LOGIC BLOOM · NEET BIOLOGY

Biomolecules

Class 11 · **Chapter 9** · The Molecular Logic of Life

Complete NCERT-based notes for NEET: chemical analysis of tissue, metabolites, biomacromolecules, carbohydrates, proteins, nucleic acids, and a deep dive into enzymes. Rebuilt to be understood at a glance, not just memorised.

NCERT Chapter 9 | Detailed Theory | 30+ Diagrams | High-Yield Tables | 1-Page Fact Sheet

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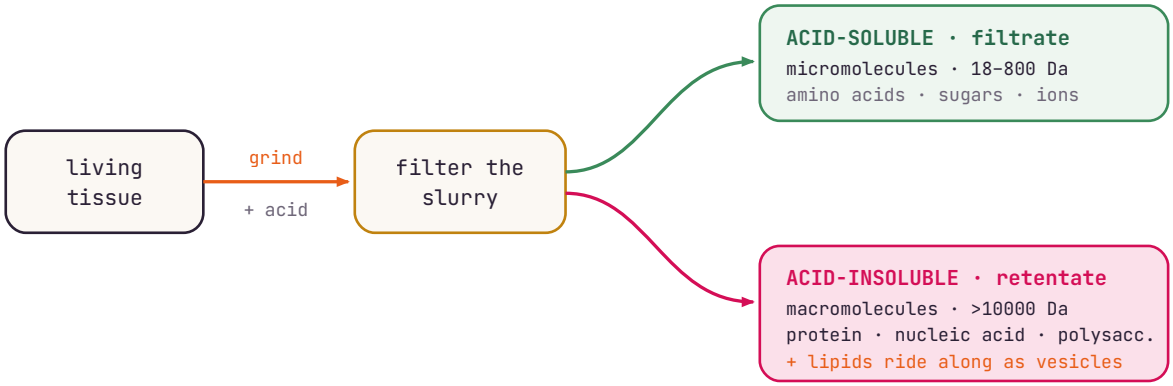
The simplest way to learn science.

Contents

1 How to Analyse the Chemical Composition of Living Tissue

The chapter opens with a deceptively simple question: what is a living organism actually made of? To find out, a biologist does something almost brutal. Take any living tissue, a vegetable or a piece of liver, grind it in acid with a mortar and pestle, and filter it. What you get is a story about the chemistry of life.

The grinding breaks open the cells and releases their contents. Filtering then separates the slurry into two parts: a **filtrate** (the acid-soluble pool that passes through) and a **retentate** (the acid-insoluble fraction trapped on the filter). This one experiment is the backbone of the whole chapter, because the two fractions correspond to two completely different scales of molecule.



One grind-and-filter splits the cell into two molecular worlds: an acid-soluble pool of micromolecules and an acid-insoluble pool of macromolecules (lipids ride along as vesicles).

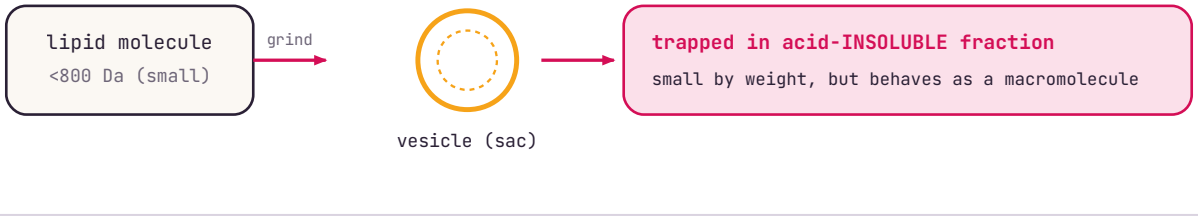
THE TWO FRACTIONS

Acid-soluble (filtrate): small molecules, roughly 18 to 800 daltons. Amino acids, nucleotides, simple sugars, fatty acids and the like, together with all inorganic ions. This is the pool of *micromolecules*.

Acid-insoluble (retentate): the giants, ten thousand daltons and above: proteins, nucleic acids and polysaccharides. This is the pool of *macromolecules*, also called biomacromolecules.

⚠ THE LIPID EXCEPTION (A CLASSIC NEET TRAP)

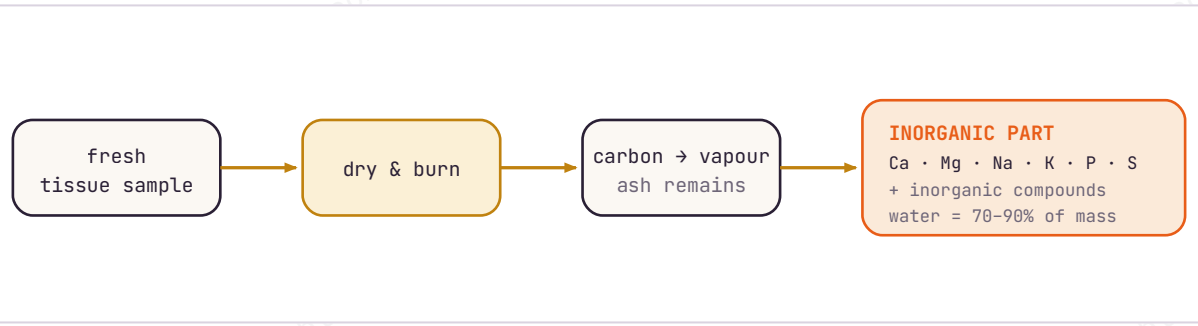
Lipids are small: molecular weight well under 800 Da, so by size they are micromolecules. Yet they show up in the acid-insoluble fraction. Why? In the cell, lipids form membranes. Grinding breaks these into little closed sacs called **vesicles** that are not water-soluble, so they get trapped with the big molecules. The rule: **lipids are micromolecules by weight, but behave as macromolecules in this analysis.** Examiners love this exception.



Why lipids land in the macromolecule fraction despite their small size.

Inorganic analysis: making ash

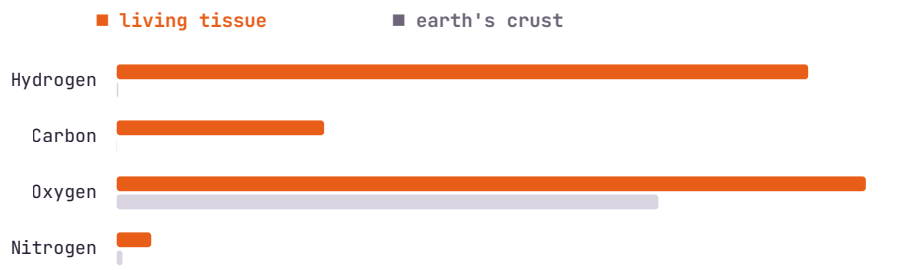
To find the inorganic constituents, a separate sample is dried and burned. Everything carbon-based goes off as vapour, leaving the **ash**. Analysing it reveals inorganic elements (Ca, Mg, Na, K, P, S) and inorganic compounds. Water, remember, is by far the most abundant single molecule, 70 to 90% of the cell's mass.



Burning a dried sample drives off all carbon and leaves the inorganic ash for analysis.

A revealing comparison

Compare the elemental make-up of living matter with the Earth's crust and the same elements appear, but the proportions differ sharply. Living tissue is enormously enriched in carbon and hydrogen.

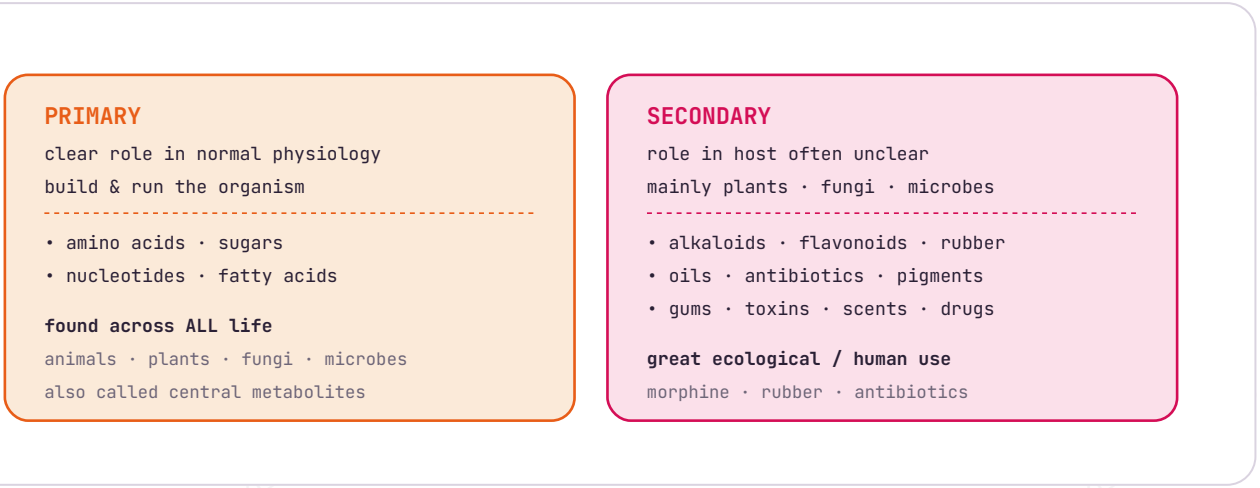


Life is enriched in C and H relative to the crust — a carbon-and-hydrogen phenomenon on a base of water.

Living tissue versus the Earth's crust — life concentrates carbon and hydrogen far above their crustal share.

2 Primary and Secondary Metabolites

The thousands of small organic molecules in the acid-soluble pool are collectively the **metabolites**: the intermediates and products of metabolism. Biologists split them into two families by the role they play in the organism.



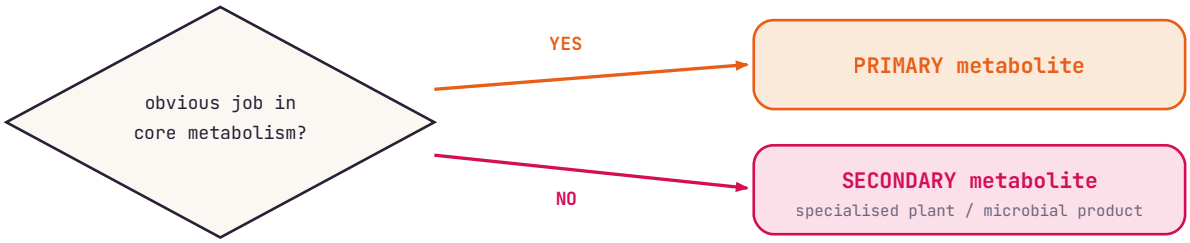
The two metabolite families side by side — primary keep the organism running; secondary are specialised products.

PRIMARY METABOLITES

Clear, identifiable roles in normal physiology: they build and run the organism. Amino acids, sugars, nucleotides and fatty acids all qualify, taking part directly in growth, respiration and photosynthesis (hence *central metabolites*). Crucially, they are found across animals, plants, fungi and microbes.

SECONDARY METABOLITES

Found mainly in plants, fungi and microbes, with an often-unclear role in the host. Examples: alkaloids, flavonoids, rubber, essential oils, antibiotics, pigments, gums, spices, scents, toxins and drugs. Many have great ecological or human use: morphine, rubber, or antibiotics from actinomycetes.



A one-question test: does the molecule have an obvious job in core metabolism?

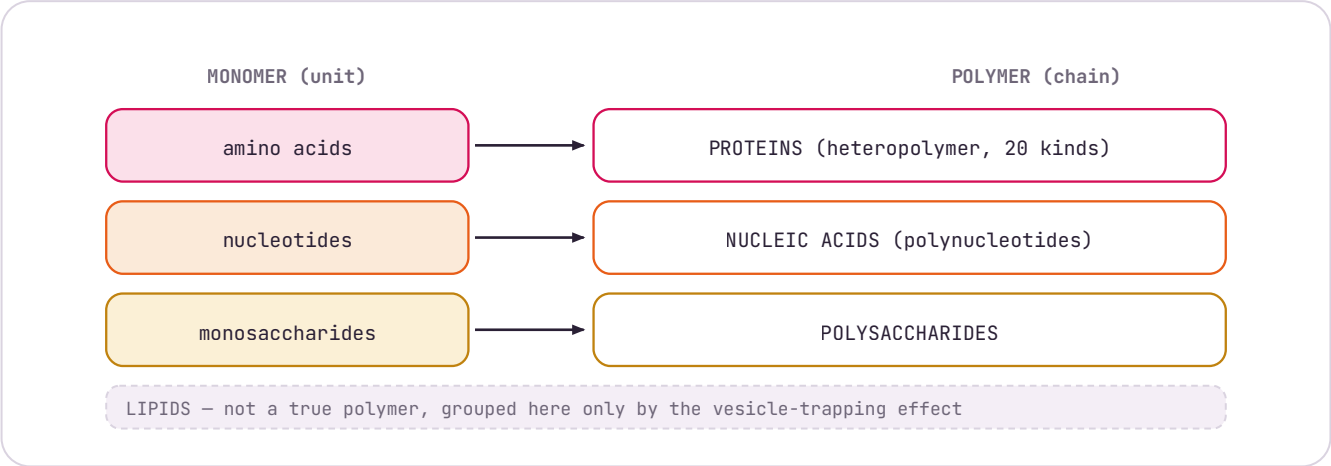
★ THE MENTAL MODEL

Primary metabolites keep the organism alive and growing; secondary metabolites help it interact with its world (defence, signalling, colour, scent) or simply happen to be useful to us. Obvious core job → primary. Specialised plant or microbial product with a fuzzy in-house role → secondary.

3 Biomacromolecules

The acid-insoluble fraction holds the true giants of the cell. Understanding what makes a macromolecule is the conceptual heart of this chapter.

A **biomacromolecule** has molecular weight above about ten thousand daltons and sits in the acid-insoluble fraction. There are only four kinds: proteins, nucleic acids, polysaccharides, and (by their membrane behaviour) lipids. Micromolecules are everything small in the acid-soluble pool.



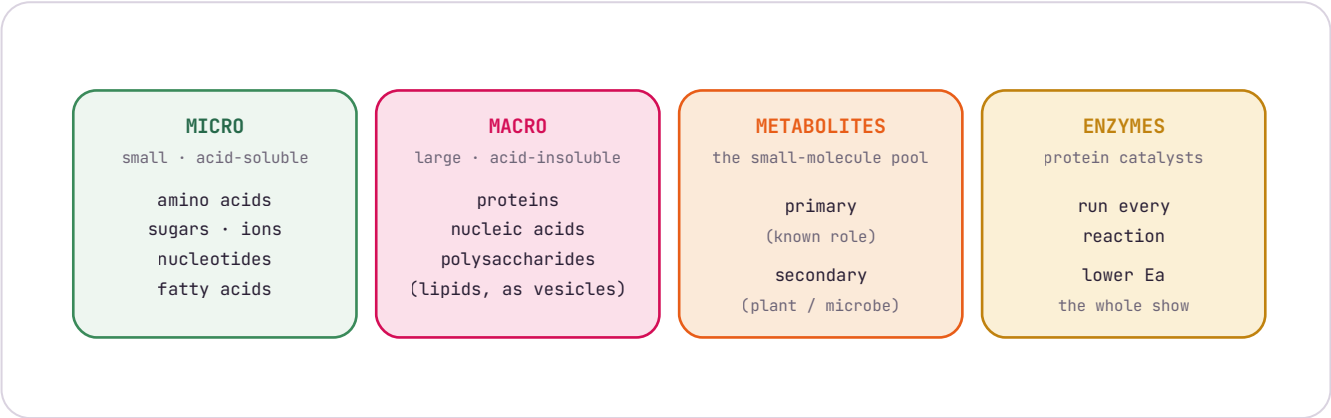
Three of the four macromolecule classes are true polymers — chains of repeating monomers. Lipids are the exception.

★ POLYMERS AND MONOMERS

Proteins are polymers of amino acids. Nucleic acids are polymers of nucleotides. Polysaccharides are polymers of monosaccharides. **Lipids are the odd one out**: not true polymers, and not really macromolecules by weight either, grouped here only because of the vesicle-trapping effect.

Organise the whole chapter into four buckets

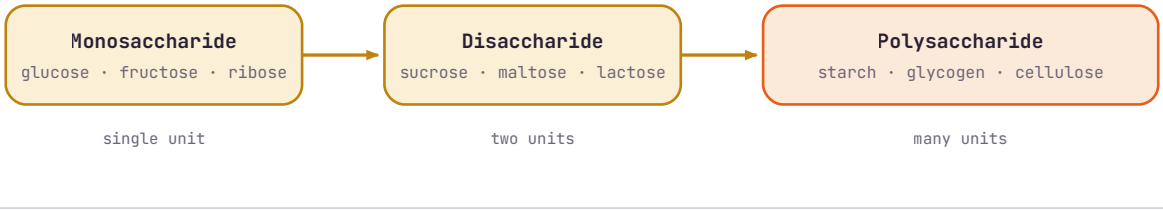
Put examples under each bucket and recall becomes fast.



The four buckets that organise the entire chapter: micromolecules, macromolecules, metabolites, and the enzymes that run everything.

4 Carbohydrates and Polysaccharides

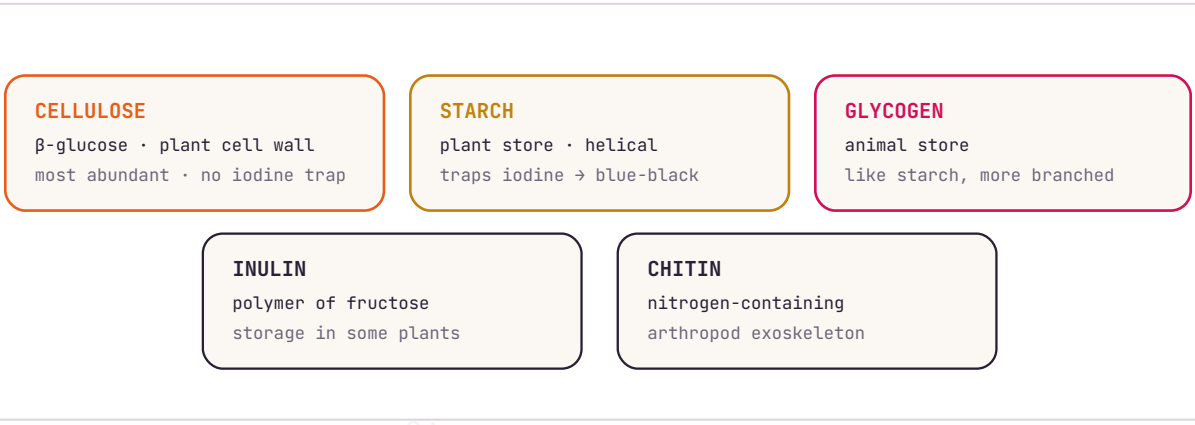
Carbohydrates are polyhydroxy aldehydes or ketones. In the living cell they run from single sugars up to vast branched storage and structural polymers.



The size ladder of carbohydrates: single units, pairs, then long chains.

Level	What it is	Examples
Monosaccharides	Single sugar units, cannot be hydrolysed further	Glucose, fructose, ribose
Disaccharides	Two sugar units joined	Sucrose, maltose, lactose
Polysaccharides	Long chains of many sugar units	Starch, glycogen, cellulose, inulin, chitin

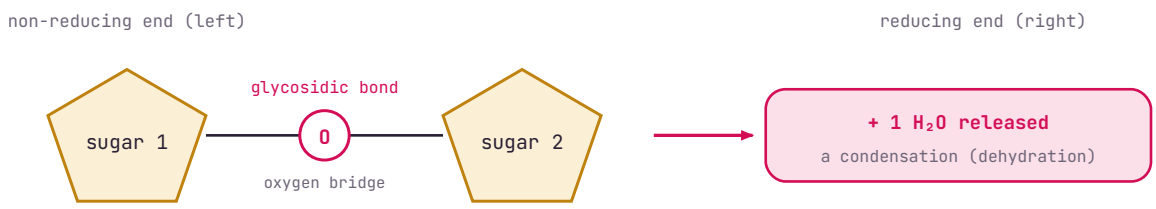
The important polysaccharides



The five polysaccharides NEET asks about, with the one fact that distinguishes each.

★ THE GLYCOSIDIC BOND

Sugar units are linked by a **glycosidic bond**: a bond between two carbon atoms of adjacent monosaccharides through an oxygen bridge, with the loss of a water molecule. In a chain, the right end is the reducing end and the left the non-reducing end. This is one of the three bonds NCERT asks you to illustrate.



Bond type 1 of the three NCERT asks you to illustrate.

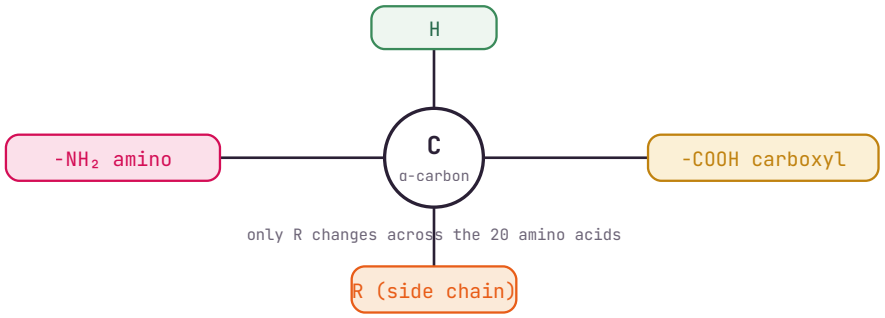
How two sugars join: a carbon-oxygen-carbon bridge forms and one water molecule leaves.

5 Proteins

Proteins are the most versatile macromolecules in the cell, and the most abundant in the acid-insoluble fraction. They are **heteropolymers**: chains drawn from twenty different amino acids, so the sequence carries real information.

Amino acids: the building blocks

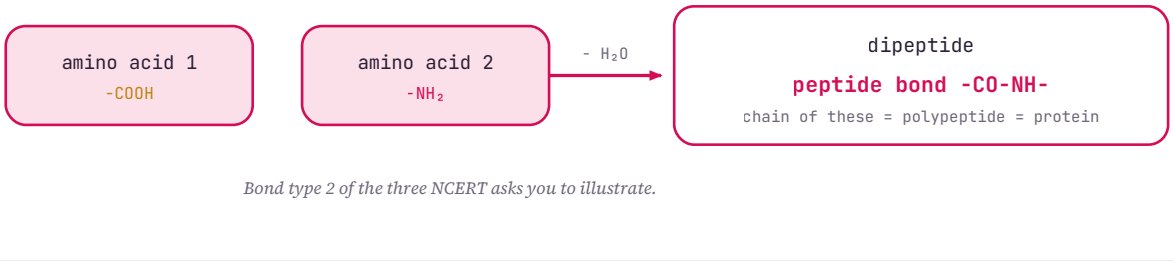
An amino acid is a substituted methane: a central carbon carrying four groups, an amino group ($-NH_2$), a carboxyl group (−COOH), a hydrogen, and a variable side chain (the R group). Twenty standard amino acids differ only in that R group. Carrying both an acidic and a basic group, amino acids are ionisable and exist as dipolar *zwitterions* at intermediate pH.



The universal amino acid plan — four groups on one central carbon. Only R changes across the twenty.

The peptide bond

Amino acids join when the carboxyl of one reacts with the amino group of the next, releasing water and forming a **peptide bond** (−CO−NH−). Chains so joined are polypeptides; a functional polypeptide is a protein. This is the second of the three bonds NCERT asks you to illustrate.



Bond type 2 of the three NCERT asks you to illustrate.

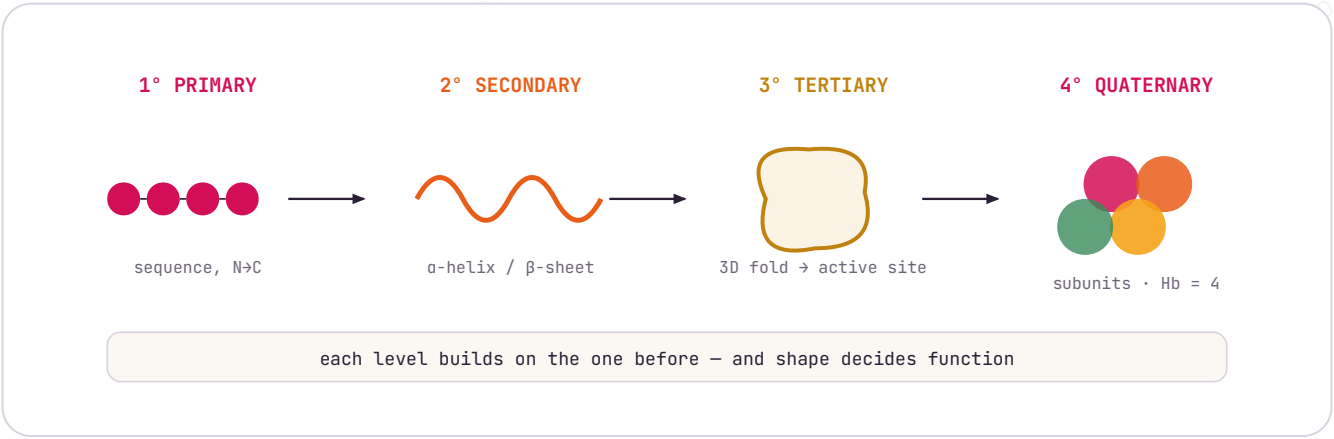
Peptide bond formation: a condensation that links two amino acids and releases one water.

★ PROTEIN FUNCTIONS (A FAVOURITE ONE-MARK LIST)

Proteins do almost everything, as shown below. Remember: **collagen** is the most abundant protein in the animal world, and **RuBisCO** is the most abundant protein on Earth overall.

Six headline roles proteins play in the cell.

The four levels of protein structure



Sequence, then local coils and sheets, then the full 3D fold that creates the active site, then the packing of several folded subunits.

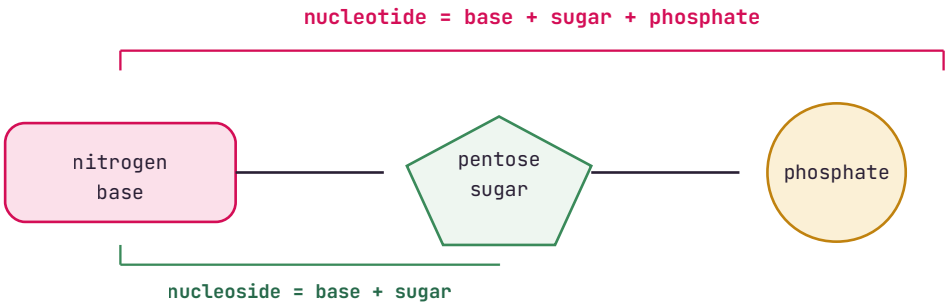
Primary: the linear amino-acid sequence (N-terminal first, C-terminal last), held by peptide bonds. **Secondary:** regions coil into a right-handed α-helix or fold into a β-pleated sheet, held by hydrogen bonds. **Tertiary:** the whole chain folds into a compact 3D shape whose pocket becomes the active site. **Quaternary:** when several subunits pack together, as in haemoglobin (two α and two β).

SEEING STRUCTURE AS AN ANALOGY

NCERT offers a lovely image. The primary structure is a line of beads on a thread. The secondary is where parts of that thread coil like a telephone cord. The tertiary is how the whole coiled thread folds to fit inside a tiny box, and this fold is what makes it work. The quaternary is several such folded threads clustering together.

6 Nucleic Acids

Nucleic acids are the acid-insoluble macromolecules that carry hereditary information. They are **polynucleotides**: long chains of nucleotide monomers.

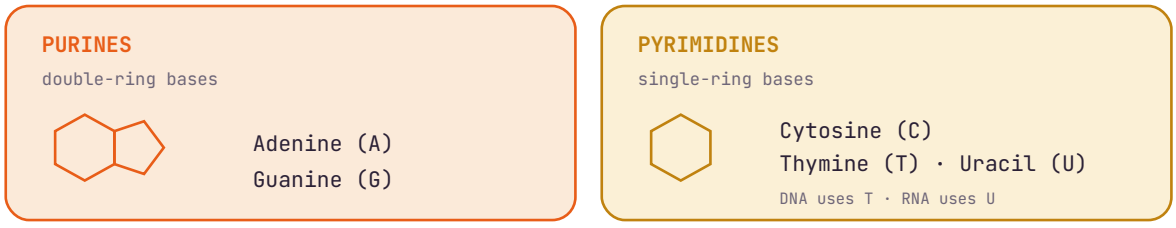


Building a nucleotide: base + sugar makes a nucleoside; adding a phosphate makes the nucleotide.

★ BUILDING A NUCLEOTIDE

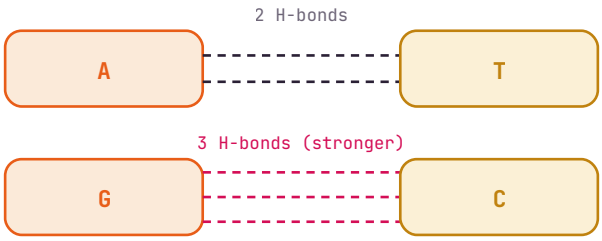
A nitrogenous base + a pentose sugar = a **nucleoside** (adenine + ribose = adenosine). A nucleoside + a phosphate group = a **nucleotide**. So nucleotide = base + sugar + phosphate. The phosphate is the difference between the two, and that is a standard exam point.

The bases: purines and pyrimidines



Double-ring purines versus single-ring pyrimidines. DNA uses thymine; RNA swaps in uracil.

Base pairing and Chargaff's rule



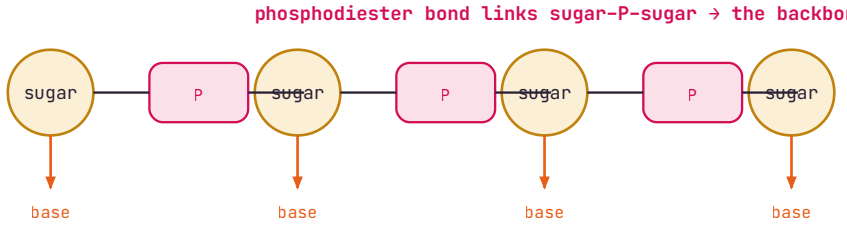
Chargaff's rule

A = T and G = C

GC-rich DNA is more heat-stable

Strict complementarity: A–T by two hydrogen bonds, G–C by three. The G–C pair is stronger, so GC-rich DNA resists heat.

The phosphodiester bond and the backbone



Bond type 3 of the three NCERT asks you to illustrate. Bases project outward from the backbone.

Phosphate bridges the sugars of adjacent units, building a repeating sugar-phosphate backbone with bases projecting out.

In DNA, two such strands twist into the **Watson-Crick double helix** (proposed 1953), held together by hydrogen bonds between complementary bases.

Feature	DNA	RNA
Sugar	2-deoxyribose	Ribose
Bases	A, G, C, T	A, G, C, U
Strands	Double-stranded helix	Usually single-stranded
Role	Stores hereditary information	Gene expression (mRNA, tRNA, rRNA)
Stability	More stable (deoxyribose, 2 strands)	Less stable (ribose reactive)

7 Enzymes: The Catalysts of Life

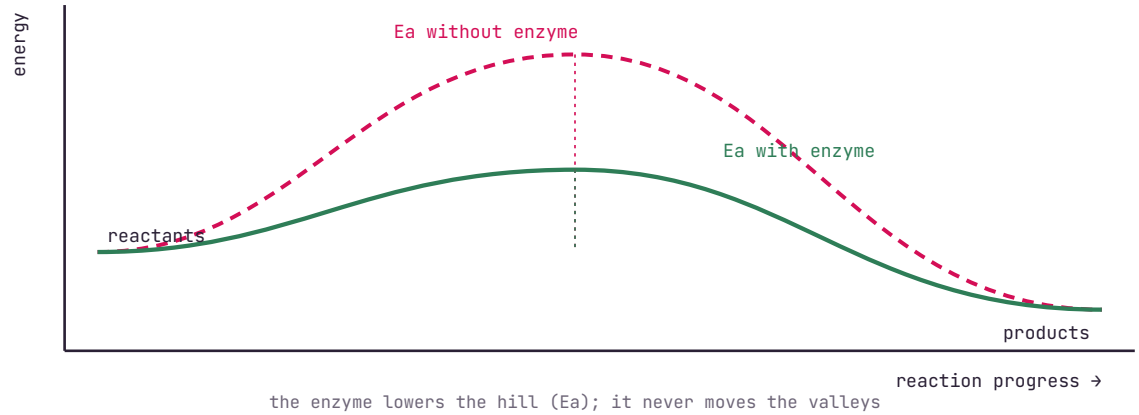
Enzymes are the busiest and most-tested topic in this chapter. Almost all enzymes are proteins, and the shape of the protein *is* the mechanism. A cell running thousands of reactions per second at body temperature is only possible because enzymes exist.

★ WHAT AN ENZYME IS

A biological catalyst that speeds up a reaction without being consumed and without changing the equilibrium. The tertiary fold creates a pocket, the **active site**, into which the substrate fits. One exception: some RNA molecules act as catalysts, called **ribozymes**. So the safe statement is "almost all enzymes are proteins, except ribozymes, which are nucleic acids."

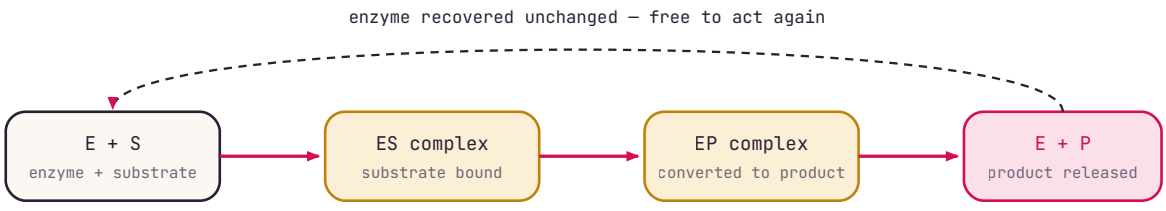
How enzymes work: lowering activation energy

Every reaction has an energy barrier, the **activation energy**, that reactants must climb. Picture a substrate that must pass over a hill to reach the product valley. An enzyme does not change the height of the valleys; it **lowers the hill**. With a smaller barrier, vastly more molecules can react, so the rate can rise a millionfold or more.



The enzyme lowers the activation-energy hill between reactants and products, never the energy of the valleys themselves.

The mechanism runs through an **enzyme-substrate (ES) complex**: the substrate binds, is converted while bound, and the product is released, leaving the enzyme unchanged and ready to act again.



The catalytic cycle: E + S → ES → EP → E + P, with the enzyme recovered intact each time.

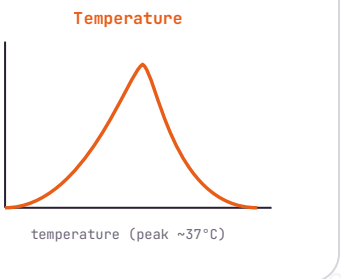
The two models of the active site

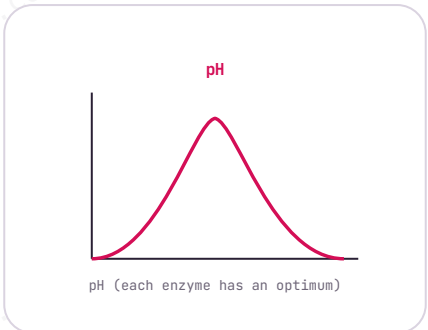
Both explain specificity — induced-fit is the accurate model NCERT favours.

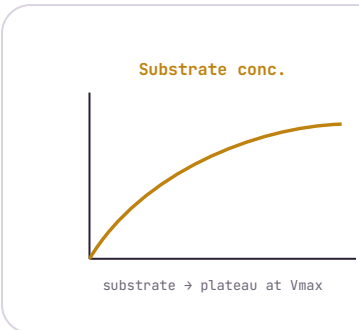
Lock-and-key treats the site as rigid; induced-fit (the accurate model) has a flexible site that moulds around the substrate.

Factors affecting enzyme activity

Because activity depends on the delicate 3D shape, anything that disturbs that shape changes the rate.







Temperature and pH each have an optimum, beyond which the protein denatures; rate rises with substrate until every active site is busy (Vmax).

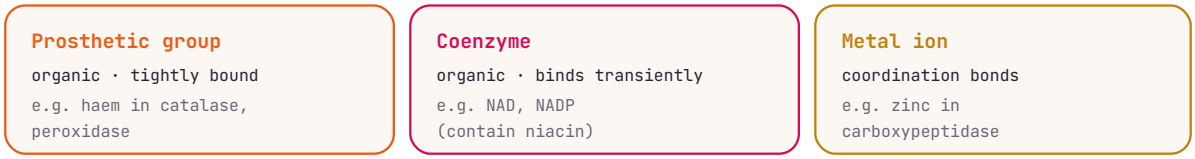
ENZYME INHIBITION

Inhibitors reduce activity. The classic type is **competitive inhibition**: the inhibitor resembles the substrate closely enough to occupy the active site. The textbook example is **malonate**, which competitively inhibits succinate dehydrogenase by mimicking succinate. This is the basis of many drugs.

Cofactors: when the protein needs help

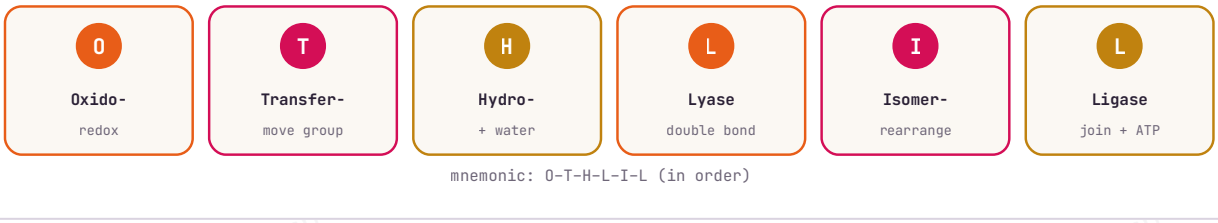
Many enzymes need a non-protein partner. The protein part alone is the **apoenzyme**; the helper is the **cofactor**; together they form the active **holoenzyme**.

Apoenzyme plus cofactor equals the complete, catalytically active holoenzyme.



The three kinds of cofactor, with the example NEET expects for each.

Classification: the six IUB classes



Every enzyme falls into one of six classes by the reaction it catalyses — remembered as O-T-H-L-I-L.

Class	Reaction catalysed	Example / note
Oxidoreductases	Oxidation-reduction (electron transfer)	Dehydrogenases, oxidases
Transferases	Transfer of a functional group between molecules	Transaminases
Hydrolases	Hydrolysis (breaking bonds using water)	Digestive enzymes
Lyases	Remove groups to leave double bonds (not by hydrolysis)	Decarboxylases
Isomerases	Rearrangement within one molecule	Isomerases
Ligases	Join two molecules using energy (ATP)	DNA ligase

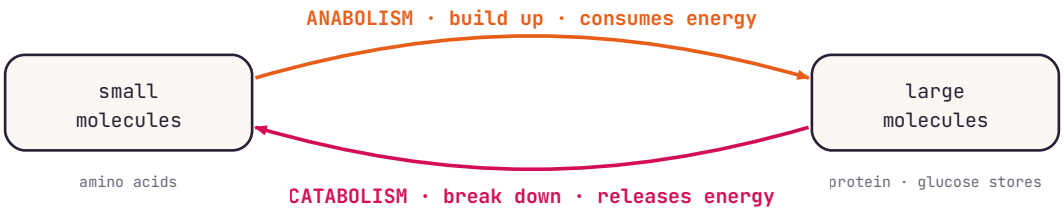
PROPERTIES OF ENZYMES (QUICK RECALL)

Proteinaceous (except ribozymes), high molecular weight · highly specific via active-site shape · reusable, recovered unchanged · extremely efficient (catalase clears millions of H_2O_2 per minute) · sensitive, denatured by heat and pH extremes.

8 Metabolism and the Dynamic State of the Body

The chapter closes with the big picture: none of these molecules sit still. They are all part of a ceaseless flow called **metabolism**.

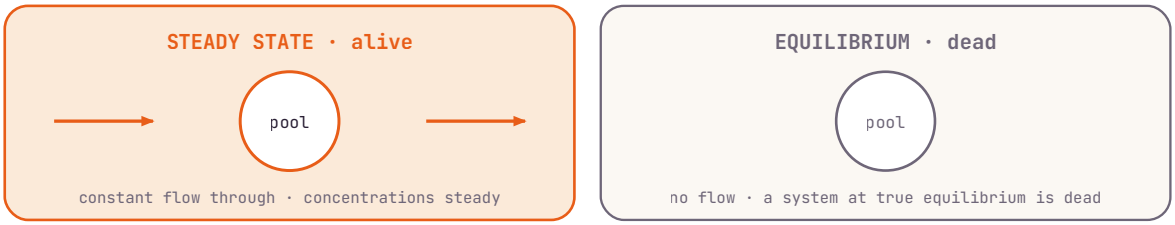
Every biomolecule is constantly made and broken down, each conversion catalysed by an enzyme. Reactions that build larger molecules from smaller ones and consume energy are **anabolic** (protein synthesis from amino acids). Reactions that break larger molecules into smaller ones and release energy are **catabolic** (glucose breakdown in respiration).



The two directions of metabolism: anabolism builds up and stores energy; catabolism breaks down and releases it.

The dynamic state and living organisation

Metabolites are continuously turned over: the body is in a **dynamic state**, not a static one. Yet concentrations stay remarkably steady, a balance called the **metabolic pool** or steady state.



Life sits in a steady state, not at equilibrium — a system at true equilibrium has no flow, and is dead.

★ THE DEEP IDEA NCERT ENDS ON

Living organisms exist in a **steady state, not at equilibrium**, because a system at true equilibrium is dead. It is the constant flow of energy through the living machine, driven by enzymes, that keeps it organised and alive.

★ Biomolecules · One-Page Fact Sheet

Everything for revision day. Print this page alone.

CHEMICAL ANALYSIS

grind + acid + filter
acid-soluble = micromolecules
acid-insoluble = macromolecules
lipids: small but insoluble
ash = inorganic part

METABOLITES

primary: known role (amino acids, sugars)
secondary: plants/microbes (alkaloids, rubber, oils)
found across all life → primary

MACROMOLECULES

MW > 10,000 Da
protein → amino acids
nucleic acid → nucleotides
polysacc → monosaccharides
lipid: not a true polymer

CARBOHYDRATES

cellulose: β-glucose, most abundant
starch: plant store, +iodine
glycogen: animal store
inulin: fructose
glycosidic bond: O-bridge

PROTEINS

monomer: amino acid (20)
peptide bond –CO–NH–
collagen: most abundant (animal)
RuBisCO: most abundant (Earth)
roles: enzyme, transport, defence

PROTEIN STRUCTURE

1°: sequence, N→C
2°: α-helix / β-sheet (H-bond)
3°: 3D fold, active site
4°: subunits (Hb = 4)
shape = function

NUCLEIC ACIDS

nucleoside: base + sugar
nucleotide: + phosphate
purine: A, G (2-ring)
pyrimidine: C, T, U (1-ring)
A=T (2 H-bonds), G=C (3)

ENZYMES

biocatalyst, lowers Ea
almost all protein; RNA = ribozyme
lock-key / induced fit
apo + cofactor = holo
competitive: malonate / succinate DH

ENZYME 6 CLASSES

Oxidoreductase
Transferase, Hydrolase
Lyase, Isomerase, Ligase
optimum T and pH
denatured by heat / pH

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★ CONCEPT STILL NOT CLICKING?

Play it. Then practice it.

If something here didn't land, open the chapter in the Logic Bloom app: play the concept as a game, then drill practice questions till it clicks.

SCAN → PLAY THE GAME · PRACTICE NOW