arthropods



Chitin is the second most abundant polysaccharide (after cellulose) in nature. It is a long-chain polymer of a β -D-N-acetylglucosamine. Chitin is the main component of cell walls of fungi, crustaceans (such as crabs, shrimps, lobsters) and insects.

In terms of structure, chitin may be compared to polysaccharide cellulose. Chitin has proven useful for several medical and industrial purposes.

Chitin's properties as a flexible and strong material make it favorable as surgical thread. Its biodegradability means it wears away with time as the wound heals. Also, chitin has some unusual properties that accelerate healing of wounds in humans.

Preparation

- Biosynthesis: enzyme-mediated polymerization (glycogen synthase, starch synthase)
- Chemical modification: oxidation, reduction, esterification, acetylation
- Isolation: extraction from plant/animal tissues, enzymatic hydrolysis

Chemical Properties

- Hydrolysis:
 - Acidic hydrolysis yields monosaccharides
 - Enzymatic hydrolysis (amylases, cellulases, chitinases)
- Oxidation and reduction reactions
- Formation of esters and ethers
- Interaction with iodine:
 - Starch – blue complex
 - Glycogen – red-brown

Physiological Roles

- Energy storage: starch and glycogen

- Structural functions: cellulose, chitin
- Hydration and lubrication: hyaluronic acid
- Anticoagulant activity: heparin
- Cell communication and immune response: glycosaminoglycans, oligosaccharides on cell surfaces

Questions for Knowledge Assessment

1. What are the main structural differences between di-, oligo-, and polysaccharides?
2. What types of glycosidic linkages exist, and how do they determine polymer properties?
3. Which disaccharides are reducing and which are non-reducing?
4. What is the biological significance of oligosaccharides in glycoproteins?
5. Compare the structures of starch, glycogen, and cellulose.
6. What enzymes are responsible for the hydrolysis of major polysaccharides?
7. What physiological functions are performed by heteropolysaccharides?

Recommended Literature

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