LOGIC BLOOM · NEET & JEE BIOLOGY / CHEMISTRY

Biomolecules

Class 12 · **The Chemistry of Life** · NEET & JEE

Complete NCERT-based notes: carbohydrates, proteins, enzymes, vitamins and nucleic acids, with the high-yield facts and tables that win marks.

NCERT-based | High-Yield Tables | Fact Sheet

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Contents

1 What Are Biomolecules?

Biomolecules are the organic compounds that build and run every living cell: carbohydrates, proteins, lipids, nucleic acids, vitamins and hormones. They are made mostly of carbon, hydrogen, oxygen and nitrogen, and their endless variety comes from how these few atoms are arranged and bonded. This chapter is one of the most fact-dense and reliably scoring in the syllabus, and almost every question traces back to a specific NCERT line or table.

★ HIGH-YIELD SUPERLATIVES (LEARN THESE COLD)

- Most abundant biomolecule in a cell: **water**.
- Most abundant carbohydrate in nature: **cellulose**.
- Most abundant protein in the biosphere: **RuBisCO**; in the animal kingdom: **collagen**.
- Number of standard amino acids: **20**.
- Approximate dry-cell composition: proteins 10 to 15%, nucleic acids 5 to 7%, carbohydrates about 3%, lipids about 2%.

2 Carbohydrates

Carbohydrates are polyhydroxy aldehydes or ketones, or compounds that yield these on hydrolysis. General formula $C_x(H_2O)_y$. They are the cell's primary energy source and, as cellulose, its main structural material.

Class	Definition	Examples
Monosaccharides	Cannot be hydrolysed to simpler sugars	Glucose, fructose, galactose, ribose
Oligosaccharides	Yield 2 to 10 monosaccharides on hydrolysis	Sucrose, maltose, lactose (all disaccharides)
Polysaccharides	Yield many monosaccharides on hydrolysis	Starch, glycogen, cellulose

REDUCING VS NON-REDUCING SUGARS

A **reducing sugar** has a free aldehyde or ketone group and so reduces Tollens' and Fehling's reagents. All monosaccharides and most disaccharides (maltose, lactose) are reducing. **Sucrose is non-reducing**, because both its anomeric carbons are locked in the glycosidic bond. This single fact is a perennial NEET question.

KEY DEFINITIONS

- **Glucose:** an aldohexose ($C_6H_{12}O_6$); reduces Tollens' and Fehling's reagents.
- **Glycosidic linkage:** the oxygen bridge joining two monosaccharide units.
- **Invert sugar:** the equal glucose-plus-fructose mixture from sucrose hydrolysis; the optical rotation inverts from dextro (sucrose) to laevo, hence the name.
- **Starch** = amylose + amylopectin (plant storage); **glycogen** = animal storage; **cellulose** = structural, made of β-glucose units.

3 Proteins & Amino Acids

Proteins are polymers of α-amino acids joined by peptide bonds. There are 20 standard amino acids; those the body cannot synthesise are called essential and must come from diet. Amino acids are bifunctional (an amino group and a carboxyl group) and exist as dipolar zwitterions.

THE PEPTIDE BOND

A **peptide bond** is the –CO–NH– linkage formed when the carboxyl group of one amino acid condenses with the amino group of the next, releasing water (dehydration synthesis). Its detection is the basis of the **biuret test**, which gives a violet colour with peptide bonds.

★ THE FOUR LEVELS OF PROTEIN STRUCTURE

- **Primary:** the linear sequence of amino acids, held by peptide (covalent) bonds.
- **Secondary:** local folding into α-helix or β-pleated sheet, stabilised by hydrogen bonds.
- **Tertiary:** the overall 3D shape, stabilised by hydrogen bonds, disulphide bridges, ionic and hydrophobic interactions.
- **Quaternary:** the arrangement of two or more polypeptide subunits (for example, haemoglobin's four chains).

Type	Solubility	Examples
Fibrous proteins	Water-insoluble	Keratin, myosin, collagen
Globular proteins	Water-soluble	Insulin, albumin, haemoglobin

⚠ DENATURATION

When a protein in its native form is exposed to heat, extreme pH, or heavy-metal ions, the non-covalent bonds holding its secondary, tertiary and quaternary structure collapse. The chain unfolds, the helix uncoils, and the protein **loses its biological activity**. Crucially, the **primary structure (the peptide bonds) stays intact**; only the higher-order folding is destroyed. A boiled egg is the classic example.

4 Enzymes

Enzymes are biocatalysts, almost all of them globular proteins, that speed up biochemical reactions by lowering the activation energy. Their power comes from a specific three-dimensional active site, which makes them highly substrate-specific.

★ ENZYME TERMINOLOGY (MEMORISE THE DEFINITIONS)

- **Apoenzyme:** the protein part alone (inactive).
- **Cofactor:** a non-protein helper; if a metal ion (for example Zn^{2+} for carboxypeptidase) it binds at the active site.
- **Coenzyme:** an organic cofactor loosely bound for a short time; many are vitamin-derived (NAD and NADP contain niacin).
- **Prosthetic group:** a cofactor tightly (permanently) bound to the enzyme.
- **Holoenzyme:** apoenzyme + cofactor = the complete, active enzyme.

MECHANISM: LOCK-AND-KEY VS INDUCED FIT

In the **lock-and-key** model the substrate fits a rigid, pre-shaped active site like a key in a lock. In the more accurate **induced-fit** model the active site is flexible and moulds itself around the substrate on binding. Enzyme activity depends on temperature, pH, and substrate concentration, each with an optimum.

5 Vitamins

Vitamins are organic micronutrients required in small amounts for normal growth and metabolism. They do not supply energy; many act as coenzymes. They are classified by solubility, and this classification carries real consequences for storage and toxicity.

★ FAT-SOLUBLE VS WATER-SOLUBLE (A HIGH-FREQUENCY DISTINCTION)

Fat-soluble (A, D, E, K): stored in liver and fatty tissue, so daily intake is not essential and overdose can cause hypervitaminosis (vitamin A toxicity gives headache and liver damage).
Water-soluble (B-complex and C): excreted in urine within hours and not stored (except B12), so they must be supplied regularly; toxicity is rare.

Vitamin	Chemical name	Deficiency disease
A	Retinol	Night blindness, xerophthalmia
B1	Thiamine	Beriberi
B12	Cyanocobalamin	Pernicious anaemia
C	Ascorbic acid	Scurvy
D	Calciferol	Rickets (children), osteomalacia (adults)
E	Tocopherol	Reproductive / muscular issues
K	Phylloquinone	Poor blood clotting

6 Nucleic Acids

Nucleic acids (DNA and RNA) are polymers of nucleotides that store and transmit genetic information. Each nucleotide has three parts: a nitrogenous base, a pentose sugar, and a phosphate group. A base plus sugar alone is a nucleoside; add the phosphate and it becomes a nucleotide.

BASES: PURINES VS PYRIMIDINES

- **Purines** (double-ring): Adenine (A) and Guanine (G).
- **Pyrimidines** (single-ring): Cytosine (C), Thymine (T, in DNA only) and Uracil (U, in RNA only).

The sugar-phosphate backbone is joined by **phosphodiester linkages**; the two strands are held together by **hydrogen bonds** between complementary bases.

★ BASE PAIRING & CHARGAFF'S RULE

Bases pair specifically: **A with T** (two hydrogen bonds) and **G with C** (three hydrogen bonds). Hence Chargaff's rule: in DNA, A = T and G = C. The Watson-Crick double-helix model was proposed in **1953**.

Feature	DNA	RNA
Sugar	2-deoxyribose	Ribose
Bases	A, G, C, T	A, G, C, U
Strands	Double-stranded helix	Usually single-stranded
Function	Stores hereditary information	Protein synthesis (mRNA, tRNA, rRNA)

7 Lipids & Hormones (Quick Coverage)

Two smaller topics that still yield the occasional NEET question.

LIPIDS

Lipids are water-insoluble, non-polymeric biomolecules. They include fats and oils (triglycerides, esters of glycerol and fatty acids), phospholipids (the basis of cell membranes), and steroids. **Saturated** fatty acids have no C=C double bonds (usually solid, animal fats); **unsaturated** ones have double bonds (usually liquid oils). Fats are the most concentrated energy store.

HORMONES

Hormones are chemical messengers secreted by endocrine glands. By chemistry they fall into groups: **steroid hormones** (for example testosterone, estrogen, cortisol), **amino-acid-derived** (adrenaline, thyroxine), and **peptide/protein hormones** (insulin, glucagon). They regulate metabolism, growth and reproduction, and act in tiny amounts.

★ Biomolecules: One-Page Fact Sheet

Everything for revision day. Print this alone.

SUPERLATIVES

cell: water
carb in nature: cellulose
protein biosphere: RuBisCO
protein animals: collagen
amino acids: 20

CARBOHYDRATES

polyhydroxy aldehyde/ketone
mono/oligo/poly
reducing: has free CHO/C=O
sucrose = non-reducing
glycosidic = O-bridge

SUGARS

glucose: aldohexose
invert sugar: glu+fru
starch: plant store
glycogen: animal store
cellulose: β-glucose

PROTEINS

monomer: α-amino acid
peptide bond -CO-NH-
biuret test: violet
fibrous: keratin (insol.)
globular: insulin (sol.)

PROTEIN STRUCTURE

1°: sequence (peptide)
2°: helix/sheet (H-bond)
3°: 3D (S-S, ionic)
4°: subunits
denatur: 1° intact

ENZYMES

biocatalysts, globular
apo + cofactor = holo
coenzyme: organic, vit.
lock-key / induced fit
lower activation energy

VITAMINS FAT-SOL

A D E K, stored in liver
toxicity possible
A: night blindness
D: rickets
K: clotting

VITAMINS WATER-SOL

B, C not stored
C: scurvy (ascorbic)
B1: beriberi
B12: pernicious anaemia
supply daily

NUCLEIC ACIDS

nucleotide: base+sugar+PO4
nucleoside: base+sugar
purine: A,G (2-ring)
pyrimidine: C,T,U (1-ring)
A=T, G=C (Chargaff)

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