FREE NOTES · NCERT + JEE/NEET LEVEL

Biomolecules

Carbohydrates (glucose, fructose, disaccharides, polysaccharides), proteins (amino acids, peptide bond, structure, denaturation), enzymes, vitamins and nucleic acids (DNA, RNA).

01 Carbohydrates: classification
02 Glucose
03 Cyclic structure & fructose
04 Disaccharides & polysaccharides
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01 Carbohydrates: classification

Carbohydrates are optically active polyhydroxy aldehydes or ketones, or compounds that give these on hydrolysis. General formula often $C_x(H_2O)_y$.

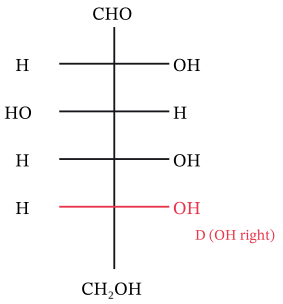
Class	Hydrolysis gives	Examples
Monosaccharides	Can't be hydrolysed	Glucose, fructose, ribose
Oligosaccharides (2–10)	2–10 monosaccharides	Sucrose, maltose, lactose
Polysaccharides	Many units	Starch, cellulose, glycogen

- **Sugars** are sweet and crystalline (mono and oligo); polysaccharides are non-sugars.
- **Reducing sugars** reduce Tollens'/Fehling's (free aldehyde/ketone group): all monosaccharides, maltose, lactose. **Sucrose is non-reducing.**
- Aldose (–CHO) vs ketose (C=O): glucose is an aldohexose, fructose a ketohexose.

02 Glucose

Preparation: sucrose + dil. HCl → glucose + fructose; starch + dil. H_2SO_4 (393 K, 2–3 atm) → glucose.

Reaction	Proves
HI, heat → n-hexane	6 C in a straight chain
NH_2OH → oxime; HCN → cyanohydrin	C=O present
Br_2 water → gluconic acid	C=O is an aldehyde
Acetic anhydride → pentaacetate	5 –OH groups
HNO_3 → saccharic acid	A 1° alcohol (–CH_2OH)



D-(+)-glucose, Fischer projection

"D" refers to the configuration of the lowest chiral C (–OH on the right, like D-glyceraldehyde); "+" means dextrorotatory. They are unrelated.

03 Cyclic structure & fructose

Open-chain glucose can't explain some facts: no Schiff's test, no $NaHSO_3$ adduct, pentaacetate doesn't react with NH_2OH, and two forms α and β exist. So glucose forms a **six-membered ring** (pyranose) by the C5 –OH attacking C1 –CHO (hemiacetal).

- **Anomers:** α and β differ only at C1 (the anomeric carbon).
- **Fructose:** ketohexose, C=O at C2; forms a five-membered ring (**furanose**). D-(–)-fructose is laevorotatory.

04 Disaccharides & polysaccharides

Sugar	Units	Linkage	Reducing?
Sucrose	α-D-glucose + β-D-fructose	C1–C2 glycosidic	No
Maltose	2 α-D-glucose	C1–C4	Yes
Lactose (milk sugar)	β-D-galactose + β-D-glucose	C1–C4	Yes

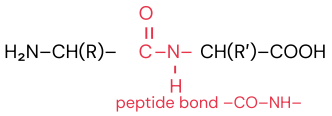
Invert sugar: sucrose (+66.5°) hydrolyses to glucose (+52.5°) + fructose (–92.4°); the mixture is laevorotatory, so the sign "inverts".

Polysaccharide	Made of	Note
Starch	Amylose (15–20%, linear, water-soluble, α C1–C4) + amylopectin (80–85%, branched, C1–C6 at branches)	Plant storage
Cellulose	β-D-glucose, C1–C4 linear	Plant cell walls; humans can't digest
Glycogen	Highly branched like amylopectin	"Animal starch" in liver, muscles

05 Amino acids

Contain $-NH_2$ and $-COOH$. **α-amino acids** (both on the same C) make proteins. All except glycine are optically active (mostly L-form).

- **Essential** (from diet): valine, leucine, isoleucine, lysine, threonine, methionine, phenylalanine, tryptophan, histidine, arginine. **Non-essential**: made in the body (glycine, alanine, …).
- Neutral, acidic (extra $-COOH$: aspartic, glutamic acid) or basic (extra $-NH_2$: lysine, arginine).
- **Zwitterion:** in water, H^+ moves from $-COOH$ to $-NH_2$ ⇒ $H_3N^+-CHR-COO^-$. Amino acids are amphoteric, high melting, water-soluble. At the **isoelectric point** net charge is zero.



A dipeptide: $-COOH$ of one + $-NH_2$ of the next, losing water

06 Proteins

- **Fibrous** (thread-like, water-insoluble: keratin, myosin) and **globular** (spherical, soluble: insulin, albumin).

Structure	What it means	Held by
Primary	Sequence of amino acids	Peptide bonds
Secondary	α-helix or β-pleated sheet	H-bonds between –CO and –NH
Tertiary	Overall folding (fibrous/globular)	H-bonds, disulphide, ionic, van der Waals
Quaternary	Arrangement of several sub-units	Same forces

DENATURATION

Heat or pH change breaks H-bonds ⇒ 2° and 3° structures are lost, the protein loses its biological activity; the 1° structure stays. Examples: boiling an egg (albumin coagulates), curdling of milk.

07 Enzymes & vitamins

Enzymes are mostly globular proteins that act as specific biological catalysts (maltase: maltose → glucose). They lower activation energy (sucrose hydrolysis E_a 18 → 6 kJ/mol with sucrase).

Vitamin	Source	Deficiency disease
A	Fish oil, carrot, milk	Night blindness, xerophthalmia
B_1 (thiamine)	Yeast, milk, cereals	Beri-beri
B_2 (riboflavin)	Milk, egg white	Cheilosis, digestive disorders
B_6 (pyridoxine)	Yeast, milk, cereals	Convulsions
B_{12}	Meat, fish, egg (not in plants)	Pernicious anaemia
C (ascorbic acid)	Citrus fruits, amla	Scurvy (bleeding gums)
D	Sunlight, fish, egg yolk	Rickets, osteomalacia
E	Vegetable oils, nuts	Fragile RBCs, muscle weakness
K	Green leafy vegetables	Delayed blood clotting

Fat-soluble (stored in body): A, D, E, K. **Water-soluble** (must be taken daily): B group, C. B_{12} is an exception that is stored in the liver.

08 Nucleic acids

- Polymers of **nucleotides**. Nucleoside = base + sugar; nucleotide = nucleoside + phosphate. Nucleotides join by **phosphodiester** links (5′–3′).
- **DNA:** 2-deoxyribose; bases A, G, C, **T**. Double helix; A pairs with T (2 H-bonds), G with C (3 H-bonds). Stores genetic information, self-replicates.
- **RNA:** ribose; bases A, G, C, **U**. Single strand. Types: mRNA, rRNA, tRNA; carry out protein synthesis.
- Purines: A, G. Pyrimidines: C, T, U.

09 JEE Extra + Tricks

JEE LEVEL

- Glucose: open-chain fails to explain no reaction with $NaHSO_3$ and Schiff's reagent and existence of α, β anomers ⇒ cyclic (pyranose) structure; mutarotation.
- Reducing sugars: glucose, fructose, maltose, lactose. Sucrose is non-reducing (C1 of glucose and C2 of fructose linked) and is invert sugar after hydrolysis.
- Starch: amylose (linear, α-1,4) + amylopectin (branched, α-1,6 at branches); cellulose β-1,4.
- Essential amino acids (10): "**PVT TIM HALL**". Isoelectric point: amino acid exists as zwitterion with no net charge.
- Vitamins: fat-soluble A, D, E, K (stored in body); water-soluble B group and C (must be supplied regularly; B_{12} is stored in liver).
- DNA vs RNA: deoxyribose vs ribose; thymine vs uracil; double vs single strand.

10 Solved questions

Q1. Why is sucrose non-reducing?

Both reducing groups (C1 of glucose and C2 of fructose) are used in the glycosidic bond, so no free C=O is left.

Q2. What happens to a protein's primary structure on denaturation?

It stays intact; only 2° and 3° structures are lost.

Q3. Name the linkage in proteins, polysaccharides and nucleic acids.

Peptide, glycosidic and phosphodiester respectively.

11 Mistakes & practice

- Thinking D/L tells you the direction of rotation.
- Calling sucrose a reducing sugar.
- Writing uracil in DNA or thymine in RNA.
- Saying vitamin C is fat-soluble.

1. Which vitamin's deficiency causes scurvy?
2. Which carbohydrate is called animal starch?
3. Which bond holds the α-helix?
4. Which amino acid is not optically active?
5. Monomers of cellulose?

ANSWERS

1) Vitamin C · 2) Glycogen · 3) Hydrogen bonds · 4) Glycine · 5) β-D-glucose

12 Quick revision: 5 minutes before the exam

CARBOHYDRATES

- Glucose: aldohexose, pyranose.
- Fructose: ketohexose, furanose.
- Sucrose non-reducing; invert sugar.

POLYSACCHARIDES

- Starch: amylose + amylopectin.
- Cellulose: β-glucose.
- Glycogen: animal starch.

PROTEINS

- Peptide bond –CO–NH–.
- 1°, 2° (helix/sheet), 3°, 4°.
- Denaturation: 1° stays.

OTHERS

- Fat-soluble: A, D, E, K.
- DNA: A=T, G≡C, deoxyribose.
- RNA: U, ribose.

Have a doubt? Ask the AI Doubt Solver at padhaiadda.netlify.app, or take the mock test on this chapter.