

PHARMACIST BOOSTER - 7

BIOCHEMISTRY

CARBOHYDRATES



Important for RRB, AIIMS, ESIC,
SEPOY, CISF, GSSSB, DSSSB,
SSC, CGHS etc.

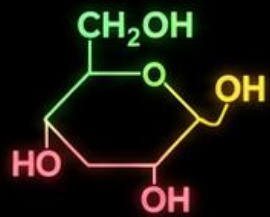


Concept + Revision
कॉन्सेप्ट + रिविजन

हिंदी + English में



Tanu Ma'am



Carbohydrates

कार्बोहाइड्रेट्स

 **Energy**
4 kcal/g



Carbohydrates are the most **abundant** organic biomolecules.



They are mainly made of carbon, hydrogen, and oxygen, usually in a **1:2:1** ratio.



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



They are the major source of **energy** and provide **4 kcal/g**.



Glycoproteins and **glycolipids** are important parts of cell membranes.



Glycogen acts as the storage form of carbohydrate in the body.



कार्बोहाइड्रेट प्रकृति में **सर्वाधिक** पाए जाने वाले कार्बनिक जैव-अणु हैं।



ये मुख्यतः कार्बन, हाइड्रोजन और ऑक्सीजन से बने होते हैं, सामान्यतः **1:2:1** अनुपात में।



ये **polyhydroxy aldehydes/ ketones** होते हैं या **hydrolysis** पर उन्हें देने वाले यौगिक होते हैं।



ये ऊर्जा का मुख्य स्रोत हैं और **4 kcal/g** ऊर्जा देते हैं।

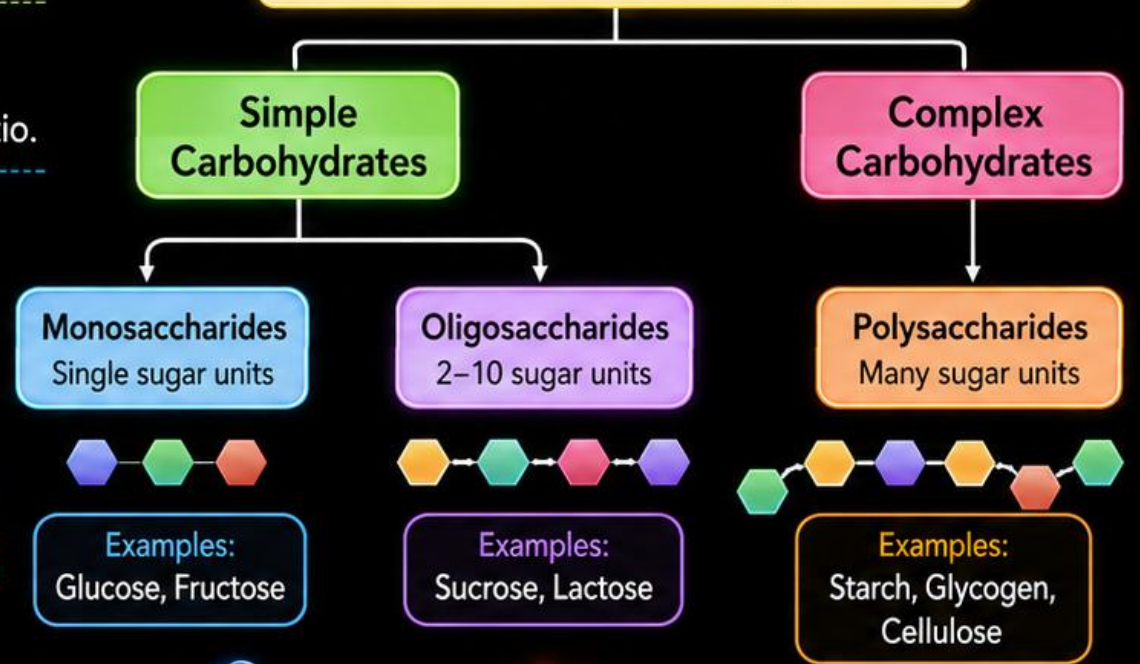


Glycoproteins और **glycolipids** cell membrane के महत्वपूर्ण घटक हैं।

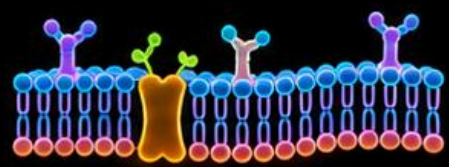


Glycogen शरीर में carbohydrate का **storage form** है।

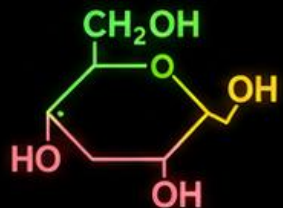
Classification of Carbohydrates



ATP



★ **Key Takeaway:** Structure → Function → Energy → Storage → Life



Monosaccharides



Energy
4 kcal/g

मोनोसैकराइड्स



Monosaccharides are the **simplest** carbohydrates and cannot be hydrolyzed into smaller sugar units.



By functional group: **Aldoses** contain an aldehyde group ($-\text{CHO}$); **Ketoses** contain a ketone group ($>\text{C}=\text{O}$).



By carbon number: **Triose** (3C), **Tetrose** (4C), **Pentose** (5C), **Hexose** (6C), **Heptose** (7C).



Combined classes include **aldohexose** (glucose, galactose, mannose) and **ketohehexose** (fructose).



Optical activity: **D-form** has $-\text{OH}$ on the right side of the chiral carbon; **L-form** has $-\text{OH}$ on the left.



Ring forms: **Pyranose** = 6-membered ring; **Furanose** = 5-membered ring.



मोनोसैकराइड्स सबसे सरल कार्बोहाइड्रेट होते हैं और इन्हें छोटे शर्करा इकाइयों में hydrolyze नहीं किया जा सकता।



Functional group के आधार पर: **Aldoses** में aldehyde group ($-\text{CHO}$) और **Ketoses** में ketone group ($>\text{C}=\text{O}$) होता है।



Carbon atoms के आधार पर: **Triose** (3C), **Tetrose** (4C), **Pentose** (5C), **Hexose** (6C), **Heptose** (7C)।



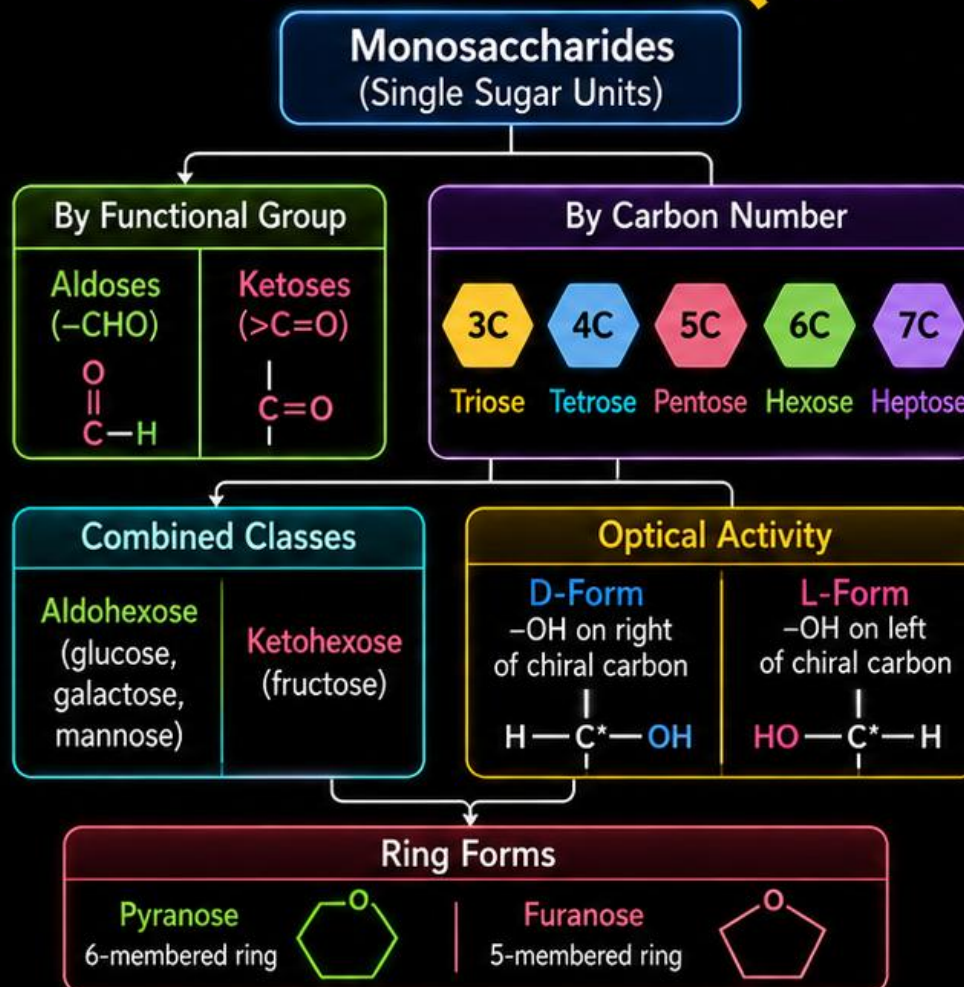
Combined classes में **aldohexose** (glucose, galactose, mannose) और **ketohehexose** (fructose) शामिल हैं।



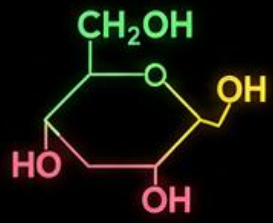
Optical activity: **D-form** में chiral carbon के दाईं ओर $-\text{OH}$ होता है, जबकि **L-form** में बाईं ओर $-\text{OH}$ होता है।



Ring forms: **Pyranose** = 6-membered ring, **Furanose** = 5-membered ring.



★ **Key Takeaway:** Structure → Function → Energy → Storage → Life



Aldose, Ketose & Reduction



Energy
4 kcal/g

एल्डोज, कीटोज और रिडक्शन



Reduction of monosaccharides converts sugars into **sugar alcohols**.



Glucose → Sorbitol (Glucitol);
Galactose → Dulcitol (Galactitol).



Mannose → Mannitol;
Fructose → Sorbitol + Mannitol.



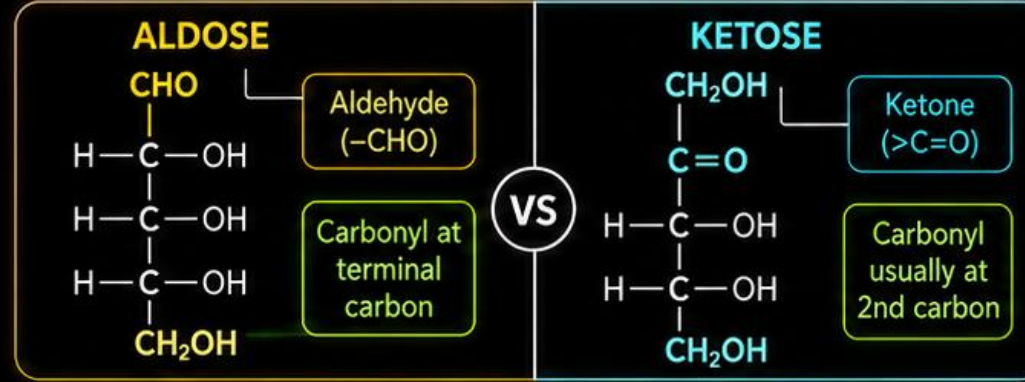
Aldose contains an aldehyde group and the carbonyl is at the terminal carbon.



Ketose contains a ketone group and the carbonyl is usually at the second carbon.



First members: Glyceraldehyde is the first aldose; Dihydroxyacetone is the first ketose. **Aldoses** are reducing; most **ketoses** also reduce after tautomerism.



REDUCTION: SUGARS → SUGAR ALCOHOLS



Feature	Aldose	Ketose
Functional group	Aldehyde ($-\text{CHO}$)	Ketone ($>\text{C}=\text{O}$)
Carbonyl position	Terminal carbon (C-1)	Usually 2nd carbon (C-2)
Example	Glyceraldehyde, Glucose	Dihydroxyacetone, Fructose
Reducing nature	Reducing sugars	Mostly reduce after tautomerism



Monosaccharides का reduction होने पर **sugar alcohols** बनते हैं।



Glucose → Sorbitol (Glucitol);
Galactose → Dulcitol (Galactitol)।



Mannose → Mannitol;
Fructose → Sorbitol + Mannitol।



Aldose में aldehyde group होता है और carbonyl terminal carbon पर होता है।

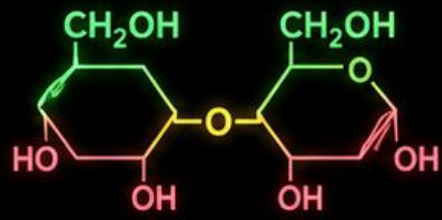


Ketose में ketone group होता है और carbonyl सामान्यतः दूसरे carbon पर होता है।



प्रथम सदस्य: Glyceraldehyde पहला aldose हैं और Dihydroxyacetone पहला ketose है। **Aldoses** reducing sugars होते हैं; अधिकांश **ketoses** tautomerism के बाद reducing behavior दिखाते हैं।

★ **Key Takeaway:** Structure → Function → Reduction → Sugar Alcohols



Disaccharides

डाइसैकराइड्स



Energy
4 kcal/g



Disaccharides are made of **two monosaccharide units** joined by a **glycosidic bond**.



They are formed by **dehydration reaction** with removal of **H₂O**.



They are usually **soluble**, **sweet**, and may be **reducing** or **non-reducing**.



Sucrose = Glucose + Fructose; bond **α -1,2**; non-reducing sugar.

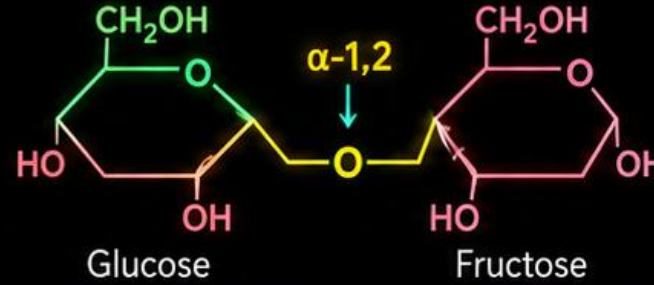


Lactose = Glucose + Galactose; bond **β -1,4**; reducing sugar.

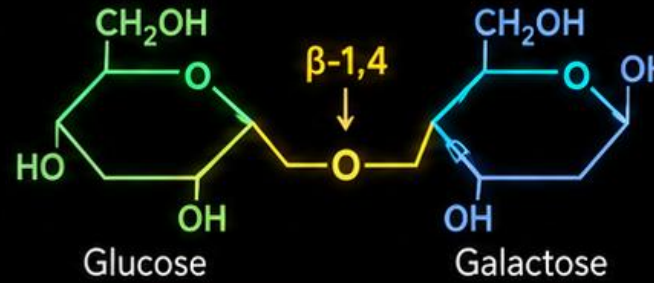


Maltose = Glucose + Glucose; bond **α -1,4**; reducing sugar.

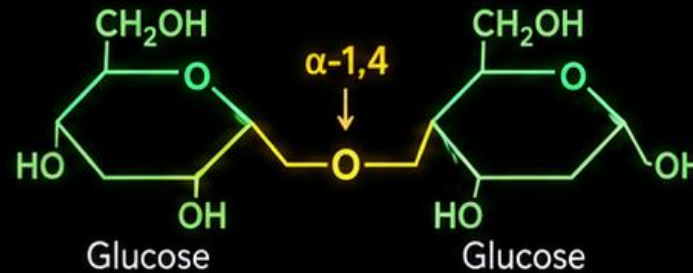
Sucrose
(Non-reducing sugar)



Lactose
(Reducing sugar)



Maltose
(Reducing sugar)



डाइसैकराइड्स दो **monosaccharide units** से मिलकर बनते हैं, जो **glycosidic bond** से जुड़े होते हैं।



ये **dehydration reaction** द्वारा बनते हैं, जिसमें **H₂O** निकलता है।



ये सामान्यतः **water soluble** और **sweet** होते हैं तथा **reducing** या **non-reducing** हो सकते हैं।



Sucrose = Glucose + Fructose; bond **α -1,2**; non-reducing sugar।

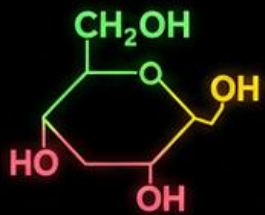


Lactose = Glucose + Galactose; bond **β -1,4**; reducing sugar।



Maltose = Glucose + Glucose; bond **α -1,4**; reducing sugar।

★ **Key Takeaway:** Structure → Formation → Properties → Examples



Polysaccharides

पॉलीसैकराइड्स

Types & Functions of Polysaccharides

Homopolysaccharides

(Only one type of monosaccharide)

Linear



Branched



Examples

Glycogen

Cellulose

Inulin

Chitin

Functions



Energy
Storage
(Animals)



Structural
Support
(Plant Cell Wall)

Heteropolysaccharides

(Two or more types of monosaccharides)

Linear



Branched



Examples

Hyaluronic
Acid

Chondroitin
Sulfate

Heparin

Keratan
Sulfate

Functions



Joint
Lubrication



Cartilage
Elasticity



Anticoagulation



Corneal
Transparency

★ Key Takeaway: Polysaccharides = Structure & Function for Life



Energy
4 kcal/g



Polysaccharides are **complex** carbohydrates made of **more than 10** monosaccharide units.



They may be **linear** or **branched** and are generally **insoluble**, **tasteless**, and **non-sweet**.



Homopolysaccharides include **glycogen**, **cellulose**, **inulin**, and **chitin**.



Glycogen stores **energy** in animals; cellulose provides **structural support** in plant cell walls.



Heteropolysaccharides include **hyaluronic acid**, **chondroitin sulfate**, **heparin**, and **keratan sulfate**.



Important roles: **joint lubrication**, **cartilage elasticity**, **anticoagulation**, and **corneal transparency**.



पॉलीसैकराइड्स जटिल कार्बोहाइड्रेट होते हैं, जिनमें **10 से अधिक monosaccharide units** होते हैं।



ये **linear** या **branched** हो सकते हैं और सामान्यतः **insoluble**, **tasteless** तथा **non-sweet** होते हैं।



Homopolysaccharides में **glycogen**, **cellulose**, **inulin** और **chitin** शामिल हैं।



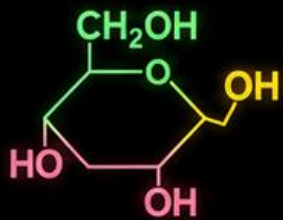
Glycogen animals में **energy** store करता है, जबकि cellulose plant cell wall को **structural support** देता है।



Heteropolysaccharides में **hyaluronic acid**, **chondroitin sulfate**, **heparin** और **keratan sulfate** शामिल हैं।



इनके प्रमुख कार्य हैं: **joint lubrication**, **cartilage elasticity**, **anticoagulation** और **corneal transparency**।



Reducing vs Non-Reducing Sugars



रिड्यूसिंग बनाम नॉन-रिड्यूसिंग शुगर



Reducing sugars have a **free anomeric carbon** and a **free aldehyde or ketone** potential.



They show **mutarotation** and give **positive Benedict's, Fehling's, and Tollen's** tests.



Examples: all monosaccharides, maltose, and lactose.



Non-reducing sugars have the **anomeric carbon blocked** in a **glycosidic bond**.



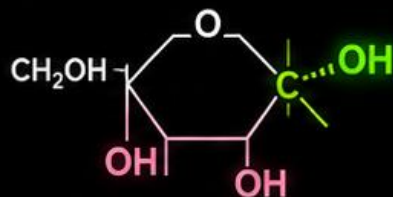
They do not show mutarotation and give **negative** reducing sugar tests.



Examples: sucrose, trehalose, and many polysaccharides.

REDUCING SUGARS

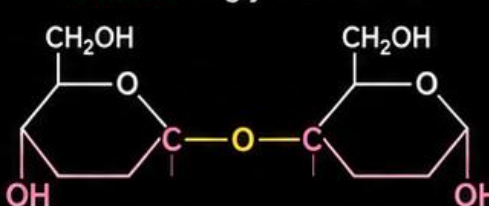
Free anomeric carbon



Can open to aldehyde or ketone

NON-REDUCING SUGARS

Anomeric carbon **blocked** in glycosidic bond



Cannot open to aldehyde or ketone

REDUCING SUGAR TESTS

Benedict's Test

Positive

Negative



Brick-red ppt



Blue solution

Fehling's Test

Positive

Negative



Brick-red ppt



Blue solution

Tollen's Test

Positive

Negative



Silver mirror



No silver mirror



Reducing sugars में **free anomeric carbon** होता है और **aldehyde** या **ketone group** की क्षमता बनी रहती है।



ये **mutarotation** दिखाते हैं तथा **Benedict's, Fehling's** और **Tollen's tests** में **positive result** देते हैं।



उदाहरण: सभी monosaccharides, maltose और lactose।



Non-reducing sugars में **anomeric carbon glycosidic bond** में **block** हो जाता है।



ये **mutarotation** नहीं दिखाते और reducing sugar tests में **negative** result देते हैं।



उदाहरण: sucrose, trehalose तथा कई polysaccharides।

★ **Key Takeaway:** Free anomeric carbon = **Reducing** → Blocked anomeric carbon = **Non-Reducing**

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Epimers

एपिमर्स



Epimers are stereoisomers that **differ in configuration** at only **one** chiral carbon atom.



They have the **same molecular formula** and the **same functional groups**.



All epimers are **diastereomers**, but not all diastereomers are **epimers**.



Glucose and **Galactose** are **C4** epimers.

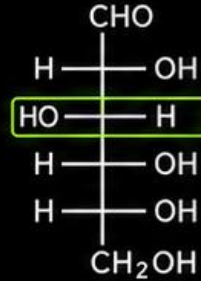


Glucose and **Mannose** are **C2** epimers.



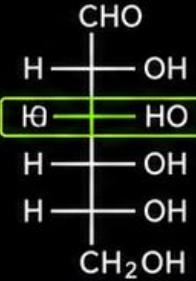
Ribose and **Arabinose** are **C2** epimers.

Glucose

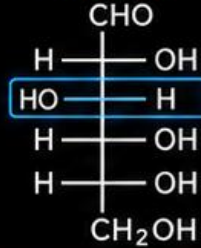


**C4
Epimers**

Galactose

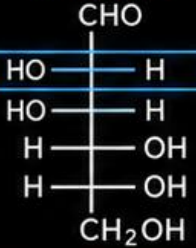


Glucose

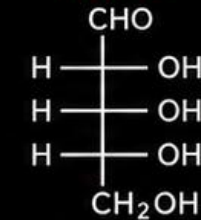


**C2
Epimers**

Mannose

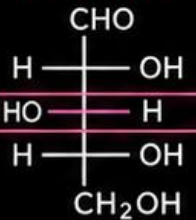


Ribose



**C2
Epimers**

Arabinose



Epimers ऐसे stereoisomers हैं जिनमें केवल एक **chiral carbon atom** पर **configuration** का अंतर होता है।



इनका **molecular formula** और **functional groups** समान होते हैं।



सभी **epimers diastereomers** होते हैं, लेकिन सभी **diastereomers epimers** नहीं होते।



Glucose और **Galactose**, **C4** epimers हैं।

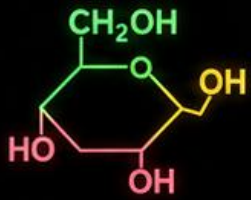


Glucose और **Mannose**, **C2** epimers हैं।



Ribose और **Arabinose**, **C2** epimers हैं।

★ **Key Takeaway:** Same Formula + Same Functional Groups → Differ at One Chiral Carbon → Epimers (Diastereomers)



Carbohydrate Metabolic Pathways



Energy
4 kcal/g

कार्बोहाइड्रेट मेटाबॉलिक पाथवे



Glycolysis occurs in cytoplasm and forms 2 pyruvate, 2 ATP, and 2 NADH; **PFK-1** is the rate-limiting enzyme.



Gluconeogenesis occurs mainly in liver and kidney and forms glucose; **fructose-1,6-bisphosphatase** is key.



Glycogenesis stores glucose as glycogen; **glycogen synthase** is the key enzyme.



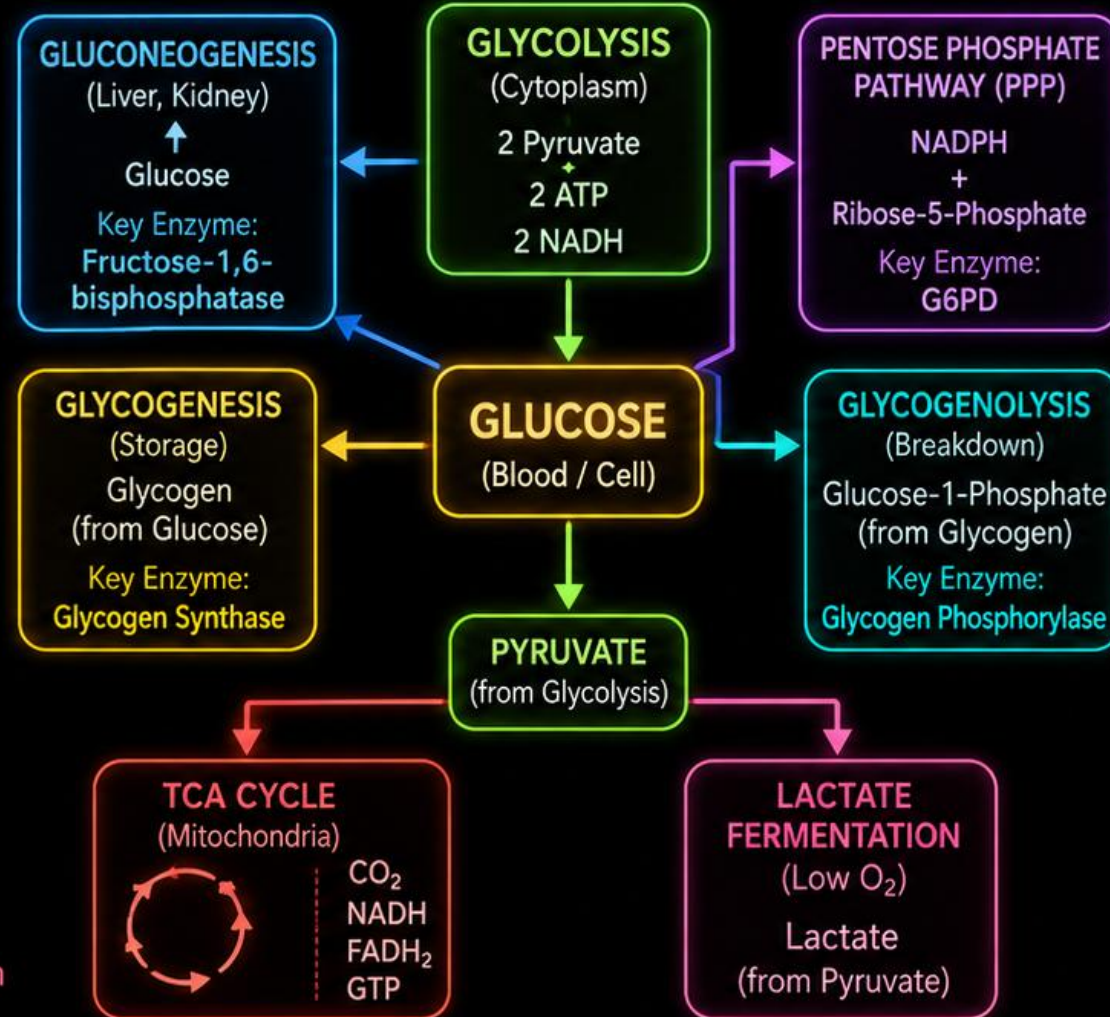
Glycogenolysis breaks glycogen to glucose-1-phosphate; **glycogen phosphorylase** is key.



Pentose phosphate pathway forms NADPH and ribose-5-phosphate; **G6PD** is the key enzyme.



TCA cycle generates CO₂, NADH, FADH₂, and GTP; **lactate fermentation** forms lactate in low O₂.



Glycolysis cytoplasm में होती है और 2 pyruvate, 2 ATP तथा 2 NADH बनाती है; इसका rate-limiting enzyme **PFK-1** है।



Gluconeogenesis मुख्यतः liver और kidney में होती है और glucose बनाती है; **fructose-1,6-bisphosphatase** इसका प्रमुख enzyme है।



Glycogenesis, glucose को glycogen के रूप में store करती है; **glycogen synthase** इसका key enzyme है।



Glycogenolysis, glycogen को glucose-1-phosphate में तोड़ती है; **glycogen phosphorylase** key enzyme है।



Pentose phosphate pathway, NADPH और ribose-5-phosphate बनाती है; **G6PD** इसका प्रमुख enzyme है।



TCA cycle से CO₂, NADH, FADH₂ और GTP बनते हैं; low O₂ में **lactate fermentation** से **lactate** बनता है।

★ **Key Takeaway:** Glucose ↔ Pathways → Energy (ATP) + Reducing Power (NADH, NADPH) + Storage (Glycogen) + Biomolecules

Glycogen Storage Diseases – Part 2

ग्लाइकोजन स्टोरेज डिजीज़ – भाग 2

V

Type V McArdle disease:

- muscle glycogen phosphorylase deficiency; skeletal muscle affected.

★ **Key features:** muscle cramps, exercise intolerance, myoglobinuria.

VI

Type VI Hers disease:

- liver glycogen phosphorylase deficiency; liver affected.

★ **Key features:** mild hypoglycemia and hepatomegaly.

VII

Type VII Tarui disease:

- muscle phosphofructokinase deficiency; muscle affected.

★ **Key features:** similar to Type V, with hemolysis.

Type	Deficient Enzyme	Affected Organ	Key Features
V	Muscle glycogen phosphorylase	Skeletal Muscle	- Muscle cramps - Exercise intolerance - Myoglobinuria
VI	Liver glycogen phosphorylase	Liver	- Mild hypoglycemia - Hepatomegaly
VII	Muscle phosphofructokinase	Skeletal Muscle	- Similar to Type V - Hemolysis

V

Type V McArdle disease:

- muscle glycogen phosphorylase की कमी; skeletal muscle प्रभावित।

★ **मुख्य लक्षण:** muscle cramps, exercise intolerance, myoglobinuria।

VI

Type VI Hers disease:

- liver glycogen phosphorylase की कमी; liver प्रभावित।

★ **मुख्य लक्षण:** mild hypoglycemia और hepatomegaly।

VII

Type VII Tarui disease:

- muscle phosphofructokinase की कमी; muscle प्रभावित।

★ **मुख्य लक्षण:** Type V जैसे symptoms, साथ में hemolysis।

★ **Key Takeaway:** Enzyme Defect → Glycogen Metabolism Impaired → Organ Dysfunction → Characteristic Clinical Manifestations



Glycogen Storage Diseases – Part 1



ग्लाइकोजन स्टोरेज डिज़ीज़ – भाग 1

I

Type I Von Gierke disease: glucose-6-phosphatase deficiency; severe fasting hypoglycemia, lactic acidosis, hepatomegaly.



II

Type II Pompe disease: lysosomal acid α -glucosidase deficiency; cardiomegaly, muscle weakness, early infant death.



III

Type III Cori/Forbes disease: debranching enzyme deficiency; milder hypoglycemia, hepatomegaly, muscle weakness.



IV

Type IV Andersen disease: branching enzyme deficiency; hepatosplenomegaly, cirrhosis, failure to thrive.



Type

Deficient Enzyme

Affected Organs

Key Features

I

Glucose-6-phosphatase deficiency



Liver



Kidney

- Severe fasting hypoglycemia
- Lactic acidosis
- Hepatomegaly

II

Lysosomal acid α -glucosidase deficiency



Heart



Muscle

- Cardiomegaly
- Muscle weakness
- Early infant death

III

Debranching enzyme deficiency



Liver



Muscle

- Milder hypoglycemia
- Hepatomegaly
- Muscle weakness

IV

Branching enzyme deficiency



Liver



Spleen

- Hepatosplenomegaly
- Cirrhosis
- Failure to thrive

I

Type I Von Gierke disease: glucose-6-phosphatase की कमी; severe fasting hypoglycemia, lactic acidosis, hepatomegaly।



II

Type II Pompe disease: lysosomal acid α -glucosidase की कमी; cardiomegaly, muscle weakness, infants में early death।



III

Type III Cori/Forbes disease: debranching enzyme की कमी; milder hypoglycemia, hepatomegaly, muscle weakness।



IV

Type IV Andersen disease: branching enzyme की कमी; hepatosplenomegaly, cirrhosis, failure to thrive।



Key Takeaway: Enzyme Defect → Glycogen Accumulation → Organ Dysfunction → Clinical Manifestations

Chemical Tests for Carbohydrates – Part 2

कार्बोहाइड्रेट्स के रासायनिक परीक्षण – भाग 2



5. Seliwanoff's test:
detects ketoses such as fructose; cherry-red color quickly.



6. Bial's test:
detects pentoses; bluish-green color.



7. Iodine test:
starch gives blue-black color; glycogen gives red-brown color.



8. Osazone test:
identifies reducing sugars by characteristic crystals.

Seliwanoff's

Bial's

Iodine

Osazone



Starch
(Blue-black)

Glycogen
(Red-brown)



5. Seliwanoff's test:
केटोसेस जैसे फ्रक्टोज को पता करता है; चेरी-रेड रंग जल्दी आता है।



6. Bial's test:
पेंटोजेस को पता करता है; ब्लूइश-ग्रीन रंग आता है।



7. Iodine test:
स्टार्च नीला-काला रंग देता है; ग्लाइकोजन लाल-भूरा रंग देता है।



8. Osazone test:
रिड्यूसिंग शुगर की पहचान उनके विशिष्ट क्रिस्टल्स से होती है।

Cherry-red color quickly

Bluish-green color

Starch: blue-black
Glycogen: red-brown

Characteristic crystals

★ **Key Takeaway:** Simple reactions → Clear colors → Accurate identification ✓

Chemical Tests for Carbohydrates – Part 1

कार्बोहाइड्रेट्स के रासायनिक परीक्षण – भाग 1



1. Molisch's test:

Detects all carbohydrates.

Positive result:

Violet / purple ring at junction.



2. Benedict's test:

Detects reducing sugars.

Positive result:

Green, yellow, orange or red precipitate.



3. Fehling's test:

Detects reducing sugars.

Positive result:

Brick-red precipitate.



4. Barfoed's test:

Detects monosaccharides.

Positive result:

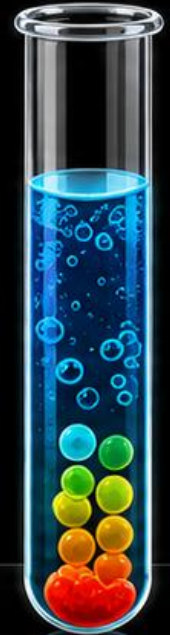
Red precipitate within 2–3 minutes.

Molisch



Violet /
purple ring
at junction

Benedict



Green,
yellow,
orange
or red ppt

Fehling



Brick-red
ppt

Barfoed



Red
ppt within
2–3 min



1. मोलिश का परीक्षण:

सभी कार्बोहाइड्रेट्स का पता लगाता है।

सकरात्मक परिणाम:

जंक्शन पर बैंगनी / बैंगनी रिंग बनती है।



2. बेनेडिक्ट का परीक्षण:

अपचायक शर्करा का पता लगाता है।

सकरात्मक परिणाम:

हरा, पीला, नारंगी
या लाल अवक्षेप बनता है।



3. फेंहलिंग का परीक्षण:

अपचायक शर्करा का पता लगाता है।

सकरात्मक परिणाम:

ईट-लाल अवक्षेप बनता है।



4. बारफोर्ड का परीक्षण:

मोनोसैकराइड्स का पता लगाता है।

सकरात्मक परिणाम:

2–3 मिनट के भीतर लाल अवक्षेप बनता है।



Key Takeaway: Simple reactions → Clear colors / precipitates → Accurate identification





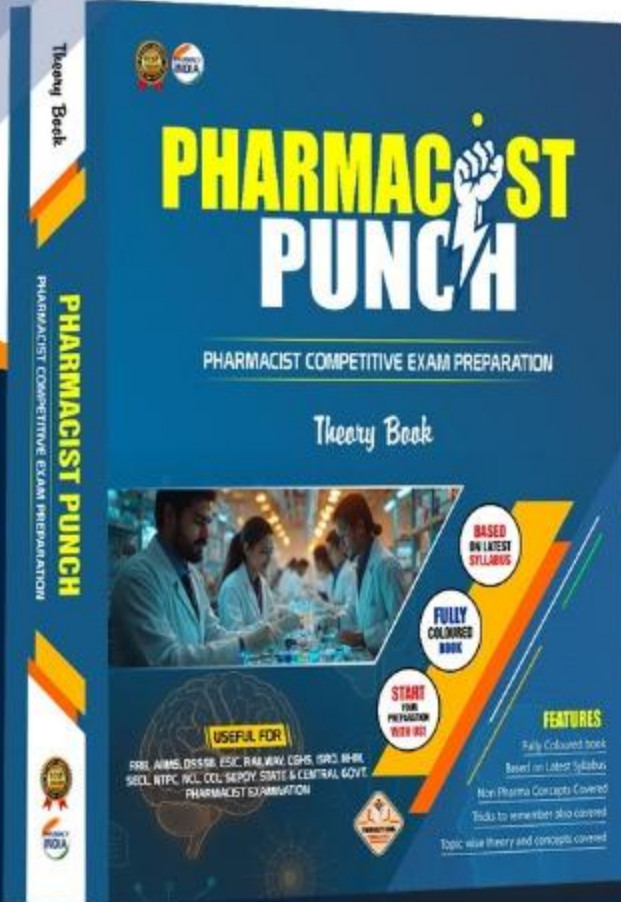
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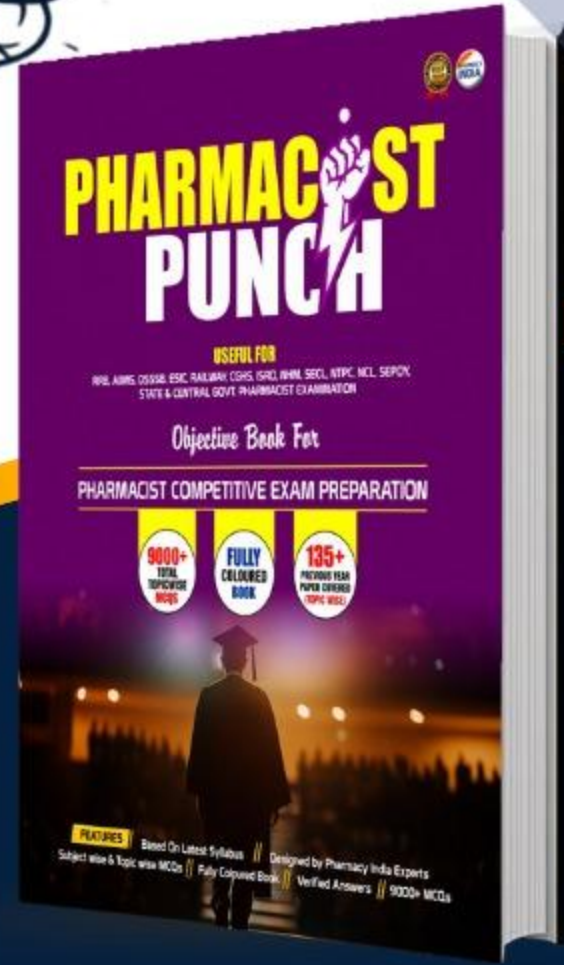
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