

# Biochemisatry and Physiology



## B.Sc. Second Semester

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**Unit-I Syllabus :** Structure and Biological importance of Carbohydrates Monosaccharide, Disaccharides Polysaccharides and Glycoconjugates

## CARBOHYDRATES

### 1. Definition of Carbohydrates

Carbohydrates are **organic compounds** composed of **carbon (C), hydrogen (H), and oxygen (O)**, generally with formula:



They are **polyhydroxy aldehydes or ketones** or substances that yield them on hydrolysis.

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### 2. Classification of Carbohydrates

Carbohydrates are classified into:

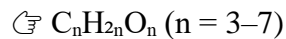
1. **Monosaccharides** (simple sugars)
2. **Oligosaccharides** (2–10 monosaccharide units)
  - Disaccharides (2 units)
3. **Polysaccharides** (>10 units)
4. **Glycoconjugates** (carbohydrates + proteins/lipids)

## MONOSACCHARIDES

### Definition

Simplest carbohydrates that **cannot be hydrolyzed further**.

### General Formula



### Classification

(A) Based on Functional Group:

- **Aldoses** → contain aldehyde group (–CHO)  
Example: Glucose
- **Ketoses** → contain ketone group (–CO–)  
Example: Fructose

(B) Based on Carbon Number:

- **Trioses** (3C) → Glyceraldehyde
  - **Tetroses** (4C)
  - **Pentoses** (5C) → Ribose
  - **Hexoses** (6C) → Glucose, Fructose
- 

## Structure of Monosaccharides

1. Open Chain Structure

- Straight chain with aldehyde/ketone group

2. Cyclic Structure (Hemiacetal Formation)

- Formation of ring (5 or 6 membered)

**Example: Glucose**

- Forms **pyranose ring (6-membered)**

### Example: Fructose

- Forms **furanose ring (5-membered)**
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## Important Concepts

### ◆ Isomerism

- Structural isomers
- Optical isomers (D and L forms)
- Epimers (differ at one carbon)
- Anomers ( $\alpha$  and  $\beta$  forms)

### ◆ Reducing Sugars

- Have free aldehyde/ketone group
  - Example: Glucose, Fructose
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## Biological Importance

- Immediate source of energy (**glucose  $\rightarrow$  ATP**)
  - Components of nucleic acids (**ribose, deoxyribose**)
  - Intermediates in metabolism
  - Building blocks of complex carbohydrates
- 

## DISACCHARIDES

### Definition

Formed by condensation of **two monosaccharides** via **glycosidic bond**.

☞ General formula:  $C_{12}H_{22}O_{11}$

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## Glycosidic Bond

- Formed between **–OH groups** of two sugars
  - Example:  $\alpha(1\rightarrow4)$ ,  $\beta(1\rightarrow4)$
- 

## Important Disaccharides

### 1. Maltose

- Glucose + Glucose
- Bond:  $\alpha(1\rightarrow4)$
- Reducing sugar

### 2. Lactose

- Glucose + Galactose
- Bond:  $\beta(1\rightarrow4)$
- Reducing sugar

### 3. Sucrose

- Glucose + Fructose
  - Bond:  $\alpha(1\rightarrow2)$
  - **Non-reducing sugar**
- 

## Biological Importance

- Energy source
  - Transport sugar in plants (**sucrose**)
  - Milk sugar (**lactose**) important in infants
- 

## POLYSACCHARIDES

### Definition

Complex carbohydrates with **many monosaccharide units**.

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## Types

### (A) Homopolysaccharides

- Only one type of monosaccharide

#### 1. Starch (*Plant storage*)

- Components:
  - Amylose (linear,  $\alpha 1 \rightarrow 4$ )
  - Amylopectin (branched,  $\alpha 1 \rightarrow 6$ )

#### 2. Glycogen (*Animal storage*)

- Highly branched
- Stored in liver & muscles

#### 3. Cellulose

- $\beta(1 \rightarrow 4)$  glucose units
- Structural component of plant cell wall
- Not digestible by humans

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### (B) Heteropolysaccharides

- Different monosaccharides

Examples:

- Hyaluronic acid
- Heparin
- Chondroitin sulfate

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## Biological Importance

- Energy storage (**starch, glycogen**)

- Structural support (**cellulose**)
  - Lubrication & protection (**mucopolysaccharides**)
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## GLYCOCONJUGATES

### Definition

Carbohydrates **covalently linked with proteins or lipids.**

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#### Types

##### 1. Glycoproteins

- Protein + carbohydrate
- Found in cell membrane

##### 2. Proteoglycans

- Protein + long polysaccharide chains
- Found in connective tissue

##### 3. Glycolipids

- Lipid + carbohydrate
  - Present in cell membrane
- 

### Functions

- Cell recognition
  - Cell signaling
  - Immune response (antigens)
  - Structural integrity
- 

## Biological Importance of Carbohydrates

### 1. Energy Source

- Glucose → ATP via respiration

## 2. Energy Storage

- Starch (plants)
- Glycogen (animals)

## 3. Structural Role

- Cellulose (plants)
- Chitin (fungi)

## 4. Component of Biomolecules

- DNA, RNA (ribose/deoxyribose)

## 5. Cell Communication

- Glycoproteins and glycolipids

## 6. Protective Functions

- Mucus, connective tissue components
- 

## 8. Key Exam Points

- Monosaccharides → simplest sugars
  - Disaccharides → glycosidic bond
  - Polysaccharides → storage & structure
  - Glycoconjugates → cell communication
  - Reducing vs Non-reducing sugars
  - $\alpha$  and  $\beta$  linkages important
- 

## CARBOHYDRATES – QUICK REVISION

### Definition

- Organic compounds: **(CH<sub>2</sub>O)<sub>n</sub>**
  - Polyhydroxy aldehydes or ketones
-

## Classification

1. **Monosaccharides** → simplest (glucose, fructose)
  2. **Disaccharides** → 2 units (maltose, lactose, sucrose)
  3. **Polysaccharides** → many units (starch, glycogen, cellulose)
  4. **Glycoconjugates** → with proteins/lipids
- 

## Monosaccharides

- Cannot be hydrolyzed
- Types:
  - Aldose (–CHO) → Glucose
  - Ketose (–CO–) → Fructose
- Forms:
  - Open chain
  - Cyclic (5 or 6 member ring)

☞ Key points:

- **D/L isomers**
  - **$\alpha$  and  $\beta$  anomers**
  - **Reducing sugars**
- 

## Disaccharides

- Two monosaccharides + **glycosidic bond**

Disaccharide	Components	Bond	Nature
Maltose	Glucose + Glucose	$\alpha(1\rightarrow4)$	Reducing
Lactose	Glucose + Galactose	$\beta(1\rightarrow4)$	Reducing
Sucrose	Glucose + Fructose	$\alpha(1\rightarrow2)$	Non-reducing

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## Polysaccharides

Storage:

- **Starch (plants)** → Amylose + Amylopectin
- **Glycogen (animals)** → highly branched

Structural:

- **Cellulose** →  $\beta(1\rightarrow4)$ , straight chain
- 

## Glycoconjugates

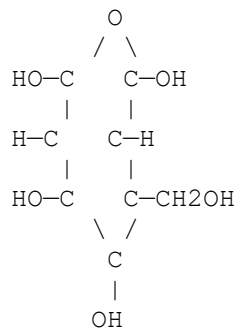
- **Glycoproteins** → cell recognition
  - **Glycolipids** → membrane structure
  - **Proteoglycans** → connective tissue
- 

## Biological Importance

- ✓ Energy → Glucose → ATP
  - ✓ Storage → Starch, Glycogen
  - ✓ Structure → Cellulose
  - ✓ Genetic material → Ribose, Deoxyribose
  - ✓ Cell communication → Glycoproteins
- 

## IMPORTANT DIAGRAMS

### ◆ 1. Glucose (Cyclic Form – Simplified)



☞ 6-membered ring → **Pyranose form**

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## 2. Starch Structure

Amylose (Linear)

Glucose–Glucose–Glucose–Glucose  
α(1→4) linkages

Amylopectin (Branched)

```
      Glucose
      |
Glucose–Glucose–Glucose
|       |
Glucose  Glucose
(α1→6 branches)
```

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## 3. Glycogen (Highly Branched)

```
      Glucose
      |
Glucose–Glucose–Glucose
|   |   |
Glucose  Glucose  Glucose
|       |
Glucose      Glucose
```

☞ More branching than starch → **fast energy release**

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### SUPER-FAST REVISION POINTS

- Glucose = main energy source
- Sucrose = non-reducing sugar
- Glycogen = highly branched
- Cellulose = β-linkage (indigestible)
- Glycosidic bond = joins sugars

**CARBOHYDRATES – QUICK REVISION (1 PAGE)**

- **Definition**
  - Organic compounds:  $(\text{CH}_2\text{O})_n$
  - Polyhydroxy aldehydes or ketones
- **Classification**
  1. **Monosaccharides** – simplest (glucose, fructose)
  2. **Disaccharides** – 2 units (maltose, lactose, sucrose)
  3. **Polysaccharides** – many units (starch, glycogen, cellulose)
  4. **Glycoconjugates** – with proteins/lipids
- **Monosaccharides**
  - Cannot be hydrolyzed
  - Aldose ( $-\text{CHO}$ ), Ketose ( $-\text{CO}-$ )
  - D / L isomers,  $\alpha$  and  $\beta$  anomers
  - Reducing sugars
- **Disaccharides**
  - Two monosaccharides + glycosidic bond

Maltose	Glucose + Glucose	$\alpha(1-4)$
Lactose	Glucose + Galactose	$\beta(1-4)$
Sucrose	Glucose + Fructose	$\alpha(1-2)$

Non-reducing
- **Polysaccharides**
  - Storage – Starch: Amylose + Amylopectin
  - Glycogen (animals): highly branched
- **Structural:** - Cellulose:  $\beta(1-4)$  chains
- **Glycoconjugates**
  - Glycoproteins  $\rightarrow$  cell recognition
  - Glycolipids  $\rightarrow$  membrane structure
  - Proteoglycans  $\rightarrow$  connective tissue

**IMPORTANT DIAGRAMS****SUPER-FAST REVISION POINTS**

- Glucose = main energy source
- Sucrose = non-reducing sugar
- Glycogen = highly branched
- Cellulose =  $\beta$ -linkage (indigestible)
- Glycosidic bond = joins sugars

**DPSingh****1. What is the general formula of carbohydrates?**

- A.  $\text{C}_n\text{H}_{2n}\text{O}_n$   
 B.  $\text{C}_n\text{H}_n\text{O}_{2n}$   
 C.  $\text{C}_n\text{H}_{2n+2}\text{O}_n$   
 D.  $\text{C}_n\text{H}_n\text{O}_n$

**Answer: A****Detailed Explanation:**

Carbohydrates are often described as “hydrates of carbon” because their empirical formula is close to  $(\text{CH}_2\text{O})_n$ , which simplifies to  $\text{C}_n\text{H}_{2n}\text{O}_n$ . This reflects that for every carbon atom, there are roughly two hydrogens and one oxygen—similar to water ( $\text{H}_2\text{O}$ ).

- Example: Glucose =  $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow$  fits formula

- However, not all carbohydrates strictly follow this (e.g., deoxyribose), but it works as a general rule.

**Why others are wrong:**

- B, C, D → do not match the typical carbohydrate ratio.
- 

**2. The simplest carbohydrate is:**

- A. Glucose
- B. Fructose
- C. Glyceraldehyde
- D. Sucrose

**Answer: C**

**Detailed Explanation:**

Carbohydrates are classified based on carbon number. The simplest are **trioses (3 carbons)**.

- **Glyceraldehyde** ( $C_3H_6O_3$ ) is the simplest aldose sugar.

It plays an important role in metabolism (glycolysis intermediate).

**Why others are wrong:**

- Glucose & fructose → hexoses (6 carbons)
  - Sucrose → disaccharide
- 

**3. Monosaccharides cannot be hydrolyzed because:**

- A. They are complex
- B. They lack glycosidic bonds
- C. They are polymers
- D. They contain nitrogen

**Answer: B**

**Detailed Explanation:**

Hydrolysis breaks **glycosidic bonds** (linkages between sugars).

- Monosaccharides are **single units**
- No glycosidic bond → cannot be broken into simpler sugars

**Why others are wrong:**

- A → monosaccharides are simplest, not complex
  - C → they are not polymers
  - D → nitrogen is irrelevant
- 

**4. Glucose is a:**

- A. Ketose
- B. Aldose
- C. Pentose
- D. Disaccharide

**Answer: B**

**Detailed Explanation:**

Glucose contains an **aldehyde group (-CHO)** at carbon 1 → hence it is an **aldose sugar**. Also, it has 6 carbons → specifically an **aldohexose**.

**Why others are wrong:**

- A → ketose has ketone group (like fructose)
  - C → pentose = 5 carbons
  - D → glucose is monosaccharide
- 

**5. Fructose is classified as:**

- A. Aldopentose
- B. Ketohehexose
- C. Aldohehexose
- D. Ketopentose

**Answer: B**

**Detailed Explanation:**

Fructose:

- 6 carbons → hexose
- Ketone group at C-2 → ketose  
→ Therefore **ketohehexose**

**Why others are wrong:**

- A & D → pentose (wrong carbon number)
  - C → wrong functional group
- 

## 6. Optical isomerism in carbohydrates is due to:

- A. Double bonds
- B. Chiral carbon atoms
- C. Hydrogen bonds
- D. Peptide bonds

**Answer:** B

### Detailed Explanation:

A **chiral (asymmetric) carbon** is attached to four different groups. This leads to **optical activity** (rotation of plane-polarized light).

Example: Glucose has multiple chiral carbons → many stereoisomers.

### Why others are wrong:

- A → double bonds don't cause chirality
  - C & D → unrelated
- 

## 7. D and L forms differ in:

- A. Molecular weight
- B. Structure
- C. Configuration at asymmetric carbon
- D. Functional group

**Answer:** C

### Detailed Explanation:

D/L configuration depends on the **orientation of OH group** at the **penultimate carbon** (second last carbon).

- OH on right → D-form
- OH on left → L-form

### Important:

D/L does NOT mean direction of rotation (+/-).

**Why others are wrong:**

- A → same molecular weight
  - B → similar structure
  - D → same functional group
- 

**8. Glucose and fructose are:**

- A. Epimers
- B. Isomers
- C. Enantiomers
- D. Homologs

**Answer: B**

**Detailed Explanation:**

They have same molecular formula ( $C_6H_{12}O_6$ ) but different structures:

- Glucose → aldehyde
- Fructose → ketone

Thus, they are **functional isomers**.

**Why others are wrong:**

- A → epimers differ at one carbon
  - C → mirror images
  - D → differ by  $CH_2$  units
- 

**9. Epimers differ at:**

- A. All carbons
- B. One carbon
- C. Two carbons
- D. No carbon

**Answer: B**

**Detailed Explanation:**

Epimers are stereoisomers differing in configuration at **only one chiral carbon**.

Example:

- Glucose vs Galactose → differ at C-4
- 

### 10. Example of epimers:

- A. Glucose & Fructose
- B. Glucose & Galactose
- C. Glucose & Sucrose
- D. Maltose & Lactose

**Answer: B**

#### **Detailed Explanation:**

Glucose and galactose differ only at **C-4 position** → classic epimers.

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### 11. Mutarotation refers to:

- A. Change in structure
- B. Change in optical rotation
- C. Polymerization
- D. Hydrolysis

**Answer: B**

#### **Detailed Explanation:**

Mutarotation = change in optical rotation when  $\alpha$  and  $\beta$  forms interconvert in solution.

Example:

- $\alpha$ -D-glucose  $\rightleftharpoons$   $\beta$ -D-glucose

This occurs via open-chain form.

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### 12. Glycosidic bond is formed between:

- A. Amino acids
- B. Fatty acids
- C. Monosaccharides
- D. Nucleotides

**Answer: C**

**Detailed Explanation:**

A **glycosidic bond** forms when:

- OH group of one sugar reacts with another
- Water is released (condensation reaction)

Example: glucose + glucose  $\rightarrow$  maltose

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**13. Sucrose is composed of:**

- A. Glucose + Glucose
- B. Glucose + Fructose
- C. Galactose + Glucose
- D. Fructose + Galactose

**Answer: B**

**Detailed Explanation:**

Sucrose =  $\alpha$ -D-glucose +  $\beta$ -D-fructose

Linked via  **$\alpha(1\rightarrow2)$  glycosidic bond**

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**14. Lactose is:**

- A. Milk sugar
- B. Fruit sugar
- C. Plant sugar
- D. Animal sugar

**Answer: A**

**Detailed Explanation:**

Lactose is found in milk and composed of:

- Galactose + Glucose
- 

**15. Maltose consists of:**

- A. Glucose + Fructose
- B. Glucose + Glucose

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- C. Galactose + Glucose
- D. Fructose + Fructose

**Answer: B**

**Detailed Explanation:**

Maltose = two glucose units linked by  $\alpha(1\rightarrow4)$  bond.

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**16. Starch is a:**

- A. Monosaccharide
- B. Disaccharide
- C. Polysaccharide
- D. Protein

**Answer: C**

**Detailed Explanation:**

Starch is a plant storage carbohydrate composed of:

- Amylose (linear)
  - Amylopectin (branched)
- 

**17. Glycogen is stored in:**

- A. Plants
- B. Animals
- C. Bacteria only
- D. Fungi only

**Answer: B**

**Detailed Explanation:**

Glycogen = animal storage polysaccharide  
Stored mainly in:

- Liver
  - Muscles
- 

**18. Cellulose is composed of:**

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- A.  $\alpha$ -glucose
- B.  $\beta$ -glucose
- C. Fructose
- D. Galactose

**Answer: B**

**Detailed Explanation:**

Cellulose consists of  **$\beta$ -D-glucose units** linked by  $\beta(1\rightarrow4)$  bonds  $\rightarrow$  linear, rigid structure.

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**19. Humans cannot digest cellulose due to:**

- A. Lack of enzyme
- B. High solubility
- C. Low molecular weight
- D. Acidic nature

**Answer: A**

**Detailed Explanation:**

Humans lack **cellulase enzyme**, which is required to break  $\beta(1\rightarrow4)$  bonds.

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**20. Glycoproteins contain:**

- A. Lipids + carbohydrates
- B. Proteins + carbohydrates
- C. DNA + proteins
- D. RNA + lipids

**Answer: B**

**Detailed Explanation:**

Glycoproteins = proteins with carbohydrate chains attached.

Functions:

- Cell recognition
  - Immune response
  - Hormone receptors
- 

**21. Glycolipids are:**

- A. Proteins + lipids
- B. Lipids + carbohydrates
- C. DNA + lipids
- D. RNA + proteins

**Answer: B**

**Detailed Explanation:**

Glycolipids are components of **cell membranes**, involved in:

- Cell signaling
  - Cell recognition
- 

**22. Which polysaccharide is highly branched?**

- A. Cellulose
- B. Amylose
- C. Glycogen
- D. Chitin

**Answer: C**

**Detailed Explanation:**

Glycogen has:

- $\alpha(1\rightarrow4)$  chains
  - $\alpha(1\rightarrow6)$  branches every 8–12 units  $\rightarrow$  highly branched
- 

**23. Amylose contains:**

- A.  $\alpha$ -1,4 bonds
- B.  $\beta$ -1,4 bonds
- C.  $\alpha$ -1,6 bonds
- D.  $\beta$ -1,6 bonds

**Answer: A**

**Detailed Explanation:**

Amylose is a **linear polymer** of glucose with  $\alpha(1\rightarrow4)$  linkages.

---

**24. Amylopectin contains:**

- A. Only  $\alpha$ -1,4
- B. Only  $\beta$ -1,4
- C.  $\alpha$ -1,4 and  $\alpha$ -1,6
- D.  $\beta$ -1,4 and  $\beta$ -1,6

**Answer: C**

**Detailed Explanation:**

Amylopectin = branched

- $\alpha(1\rightarrow4)$   $\rightarrow$  main chain
  - $\alpha(1\rightarrow6)$   $\rightarrow$  branch points
- 

**25. Chitin is found in:**

- A. Plants
- B. Animals
- C. Fungi
- D. Bacteria

**Answer: C**

**Detailed Explanation:**

Chitin is a structural polysaccharide found in:

- Fungal cell walls
  - Exoskeleton of arthropods
- 

**26. Reducing sugars are those which:**

- A. Donate electrons
- B. Accept electrons
- C. Have free aldehyde/ketone group
- D. Lack oxygen

**Answer: C**

**Detailed Explanation:**

Reducing sugars can reduce Fehling's/Benedict's reagent because they have a **free carbonyl group**.

**27. Example of reducing sugar:**

- A. Sucrose
- B. Maltose
- C. Both
- D. None

**Answer: B**

**Detailed Explanation:**

Maltose has a free anomeric carbon → reducing  
Sucrose does not.

---

**28. Sucrose is non-reducing because:**

- A. No carbon
- B. No glycosidic bond
- C. Both anomeric carbons involved
- D. No oxygen

**Answer: C**

**Detailed Explanation:**

In sucrose, both glucose and fructose anomeric carbons are linked → no free carbonyl group.

---

**29. Glycosaminoglycans are:**

- A. Neutral
- B. Acidic
- C. Basic
- D. Non-polar

**Answer: B**

**Detailed Explanation:**

They contain:

- Sulfate groups
- Carboxyl groups  
→ hence negatively charged (acidic)

### 30. Main biological role of carbohydrates:

- A. Storage of genetic material
- B. Energy source
- C. Enzyme activity
- D. Hormone synthesis

**Answer: B**

#### **Detailed Explanation:**

Carbohydrates are the **primary energy source**:

- Glucose → ATP via glycolysis
  - Stored as glycogen/starch
- 

### 31. Which monosaccharide is a pentose?

- A. Glucose
- B. Fructose
- C. Ribose
- D. Sucrose

**Answer: C**

#### **Detailed Explanation:**

Pentoses contain **5 carbon atoms**.

- **Ribose (C<sub>5</sub>H<sub>10</sub>O<sub>5</sub>)** is a pentose sugar found in RNA and nucleotides like ATP.

#### **Why others are wrong:**

- Glucose & fructose → hexoses (6 carbons)
  - Sucrose → disaccharide
- 

### 32. Deoxyribose differs from ribose in:

- A. One less oxygen
- B. One less carbon

- C. One less hydrogen
- D. One more oxygen

**Answer: A**

**Detailed Explanation:**

Deoxyribose (DNA sugar) lacks an oxygen at the **2' carbon** → hence “deoxy.”

- Ribose =  $C_5H_{10}O_5$
  - Deoxyribose =  $C_5H_{10}O_4$
- 

**33. Haworth projection represents:**

- A. Linear structure
- B. Ring structure
- C. 3D protein structure
- D. DNA structure

**Answer: B**

**Detailed Explanation:**

Haworth projection is used to represent **cyclic (ring) forms** of monosaccharides, showing  $\alpha$  and  $\beta$  forms.

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**34. Pyranose ring has:**

- A. 4 members
- B. 5 members
- C. 6 members
- D. 7 members

**Answer: C**

**Detailed Explanation:**

Pyranose ring resembles pyran → **6-membered ring** (5 carbons + 1 oxygen).

---

**35. Furanose ring has:**

- A. 4 members
- B. 5 members

- C. 6 members
- D. 7 members

**Answer: B**

**Detailed Explanation:**

Furanose resembles furan → **5-membered ring** (4 carbons + 1 oxygen).

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**36. Anomeric carbon is:**

- A. First carbon
- B. Carbonyl carbon in open chain
- C. Last carbon
- D. Middle carbon

**Answer: B**

**Detailed Explanation:**

When sugar cyclizes, the **carbonyl carbon becomes the anomeric carbon.**

- Determines  $\alpha$  or  $\beta$  configuration.
- 

**37.  $\alpha$  and  $\beta$  forms differ in:**

- A. Molecular weight
- B. Position of OH at anomeric carbon
- C. Number of carbons
- D. Functional group

**Answer: B**

**Detailed Explanation:**

- $\alpha$  → OH down (trans to CH<sub>2</sub>OH)
  - $\beta$  → OH up (cis to CH<sub>2</sub>OH)
- 

**38. Which sugar forms furanose ring?**

- A. Glucose
- B. Fructose

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- C. Galactose
- D. Maltose

**Answer: B**

**Detailed Explanation:**

Fructose commonly forms **furanose (5-membered)** ring.

---

**39. Which is a non-reducing sugar?**

- A. Glucose
- B. Lactose
- C. Maltose
- D. Sucrose

**Answer: D**

**Detailed Explanation:**

Sucrose has **no free anomeric carbon**, so it cannot act as a reducing agent.

---

**40. Benedict's test detects:**

- A. Proteins
- B. Reducing sugars
- C. Lipids
- D. DNA

**Answer: B**

**Detailed Explanation:**

Reducing sugars reduce  $\text{Cu}^{2+} \rightarrow \text{Cu}^+$  (red precipitate).

---

**41. Which disaccharide is reducing?**

- A. Sucrose
- B. Maltose
- C. Trehalose
- D. None

**Answer: B**

**Detailed Explanation:**

Maltose has one **free anomeric carbon** → reducing.

---

**42. Lactose intolerance is due to deficiency of:**

- A. Amylase
- B. Lactase
- C. Maltase
- D. Sucrase

**Answer: B**

**Detailed Explanation:**

Lactase breaks lactose → glucose + galactose.

Deficiency → lactose intolerance.

---

**43. Glycogen is also called:**

- A. Animal starch
- B. Plant starch
- C. Structural sugar
- D. Simple sugar

**Answer: A**

**Detailed Explanation:**

Glycogen is structurally similar to starch but more branched.

---

**44. Which polysaccharide is linear?**

- A. Glycogen
- B. Amylopectin
- C. Cellulose
- D. Starch

**Answer: C**

**Detailed Explanation:**

Cellulose is completely **linear ( $\beta$ -1,4 bonds)** → strong fibers.

**45. Iodine test gives blue color with:**

- A. Glycogen
- B. Amylose
- C. Cellulose
- D. Fructose

**Answer: B**

**Detailed Explanation:**

Amylose forms a **helical structure** that traps iodine → blue color.

---

**46. Glycogen gives which color with iodine?**

- A. Blue
- B. Red-brown
- C. Green
- D. Yellow

**Answer: B**

**Detailed Explanation:**

Glycogen gives **reddish-brown** due to branched structure.

---

**47. Which enzyme breaks starch?**

- A. Protease
- B. Lipase
- C. Amylase
- D. Lactase

**Answer: C**

**Detailed Explanation:**

Amylase hydrolyzes starch into maltose/glucose.

---

**48. Which bond is present in cellulose?**

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- A.  $\alpha$ -1,4
- B.  $\alpha$ -1,6
- C.  $\beta$ -1,4
- D.  $\beta$ -1,6

**Answer: C**

**Detailed Explanation:**

$\beta$ -1,4 bonds create rigid linear chains → structural strength.

---

**49. Chitin is composed of:**

- A. Glucose
- B. N-acetylglucosamine
- C. Fructose
- D. Ribose

**Answer: B**

**Detailed Explanation:**

Chitin = polymer of **N-acetylglucosamine** → structural.

---

**50. Reducing sugars reduce:**

- A. Proteins
- B. Metal ions
- C. Lipids
- D. DNA

**Answer: B**

**Detailed Explanation:**

They reduce metal ions like  $\text{Cu}^{2+}$  in Benedict's test.

---

**51. Glycoproteins are important in:**

- A. Energy storage
- B. Cell communication
- C. DNA replication
- D. Digestion

**Answer: B**

**Detailed Explanation:**

They act as receptors and signaling molecules.

---

**52. Glycolipids are present in:**

- A. Nucleus
- B. Cell membrane
- C. Cytoplasm
- D. Ribosome

**Answer: B**

**Detailed Explanation:**

They are membrane components involved in recognition.

---

**53. Proteoglycans are rich in:**

- A. Lipids
- B. Carbohydrates
- C. DNA
- D. RNA

**Answer: B**

**Detailed Explanation:**

Contain long carbohydrate chains (GAGs).

---

**54. Hyaluronic acid is a:**

- A. Protein
- B. Lipid
- C. Glycosaminoglycan
- D. Nucleic acid

**Answer: C**

**Detailed Explanation:**

It is a major component of connective tissue.

**55. Carbohydrates are stored as glycogen in:**

- A. Brain
- B. Liver and muscles
- C. Kidney
- D. Heart

**Answer: B**

**Detailed Explanation:**

Liver maintains blood glucose; muscles use glycogen for energy.

---

**56. Which sugar is found in RNA?**

- A. Deoxyribose
- B. Ribose
- C. Glucose
- D. Fructose

**Answer: B**

**Detailed Explanation:**

RNA contains ribose; DNA contains deoxyribose.

---

**57. Which sugar is found in DNA?**

- A. Ribose
- B. Glucose
- C. Deoxyribose
- D. Fructose

**Answer: C**

**Detailed Explanation:**

DNA sugar lacks oxygen at 2' position.

---

**58. Which polysaccharide is structural in plants?**

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- A. Starch
- B. Glycogen
- C. Cellulose
- D. Chitin

**Answer: C**

**Detailed Explanation:**

Cellulose provides rigidity to plant cell walls.

---

**59. Which is NOT a polysaccharide?**

- A. Glycogen
- B. Cellulose
- C. Sucrose
- D. Starch

**Answer: C**

**Detailed Explanation:**

Sucrose is a **disaccharide**, not polysaccharide.

---

**60. Carbohydrates provide energy as:**

- A. ATP
- B. DNA
- C. RNA
- D. Lipids

**Answer: A**

**Detailed Explanation:**

Glucose is oxidized → ATP (energy currency of cell).

---

**61. Which carbohydrate is the primary blood sugar?**

- A. Fructose
- B. Glucose

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- C. Galactose
- D. Ribose

**Answer: B**

**Detailed Explanation:**

Glucose is the main sugar circulating in blood and is tightly regulated by hormones like insulin and glucagon. It is the **immediate energy source** for cells.

**Why others are wrong:**

- Fructose → metabolized in liver
  - Galactose → converted to glucose
  - Ribose → structural sugar (RNA)
- 

**62. Which organ regulates blood glucose level?**

- A. Heart
- B. Liver
- C. Kidney
- D. Brain

**Answer: B**

**Detailed Explanation:**

The liver maintains blood glucose via:

- Glycogenesis (storage)
  - Glycogenolysis (release)
  - Gluconeogenesis (formation)
- 

**63. Insulin promotes:**

- A. Breakdown of glycogen
- B. Formation of glycogen
- C. Protein breakdown
- D. Fat breakdown

**Answer: B**

**Detailed Explanation:**

Insulin lowers blood glucose by converting glucose → glycogen.

**64. Glucagon causes:**

- A. Glycogenesis
- B. Glycogen breakdown
- C. Protein synthesis
- D. Lipid synthesis

**Answer: B**

**Detailed Explanation:**

Glucagon increases blood glucose by breaking glycogen into glucose.

---

**65. Which pathway breaks glucose to release energy?**

- A. Glycolysis
- B. Photosynthesis
- C. Transcription
- D. Translation

**Answer: A**

**Detailed Explanation:**

Glycolysis converts glucose → pyruvate → ATP production.

---

**66. Glycolysis occurs in:**

- A. Nucleus
- B. Cytoplasm
- C. Mitochondria
- D. Ribosome

**Answer: B**

**Detailed Explanation:**

All glycolytic enzymes are located in cytoplasm.

---

**67. ATP yield from glycolysis (net):**

- A. 1
- B. 2
- C. 4
- D. 8

**Answer: B**

**Detailed Explanation:**

4 ATP produced, 2 used → net gain = 2 ATP.

---

**68. Which carbohydrate is sweetest?**

- A. Glucose
- B. Fructose
- C. Lactose
- D. Maltose

**Answer: B**

**Detailed Explanation:**

Fructose has the highest sweetness among natural sugars.

---

**69. Which sugar is least sweet?**

- A. Fructose
- B. Glucose
- C. Lactose
- D. Sucrose

**Answer: C**

**Detailed Explanation:**

Lactose has the lowest sweetness.

---

**70. Which disaccharide is found in milk?**

- A. Sucrose
- B. Maltose
- C. Lactose
- D. Trehalose

**Answer: C**

**Detailed Explanation:**

Milk sugar = lactose (glucose + galactose).

---

**71. Glycogen has branches at:**

- A.  $\alpha$ -1,2
- B.  $\alpha$ -1,4
- C.  $\alpha$ -1,6
- D.  $\beta$ -1,4

**Answer: C**

**Detailed Explanation:**

Branches occur via  $\alpha$ -1,6 glycosidic bonds.

---

**72. Which polysaccharide is most soluble?**

- A. Cellulose
- B. Glycogen
- C. Chitin
- D. Starch

**Answer: B**

**Detailed Explanation:**

Highly branched glycogen is more soluble and readily mobilized.

---

**73. Cellulose provides:**

- A. Energy
- B. Structure
- C. Hormones
- D. Enzymes

**Answer: B**

**Detailed Explanation:**

Forms plant cell wall → rigidity and support.

**74. Which carbohydrate is part of ATP?**

- A. Glucose
- B. Ribose
- C. Fructose
- D. Galactose

**Answer: B**

**Detailed Explanation:**

ATP contains **ribose sugar**.

---

**75. Which carbohydrate is found in nucleic acids?**

- A. Glucose
- B. Ribose and Deoxyribose
- C. Fructose
- D. Maltose

**Answer: B**

**Detailed Explanation:**

RNA → ribose

DNA → deoxyribose

---

**76. Glycoconjugates include:**

- A. Glycoproteins
- B. Glycolipids
- C. Proteoglycans
- D. All of the above

**Answer: D**

**Detailed Explanation:**

All are carbohydrate-containing biomolecules.

---

**77. Function of glycolipids:**

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- A. Energy storage
- B. Cell recognition
- C. DNA synthesis
- D. Enzyme activity

**Answer: B**

**Detailed Explanation:**

They act as markers for cell–cell interaction.

---

**78. Proteoglycans are important in:**

- A. Muscle contraction
- B. Connective tissue
- C. Respiration
- D. Digestion

**Answer: B**

**Detailed Explanation:**

Provide structure and hydration to tissues.

---

**79. Glycosaminoglycans are:**

- A. Neutral
- B. Hydrophobic
- C. Negatively charged
- D. Basic

**Answer: C**

**Detailed Explanation:**

Due to sulfate/carboxyl groups → negative charge.

---

**80. Example of glycosaminoglycan:**

- A. Cellulose
- B. Glycogen
- C. Hyaluronic acid
- D. Starch

**Answer: C**

**Detailed Explanation:**

Important for lubrication (joints).

---

**81. Which is a homopolysaccharide?**

- A. Glycogen
- B. Lactose
- C. Sucrose
- D. Maltose

**Answer: A**

**Detailed Explanation:**

Made of only glucose units.

---

**82. Which is a heteropolysaccharide?**

- A. Starch
- B. Cellulose
- C. Hyaluronic acid
- D. Glycogen

**Answer: C**

**Detailed Explanation:**

Contains different sugar units.

---

**83. Which bond links monosaccharides?**

- A. Peptide
- B. Ester
- C. Glycosidic
- D. Hydrogen

**Answer: C**

---

**84. Which sugar is a ketohexose?**

- A. Glucose
- B. Galactose
- C. Fructose
- D. Ribose

**Answer: C**

---

**85. Which sugar is an aldohexose?**

- A. Fructose
- B. Glucose
- C. Ribose
- D. Xylose

**Answer: B**

---

**86. Which sugar is a ketopentose?**

- A. Ribose
- B. Xylulose
- C. Glucose
- D. Mannose

**Answer: B**

---

**87. Which is not a reducing sugar?**

- A. Glucose
- B. Maltose
- C. Lactose
- D. Sucrose

**Answer: D**

---

**88. Which carbohydrate is storage form in plants?**

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- A. Glycogen
- B. Starch
- C. Cellulose
- D. Chitin

**Answer: B**

---

**89. Which carbohydrate is structural in animals?**

- A. Starch
- B. Cellulose
- C. Chitin
- D. Glycogen

**Answer: C**

---

**90. Chitin is present in:**

- A. Plants
- B. Animals
- C. Fungi and exoskeleton
- D. Bacteria

**Answer: C**

---

**91. Which enzyme digests lactose?**

- A. Amylase
- B. Lactase
- C. Maltase
- D. Protease

**Answer: B**

---

**92. Which enzyme digests sucrose?**

- A. Lactase
- B. Sucrase

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- C. Maltase
- D. Lipase

**Answer: B**

---

**93. Which enzyme digests maltose?**

- A. Maltase
- B. Amylase
- C. Lactase
- D. Lipase

**Answer: A**

---

**94. Carbohydrates yield energy of:**

- A. 4 kcal/g
- B. 9 kcal/g
- C. 2 kcal/g
- D. 6 kcal/g

**Answer: A**

**Detailed Explanation:**

Each gram of carbohydrate provides **~4 kcal energy**.

---

**95. Glycogen is mainly stored in:**

- A. Brain
- B. Liver
- C. Kidney
- D. Heart

**Answer: B**

---

**96. Which sugar is found in honey?**

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- A. Lactose
- B. Fructose
- C. Maltose
- D. Ribose

**Answer: B**

---

**97. Which sugar is called fruit sugar?**

- A. Glucose
- B. Fructose
- C. Galactose
- D. Maltose

**Answer: B**

---

**98. Which sugar is called blood sugar?**

- A. Fructose
- B. Glucose
- C. Ribose
- D. Lactose

**Answer: B**

---

**99. Which carbohydrate is used for energy storage in animals?**

- A. Starch
- B. Glycogen
- C. Cellulose
- D. Chitin

**Answer: B**

---

**100. Final end product of carbohydrate metabolism (aerobic):**

- A. Lactic acid
- B. Ethanol

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C. CO<sub>2</sub> and H<sub>2</sub>O

D. Pyruvate

**Answer: C**

**Detailed Explanation:**

In aerobic respiration:

Glucose → CO<sub>2</sub> + H<sub>2</sub>O + ATP